DRAFT
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SPECTRUM SHARING INNOVATION TEST-BED PILOT PROGRAM

PHASE I TEST PLAN

1. BACKGROUND

One of the recommendations in the Department of Commerce reports for the Presidential Spectrum Policy Initiative directed the National Telecommunications and Information Administration (NTIA) in coordination with the Federal Communications Commission (FCC) and the Federal agencies to establish a Spectrum Sharing Innovation Test-Bed (Test-Bed) pilot program to examine the feasibility of increased sharing between Federal and non-Federal users. This pilot program is one of the key elements of the President's 21st Century Spectrum Policy Initiative and is an opportunity for the Federal agencies to work cooperatively with industry, researchers, and academia to objectively examine new technologies that can improve management of the nation's airwaves.

On February 5, 2008 NTIA published a Notice in the Federal Register describing the Test-Bed pilot program.[1] Concurrently, the FCC released a Public Notice (PN) designating 10 MHz of non-Federal spectrum to be used in the Test-Bed pilot program and providing guidance for participants.[2] As described in the Notice and the PN, the Test-Bed pilot program will evaluate the ability of Dynamic Spectrum Access (DSA) devices employing spectrum sensing and/or geo-location techniques to share spectrum with land mobile radio (LMR) systems operating in the 410-420 MHz Federal band and in the 470-512 MHz non-Federal band.[3] To address potential interference to incumbent spectrum users, the Test-Bed will include both laboratory and field measurements performed in three phases:

> **Phase I – Equipment Characterization**. Equipment employing DSA techniques will be sent to the NTIA Institute for Telecommunication Sciences in Boulder, Colorado to undergo characterization measurements of the DSA capabilities in response to simulated environmental signals.
>
> **Phase II – Evaluation of Capabilities**. After successful completion of Phase I, the DSA spectrum sensing and/or geo-location capabilities of the equipment will be examined in the geographic area of the Test-Bed.

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1. *See* Spectrum Sharing Test-Bed, 73 Fed. Reg. 6.710 (NTIA Feb. 5, 2008)(Notice of Solicitation of Participation).

2. *See* Federal Communications Commission Designates Spectrum and Provides Guidance For Participation in a Spectrum Sharing Innovation Test-Bed, ET Docket No. 06-89, *Public Notice*, FCC 08-295 (Feb. 5, 2008).

3. Dynamic Spectrum Access technology allows a radio device to (i) evaluate its radio frequency environment using spectrum sensing, geo-location, or a combination of spectrum sensing and geo-location techniques, (ii) determine which frequencies are available for use on a non-interference basis, and (iii) reconfigure itself to operate on the identified frequencies.

Phase III – Field Operation Evaluation. After successful completion of Phase II the DSA equipment will be permitted to transmit in an actual radio frequency signal environment. An automatic signal logging capability will be used during operation of the Test-Bed to help resolve interference events if they occur. A point-of-contact will also be established to stop Test-Bed operations if interference is reported.

Eleven parties submitted solicitations of interest to participate in the Test-Bed pilot program. As a result of selection criteria specified in the February 2008 Federal Register Notice the following parties were selected to participate in the Test-Bed pilot program: Adapt4 LLC, Adaptrum Inc., BAE Systems, Motorola Inc., Shared Spectrum Company, and Virginia Polytechnic Institute and State University.[4]

Although there are television (TV) broadcast stations in the 470-512 MHz band, it is the intent to focus the Test-Bed pilot program on the ability of DSA devices to share spectrum with LMR systems. If participants are also interested in demonstrating compatibility with broadcast TV stations, it should be pointed out that the FCC has adopted a Notice of Proposed Rulemaking (NPRM) to investigate the use of white spaces in the TV band.[5] As part of its evaluation process, the FCC has tested prototype equipment to gain a better understanding of the equipment's capability.[6]

2. OBJECTIVE

This document describes the types and depth of testing that NTIA intends to conduct in Phase I to assess whether DSA devices can share the frequency spectrum with LMR systems in the specified frequency bands. It should be noted that not all of the tests described in this document are applicable to all DSA devices. Furthermore, additional tests may be performed to examine any unexpected behavior of the DSA device. While the tests performed under Phase I of the Test-Bed could eventually be used in the development of compliance measurement procedures for devices employing DSA techniques, it should be recognized that additional tests could be necessary.[7]

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4. Additional information on the Test-Bed pilot program is available at http://www.ntia.doc.gov/ntiahome/frnotices/2006/spectrumshare/comments.htm.

5. *See*, In the Matter of Unlicensed Operation in the TV Broadcast Bands, *First Report and Order and Further Notice of Proposed Rulemaking*, ET Docket Nos. 04-186 and 02-380, 21 FCC Rcd. 12266 (Oct. 18, 2006).

6. At least two parties selected to participate in the Test-Bed pilot program, have also submitted equipment to the FCC for evaluation in reference to the FCC NPRM. To the extent that parties are interested in such testing, they are strongly encouraged to consult with the FCC through the ongoing NPRM process.

7. For example, for devices operating below 10 GHz, the FCC Part 15 rules require that emission measurements be performed to the tenth harmonic of the highest fundamental frequency or 40 GHz whichever is lower. *See* 47 C.F.R. §15.33(a)(1)(2007).

3. ACRONYMS AND ABBREVIATIONS

ACPR: Adjacent Channel Power Ratio

BER: Bit Error Rate

DSA: Dynamic Spectrum Access

DUT: Device Under Test

EIRP: Equivalent Isotropically Radiated Power

FM: Frequency Modulated

GPS: Global Positioning System

IF: Intermediate Frequency

I/Q: In-Phase and Quadrature

LMR: Land Mobile Radio

P25: Project 25[8]

RF: Radio Frequency

RMS: Root Mean Square

SINAD: Signal-plus-Noise-plus-Distortion-to-Noise-plus-Distortion ratio

4. DEFINITIONS

Available LMR Channels: LMR channels unoccupied by LMR signals and are not *Locked-Out LMR Channels.*

Detection Threshold: The level at which a receiver can detect the presence of a transmitted LMR signal within the *LMR Channel* bandwidth.

DUT Channel: A segment of spectrum that can be used to carry DUT signals. The *DUT Channel(s)* are specified by its channelization.

DUT Operating Channel: A collection of one or more *DUT Channel(s)* that are in use. The *DUT Operating Channel(s)* encompasses a collection of the *Available LMR Channels.*

Guard Channels: Unoccupied channels that provide frequency separation in order to avoid mutual interference.

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8. The Project 25 standards apply to conventional and trunked base, mobile, and portable systems. The standards are published in the Telecommunications Industry Association/Electronics Industries, Alliance, an American Standards Institute accredited process. For example, *see*, http://www.ANSI.org.

Hidden Node: A base, mobile, or portable LMR transceiver within the range of other LMR transceivers and cannot be detected by a DUT that is within the *Interference Range.*

In-Service Monitoring: A process to check for the presence of an LMR signal on *DUT Operating Channel(s).*

Interference Range: The maximum distance at which a DUT can cause interference to a LMR receiver using criteria specified in Telecommunications Industry Association standards as the baseline.[9]

LMR Channel: A segment of spectrum that is either 12.5 kHz or 25 kHz in width with center frequencies as specified within the NTIA channelization plan in the 410-420 MHz band or in Part 90, Subpart L of the FCC rules for the 470-512 MHz band.[10]

LMR Channel Availability Check: A process by which the DUT senses the band for LMR signals.

LMR Channel Clearance Time: The time needed by the DUT to cease all transmissions on the current *DUT Operating Channel* upon detection of a LMR signal that is above the *Detection Threshold.* This time is referenced to the time a LMR signal is present.

