Enabling the Internet of Things
IoT Certification Basics
White Paper

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ROHDE&SCHWARZ

Table of Contents

1 Introduction

One of the unique capabilities of most IoT products is their use of wireless technologies to connect to a network or the internet itself. Products that communicate in the licensed frequency spectrum must abide by a set of rules that ensure they operate successfully, while also not interfering with other devices within its proximity. As the government owns this frequency spectrum, there are established test houses that verify a product's conformance to the rules.

Even in the unlicensed spectrum there are rules and industry based governing bodies that require certifications before a product can advertise being Bluetooth, WiFi etc. certified. These rules ensure, not only compatibility between products, but also connecting the device to your home network won't disrupt the other devices in your house.

In this third and final paper of our IoT series, we focus on the pre-certification and compliance phases of the product life cycle (Fig.1). This is a very important phase in the process and also one of the biggest areas where people have issues. Understanding the certification process and integrating these best practices into your development process will improve your time to market and reduce your certification costs.

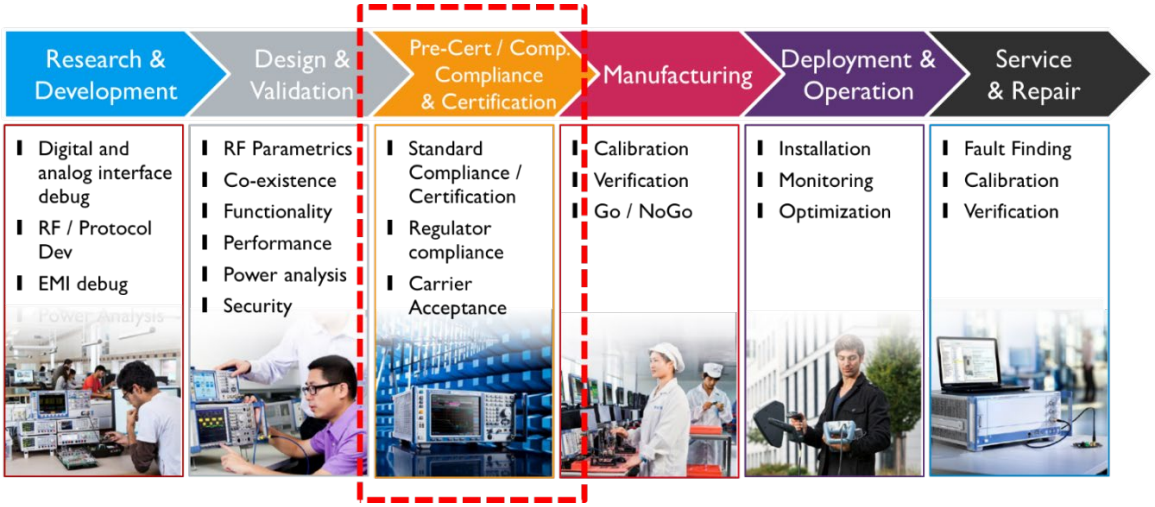


Figure 1. Understanding pre-certification and compliance testing is key to a successful product launch.

2 Wireless Device Strategy

There are two common wireless device strategies to consider – the chip on board approach or the certified module approach (Fig.2). The most common, and easiest way, is to buy an off-the shelf certified module which only needs the antenna to be attached. Going this route takes advantage of the certification work done by the module manufacturer and requires a minimal amount of certification for your product. A potential downside could be that your form factor must be designed to fit the module and you may be adding another level of technical support.

The chip on board approach involves purchasing a commercially available chipset and placing it on your own PCB. You design the RF chips, the interfaces, etc. This offers control over many of the design aspects, but at the expense of higher up-front design and certification expense. Remember, you may need not only FCC certification, but potentially the standard bodies and the carriers.

Choosing your wireless device strategy determines both the cost of your certification and how much testing needs to be done. This may include: where it needs to be done, what tools are required, and the skill level of your resources.

