



Project 25 Testing: Products, Services, and Solutions

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The Project 25 Technology Interest Group (PTIG) is proud to provide a comprehensive overview of the Project 25 testing products and services available from PTIG members today.

We have witnessed over 25 years of Project 25 Standards Evolution and P25 Product Technology Improvements in the 2800+ P25 Systems on the air today. Project 25 Technology is now well established as a primary communications solution for Government Agencies, Public Safety, and Critical Infrastructure.

Testing of Project 25 Equipment and Networks has advanced along with the evolution of P25, and dramatic improvements in P25 product and network technology testing are now available to help users in the procurement, application and maintenance of their P25 Systems.

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The topics will cover how each product or service is used to test compliance to the Project 25 Suite of Standards. Examples will be included for:

- Application of the test technology in a P25 System procurement or upgrade.
- Qualification of multiple vendor products for new and existing systems
- Testing for interoperability
- Testing for DHS Compliance Assessment Program (CAP)
- Use of testing to resolve performance Issues
- Ongoing P25 System maintenance and support.

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Definition: What is P25 Compliance?

Below is a summary from the paper “*What is P25 Compliance?*”, written by Andy Davis, Chairman TIA TR-8 Committee.

In general, “Project 25 (P25) compliance” is typically interpreted as: “adherence to the P25 standard.”

The P25 Standard is composed of over 80 documents that cover multiple interfaces, services and features associated with each interface or service. With such a quantity of material, general questions or statements about compliance to the “P25 standard” are typically vague or abstracted, as it is difficult to encapsulate this broad span of criterion into general rules. Questions or statements about any level of compliance are more effectively expressed in the context of a specific interface, in reference to a certain service, or about a particular feature, many of which have been covered in detail by published P25 standard documents.

Compliance in the context of a published P25 standard document:

The P25 Standard currently enables interoperable implementation of the following interfaces:

- FDMA Common Air Interface
- TDMA Common Air Interface
- Data Host Network Interface
- Mobile Data Terminal Interface
- Inter Key Management Facility Interface
- Key Fill Interface
- Inter Sub System Interface
- Console Sub System Interface
- Conventional Fixed Station Interface

The P25 Standard also identifies a Telephone Network Interface and a Network Management Interface. The operation of these interfaces is defined by industry standard documentation outside the P25 Standard.

As the P25 Standard consists of over 80 individual documents, it is more accurately referred to as the P25 Suite of Standards. The P25 Steering Committee determines which documents to include in the P25 Suite of Standards. To date, all documents included in the P25 Suite of Standards have been created by and are maintained by the Telecommunication Industry Association’s TR-8 Mobile and Personal Private Radio Engineering Committee. These documents comprise the TIA-102 series of standard documents.

Compliance in the context of the P25 Statement of Requirements (SoR) document:

The P25 Statement of Requirements (SoR) document is created and maintained by P25 Steering Committee’s User Needs Subcommittee (UNS). Since its inception the Project 25 Suite of Standards has been based on Radio User requirements, and users remain an integral component to the ongoing standards process. It should be noted that the P25 SoR is currently undergoing a major update and re-design that is expected to be complete in calendar year 2020.

The P25 SoR drives P25 Standard creation and content. This document contains high-level descriptions of functionality but does not include the specifications and technical definitions sufficient to enable interoperability among multiple manufacturers. The standard documents that are developed from the P25 SoR and are intended to enable that interoperability. While several P25 SoR items do trace to published standards, there are a number of items which do not. Items in the P25 SoR that do not trace to published standards are either pending standard creation or are considered system or equipment capabilities.

For these reasons, compliance statements at this level mean the functionality described in the P25 SoR has been implemented, but that implementation may or may not trace to published P25 standards. As a result, one manufacturer's implementation may or may not interoperate with another manufacturer's implementation of the same functionality.

Compliance in the context of a published P25 standard TEST document:

Compliance statements at this level mean functionality has been implemented per a P25 Standard document and has passed P25 standard tests associated with that functionality.

The P25 Suite of Standards also includes three types of standard test documents:

- Performance Test standards describe methods of measurement for important performance aspects of a P25 interface and recommended performance limits.
- Conformance Test standards describe methods for capturing and evaluating whether standard messages (defined by the P25 Standards) are exchanged in the proper order and contain the proper content in the context of specific standard features associated with a particular standard interface.
- Interoperability test standards describe the expected behavior of specific features associated with a particular interface under specific operating conditions. This testing typically documents successful interoperability between infrastructure and subscriber units from multiple manufacturers.

Compliance in the context of the DHS OIC Compliance Assessment Program (CAP):

The DHS OIC Compliance Assessment Program identifies equipment tests that may or may not be included in the P25 suite of standards. When CAP testing uses tests included in the P25 suite of standards, then compliance statements at this level indicate the following: tested functionality has been implemented per a P25 Standard document (or documents), this functionality has passed its associated P25 standard tests that are included in CAP Compliance Assessment Bulletins (CABs), and finally, the testing was performed in CAP recognized labs and the test results are reported in a CAP approved document.

The Department of Homeland Security (DHS) Office of Interoperability and Compatibility (OIC) operates the Compliance Assessment Program (CAP). While P25, TIA and CAP work together for a common cause, the DHS OIC CAP is administered independently of P25 and TIA. Manufacturer participation in the Compliance Assessment Program is voluntary and is governed by Compliance Assessment Bulletins (CABs) published by CAP.

Project 25 Compliance Assessment Program (P25 CAP)

Project 25 (P25) is a unique user-driven process that works with equipment manufacturers to establish current and emerging wireless land mobile radio (LMR) communications standards that meet the requirements of the public safety community.