LMR Operating Channels: A collection of LMR channels that are in use.

Locked-Out LMR Channels: Pre-determined LMR channels within the 410-420 MHz band or 470-512 MHz band for which DUT transmissions are not permitted.

Sensor Bandwidth: A portion of the 410-420 MHz or 470-512 MHz bands, which encompasses multiple *LMR Channels* that the DUT monitors at any given instant in time.

Standard LMR Test Signal: A LMR signal that is 10 dB above the 97 percent probability of detection threshold as determined in the Sensor Detection Sensitivity, Static Co-Channel LMR Signal test.

Unavailable LMR Channels: The *LMR Operating Channels*, any necessary *Guard Channels,* and *Locked-Out LMR Channels.*

5. LMR SIGNAL CHARACTERISTICS AND EMISSION ENVIRONMENT

There are many different types of radio technologies that represent the LMR systems operating in the Test-Bed frequency bands. A description of the different radio technologies is provided in NTIA Report 06-440.[11]

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9. Telecommunications Industry Association, *Wireless Communications System Performance in Noise Limited Situations Recommended Methods for Technology Independent Modeling*, TSB.88-1-C (May 2008) (TSB.88-1-C) (Copy on file with Agency).

10. 47 C.F.R. §90.301-317(2007)(Subpart L).

The two primary signal characteristics of LMR systems are: channelization (how the frequencies are assigned in each band) and adjacent channel power ratio.

5.1 Channelization

The center frequencies of possible LMR assignments in the 406.1–420 MHz band are in multiples of 12.5 kHz starting at 406.1125 MHz. While LMR systems were required to migrate to a 12.5 kHz channel spacing there are still legacy systems that are assigned according to a 25-kHz channel spacing scheme. To migrate to the 12.5 kHz channel spacing required that the emission bandwidth of transmissions be reduced to half the original bandwidth so that the new 12.5-kHz channelization assignments could be inserted midway between the original channels. In the 406.1–420 MHz band, the 25-kHz channelization was assigned at the frequencies (406.1 MHz) + (N x 0.025), where N = 0 to 556. The new 12.5-kHz channelization scheme adds channels midway between the older 25-kHz channelization assignments so that these channels occur at (406.1125 MHz) + (N x 0.025), where N = 0 to 555.

Similarly, the center frequencies of possible LMR assignments in the 470-512 MHz band are in multiples of 12.5 kHz. The FCC rules require these stations either migrate to 12.5 kHz technology, or utilize a technology that achieves equivalent efficiency by January 1, 2013.[12] As the availability of assignments in this band varies by city, the FCC rules should be consulted for specific information.[13]

5.2 Adjacent Channel Power Ratio (ACPR)

The ACPR is the ratio in decibels (dB) between the total transmitter power that lies within its authorized channel bandwidth and the part of the output power that falls within the bandwidth centered around the frequency assignment of the adjacent channel (expressed in units of dBc). Chapter 5 of the NTIA Manual of Regulations and Procedures for Federal Radio Frequency Management (NTIA Manual) specifies the ACPR standards for LMR systems in the 406.1-420 MHz band. The ACPR standards for maximum transmitter power are 70 dB for analog and digital wideband (25 kHz channels) and narrowband (12.5 kHz channels) in the 406.1-420 MHz band. The NTIA ACPR standards are consistent with those specified by the Telecommunications Industry Association for analog[14] and digital LMR systems.[15]

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11. NTIA Report 06-440, *Federal Land Mobile Radio Operations in the 162-174 MHz Band in the Washington, D.C. Area, Phase 1: Study of Agency Operations* (August 2006) , at Section 3,available at: http://www.ntia.doc.gov/osmhome/reports.html

12. *See*, In the Matter of Implementation of Sections 309(j) and 337 of the Communications Act of 1934 as Amended, *Fourth Memorandum Opinion and Order*, WT Docket No. 99-87, 23 FCC Rcd. 8042 (May 13, 2008).

13. *See supra* note 10.

14. Telecommunications Industry Association, *Land Mobile FM or PM--Communications Equipment--Measurement and Performance Standards*, TIA/EIA-603-C (Dec. 2004)(TIA/EIA-603-C)(Copy on file with Agency).

15. Telecommunications Industry Association, *Digital C4FM/CQPSK Transceiver Measurement Methods*, TIA-102.CAAA-B, (Aug. 2004) (TIA-102.CAAA-B)(Copy on file with Agency).

5.3 Emission Environment

Other factors that determine measurement parameters are those that comprise the emission environment – factors such as the range of in-band signal levels, out-of-band signal characteristics, and the nature of radio frequency (RF) noise. Because LMR systems by their very nature are mobile, the signal power can be time varying and span a range as great as 100 dB in power – the weakest signals typically coming from distant transmissions and the stronger signals typically coming from nearby base stations and local mobile and portables that approach the Device Under Test (DUT). Not only can a single frequency assignment vary greatly in power from time to time, but power can vary greatly between adjacent frequencies. Because of this broad range of signal powers, depending upon the degree of sensitivity of the DUT, the DUT must have a wide instantaneous dynamic range (*i.e.*, be able to resolve the individual signal powers without varying the sensitivity of the system across the detection bandwidth).

NTIA performed measurements to characterize channel occupancy in the 406.1-420 MHz band in the Washington, D.C. area.[16] The LMR channel occupancy in the Washington D.C. area appears consistent with the LMR channel occupancy in other metropolitan areas.

6. TEST SIGNALS

The analog and digital test signals will be generated using commercially available signal generators with characteristics provided below:

> Analog frequency modulated (FM) signals with a 25 kHz bandwidth conforming to Section 5.3.5.1 of the NTIA Manual will be generated using a 1 kHz modulating signal and setting the maximum frequency deviation to 3 kHz; and
>
> Digital signals with a 12.5 kHz bandwidth conforming to Section 5.3.5.2 of the NTIA Manual will be generated using a 1.011 kHz continuous wave bit pattern with 4-level frequency shift keyed modulation.

In addition to the analog and digital LMR test signals, band-limited noise test signals will be generated.[17]

7. OVERVIEW OF PHASE I TESTS

In Phase I of the Test-Bed, the DSA capabilities of the DUTs will be characterized. An overview of the test cases to be performed under Phase I are shown in Figure 1.

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16. *See*, NTIA Report TR-07-448, *Measurements to Characterize Land Mobile Channel Occupancy for Federal Bands 162-174 MHz and 406-420 MHz in the Washington, D.C. Area* (July 2007), available at http://www.its.bldrdoc.gov/pub/ntia-rpt/07-448/;NTIA Report TR-08-455, *Measurements to Characterize Land Mobile Channel Occupancy for Federal Bands 162-174 MHz and 406-420 MHz in the Denver, Co. Area* (September 2008), available at http://www.its.bldrdoc.gov/pub/ntia-rpt/08-445/.

17. The noise signal used in the tests described in this plan has a 3 dB bandwidth of approximately 6 kHz and is attenuated by a minimum of 70 dB in the adjacent 12.5 kHz LMR channel. The use of a band limited noise signal is preferred as its spectrum can be more tightly filtered than a typical LMR signal.