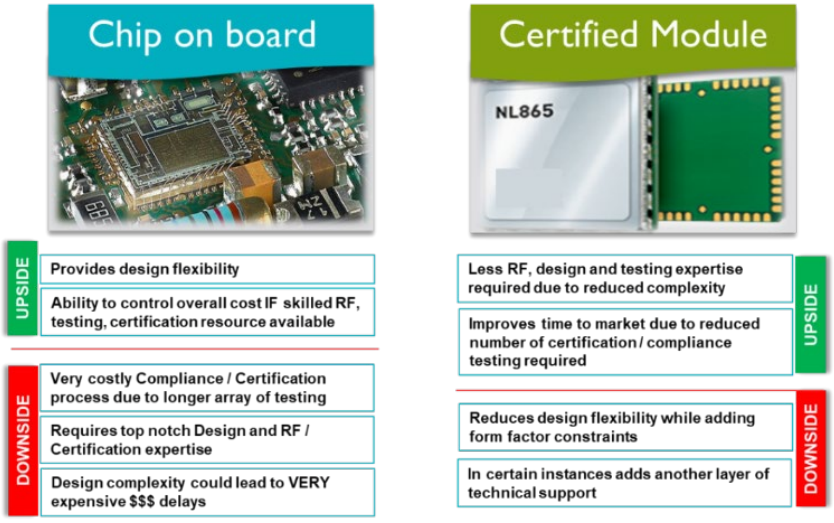


Figure 2. Wireless Device Strategy

2.1 Chip on board Case Study

We worked with an IoT device manufacturer that used the chip on board approach. They were making a home automation product that would control everything it had in the house. They wanted to have design flexibility as they were including Bluetooth, WiFi, LTE, WCDMA, ZigBee, and proprietary technologies.

The customer had limited access to internal test equipment and relied solely on the chip set manufacturer to help them through the process. Unfortunately, the test house uncovered many issues and they didn't have the internal expertise to debug and resolve problems. In the end, the product launch was delayed by over six months and the cost of the compliance and certification testing was about $1.2 million.

It's very important to pick a strategy that matches your priorities and capabilities. This ensures that you have the right resources in-house to enable what you need to do. If you're new to RF wireless applications, the module approach may be a lower risk approach.

Certification vs Compliance vs Conformance

First let's define and clarify three key terms that are common to this process. Sometimes these words may seem similar, but they have distinctly different meanings. It is important to understand the subtle and even legal differences in the words – certification, compliance and conformance (Fig.3).

Certification is the act of certifying something, in this case it means that a product has been approved by a recognized third-party. It certifies that your product meets the requirements of a government regulatory agency or industry standard.

Compliance is the act or process of complying to the rules of a regulatory body. When you are designing and manufacturing your product, you test it to be sure that it complies to the regulations. The next step may be to take the product to a recognized test house for certification. The FCC in the US is typically the main regulatory body for compliance. In Europe, you have the CE and in Canada you have Industry Canada.

Conformance is the act or process of conforming to the rules developed for an industry standard such as Bluetooth, WiFi or LTE. In the wireless space, there are numerous agencies and network operators who work across the industry to define wireless standards. They manage certain technologies and the protocols for when things interact. They want to make sure that you are conforming to the industry rules. Network operators have their own set of requirements that must be confirmed before they allow a device on their network. Both the wireless agencies and network operators work with test houses to certify conformance to the industry and network standards.

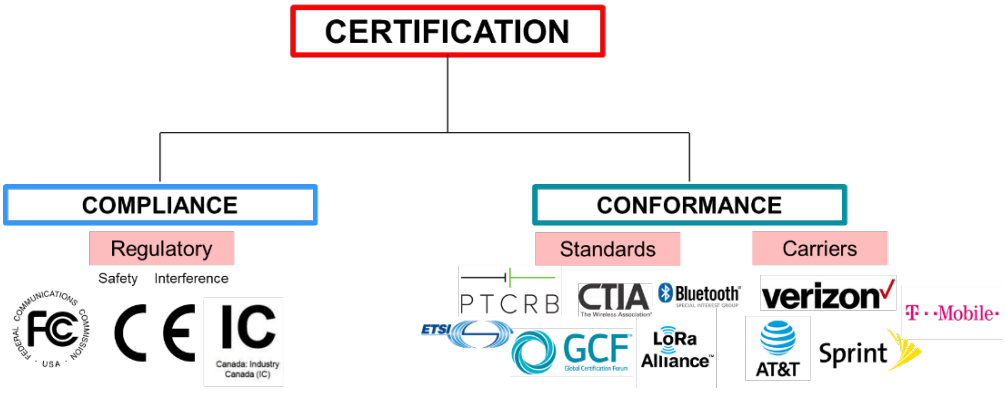


Figure 3. Understanding certification terminology.