P25 Compliance Assessment Program (P25 CAP) is a voluntary program that enables suppliers to publicly attest to their products' compliance through P25 CAP testing at DHS-recognized laboratories. It establishes requirements for lab recognition, equipment testing and test report content for ensuring digital communications equipment has been built to the P25 Standards

All equipment suppliers that participate in the P25 CAP must use DHS-recognized laboratories to conduct performance, conformance, and interoperability tests on their products.

Test laboratories must demonstrate their competence through a rigorous and objective assessment process conducted by the approved accreditation bodies. This promotes the user community's confidence and acceptance of test results.

After successful testing, suppliers submit Summary Test Report (STR) and Supplier's Declaration of Compliance (SDOC) documents to report the test results. These documents are available on the Approved (Grant-Eligible) Equipment page, as allowable equipment to be purchased by several federal grant programs.

This program serves to increase the public's confidence in the performance, conformance and interoperability of P25 equipment.

Common P25 terminology -

1. P25 Statement of Requirements (SoR): Approved by the P25 Steering Committee, this is the basis for P25 standards development. Not all items in the P25 SoR have accompanying standards.
2. P25 Standard: TIA-102 Standards are developed by the Telecommunications Industry Association (TIA), an American National Standards Institute-accredited standards development organization. They may be adopted by the P25 Steering Committee into the P25 Standard.
3. P25 Standard Test: The TIA-TR8 Engineering Committee develops standardized, published testing procedures which may then be adopted for P25 CAP Compliance testing. These testing procedure documents are known as Recommended Compliance Assessment Tests (RCATs). Not all features defined by P25 Standards have standardized testing procedures.
4. Non-P25 CAP Test - Testing may be done against standards outside the P25 CAP Compliance Program but cannot be used to determine P25 CAP Compliance.
5. Compliance Assessment Bulletins (CABs) – CAB's define all the test cases for P25 CAP testing. Independently accredited laboratories must conduct P25 CAP test scenarios exactly as described in these CAB's. Not all features defined by P25 Standards have approved CAB's.

6. CAP Compliant means that the manufacturer has tested all supported P25 features for the tests identified in the CAB and the testing has been performed in a CAP recognized lab and the SDOC and STR have been approved and posted by CAP.

CAB versions:

Newly published CABs (October 2018) take the place of previous CABs. Equipment must be tested to 2016/2017/2018 CAI CAB requirements to be listed on the “Approved (Grant-Eligible) Equipment List.”

Rules for the Application of CABs -

REF: DHS Science and Technology Office for Interoperability and Compatibility
Technology Center
Project 25 Compliance Assessment Bulletin
Project 25 Compliance Assessment Program, P25 CAP Compliance Testing Rules
P25-CAB_TESTING_RULES_FOR_P25CAP
October 2019

1. Any (conventional only, conventional/trunked FDMA only, or conventional/trunked FDMA/TDMA) new product (new hardware, new software and never been P25 CAP tested before) must be tested to [CAI-CAB-2018].
2. If the product started the P25 CAP testing process using [CAI-CAB-2017], the product can finish the testing process and be submitted as tested under the 2017 CAB.
3. Products that support conventional/trunked FDMA/TDMA and have already been tested to [CAI-CAB-2017], do not need to be gap tested to [CAI-CAB-2018]. Gap testing for Rule 3 refers to testing of the new test cases and changes that were added to [CAI-CAB-2017], which then became [CAI-CAB-2018].
4. Products that only support conventional FDMA or conventional/trunked FDMA and tested to [CAI-CAB-2016], do not need to be gap tested to [CAI-CAB-2017] or [CAI-CAB-2018]. Gap testing for Rule 4 refers to testing of the new test cases and changes that were added to [CAI-CAB-2016], which then became [CAI-CAB-2017].
5. Given rules 1-4, any product that has already been tested and submitted under [CAI-CAB-2017], may be gap tested and new SDOC and STR submitted under [CAI-CAB-2018].
6. Any time modifications/updates are made to a product (a particular model or a model class) that would change previously reported SDOC and STR test case results, the product manufacturer is required to gap test the test case results that changed and submit a new SDOC and STR using the latest published CABs.
7. If a product is still available for procurement 5 years after the product was originally approved by P25 CAP and the STR results are still valid, the product manufacturer is required to submit a new SDOC that confirms the product is still P25 CAP Compliant.

P25 CAP Task Force (TF)

Draft Test Procedures and CAB's are considered by the newly formed SAFECOM CAP Task Force (TF). The draft documents are forwarded to the DHS P25 CAP Program Office for consideration and approval by the Advisory Panel (AP) for public comment. The purpose of the Task Force is to provide an opportunity for broader user participation. The current membership of the Task Force includes SAFECOM members and public safety users.

Role of the Independent & Manufacturer Test Labs:

There are multiple independent test laboratories recognized by DHS to perform P25 CAP testing. In addition, a number of P25 Manufacturers operate their own recognized test labs. A list of these laboratories can be found on the DHS website at <https://www.dhs.gov/science-and-technology/recognized-labs>. Use of an Independent lab can free up a Manufacturer's resources to perform their expertise without the cost or time to run an accredited test lab and file documents.

P25 CAP Program Services offered by Independent and Manufacturer Labs

1. Analyze the features and services of the manufacturer's product to determine which P25 CAP test cases apply.
2. Review any legacy P25 CAP reports tested to 2016/2017/2018 CAB requirements. Define any GAP testing or document upgrades needed to comply with 2017/2018 CAB's.
3. Provide Detailed Test Reports (DTR) of results for each and every test.
4. Create Summary Test Report (STR) and Supplier's Declaration of Compliance (SDOC) documents.
5. Submit STR/SDOC's to DHS S&T, answer all questions and resolve format or content issues.