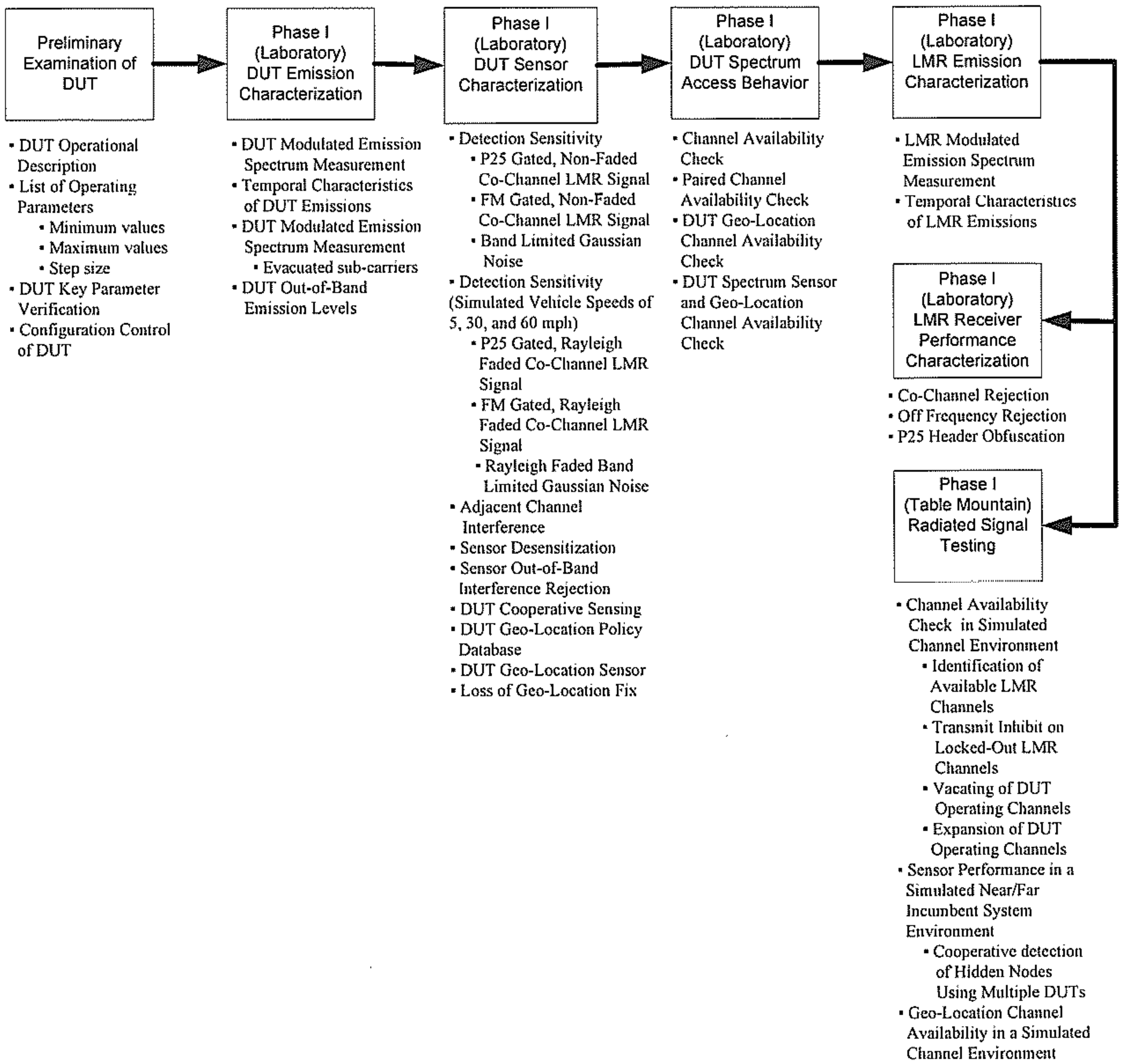

Figure 1. Overview of Phase I Test Cases

8. PRELIMINARY EXAMINATION OF DUT

Prior to performing the tests outlined below, the Test-Bed participant will provide to NTIA, a description of how the DUT operates along with values for the operating parameters. A preliminary examination will be performed to verify the key parameters of the DUT. During the preliminary examination, the Test-Bed participant will have the opportunity to ensure that the DUT is functioning properly. After this point the Test-Bed participant will not be allowed to change the DUT, including the operational parameters, without prior coordination with NTIA. Depending on the significance of the changes, the previous tests performed on the DUT may have to be repeated.

9. PHASE I TEST CASES (LABORATORY)

The Phase I laboratory test cases are broken down into five categories: DUT emission characterization, DUT sensor characterization, DUT spectrum access behavior, LMR emission characterization, and LMR receiver performance characterization.

The measurements described in this section use conducted signals.

9.1 DUT Emission Characterization

9.1.1 DUT Modulated Emission Spectrum Measurement

Purpose: Characterize the spectral emissions of the DUT at the minimum and maximum operating power levels. This test will allow a determination of the necessary *Guard Channels* and the *Interference Range*.

Procedure: Conduct an emissions spectrum measurement using standard methods for selected *DUT Operating Channel* bandwidths. Measure the DUT emissions across the range of operating parameters; the operating frequency band(s); operating bandwidths and modulations within the DUT transmitter capabilities. The DUT Equivalent Isotropically Radiated Power (EIRP) levels will be calculated using the measured emission values.

9.1.2 Temporal Characteristics of DUT Emissions

Purpose: Characterize the temporal characteristics of the DUT emissions for use in signal environment simulation and analysis.

Procedure: Conduct an in-phase and quadrature (I/Q) capture of the emissions which show the time domain characteristics of the DUT transmissions. Perform this test with a source of test data for the DUT to transmit, and with no test data.

9.1.3 DUT Modulated Emission Spectrum Measurement: Evacuated Sub-Carriers

Purpose: This test would apply to a DUT with the capability to transmit on non-contiguous blocks of *Available LMR Channels*. A DUT may be configured to disable subcarriers to notch out transmissions on specific *Unavailable LMR Channels*. This test will determine the emission level of the DUT on deactivated subcarriers, which will appear as noise to an LMR receiver.

Procedure: Manually configure the DUT to transmit at the maximum operating power level on a block of channels encompassing a *Locked-Out LMR Channel*. Measure the power level on the *Locked-Out LMR Channel* with a spectrum analyzer set to zero span mode and a resolution bandwidth equivalent to an LMR IF stage noise bandwidth of 12.5 kHz (25 kHz channelization) and 7.8 kHz (12.5 kHz channelization) as specified in Telecommunications Industry Association Telecommunications System Bulletin-88-C-1.[18]

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18. *See* TSB.88-1-C, *supra* note 9, at Table 2.

9.1.4 DUT Out-of-Band Emission Levels

***Purpose*:** Characterize the spectral characteristics of the DUT emissions in harmonically related frequency bands and in the frequency bands used by the Global Positioning System (GPS).

***Procedure*:** The DUT emission levels at frequencies corresponding to the second through sixth harmonics are to be measured. The DUT is to be operating at the maximum power level and transmitting the test data file. The harmonic levels are to be measured using a bandwidth commensurate with the DUT transmission.

The wideband and narrowband conducted DUT emission levels in the 1164-1240 MHz and 1559-1610 MHz GPS frequency bands are to be measured at the maximum operating power level and transmitting the test data file. The DUT emission levels in these frequency bands are to be measured using a root mean square (RMS) spectrum analyzer detector function. The wideband DUT emission levels are to be measured using a 1 MHz resolution bandwidth. The narrowband DUT emission levels are to be measured using a 1 kHz resolution bandwidth. For the wideband DUT emission measurement, the RMS levels are to be measured using a 2 millisecond averaging time over each 1 MHz segment. The video bandwidth of the spectrum analyzer should not be less than the resolution bandwidth. The measurement system must have a noise floor of approximately -141 dBW as measured in a 1 MHz resolution bandwidth. The DUT EIRP levels will be calculated using the measured conducted emission values and the appropriate antenna characteristics.