3 Certification Bodies

First you need to consider the location or country where your device will be launched. What are their regulatory requirements and network operator requirements (if applicable). The US, Canada, Europe, Asia, etc. all have regulatory bodies (Table 1). In some cases, industry standards are common across the various countries. Often, they may have many similarities, but be at different frequencies or have unique signal requirements.

While at first it might seem overwhelming, keep in mind that there are many test houses that will work with you to get the information needed to get started. In this section we review the agencies for certifying your product in the United States.

1.Regulatory Certifications
FCC (USA) • PTCRB (USA) •CE (Europe) • IC (Canada) • GCF (Europe) • RCM (Australia / New Zealand) • E-Mark (Europe) • TRA (UAE) • iDA (Singapore) • RoHS • NBTC (Thailand) • SIRIM (Malaysia) • SDPPI (Indonesia) • SRRC/CCC/NAL (China) • ICASA (South Africa) • MIC (Vietnam) etc

2. Ruggedized Certifications
•IP Certifications (Ingress Protection or International Protection)– IP65, IP66, IP67, MIL-STD-810

3. Carrier Certifications
•AT&T, Verizon, Vodaphone, Telstra etc.

4.Specialized certifications :
•Food, Pharma, Medical, Oil & Gas

Table 1 Certification Bodies

3.1 FCC

The FCC's mandate is to regulate interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories. It's an independent U.S. government agency overseen by Congress and the FCC commission is the United States' primary authority for communications law, regulation and technological innovation.

Their objective is to ensure that your product does not harm or interfere with other players within the spectrum – both licensed and unlicensed. In addition, they make sure that your device will be immune to interference from the other players.

The FCC has published their rules in the Code of Federal Regulation (CFR www.ecfr.gov) Part 47 (Telecommunications). They require that testing must be done in accredited FCC labs. The following are the mandatory required certifications:

- SAR under 47 CFR Part 2, section 2.1093, 1.1310 (For devices used within 20cm of the human body)

- FCC Part 15 Subpart C for intentional Radiators
- FCC Part 15.1b, unintentional radiator requirements
- FCC Part 22/24/27 for Cellular, PCS, Broadband transmission Certification

3.2 CTIA

CTIA represents the U.S. wireless communications industry and companies throughout the mobile ecosystem. It manages and administers many certification programs and test plans (Fig.4). WiFi, Bluetooth and ZigBee are administered by CTIA in North America. Each of these technologies have their own dedicated certification tests (https://www.ctia.org/initiatives/certification/certification-test-plans). While the wireless standard certification is not compulsory, it is required to use the branding and achieve proper interoperability. All wireless products must also all pass the FCC certifications.