"Beyond" P25 CAP Program

"Beyond" P25 CAP Program testing may be performed by both independent laboratories and manufacturer's laboratories and making the results available to the public for review. Independent laboratories can be contracted to test features an agency finds important, or want verified, such as in the scenarios listed below:

1. P25 features with no published CAB's - Agencies may want testing features/services to P25 standards not yet included in CAB's ("Beyond P25 CAP"). These features or services may be important to the agency to accomplish their mission.
2. Non P25 features - Agencies may want testing to verify features/services/specifications not included in the Project 25 program. These features or services may be important to the agency to accomplish their mission.

Independent Laboratory Testing

Independent testing laboratories are available to assist both manufacturers and government agencies with CAP testing. A list of these laboratories can be found on the DHS website at <https://www.dhs.gov/science-and-technology/recognized-labs>

COMPLIANCE TESTING, LLC has been providing worldwide compliance testing for FCC, IC and CE marks for over 50 years. They are listed on the DHS website as “Recognized for 2016 Test Requirements Phase 1” and “Recognized for 2017 Test Requirements Phase 1/Phase 2”. They are able to offer services for the U.S., Canada, European Union, Australia/New Zealand, Korea, Japan and many others.

COMPLIANCE TESTING, LLC is able to create a custom test plan for the agency or their supplier to verify their compliance to the SoR or TIA-102 standard. They will also create a custom test plan for the agency or their supplier to verify their compliance to the manufacturer’s features/services/specifications. COMPLIANCE TESTING, LLC will provide a detailed test report of all tests and results for use in a procurement or acceptance process.

P25 Network Interface Test Solutions and Software

The P25 ISSI and CSSI standards have been developed to interconnect both P25 LMR systems with one another, and to interconnect non-native consoles with P25 systems. These standards become especially important when interconnecting radio cores or radio frequency subsystems (RFSS) and console systems from disparate manufacturers. ISSI and CSSI both provide a standards-based IP connection between two or more ISSI/CSSI-capable P25 networks to form a “system of systems.” The ISSI connects radio cores/RFSS, and the CSSI connects “foreign” consoles to an RFSS(s).

Inter-RF Subsystem Interface (ISSI)

The ISSI provides a standardized, non-proprietary IP connection of two or more P25-compliant trunked systems while maintaining appropriate levels of local control. When paired with appropriate system planning, testing, and management, standard operating procedures (SOP) and periodic training, the ISSI can be an invaluable tool to increase the efficiency and reliability of interoperable communications during emergency response and daily operations. ISSI-enabled RFSSs may be from different manufacturers, may operate in different frequency bands (e.g., Very High Frequency, Ultra High Frequency, 700/800 megahertz), and may use different versions of P25 (Phase 1 or Phase 2).

Console Subsystem Interface (CSSI)

The CSSI provides a standardized, non-proprietary IP connection between the RFSS and console equipment. Prior to P25’s move toward digital IP connectivity, console systems had typically linked to the RFSS via analog signaling. The creation of the CSSI standard brought the same level of standardized IP connectivity to the P25 trunked RFSS environment. This provides improved interoperability between multiple dispatch console vendors and system infrastructure manufacturers, enabling interested agencies to consider third-party P25 console options and

allowing implementing agencies to have additional console equipment choices during the acquisition process.

Importance of ISSI and CSSI Testing

The P25 accredited technical standards for ISSI and CSSI are designed to provide manufacturers latitude to determine what specific features and functions that they may ultimately implement to support their P25 standards compliant offerings. Manufacturers are not required to implement or support every criterion presented in the standards documents. Therefore, organizations interested in potentially implementing an ISSI or CSSI MUST become educated regarding the features and functions that are supported and available from the various manufacturers that best meet or exceed the organizations developed requirements.

It is incumbent upon organizations to include comprehensive, detailed, and specific requirements in any procurement solicitations to ensure both P25 standards compliance and the provision of expected interoperability. This is of the utmost importance when implementing CSSI or ISSI that will connect different manufacturer's infrastructures.

Furthermore, as CAP testing for CSSI and ISSI remains under development, it is necessary that organizations implementing ISSI or CSSI must comprehensively test the features and functions provided by any manufacturer's offerings. This testing should ensure P25 standards compliance, interoperability and that the required features and functions operate as intended and produce the expected outcomes.

Informal (Non-CAP) Reporting of P25 ISSI/CSSI Interoperability Testing

In 2018, the Association of Public-Safety Communications Officials (APCO) International P25 Interface Committee's (APIC) Compliance Assessment Process and Procedures Task Group (CAPPTG) created an Excel template to provide a consistent method for reporting ISSI or CSSI testing performed outside the CAP. Unlike CAP, this template does not require testing a set of standard features and does not require particular test procedures. The template only intends to define a consistent method for reporting what has been tested. As another distinction from CAP, this testing may or may not be performed in an ISO-recognized lab.

The aim of the CAPPTG template is to enable P25 equipment providers or users to report on interoperability testing that they performed. This testing would identify the common set of standard ISSI or CSSI features that both end point manufacturers support.

[Valid8](#)

The Valid8 platform delivers technology to streamline the testing process. The ISSI & CSSI interface test solution from Valid8 enables conformance or load testing of these interfaces in the P25 public safety network.