9.2 DUT Sensor Characterization

The tests below assess the sensing capabilities of the DUT. These tests will be conducted for the various operational modes of the DUT as applicable, such as: 1) the *LMR Channel Availability Check* mode used to identify *Unavailable LMR Channels* and 2) the *In-Service Monitoring* mode of the *LMR Channels* in use by the DUT.

The DUT should provide a mechanism with which to maintain it in the *LMR Channel Availability Check* mode, if that mode is applicable to the normal operation of the DUT. In addition, the DUT should produce external signals that indicate: 1) the start of the *LMR Channel Availability Check* mode, and 2) when an *LMR Channel* is declared as no longer being available for use by the DUT. These external signals should be suitable for triggering the test equipment used for the timing measurements.

In order to facilitate the sensor characterization during the *In-Service Monitoring* mode there will be a need for multiple DUTs operating in a typical environment, such as an ad-hoc network or a client-server network.[19] The DUTs should produce an external signal that indicates the detection of an LMR signal on the current *DUT Operating Channel*.

19. Two DUTs may be used to form an ad-hoc network. Two or three DUTs may be used to form a client-server network where one DUT is the network server or base station.

In these tests, the analog channels will have a bandwidth of 25 kHz and the digital channels will have a bandwidth of 12.5 kHz.

9.2.1 Detection Sensitivity for Non-Faded, Co-Channel LMR Signals and a Noise Signal

Purpose: To determine the probability of successful detection of low-level, non-faded co-channel LMR transmissions by the DUT.

Procedure: To perform the detection sensitivity test for the *LMR Channel Availability Check* mode, the DUT should be configured to remain in this initial spectrum scanning state. The DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of *LMR Channels* as *Locked-Out LMR Channels*, or by the application of a collection of *Standard LMR Test Signals* to the DUT.

Generate a single, simulated, non-faded digital (P25) LMR signal that falls within the *DUT Operating Channel*. The amplitude of the simulated LMR signal at the input of the DUT will be varied in 1 dB increments to fully explore the detection range from 0 to 100 percent. Using an external signal from the DUT to indicate the start of the *LMR Channel Availability Check* process, the simulated LMR signal will be gated on for 5 seconds. While the LMR signal is gated on, use an external signal from the DUT to indicate that an *LMR Channel* is declared as no longer being available for use by the DUT. Record the elapsed time from when the simulated LMR signal was gated until the DUT detects the LMR signal. If during a trial the 5 seconds is elapsed and the DUT does not detect the LMR signal this trial will be referred to as a "no detection". Repeat this test 100 times. Increase the amplitude of the simulated LMR signal by 1 dB and repeat this test. Continue this test until the DUT detects the presence of the LMR signal for 100 percent of the trials at a given LMR signal power level, or when the LMR signal power level reaches -100 dBm. Repeat this test using a simulated non-faded analog (FM) LMR signal, and using band limited Gaussian noise as the input to the DUT.

To perform this test for the *In-Service Monitoring* mode of the spectrum, configure two or three DUTs in either an ad-hoc or client-server network. Each DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of *LMR Channels* as *Locked-Out LMR Channels*, or by the application of a collection of *Standard LMR Test Signals* to each DUT.

Generate a single, simulated, non-faded digital (P25) LMR signal that can be gated on at the input to one of the DUTs when that DUT begins to transmit on the *DUT Operating Channel*. The simulated LMR signal should be tuned to a frequency that falls within the *DUT Operating Channel*. The amplitude of the simulated LMR signal at the input to the DUT will be varied in 1 dB increments to fully explore the detection range from 0 to 100 percent. The length of the gated-on time will be 5 seconds. While each DUT is operating on a *DUT Operating Channel*, the simulated LMR signal will be gated on coincident with the start of transmission for one of the DUTs. While the LMR signal is gated on, use an external signal from the DUT to indicate that an *LMR Operating Channel* is detected within the *DUT Operating Channel.* Record the elapsed time from when the simulated LMR signal was gated on until the DUT detects the LMR signal. Record the elapsed time from when the LMR signal was gated on until all DUTs cease transmitting on the frequency corresponding to the LMR signal. If during a trial the 5 seconds is elapsed and the DUT does not detect the LMR signal this trial will be referred to as a "no detection." Repeat this test 100 times. Increase the amplitude of the simulated LMR signal by 1 dB and repeat this test. Continue this test until the DUT detects the presence of the simulated LMR signal for 100 percent of the trials at a given LMR signal power level, or when the simulated LMR signal power level reaches -100 dBm. Repeat this test using a simulated non-faded analog (FM) LMR signal, and band limited Gaussian noise signal as the input to the DUT.

For both the *LMR Channel Availability Check* and *In-Service Monitoring* modes of DUT operation, the results corresponding to the time-to-detect the LMR signal in 10, 50 and 97 percent of the trials will be used to develop graphs of DUT time-to-detect and time-to-turn-off as a function of LMR signal power.

If a control channel is used to communicate control and signaling information between networked DUTs, this test above will be repeated with the simulated LMR signals centered on the frequency used by the control channel.

9.2.2 Detection Sensitivity for Faded, Co-Channel LMR Signals and a Noise Signal

Purpose: To determine the probability of successful detection of Rayleigh faded co-channel transmissions for the DUT.[20]

Procedure: To perform the detection sensitivity test for the *LMR Channel Availability Check* mode, the DUT should be configured to remain in an initial spectrum scanning state. The DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of *LMR Channels* as *Locked-Out LMR Channels*, or by the application of a collection of *Standard LMR Test Signals* to the DUT.

Generate a single, simulated digital (P25) LMR signal that falls within the *DUT Operating Channel.* The LMR signal power is set to the power level corresponding to a 10 percent probability of detection from the non-faded detection sensitivity test. Using this signal power level, generate a Rayleigh-distributed input signal to the DUT. The Rayleigh fading simulator will be used to simulate fading commensurate with a vehicle speed of 5 miles per hour. Using an external signal from the DUT to indicate the start of the *LMR Channel Availability Check* mode, the simulated LMR signal will be gated on for 5 seconds. While the LMR signal is gated on, an external signal from the DUT is used to indicate that an *LMR Channel* is declared as no longer being available for use by the DUT. Record the elapsed time from when the simulated LMR signal was gated on, until the DUT detected the presence of the LMR signal. If during a trial the 5 seconds is elapsed and the DUT does not detect the LMR signal this trial will referred to as a "no detection." Repeat this test 100

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20. The methods described in TIA-102.CAAA-B, Section 1.5.33 will be used for validating the fading simulator. *See* TIA-102.CAAA-B, *supra* note 15, at Section 1.5.33.

times. Increase the amplitude of the simulated LMR signal to the power level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test, and then repeat the above test. Increase the amplitude of the simulated LMR signal to the power level corresponding to a 97 percent probability of detection as measured for the non-faded detection sensitivity test, and repeat the above test.

The tests described above are to be repeated for the faded signal conditions using simulated vehicle speeds of 30 and 60 miles per hour.

The tests described above are to be repeated using an analog (FM) LMR signal and a band limited Gaussian noise signal as the input to the DUT.

To perform this test for the *In-Service Monitoring* mode, configure two or three DUTs in either an ad-hoc or client-server network.[21] Each DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of *LMR Channels* as *Locked-Out LMR Channels*, or by the application of a collection of *Standard LMR Test Signals* to each DUT.