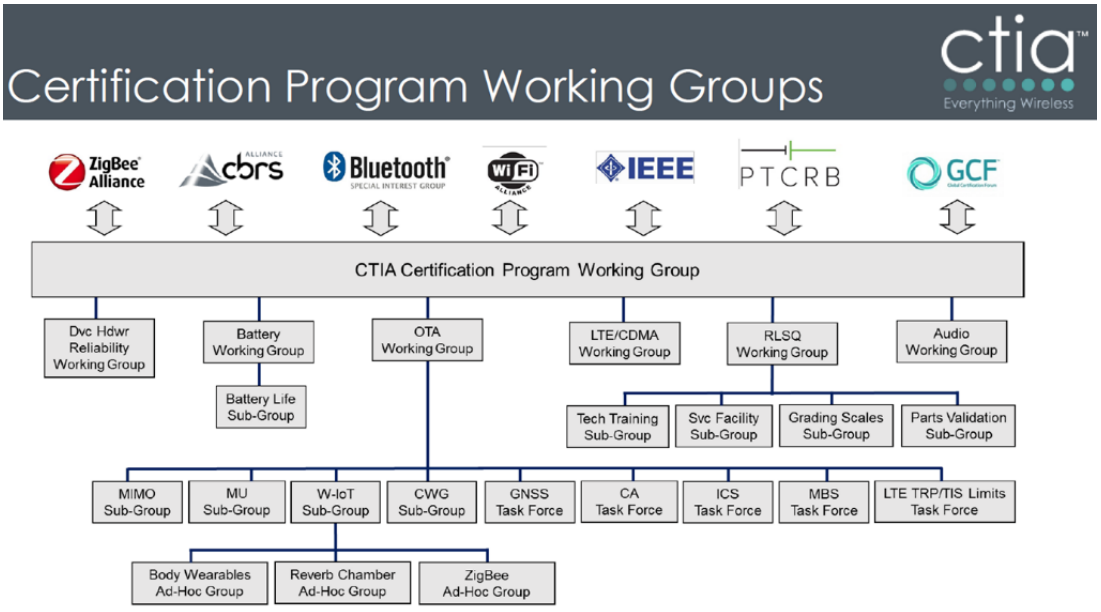


Figure 4. CTIA manages and administers certification programs for WiFi, Bluetooth, ZigBee and other technologies.

3.3 PTCRB

PTCRB (https://www.ptcrb.com) is a certification organization established in 1997 by leading wireless North American operators to define test specifications and methods to ensure device interoperability on global wireless networks. The certification is required by North American cellular carriers, with the exception of Verizon Wireless (Fig.5). PTCRB testing covers conformance (3GPP / OMA Specs) and OTA (Over-the-Air) performance. CTIA is the current administrator of the PTCRB Certification process.

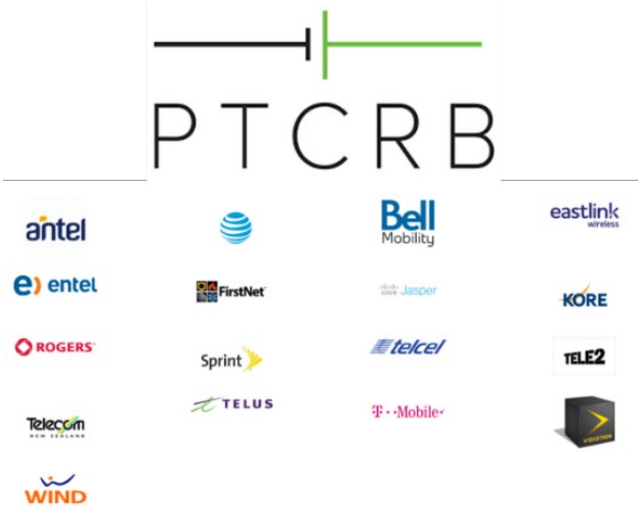


Figure 5. PTCRB is a certification organization that ensures device interoperability on global wireless networks.

3.4 Network Operators

In addition to certification by the standard bodies, each network operator has their own requirements, which IoT devices must meet to be allowed on their network. Table 2 highlights the requirements of each of the network operators. Each offer their own test plans and will help you understand their certification process.

- PTCRB
- TRP: Total Radiated Power (test limits in dBm, protected by NDA)
- TIS: Total Isotropic Sensitivity (test limits in dBm, protected by NDA)
- AT&T Compatibility Testing

- verizon ODI process can be found online
  - No PTCRB
  - TRP and TIS for LTE;
  - LTE: Conducted RF testing; antenna ECC; SAR if tablet, CAT-M1, NB-IoT etc
  - Conformance testing, field testing

Sprint
- No PTCRB
- GCF, TRP and TIS (they will test first attempt for free at their lab)

T··Mobile· PTCRB, but no TRP or TIS for M2M

Table 2: Network operator IoT device requirements

4 Certification Testing

4.1 Specific Absorption Rate

Specific Absorption Rate (SAR) testing measures the amount of electromagnetic energy absorbed by biological tissue when using a wireless device over a period of time. It allows you to demonstrate that your product complies with internationally established RF exposure SAR limits.

Most mobile devices will be used within 20cm of the body, head, ankle or wrist. At this proximity the user is exposed to electromagnetic fields (EMF), which are a form of non-ionizing radiation. These fields are the basis of how a wireless device communicates.