P25 ISSI CSSI Conformance Tester

For radio equipment providers, technology vendors, and public safety organizations that need to test the dispatch console and the RFSS on the ISSI and CSSI interfaces according to the TIA

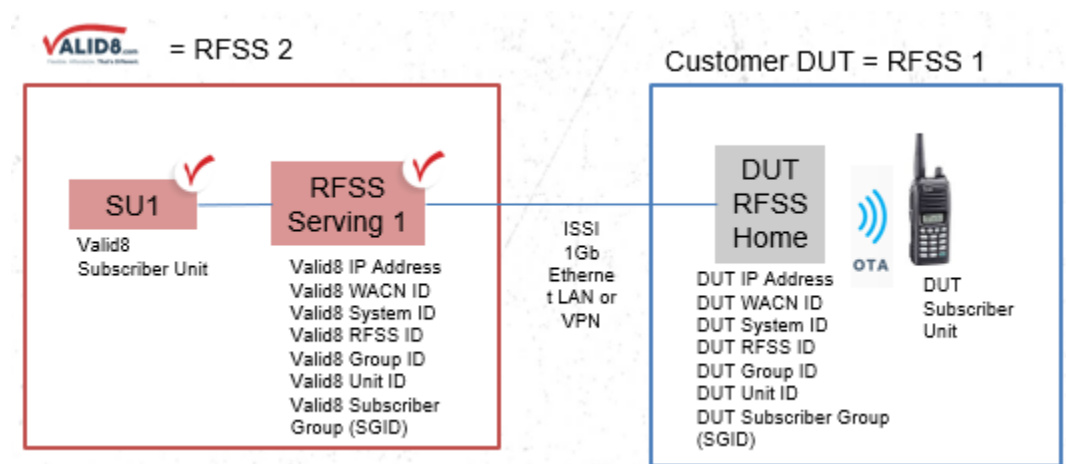
and CAP standards, Valid8's P25 ISSI CSSI Protocol Conformance Test Suites provide a convenient, cost-effective option. The ISSI & CSSI interface test solution from Valid8 enables conformance testing of these interfaces in the P25 public safety network. This system allows the tester to come up with pre-made test scenarios and procedures.

Among the key features of the test suite are the following:

- Simulating RFSSs to test Consoles and RFSSs
- Checking power-on, registration, PTT voice calls, emergency, data
- Checking parameters in messages from DUT and flag errors
- Measuring KPIs including the number of PASS/FAIL results
- Supports sending invalid responses including malformed, dropped and mis-ordered packets
- Alerts and notifications
- Simulating DoS attacks (optional)
- REST API controlled for automated testing

Security and feature testing can be performed on the ISSI and CSSI interfaces, with fully customizable message flows and content.

As with all Valid8 Products, the ISSI/CSSI tester provides alerts and notifications along with a simple, configurable user interface, allowing the user to tailor the solution to test custom requirements or scenarios. In addition, the tester can be deployed via VPN, in your lab, or at Valid8's lab.



Compliance Testing, LLC

ISSI/CSSI Interoperability Testing

The American Association for Laboratory Accreditation (A2LA) and ANSI National Accreditation Board (ANAB) are accepting requests from testing laboratories to be accredited for ISSI/CSSI Interoperability testing. These labs will then be able to test manufacturers' ISSI and CSSI equipment to P25 CAP's interoperability requirements.

Compliance Testing, LLC is starting this accreditation process now, and will begin ISSI/CSSI Field Interoperability testing in the second quarter of 2020.

One vendor laboratory, JVCKENWOOD — EFJohnson division, has been accredited to perform P25 ISSI/CSSI interoperability testing under CAP.

ISSI/CSSI Conformance Testing

DHS is validating an ISSI/CSSI Conformance testing tool.

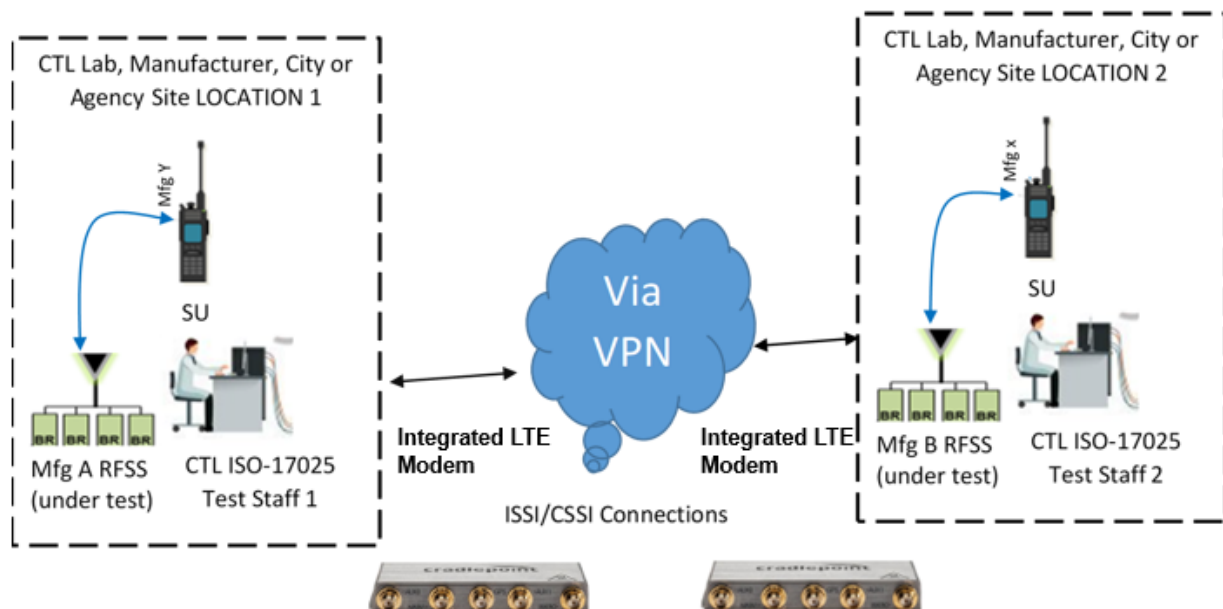
Compliance Testing, LLC intends to utilize this tool in its lab for Conformance Testing once it is approved and available.