Generate a single, simulated digital (P25) LMR signal that can be gated on at the input to one of the DUTs when that DUT begins to transmit on the *DUT Operating Channel*. The LMR signal power is set to the power level corresponding to a 10 percent probability of detection as measured for the non-faded detection sensitivity test. Using this signal power level, generate a Rayleigh-distributed input signal to the DUT. The Rayleigh fading simulator will be used to simulate fading commensurate with a vehicle speed of 5 miles per hour. The length of the gated-on time will be 5 seconds. While the DUTs are operating on a *DUT Operating Channel*, the LMR signal will be gated on coincident with the start of transmission for one of the DUTs. While the LMR signal is gated on, an external signal from the DUT will be used to indicate that an *LMR Channel* is detected within the *DUT Operating Channel*. Record the elapsed time from when the simulated LMR signal was gated on, until the DUT detected the presence of the LMR signal. If during a trial the 5 seconds is elapsed and the DUT does not detect the LMR signal this trial will referred to as a "no detection." Record the elapsed time from when the LMR signal was gated on until all DUTs cease transmitting on the frequency corresponding to the simulated LMR signal. Repeat this test 100 times. Increase the amplitude of the simulated LMR signal to the power level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test, and repeat the above test. Increase the amplitude of the simulated LMR signal to the power level corresponding to a 97 percent probability of detection as measured for the non-faded detection sensitivity test. Repeat the above test increasing the amplitude of the simulated LMR signal in 1 dB increments to a maximum value of 20 dB above the power level corresponding to a 97 percent probability of detection as measured for the non-faded detection sensitivity test.

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21. Two DUTs may be used to form an ad-hoc network. Two or three DUTs may be used to form a client-server network where one DUT is the network server or base station.

The tests described above are to be repeated for the faded signal conditions using simulated vehicle speeds of 30 and 60 miles per hour.
The tests described above are to be repeated using a simulated analog (FM) LMR signal, and using band limited Gaussian noise as the input to the DUT.

The cumulative distribution of the number of detections as a function of time will be determined for each value of LMR test signal power level and using both the DUT *LMR Channel Availability Check* and *In-Service Monitoring* modes.

If a control channel is used to communicate control and signaling information between networked DUTs, this test will be repeated with the LMR signals centered on the frequency used by the control channel.

9.2.3 Adjacent Channel Interference

Purpose: To determine the adjacent LMR channel interference rejection characteristics of the DUT sensor. This test is intended to characterize the detection performance of the DUT sensor when strong signals are present on *LMR Channels* that are adjacent to a *LMR Channel* that fall within the *Sensor Bandwidth.*

Procedure: To perform the adjacent channel interference test for the LMR Channel Availability Check mode, the DUT should be configured to remain in an initial spectrum scanning mode. In this test all of the *LMR Channels* will be *Locked-Out LMR Channels* with the exception of one *LMR Channel.*

Generate a single, band-limited Gaussian noise signal. Initially set the center frequency of the noise signal to one adjacent channel away from a selected *Available LMR Channel.*[22] The noise signal amplitude at the input of the DUT will be set to -100 dBm and will be gated on/off for 5 seconds. Increase the noise signal amplitude in 1 dB steps up to a maximum level of -20 dBm. Record the noise signal level corresponding to one detection on the first adjacent channel. Repeat this test with the noise signal tuned to the second adjacent channel and then the third adjacent channel. Record the noise signal levels corresponding to one detection on the second adjacent channel and then the third adjacent channels. This series of tests will be repeated 10 times for *LMR Channels* located at the low, mid and high portions of the *Sensor Bandwidth.*

To perform this test for the *In-Service Monitoring* mode, configure two or three DUTs in either an ad-hoc or client-server network. Each DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of LMR Channels adjacent to the *DUT Operating Channel* as *Locked-Out LMR Channels.*

Generate a single, band-limited Gaussian noise signal that will be applied to only one DUT in the network. Initially set the center frequency of the noise signal to a *Locked-Out LMR*

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22. The resolution bandwidth of the DUT sensor may differ from the *LMR Channel* bandwidth. The adjacent channel test signal is chosen to occupy an *LMR Channel* that has the least overlap with a nearest DUT sensor channel.

Channel that is one adjacent channel away from the *DUT Operating Channel.* The noise signal amplitude at the input of the DUT will be set to -100 dBm and will be gated on/off for 5 seconds. Increase the noise signal amplitude in 1 dB steps up to a maximum level of -20 dBm. Record the noise signal level corresponding to one detection on the first adjacent channel. Repeat this test with the noise signal tuned to the second adjacent channel and then the third adjacent channel. Record the noise signal levels corresponding to one detection on the second adjacent channel and then the third adjacent channels. This series of tests will be repeated 10 times for *LMR Channels* located at the low, mid and high portions of the *Sensor Bandwidth.*

9.2.4 Sensor Desensitization

Purpose: To determine the ability of a DUT to successfully detect a low-level LMR transmission in the presence of multiple high amplitude in-band LMR transmissions. This test is intended to determine whether the presence of strong signals desensitize the DUT such that it fails to detect *LMR Operating Channels* in another part of the *Sensor Bandwidth.*

Procedure: To perform the detection sensitivity test for the *LMR Channel Availability Check* mode, the DUT should be configured to remain in the initial spectrum scanning state. The DUT will be configured to operate on its minimum *DUT Operating Channel* by assigning a collection of *LMR Channels* as *Locked-Out LMR Channels* in addition to the application of a simulated 6-channel trunked LMR station.

Generate a single LMR signal at a signal level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test in 5 seconds. Generate a simulated 6-channel trunked LMR signal, offset by a minimum of four *LMR Channels* to avoid any adjacent channel interference effects. The simulated trunked LMR transmissions should have bandwidths of 12.5 kHz and transmitted at a signal level of -70 dBm at the input of the DUT. Using the DUTs external indication of the start of the scan process, the single LMR signal will be gated on for 5 seconds. The DUT's external indication of the single LMR signal being detected (*i.e., LMR Channel* no longer available for use by the DUT) will be recorded. Repeat this test 30 times and record the percentage of trials that the DUT detected the single LMR signal. Increase the amplitude of the simulated trunked LMR signal level by 5 dB and repeat this test until the signal level reaches -10 dBm. Continue this test until the DUT detects the presence of the single LMR signal for 10 percent of the trials, or when the signal level of the simulated trunked LMR signal reaches -10 dBm, and record the signal level of the simulated trunked LMR signal. Repeat the above tests for the single LMR signal and the trunked *LMR Channels* on opposite ends of the *Sensor Bandwidth.*

To perform this test for the *In-Service Monitoring* mode of the spectrum, configure two or three DUTs in either an ad-hoc or client-server network. The procedure differs from that used for the *LMR Channel Availability Check* mode as follows:

The single LMR signal generated at a level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test in 5 seconds is applied to one DUT in the network. The simulated trunked LMR signals are applied to the same DUT.

While the DUTs are operating on a *DUT Operating Channel*, the single LMR signal will be gated on coincident with the start of transmission for the one DUT indicated above. The single LMR signal will be gated on for 5 seconds. Observe and record the DUTs external indication of the single LMR signal being detected (*i.e., LMR Channel* no longer available for use by the DUT). Repeat this test 30 times and record the percentage of trials that the DUT detected the single LMR signal. Increase the amplitude of the simulated trunked LMR signal by 5 dB. Continue this test until the DUT detects the presence of the single LMR signal for 10 percent of the trials, or when the signal level of the simulated trunked LMR signal reaches -10 dBm, and record the signal level of the simulated trunked LMR signal. Repeat the above tests for the single LMR signal and the trunked *LMR Channels* on opposite ends of the *Sensor Bandwidth.*

9.2.5 Sensor Out-of-Band Interference Rejection

Purpose: To determine the ability of the DUT to detect a weak LMR signal in the presence of high amplitude signals operating adjacent to the 410-420 MHz or 470-512 MHz bands.