SAR testing involves the use of a “phantom” which simulates the human head (Fig.6). A liquid which is designed to be the electromagnetic equivalent of human tissue (brain) is placed in this phantom. The device under test is put into a “call” at maximum power and a robotic arm then moves a measurement antenna through the liquids and makes electric field measurements.

Courtesy: UL Labs

Figure 6. Specific Absorption Rate Testing

4.2 Intentional Radiators

The FCC's Part 15C Intentional Radiator emission specification is for devices that are deliberately designed to produce radio waves in the unlicensed frequency. Radio transmitters of all kinds, including a garage door opener, cordless telephone, wireless video sender, wireless microphone, and many others fall into this category.

These types of devices fall into three main radio communication schemes:

- Digital Modulation: WiFi, Zigbee, Lora
- Frequency Hopping Modulation: Bluetooth
- Low power Narrow band transmission: Garage Door openers, Keyless entry for automobiles

The FCC's Part 22, 24, 27 Intentional Radiator emission specification is for devices that are deliberately designed to produce radio waves in the licensed bands (Cellular, PCS, Broadband transmission Certification). If you are leveraging a certified module, you can avoid Part 22, 24, 27 testing if your device:

- Has NO Co-location: Another radio within 20cm that can transmit at the same time
- Is Not portable: portable means used within 20cm of human body

The intentional radiator testing is usually done in an EMC radiated test facility (Fig.7).

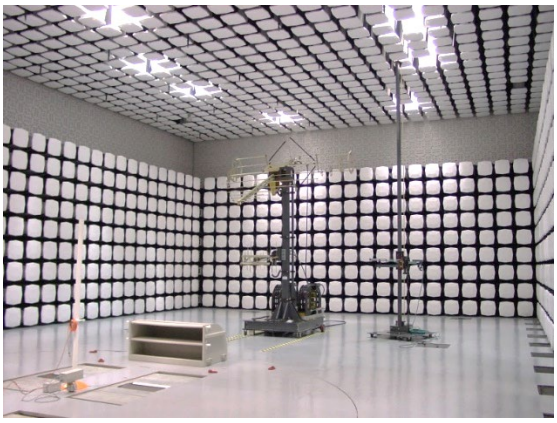


Figure 7. EMC test facility

4.3 Un-Intentional Radiators

The FCC's Part 15b Unintentional Radiator emissions specification regulates undesired signals from the radio or other parts of the device including the IoT radio receiver, clock generator, power supplies and digital circuits. For most rule sections, these unintentional emissions must be measured to the 10th harmonic of the transmitting signal. For example,

if your WiFi device is transmitting at 2.5 GHz, you would be required to make sure the 10th harmonic signal at 25 GHz is below the FCC requirement. So, even though your operational frequency is at 2.5 GHz, your spectrum analyzer would need to be able to cover frequencies up to 25 GHz.

5 Certification Tips

5.1 Estimating Cost

While it is difficult to estimate certification costs for every application, the relative cost tradeoffs between the chip on board vs. certified module approach may be similar (Fig.8). The following LTE application cost estimates were provided by a certified module vendors.

If you buy a chip, it will be much lower cost than the certified module. However, there will be a high non-reoccurring engineering expense. In addition, the certification costs can be over a million dollars or more. Since the certified module has gone through testing and is pre-approved, its initial cost will be much higher than the chip. The module certification, if it's done right, might cost between $30,000.00 to $100,000.00. So, there's almost a 95 percent cost reduction when it comes to the module approach. For a major cell phone manufacturer, the chip on board approach may be the only way to go. However, for a low cost IoT product in a new application space, it's advisable to go with the certified module approach. You have less headache and potentially a faster time to market. Plus, it's cheaper if you are just getting started.