The Department of Interior (DOI) Denver lab is seeking International Organization for Standardization (ISO) 17025 accreditation, so it can eventually conduct ISSI/CSSI conformance tests, with ISO accreditation expected by summer 2020.

Per DHS Website – “As vendors complete one set of tests (e.g., Interoperability), DHS will post test results on an ‘ISSI/CSSI Equipment Testing in Progress’ page. Once vendors successfully complete both sets of tests for Interoperability and Conformance, DHS will publish completed results in the Approved (Grant-Eligible) Equipment List on the P25 CAP website.”

Agency P25 ISSI/CSSI Interoperability field testing

Compliance Testing performs P25 ISSI/CSSI interoperability field testing for systems contemplated by or in actual operation by Public Safety Agencies. Actual installed FNE’s are connected and tested via VPN, verifying that the ISSI/CSSI is really working under real world operations. This testing can be used to validate a system’s compliance prior to purchase or after installation.



P25 Test Equipment

P25 radio systems and subscriber radios require test equipment designed to be used on P25 equipment. Radio test equipment manufacturers have developed equipment and test platforms for P25 systems and radios.

VIAVI

VIAVI Solutions is a global leader in both network and service enablement and optical security performance products and solutions. Our technologies contribute to the success of a wide range of customers from the world's largest mobile operators and governmental entities to enterprise network and application providers to contractors laying the fiber and building the towers that keep us connected.

These industry-leading radio test sets validate all Land Mobile Radio technologies worldwide, including P25 Phase 1 and Phase 2. The product lineup hosts the largest library of OEM-approved automated test and alignment applications for multiple radio families.

VIAVI manufactures communication test solutions for the support of P25 subscriber units and infrastructure such as the 3920B Radio Test Platform, the 8800SX Digital Radio Test Set and the 3550R Touch-Screen Radio Test System.

8800SX Digital Radio Test Set

The 8800SX supports all modern land mobile radio technologies. This hybrid portable test instrument is ideal for both bench and field use with its internal swappable battery that has up to 3 hours of battery life. The 8800SX provides fast VSWR and return loss plots for field analysis of antennas, duplexers, and combiners. These accurate distance to fault measurements are useful for locating problems in cables used in vehicles and at infrastructure sites. These features, along with advanced automated test and alignment, make the 8800SX the most versatile radio test set on the market today.



3920B Series Analog and Digital Radio Test Platform

The 3920B is the most advanced radio test solution from VIAVI Solutions for engineering, production and field service applications. It features an RF signal generator phase noise specification of -110 dBc/Hz at 10 kHz offset. The instrument supplies a comprehensive range of general-purpose analog measurement facilities as well as advanced digital test options. The 3920B has the largest library of OEM-approved Auto-Test Applications on the market: this feature allows you to automatically test and align a radio in as little as 5 minutes. VIAVI works directly with radio manufacturers to ensure that the Auto-Test Applications precisely follow the manufacturer's test and alignment procedures.



3550R Touch-Screen Radio Test System

The 3550R is a truly handheld touch-screen radio communication system. The 3550R takes testing to the next level with its easy to use, integrated test system for complete radio receiver and transmitter performance testing, cable fault, and antenna system analysis. With its ultra-responsive resistive touchscreen, the 3550R will meet the needs of users that require the test set to operate under all conditions, whether on the bench or in the field. Perfect for cold or wet weather applications, the 3550R also features a wider operating range of -20 C to +55 C and MILPRF28800F Class 2 specification for toughness required for extreme conditions.



FREEDOM, an Astronics Company

FREEDOM, an Astronics Company is the world's only firm dedicated exclusively to the Land Mobile Radio test equipment market. Headquartered in Kilgore, Texas, along with our Engineering and Manufacturing teams, every member of our team has years of experience in the LMR test equipment business.

FREEDOM R8100 and R8000 Communications System Analyzers perform comprehensive signal quality analysis for both P25 Phase 1 and Phase 2 radios. Among the P25 specific measurements made by the R8100 and R8000 are Symbol Deviation, Symbol Rate Error and Bit Error Rate. The P25 option also performs real-time decoding of voice frames and in P25 Trunking mode, displays Network Identifiers, Header Words and Link Control information.

FREEDOM analyzers generate and receive every test pattern and modulation type called out in the P25 standard. Multiple graphical displays are available including Eye Diagram, Distribution Plot, Constellation and Power Profile. Recovered audio can be heard with our vocoder option.

R8000C Communications System Analyzer

The R8000C is the third generation of the industry-standard LMR communications system analyzer first shipped in 2009. Weighing just 14 pounds, the R8000 is the only test set to offer complete benchtop functionality in a portable, software-defined package. Firmware upgrades are available free for the life of the unit, so the R8000's capabilities only expand over time. The R8000 tests every major digital LMR protocol, is highly expandable, and boasts the best spectral purity in the industry. In fact, its RF specification meets or surpasses those of instruments costing thousands of dollars more.



R8100 Communications System Analyzer

The R8100 is the premium, ultra-portable member of our product family. It has all the functionality and test capabilities of our industry-standard R8000 communications system analyzer, but also features an internal battery, premier ergonomics and suite of advanced features that are optional on the R8000. With the R8100, there's absolutely no trade-off between benchtop power and total portability and the unit's Class 3 Mil-Spec shock and vibration rating at test to its suitability for nearly any LMR test environment.



FREEDOM, an Astronics Company

R8600 Radio Test Hub

The R8600 Radio Test Hub is designed to meet the demanding requirements of RF production environments. Able to withstand 150 Watts of continuous RF power input, the R8600 was explicitly engineered to provide a cost-effective solution for 24/7 manufacturing use. Once deployed, it requires minimal operator intervention beyond making the physical RF connections.