Procedure: Generate a desired LMR signal at a signal level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test during a 5 second interval. The desired LMR signal will be transmitted on an *LMR Channel* in the center of the *Sensor Bandwidth.* Generate several (at least six) noise-like signals with bandwidths of 100 to 500 kHz and signal amplitudes in the range of -25 to -35 dBm at the input of the DUT. These interfering signals should be operating on frequencies on both sides of the Test-Bed frequency bands and within 15 MHz of the band edges. With the LMR signal turned off, and the DUT turned on, monitor the DUT to determine if any false detections of the LMR signal have occurred. Using the DUT's external indication of the start of the spectrum scanning process, the single LMR signal will be gated on for 5 seconds. The DUT's external indication of the single LMR signal being detected (*i.e., LMR Channel* no longer available for use by the DUT) will be recorded. The detection of the single LMR signal will be observed over 30 trials and the probability of detection determined. Increase the out-of-band signal levels in 5 dB steps and repeat this test until the probability of detection of the LMR signal drops to 10 percent or the out-of-band signal amplitudes are in the range of -10 to -20 dBm.

Repeat the test above with all out-of-band signals positioned on one side of the Test-Bed frequency band. Repeat the test above with all out-of-band signals positioned on the opposite side of the Test-Bed frequency band.

To perform this test for the *In-Service Monitoring* mode of the spectrum, configure two or three DUTs in either an ad-hoc or client-server network. The procedure differs from that used for the *LMR Channel Availability Check* mode as follows:

The single LMR signal generated at a level corresponding to a 50 percent probability of detection as measured for the non-faded detection sensitivity test in 5 seconds is applied to one DUT in the network. The same DUT is subjected to the simulated noise-like out-of-band signals. While the DUTs are operating on a *DUT Operating Channel*, the single LMR signal will be gated on coincident with the start of transmission for the one DUT indicated above.

The single LMR signal will be gated on for 5 seconds. Observe and record the DUTs external indication of the single LMR signal being detected (*i.e., LMR Channel* no longer available for use by the DUT).

9.2.6 DUT Cooperative Sensing

Purpose: To determine the ability of multiple DUTs to cooperatively detect and communicate the presence of a *Hidden Node*. This test will be performed using the DUT *In-Service Monitoring* mode.

Procedure: Configure two DUTs and verify they are communicating with each other. Introduce an LMR signal into DUT #1 at the *Standard LMR Test-Signal Level* on a randomly selected *LMR Channel* within the Test-Bed frequency bands. DUT #2 will be isolated from the LMR signal which is introduced to DUT #1. Monitor DUT #2 and verify that it does not transmit on any of the *Unavailable LMR Channels*. Increase the number of LMR signals input to DUT #1 that coincide with the *DUT Operating Channel*. Monitor both DUTs to ensure that they do not transmit on *Unavailable LMR Channels*. Continue until the *DUT Operating Channel* for DUT #1 is sufficiently occupied with LMR signals such that the *DUT Operating Channel* is no longer available for use. Monitor both DUTs for a specified period of time to ensure that all transmissions cease.[23] Next turn off an LMR signal within the *DUT Operating Channel* of DUT #1 and monitor both DUTs for a specified period of time and verify the initiation of a transmission on the *Available LMR Channel*. Continue to turn off LMR signals within the *DUT Operating Channel* and verify the DUTs only transmit on *Available LMR Channels*. This series of tests will be repeated 10 times for *LMR Channels* located at the low, mid and high portions of the *Sensor Bandwidth*.

9.3 DUT Geo-Location Characterization

The test cases below assess the geo-location capabilities of the DUT. The test cases assume that the geo-location equipped DUTs have the ability to load and edit the contents of a policy database for testing purposes.[24] In addition, the tests assume the ability to monitor the DUT to determine when it has established a position fix.[25]

9.3.1 DUT Geo-Location Policy Database

Purpose: To determine the ability of the DUT to recognize it has a current geo-location policy database before transmission.

23. The time period will be sufficiently long so that a normally functioning DUT will complete the intended action.

24. Examples of the type of information that could be included in geo-location policy database include: location boundary, set(s) of available channels, channel validity period, time stamp, etc.

25. If the DUT does not provide an indication of position fix, the vendor may specify a wait time for establishing a position fix.

Procedure: Configure two DUTs (DUT #1 and DUT #2) with identical, current geo-location policy databases, and verify that they have access to the geo-location signals required to establish a position fix. Verify that the DUTs can communicate with each other. Cease transmitting on DUT #1 and remove its geo-location policy database. Verify that DUT #1 is no longer able to transmit.

Re-load DUT #1 with an expired geo-location policy database. Verify that DUT #1 is not able to transmit.

Re-load DUT #1 with a current geo-location database that is identical to the database in use by DUT #2. Verify that DUT #1 is able to communicate with DUT #2.

9.3.2 DUT Geo-Location Sensor

Purpose: To determine the DUT geo-location sensor functionality during start-up and when the position fix becomes unavailable.

Procedure: Configure two DUTs (DUT #1 and DUT #2) with identical, current geo-location policy databases that have a limited number of *Available LMR Channels* over which to transmit on in the geographic area encompassing the test location. Verify the DUTs can establish a position fix.

Turn off DUT #1. Turn on DUT #1 and verify that it can transmit to DUT #2 on one or more of the *Available LMR Channels* only after acquiring a position fix.

Turn off DUT #1 and deny its access to the geo-location signals required to establish a position fix. Turn on DUT #1 and verify it does not transmit.

9.3.3 Loss of Geo-Location Fix

Purpose: To determine the DUT geo-location sensor behavior when subjected to a loss of geo-location signals needed to establish a position fix. This test is intended to characterize the time during which the DUT continues to transmit when subjected to a loss of position fix.

Procedure: Configure two DUTs (DUT #1 and DUT #2) with identical, current geo-location policy databases that have a limited number of *Available LMR Channels* on which to transmit in the geographic area encompassing the test location. Verify the DUTs can establish a position fix. Verify that DUT #1 can transmit to DUT #2 on one or more of the *Available LMR Channels* only after acquiring a position fix.

While DUT #1 is operating, remove the geo-location signals required to establish a position fix. Measure the time from loss of these signals until DUT #1 ceases to transmit. Repeat this test 30 times and compute the average time to cease transmitting after the loss of a position fix.

9.4 DUT Spectrum Access Behavior

The test cases below assess the sensing and geo-location spectrum access capabilities of the DUT. In these tests, the analog channels will have a bandwidth of 25 kHz and the digital channels will have a bandwidth of 12.5 kHz.

9.4.1 Channel Availability Check[26]

Purpose: To determine whether the DUT: 1) can properly identify *Available LMR Channels* when it first turned on; 2) does not transmit on *Locked-Out LMR Channels*; 3) vacates the *DUT Operating Channels* as the number of available *DUT Channels* is reduced; and 4) can expand the *DUT Operating Channel* as the number of available *DUT Channels* is increased. This test is intended to demonstrate that the DUT does not transmit on *Unavailable LMR Channels*.