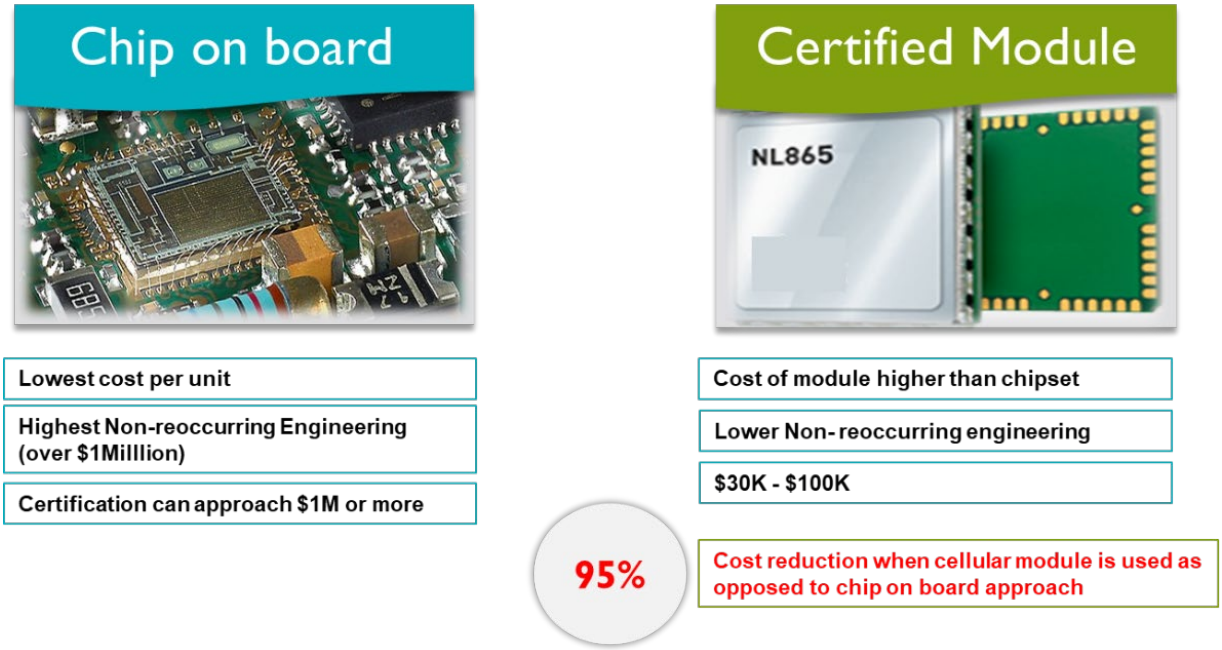


Figure 8. Certification cost estimates for a Cellular 2G, 3G, LTE application.

5.2 Common Issues (This could be done in bullet point format)

What are the most common certification issues? When you are spending money at a test house, that is the last place you want to learn about certification problems.

First, many manufacturers focus all their efforts on product design and only consider compliance after the design is complete. So, the product works but fails certification.

Invest the time to study what needs to be done and consider adding resources to support your efforts. Misunderstandings of the certification rules can be costly and add delay to your product launch.

Be sure to include interfaces for your device for when it goes to test. Serial ports, APIs, etc. may be needed to help exercise your product during testing.

Many of these IOT devices are going onto data networks and will need Retry Failback capabilities. Network in the future may have billions of connected devices, if there's a network outage and they all try to come back at the same time it could bring down the network. Your product may need to include mechanisms that allow for a timely retry failback activities.

Make sure that the equipment you're using has up to date calibrations. This ensures that your measurements are accurate. Regularly check your pre-test setup and lab area to make sure there's no interference polluting your results.

Keep in mind that the OTA requirements from the network operators can be stringent. You need their approval before you can get on the network. Similar for getting PTCRB approvals. Everyone today expects to have the WiFi, Bluetooth certification.

When you're taking your device to get certified, be sure it's the same device you have used in your pre-testing. Don't use new a device. There might be variations. You want to go with a known entity.

5.3 Mitigating Failures

- Focus on your product design, but keep an eye on certification test requirements
- Pay close attention to the Antenna design
- Space is key, make room.
- Keep away from metal such as PCB, display, cables enclosure
- Build support interfaces
- Pass through mode to access the module
- SW update capability and back off periods
- Pretest!