The Radio Test Hub provides reliable, easy-to-operate testing for manufacturers of LMR radios and other RF devices. It operates without an embedded display to make efficient use of manufacturing rack space in an ATE environment, and features an expansive suite of scripting options including our native Monitor & Control language and HP8920 emulation.



Powered by our Software Defined Radio architecture, the R8600 is ideal as both an upgrade to enable testing of modern digital radio technologies and for the production of analog radios and RF devices.

Two units can fit side-by-side in a standard 19" rack. The units stand less than 4RU high. A backpack accessory is also available for portable use.

R9000 Communications System Analyzer

The R9000 is the first and only LTE-ready test set that also supports the full range of digital and analog LMR protocols.



P25 Diagnostic and Coverage Test Solutions

P25 testing solutions consist of: Over the Air Radio Diagnostics, In-building coverage testing, and Outdoor coverage testing.

Over-the Air Radio Diagnostics

LocusUSA

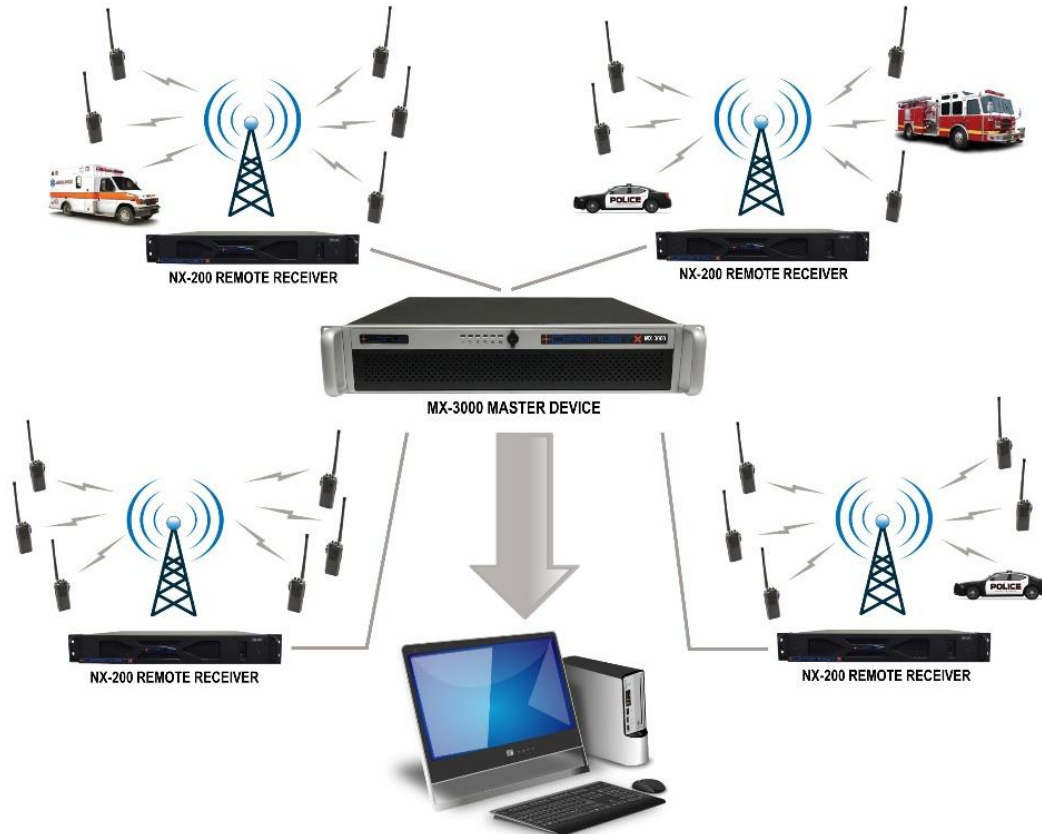
Given the large number of subscriber radios on LMR Systems today, it can be expensive and time prohibitive to bring each radio in for maintenance every year. Statistics have shown that 75 to 85 percent of radios on an LMR network typically operate within specifications when only 15 to 25 percent require attention.

There is a solution that can ensure operational readiness by providing a more proactive approach public safety and government agencies can use to maintain their two-way radios, instead of taking a reactive one. The solution is **DiagnostX touch-free, over-the-air radio waveform analyzer.**



Agencies can use this state-of-the-art technology to detect a problem radio long-range over-the-air by monitoring and evaluating its transmitting waveform in real-time without any user intervention or impact to the network. This process identifies, analyzes, and verifies frequency error and misalignment of poorly performing radios. A technician will be able to review the measured key metrics and schedule radio repairs on a priority basis and will not have to wait until a radio fails. This unique technology can improve public safety responders' ability to hear and be heard during an emergency when they are needed the most.

The DiagnostX device generates reports for radio system managers so they can prioritize maintenance schedules based on subscriber performance. There is never a need to waste precious time testing fully functional radios. With one glance, managers can verify network health and identify which radios require alignment. Managers can choose between a variety of coverage configurations and scalable options to align with their operational needs.



As an optional safeguard, DiagnostX can identify which radios are receiving a temporary correction, which aids in adjusting frequency errors or frequency misalignment. This embedded technology found in some manufacturer's radios is known as Automatic Frequency Control (AFC). DiagnostX provides yet another layer of protection for system managers dealing with multiple facets of mission-critical technology but does not replace routine radio maintenance.

DiagnostX touch-free, over-the-air radio waveform analyzer provides agencies an affordable solution to two (2) expensive problems: protecting both public safety responders from the rising costs of maintenance and the elevated risk of a communication breakdown.