Procedure: Configure two DUTs and verify they are communicating with each other. The DUTs should then be turned off and restarted. Designate a set of *LMR Channels* as being *Locked-Out LMR Channels* in DUT #1. Introduce an LMR signal into DUT#1 at the *Standard LMR Test-Signal Level* on randomly selected *LMR Channels* within the Test-Bed frequency bands that are not already assigned as *Locked-Out LMR Channels*. Verify that DUT#1 does not transmit on any of the *Unavailable LMR Channels*. Increase the number of LMR signals that coincide with the *DUT Operating Channel*. Monitor DUT #1 to ensure that it does not transmit on *Unavailable LMR Channels*. Continue until the *DUT Operating Channel* for DUT #1 is sufficiently occupied with LMR transmissions such that the *DUT Operating Channel* is no longer available for use. Continue monitoring DUT #1 for a specified period of time to ensure that all transmissions cease. Next turn off an LMR signal within the *DUT Operating Channel* and monitor DUT #1 for a specified period of time and verify the initiation of a transmission on the *Available LMR Channels*. Continue turning off LMR signals within the *DUT Operating Channel*, each time monitoring to ensure that DUT#1 only transmits on *Available LMR Channels*. Repeat this process 10 times, using randomly chosen *LMR Channels* as the *Locked-Out LMR Channels* and *LMR Operating Channels*.

9.4.2 Paired-Channel Availability Check

Purpose: To determine whether DUTs that exploit *LMR Channel* pairing properly avoid transmitting on an *LMR Channel* when an LMR signal is present on the paired *LMR Channel*.

Procedure: Configure two DUTs with identical policy databases that identify *LMR Channel* pairs and verify the DUTs are communicating with each other. Designate a set of *LMR Channels* as being *Locked-Out LMR Channels* in DUT #1 such that the *DUT Operating Channel* is restricted to *LMR Channels* that include the paired-channels in the policy database. Introduce a simulated LMR signal into DUT #1 at the *Standard LMR Test-Signal*

26. This test will not be performed for DUTs that only employ geo-location spectrum access techniques.

Level on the frequency of one of the paired-channels. Monitor both DUTs to verify that they cease transmitting on both of the paired-channels.

9.4.3 DUT Geo-Location Channel Availability Check

Purpose: To determine the ability of the geo-location equipped DUT to properly transmit on *Available LMR Channels* and avoid transmitting on *Locked-Out LMR Channels* based on geographic location.

Procedure: Configure two DUTs (DUT #1 and DUT #2) with identical, current geo-location policy databases that have the same set of *Available LMR Channels* on which to transmit in the geographic area encompassing the test location.[27] Verify that the DUTs only transmit on the *Available LMR Channels*.

Re-load DUT #1 with a database that defines a different set of *Available LMR Channels* than the set that DUT #2 is configured to use (*i.e.*, DUT #1's *Available LMR Channels* intersect DUT #2's *Locked-Out LMR Channels*). Verify that the DUTs only attempt to transmit on the *Available LMR Channels* that they are each configured to use, and not on the other's *Locked-Out LMR Channels*.

Re-load DUT #1 with a database that defines the same set of *Available LMR Channels* as those used by DUT #2. Load DUT #1 with geographic coordinates that are outside of the geographic area corresponding to the test location. Verify that although DUT #2 attempts to transmit on the *Available LMR Channels*, and DUT #1 does not attempt to transmit on them until it is located inside of the geographical location corresponding to the test area.

9.4.4 DUT Spectrum Sensor and Geo-Location Channel Availability Check

Purpose: To determine the ability of a DUT having both spectrum sensing and geo-location capabilities to properly identify *Available LMR Channels*.

Procedure: Configure two DUTs (DUT #1 and DUT #2) with identical, current geo-location policy databases that have a limited number of *Available LMR Channels* on which to transmit in the geographic area encompassing the test location. Verify that the DUTs transmit only on the *Available LMR Channels* corresponding to the current geographic location of each DUT.

While the two DUTs are communicating with each other, introduce an LMR signal into DUT #1 at the *Standard LMR Test-Signal Level* on an *LMR Channel* that is in use as a *DUT Operating Channel*. Verify that the DUTs cease transmitting on this *LMR Channel*. Increase the number of LMR signals that coincide with the *DUT Operating Channels*. Monitor the DUTs for a specified period of time to verify they do not transmit on the *Unavailable LMR Channels*. Continue adding LMR signals until the *DUT Operating Channel* is sufficiently occupied with LMR signals such that the *DUT operating Channel* is no longer available for use. Monitor the DUTs to verify that the DUTs cease transmitting.

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27. For the purpose of this test the geographic area is defined by a circle around a specific latitude and longitude representing the center point.

Turn off and restart the DUTs. Monitor for a specified period of time to verify that the DUTs do not transmit.

9.5 LMR Emission Characterization

9.5.1 LMR Modulated Emission Spectrum Measurement

Purpose: To characterize the spectral emissions of the LMR transmitters at the range of operating power levels. This test will be used in evaluating the test results which will be a function of both the LMR transmitter and the detection process of the DUT.

Procedure: Conduct an emissions spectrum measurement using standard methods for selected *LMR Operating Channel* bandwidths. Measure the LMR emissions across the range of operating parameters for analog and digital LMR signals.

9.5.2 Temporal Characteristics of LMR Emissions

Purpose: To characterize the temporal characteristics of the analog and digital LMR transmitter emissions for use in signal environment simulation and analysis.

Procedure: Conduct an I/Q capture of the emissions which show the time domain characteristics of the digital and analog LMR transmissions.

9.6 LMR Receiver Performance Characterization

The performance of digital and analog LMR receivers will be measured using the procedures and criteria specified in TIA-102.CAAA-B.[28] For the digital modulation receivers a 5 percent bit error rate (BER) performance threshold will be used.[29] For the analog FM receiver a 12 dB signal-plus-noise-plus-distortion-to-noise-plus-distortion ratio (SINAD) performance threshold will be used.

9.6.1 LMR Receiver Co-Channel Rejection

Purpose: To determine, using a waveform that was captured from actual DUT transmissions as a signal source, the degree to which those emissions would interfere with typical LMR receivers including base, portable, and mobile stations. This test will be used to estimate the *Interference Range*.

Procedure: Based on TIA-102.CAAA-B, Section 2.1.8, Co-Channel Rejection. The co-channel rejection is the ratio of the reference sensitivity to the level of an unwanted input signal. The unwanted signal has an amplitude that causes the BER produced by a wanted signal 3 dB in excess of the reference sensitivity to be reduced to the standard BER of 5 percent. For analog LMR receivers the same procedure will be used with a 12 dB SINAD performance threshold.

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28. *See* TIA-102.CAAA-B, *supra* note 15.

29. The specified BER is at the input to the detector.

9.6.2 LMR Receiver Off Frequency Rejection

Purpose: To determine, using a waveform that was captured from actual DUT transmissions as a signal source, the degree to which those emissions would desensitize typical base, portable, and mobile station LMR receivers. This test can be used to determine the degradation in the LMR receiver sensitivity due to adjacent channel emissions from the DUT. The adjacent channel signal source will be offset in frequency from the desired signal source by one half the DUT emission bandwidth plus a 12.5 kHz increment.

Procedure: The adjacent channel rejection of the LMR signal will be measured based on procedures and criteria in TIA-102.CAAA-B.[30] The unwanted signal has an amplitude that causes the BER produced by a wanted signal 3 dB in excess of the reference sensitivity to be degraded to the standard BER of 5 percent. For analog LMR receivers, the same procedure will be used with a 12 dB SINAD performance threshold. The unwanted signal will be operated in 12.5 kHz increments on the first through third adjacent channel of the LMR receiver to measure the adjacent channel rejection characteristics. Whatever side of the tuned frequency was selected for the initial adjacent channels, the tests will be repeated for the adjacent channels on the other side of the tuned frequency.