- Invest in validation and pre-compliance setups
- Prevent costly design change and delay late in the development process. Testing should be an iterative process right from R&D to launch
- Start EMI testing early in the process

6 Test Solutions

Testing may seem to be very complicated, time-consuming and costly, especially for players entering the wireless communications arena for the first time Fig.9. As an expert in wireless communications, Rohde & Schwarz will help you understand the critical testing requirements for your IoT device and can provide you with the proper test solutions to validate your device from the early R&D phase all the way through to manufacturing.

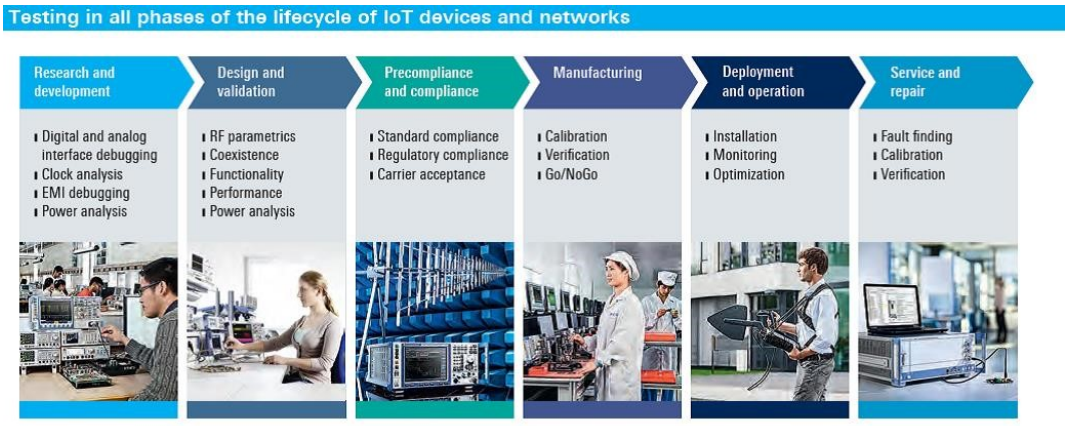


Figure 9: Rohde and Schwarz supports testing throughout the entire product lifecycle.

Test and measurement solutions from Rohde & Schwarz cover all major cellular and non-cellular technologies. Our comprehensive product portfolio offers the right solution for your IoT device – from the first product idea through the full device lifecycle. The following are examples of our many solutions for IoT product development:

Smart debugging of embedded designs.

Troubleshoot your IoT device at the system level through time-correlated analysis of analog components, digital interfaces, protocol-based buses, power supplies and RF signals with a digital oscilloscope.

End-to-end application testing.

Explore the functionality and performance of your IoT device from the end-to-end perspective by analyzing data and signaling traffic, quality of service and battery consumption under realistic network conditions.

Wireless test setups for R&D and manufacturing.

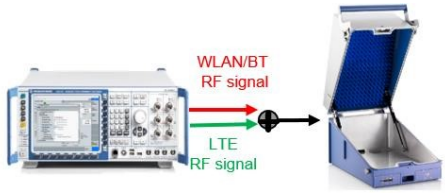
Test the radio interface of various wireless standards over the air with a compact test system consisting of a signal generator, spectrum analyzer and RF shielded box.

Conformance testing.

Test the EMC conformance of your IoT devices operating in the 2.4 GHz and 5 GHz ISM bands such as Bluetooth® and Wi-Fi.

Antenna Performance testing.

Verify proper functionality for IoT device transmitter and receiver within specification by performing TRP/TIP measurements in an Over-the-Air test environment.



Co-Existence testing.

Analyze receiver sensitivity by testing the device under conditions where multiple technologies are communicating at the same time. Eg. WLAN (or BT) and LTE.

Rohde & Schwarz

The Rohde & Schwarz electronics group offers innovative solutions in the following business fields: test and measurement, broadcast and media, secure communications, cybersecurity, radiomonitoring and radiolocation. Founded more than 80 years ago, this independent company has an extensive sales and service network and is present in more than 70 countries.

The electronics group is among the world market leaders in its established business fields. The company is headquartered in Munich, Germany. It also has regional headquarters in Singapore and Columbia, Maryland, USA, to manage its operations in these regions.

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Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

Certified Quality Management ISO 9001

Certified Environmental Management ISO 14001

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