[Etherstack](#)

Etherstack is a global radio and wireless communications technology company. Etherstack is a leading independent specialist provider of technology from wireless protocol stacks (waveforms) for embedded hardware and Software Defined Radio through to complete IP wide-area networks and cryptographic solutions.

Etherstack has substantial APCO P25 experience. They are an active member of the TIA APCO P25 Standards development process and systematically update their APCO P25 products in accordance with the ongoing TIA standardization process.

Etherstack's Off-Air Monitor snoops the inbound and outbound frequencies of an APCO P25 control, traffic, repeater or direct mode channel and displays the results on the Off-Air Monitor Display Application.

Inside the rack mount unit, a pair of Off-Air Monitor Receiver devices tune to the channel selected by the user in the Display Application and capture messages – as well as physical channel information such as quality metrics – to pass to the Display Application on the PC.

The Off-Air Monitor Display Application is responsible for interpreting and monitoring inbound and outbound messages, for coordinating the display of these messages to the user, and for issuing control instructions to the Off-Air Monitor Receivers. It contains substantial APCO P25 intelligence in order to parse incoming messages and display them in a meaningful, interpreted manner.

Traffic in both directions is dynamically displayed both in raw binary and interpreted formats on the application's intuitive Graphical User Interface. All activity is also logged in a capture file that can be saved and reloaded for retrospective analysis. The Display Application can be programmed with Unit and Group IDs to enable the Off-Air Monitor to shadow the movement of a mobile between traffic and control channels.



Etherstack's Off-Air-Monitors are non-intrusive intercept tools for trunked and conventional air interface testing and interoperability verification, maintenance and diagnostics.

A wideband receiver permits simultaneous observation of up to 4 air interface links across an RF range from 1MHz up to 2GHz. This is ideal for investigating the relationship between trunked control and traffic channels. Captured information is interpreted and displayed in real time on an easy to navigate, user interface, and all logged traffic can also be dumped and saved for later analysis.

Etherstack's Network and Mobile Test Systems allow verification of advanced features in the standards against a fielded, interoperability tested reference at both RF and baseband test points. All test systems are shipped with user documentation and a test environment comprising hundreds of test scripts, for fully automated simulation of a wide range of typical scenarios.

In-Building Coverage Testing

An In-Building Public Safety Communication System ensures that radio signals are accessible in all areas of buildings, including areas that are especially difficult for RF to penetrate such as stairwells, elevators, basements, and thick-walled or shielded areas.

First responders need a reliable, resilient, optimized wireless broadband network to carry out their mission. Not only must they communicate instantly without interruption, but agencies must collect and filter through all the information streaming in from the community. Interoperability

among agencies and secure transmissions are critical to an effectively coordinated response. An optimized Public Safety network is needed to assure priority communications the moment they are needed.

The need for in-building wireless communications has driven efforts to develop national model codes by the National Fire Protection Association (NFPA) and the International Code Council (ICC). Codes issued by these groups include the National Fire Code, National Electrical Code, International Fire Code, and International Building Code. Almost every city and county in the United States subscribes to and complies with one or more of these codes. The NFPA and ICC continue to develop national level model codes focused on In-Building Public Safety Communication Systems. National level model codes should also lead to standardization of the quality of equipment and to additional qualified in-building system engineers and installers.

A number of jurisdictions have enacted or are considering enactment of local ordinances and codes which require a requisite level of public safety communications reliability in building as a condition for occupancy. The specifics of these ordinances and codes vary, but most include:

- A minimum signal strength limit and/or minimum DAQ.
- Application of the limit over a specified percentage of each floor;
- A specific level of reliability (power backup, water protection, cable protection);
- A specified frequency band or bands for public safety coverage;
- Testing requirements and procedures;
- Ongoing Monitoring and Maintenance Standards;
- Provisions for penalties; and
- Provisions for waivers of the requirements.

Testing for code compliance should be undertaken by those with familiarity with the highly technical aspects of in-building coverage testing and the specific local and national code requirements.

PCTEL

PCTEL's Public Safety Network Testing Solution streamlines in-building coverage and signal quality testing of P25 networks. The solution's grid-based testing and reporting system produces accurate, repeatable results that conform to National Fire Protection Agency (NFPA 1221) and International Fire Code (IFC 510) standards. Since multiple frequencies or networks can be tested simultaneously, it can reduce testing time up to 75%. The simple pass/fail grading system produces instant results and automated, printable reports. Measurements and reporting criteria can be customized to meet local jurisdiction codes.

The solution includes PCTEL's SeeHawk® Touch software on an Android™ tablet and the lightweight IBflex® scanning receiver hardware, with a band range of 140-990 MHz (upgradable to 10 MHz-6 GHz). The solution can also be used to conduct walk and drive testing for design, verification, benchmarking, and optimization of P25 networks. It also includes spectrum analyzer and Antenna Verification Testing functions for network commissioning and troubleshooting.

P25 measurements, including SINR, RSSI, Out-of-service BER, Frame BER, Network ID, and Auto Classification of Phase and Modulation Type Channel, are automatically collected by the SeeHawk Touch software from the IBflex scanning receiver for inclusion in grid-based reporting or drive test data. Additional measurements (such as DAQ and uplink) can be entered into grid-based testing tool for automatic grading. The IBflex measures channel power (RSSI) at a rate of

PCTEL

100 ch/sec and passively decodes P25 Phase 1 and 2 signals at a rate of up to 5.4 channels/sec (2.7 ch/sec typical). Relative accuracy for SINR is ± 1 dB over 8 to 25 dB; ± 2 dB over 3 to 8 dB, 25 to 30 dB. Relative accuracy for RSSI is ± 1 dB over -118 to -10 dBm.