9.6.3 P25 Header Obfuscation

Purpose: To determine the susceptibility of a P25 LMR receiver to go into Late Entry as a result of corruption to the P25 header caused by sufficiently high DUT emission levels and sufficiently excessive *LMR Channel Clearance Times.*[31]

Procedure: Measure a variation of the receiver throughput delay on an LMR reference receiver based on the procedure outlined in TIA-102.CAAA-B Section 2.1.18 with the exception that the modulation source will produce a valid conventional P25 message containing a header, 5 consecutive standard tone test patterns superframes, and a terminator data unit.[32] The LMR input signal will be at the *Standard LMR Test Signal Level*. The modified throughput delay will be the elapsed time from the transmission of the first symbol of the header until a tone is produced on the audio output of the receiver. Combine the desired LMR signal with a simulated DUT waveform that can be gated on and off. The initial simulated DUT waveform power level will be set to -135 dBm. The simulated DUT waveform will be transmitted for a duration of 5 milliseconds (e.g., it will be gated off 5 milliseconds after the introduction of the LMR signal). This corresponds to the duration of a P25 header frame synchronization. Repeat the transmission of both signals in synchronization while increasing the simulated DUT waveform power level until a marked increase (*e.g.*, greater than 20 milliseconds) is observed in the receiver throughput delay. This is an indication that the receiver had to perform a "Late Entry" as a result of header obfuscation. Repeat the transmission at this DUT power level 30 times and record the

30. *See* TIA-102.CAAA-B, *supra* note 15.

31. A Late Entry has the effect of clipping the beginning of the voice audio.

32. *See* TIA-102.CAAA-B, *supra* note 15, at Section 2.1.18.

percentage of DUT transmissions that caused a late entry. Increase the DUT power level in 1 or 2 dB increments recording the probability of a "late entry" at each power level increment until the probability of a "late entry" is 100 percent.

10. PHASE I TEST CASES (TABLE MOUNTAIN FACILITY)

The Phase I tests at the Table Mountain Facility are an extension of the laboratory test cases. The measurements described in this section use radiated signals.

10.1 Channel Availability Check in a Simulated Channel Environment

Purpose: To determine whether the DUT: 1) can properly identify *Available LMR Channels* when it first turned on; 2) does not transmit on *Locked-Out LMR Channels*; 3) vacates the *DUT Operating Channel* as the number of available *DUT Channels* is reduced; and 4) increases the *DUT Operating Channel* as the number of available *DUT Channels* is increased. This test is intended to demonstrate that the DUT does not transmit on *Unavailable LMR Channels*, both on power up and during ongoing operation.

Procedure: Configure two DUTs and verify they are communicating with each other. The DUTs should then be turned off and restarted. Designate a set of *LMR Channels* as being *Locked-Out LMR Channels* in DUT #1. Introduce an LMR signal into DUT #1 at the *Standard LMR Test-Signal Level* on randomly selected *LMR Channels* within the Test-Bed frequency bands that are not already assigned as *Locked-Out LMR Channels*. Verify that DUT#1 does not transmit on any of the *Unavailable LMR Channels*. Increase the number of LMR signals that coincide with the *DUT Operating Channel*. Monitor DUT#1 to verify that it does not transmit on *Unavailable LMR Channels*. Continue until the *DUT Operating Channel* is sufficiently occupied with LMR transmissions such that the minimum *DUT Operating Channel* is no longer available for use. Continue monitoring DUT #1 for a specified period of time to verify that is ceases to transmit. Next turn off an LMR signal within the *DUT Operating Channel* and monitor DUT #1 for a specified period of time. Continue turning off LMR signals within the *DUT Operating Channel*, each time monitoring to verify that DUT #1 only transmits on *Available LMR Channels*. Repeat this process 10 times, using randomly chosen *LMR Channels* as the *Locked-Out LMR Channels* and *LMR Operating Channels*.

10.2 Sensor Performance in a Simulated Near/Far Incumbent System Environment

Purpose: To determine the ability of multiple DUTs to cooperatively detect and communicate the presence of a *Hidden Node*.

Procedure: Configure two DUTs and verify they are communicating with each other. Introduce an LMR signal into DUT #1 at the *Standard LMR Test-Signal Level* on randomly selected *LMR Channels* within the Test-Bed frequency bands. DUT #2 will be isolated from the LMR signal which is introduced to DUT #1. Monitor DUT #2 and verify that it does not transmit on any of the *Unavailable LMR Channels*. Increase the number of LMR signals input to DUT #1 that coincides with the *DUT Operating Channel*. Monitor both DUTs to ensure that they do not transmit on *Unavailable LMR Channels*. Continue until the *DUT*

Operating Channel for DUT # 1 is sufficiently occupied with LMR signals. Monitor both DUTs for a specified period of time to verify that they cease to transmit. Next turn off an LMR signal within the *DUT Operating Channel* and monitor both DUTs for a specified period of time and verify the initiation of a transmission on the *Available LMR Channel.* Continue to turn off LMR signals within the *DUT Operating Channel* each time monitoring to verify the DUTs only transmit on *Available LMR Channels.* Repeat this process 10 times, using randomly chosen *LMR Operating Channels.*

10.3 Geo-Location Channel Availability in a Simulated Channel Environment

Purpose: To determine the ability of a geo-location equipped DUT to transmit only on *Available LMR Channels* as determined by its geographic location.[33]
Procedure: Configure two DUTs with identical, current geo-location policy databases. The databases should contain policies for two non-overlapping geographical areas. The first geographic area (Area #1) has a limited number of *Available LMR Channels* (Channel Set #1) may be used for transmission, and a second geographic area (Area #2) has a second set of *Available LMR Channels* (Channel Set #2) may be used. The geographic areas and sets of *Available LMR Channels* should be distinct (*e.g.*, no overlap).

With both DUTs co-located (Area #1) on the Table Mountain Test Facility, turn on the DUTs and verify that after they establish position fixes, the DUTs are able to communicate with each other using only the *Available LMR Channels* (Channel Set #1) corresponding to their location on Table Mountain Test Facility.

Move DUT #1 to Area #2 and verify that it only attempts to communicate using Channel Set #2, while DUT #2 (still located in Area #1) continues to attempt to communicate using Channel Set #1.

Move DUT #2 to Area #2 and verify that it now can communicate with DUT #1 using only the *Available LMR Channels* defined in Channel Set #2.

11. DUT CHANNEL LOADING

Testing will be performed with a designated test file to represent continuous speech voice and/or data traffic to fully load the channel transmitted by the DUT. NTIA will work with the Test-Bed participants to create the test files.

12. MEASUREMENT FACILITY LOCATION

The measurements will be performed at the NTIA ITS laboratory and Table Mountain facility located in Boulder Colorado.[34]

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33. The *Available LMR Channels* will need to be selected so as not to interfere with LMR channels that are in use within the area.

34. The ITS Table Mountain Facility is afforded radio quiet zone protection by both State and Federal laws from strong, external signals, which makes this site ideal for sensitive radio or electromagnetic experiments.

13. EQUIPMENT REQUIREMENTS

The Test-Bed participant will provide the transmitters, receivers, and antennas associated with the DUT. The Test-Bed participant will also provide the technical support to operate the DUT and extract the technical data specified in the measurement plan.

NTIA will provide the engineering support, test equipment and software necessary to perform the measurements called for in the test plan.

14. DOCUMENTATION

The test procedures, test conditions, and results of Phase I tests will be documented in a report and made available for public review and comment.

15. SCHEDULE

The Phase I testing will begin in January 2009. The approximate time to complete testing for each DUT is four months. All efforts will be made to perform simultaneous testing of the DUTs. If unexpected problems are encountered with a DUT this could impact the time required to complete Phase I testing.