VIAVI

The VIAVI NEON[®] Signal Mapper automates the geo-referencing cloud storage, and 3D visualization of LMR test data for technicians who use VIAVI test equipment to record and analyze two-way radio signals inside building and outdoors. The process of taking indoor measurements is intuitive and easy to setup. The NEON Signal Mapper automatically calculates the user's location with or without GPS, thereby eliminating manual check-ins, providing continuous logging of data in three dimensions, including typically difficult to map stairwells, elevators, and tunnels. Coverage heat maps can be visualized in two and three dimensions and users can easily export the signal data into iBwave for additional processing.



Outdoor Coverage Testing

When procuring a P25 radio system, attention is needed to ensure the infrastructure equipment (System Core and Radio Base Stations), dispatch consoles, subscribers (mobile/portable radios and desktop console radios), and interoperability solutions (ISSI or CFSI gateways) are tested correctly and comply with the P25 Standard.

During the procurement of a P25 radio system or when upgrading a P25 system, a test plan should be developed to test the vendor's solution or equipment to ensure compliance to the terms of the contract and to the required P25 standards. This testing is generally performed in several stages, which evaluate system functionality in several different scenarios.

The system hardware and software features are verified to meet the requirements of operations and performance. Subscriber equipment is tested for performance on the system installed to ensure proper operation and system interface.

P25 Consultant Support for System Testing and Maintenance

Professional Communications Consultants with strong P25 application and technology backgrounds are available to help P25 users identify and deploy the testing products and services that best suit their needs. This includes testing strategies and procedures for both P25 system procurement and ongoing system maintenance needs.

Specification Development and Procurement

Working with a professional communications consultant throughout the specification development and procurement can ensure that your new P25 radio system will be critically tested. When developing a specification, a consultant can assist with writing testing and coverage requirement sections. DAQ coverage testing is recommended for all new public safety radio systems and is defined in the TSB-88 standards. The standards provide valuable definitions that must be properly referenced to the requirements of the procuring agency. Burn

During system procurement a public safety communications consultant can provide a detailed review of all testing proposed by vendors. Both the vendors proposed coverage and testing of coverage, should also be critically reviewed to ensure that all coverage requirements are met by the proposers.

Implementation Oversight

Throughout the implementation of a P25 radio system there are many different stages of testing. Typically, the following tests will be performed for a new P25 radio system:

- Staging Test
- Field Acceptance Testing
- Coverage Acceptance Testing
- Burn-In / Operational Testing

During the detailed design review for a new P25 radio system, the system vendor will provide draft test plans for each of the described testing phases. A consultant can assist with reviewing

these draft test plans, identify missing tests, and help negotiate the final test plan with the system vendor. All test plans should be finalized at least 30 days prior to the testing start date. Extensive test plans for larger system may require additional time.

During the staging and field acceptance testing, a communications consultant should be on-site to witness and participate in the testing and make sure that the system vendor follows the test plans and successfully completes all tests.

Coverage test plans must be carefully constructed to ensure they accurately represent the actual coverage of the system, the coverage requirements of the procuring agency, and that they are technically accurate and defensible should system coverage fall short. There are multiple methods of performing coverage testing which meet these goals such as Bit Error Rate (BER), Received Signal Strength Indicator (RSSI), and Delivered Audio Quality (DAQ). A typical P25 system is used for both talk out and talk in voice communications. Therefore, DAQ is the recommended method of testing coverage.

A recommended method of DAQ coverage testing consists of two teams (one at the dispatch console, and one in the field) each typically of three people. The three-person team should consist of one representative of the System Vendor, one from the System Owner, and an unbiased Communications Consultant or third party. By having three-person test teams there can be no “ties” in the pass/fail votes for each tested grid. The test should be configured so that the team in the field will drive throughout the P25 radio system service area on a route attempting to reach as many tiles as possible in the service area. In each test tile the field team will make a call to the console, and the team at the console will score the tile as pass/fail in accordance with the DAQ definitions from TSB-88. The same process will be repeated for the talk-out direction (console to field team). After coverage testing is complete a consultant will review testing results, and confirm that enough tiles were tested to be a statistically valid test based on the TSB-88 standard.

P25 Consultant Contacts:

ACD Telecom	www.acdtelecom.com
CTA Consultants LLC	www.cta-c.com
Federal Engineering, Inc.	www.fedeng.com
Televate	www.televate.com

Conclusion

Over the last 30 years, testing technology for P25 Equipment and Networks has advanced. It continues to advance and evolve along with the Project 25 Suite of Standards. This Whitepaper has defined the multiple levels of P25 Compliance. P25 Standards tests have been identified as well as their use in development of tests for the CAP testing program available through DHS. In addition, test solutions that go beyond the P25 Standards have been described.

A full range of P25 testing hardware and software products as well as laboratory services have been described including: P25 Test Equipment, Network Test solutions and Software, Over the Air Test solutions, Test Laboratories: Services and Capabilities, and P25 Consultants Offering System Support and Maintenance.

These resources form a rich fabric of support to help P25 users in the procurement, application and maintenance of their P25 Systems. As a result, P25 continues to evolve as a primary communications solution for Government Agencies, Public Safety, and Critical Infrastructure.

[Resources and Contacts](#)

Resource	Contact	Web
Project 25 Technology Interest Group (PTIG)	Stephen Nichols director@project25.org	www.project25.org
Project 25 Steering Committee	Project25SC@cisa.dhs.gov	
DHS CAP Program	P25CAP@hq.dhs.gov	
Compliance Testing LLC	Chrisl@compliance-testing.com	www.compliance-testing.com
Valid8	tia-p25@valid8.com	www.valid8.com
LocusUSA	ecole@locususa.com	www.locususa.com
Etherstack	info.na@etherstack.com	www.etherstack.com
Viavi	amy.lawrence@viavisolutions.com	www.viavisolutions.com
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