Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

October 21, 2016

U-NII-4 PROTOTYPE DEVICE TESTING OPEN HOUSE SUMMARY

The Office of Engineering and Technology held an open house to review the U-NII-4 to DSRC phase 1 test plan on October 21, 2016 at its Laboratory located in Columbia, MD. The test plan consists of three major components as listed below:

> **RF Characterization Measurements**. This portion of the test and measurement program will focus on determining values associated with traditional EMC-related transmission parameters such as occupied bandwidth (OBW), channel power, and out-of-band emission (OOBE) characteristics.
>
> **Benchtop Interference Susceptibility Tests**. This portion of the test effort will focus on quantifying the potential impact to DSRC basic safety message (BSM) reception from unmitigated co-channel and adjacent-channel transmissions from the prototype devices.
>
> **Interference Mitigation Tests**. This portion of the testing will evaluate the different distinct strategies that have been proposed for mitigating interference to the DSRC BSM operations from proposed U-NII-4 transmissions.

A copy of the materials presented and list of those in attendance is attached.

Federal Communications Commission
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AGENDA

U-NII-4 PROTOTYPE DEVICE TESTING OPEN HOUSE

FCC Laboratory, Columbia, MD
October 21, 2016
10:00 AM to 12:00 PM

1. Introduction – Rashmi Doshi

2. U-NII-4-to-DSRC EMC Test and Measurement Plan Overview – Steve Jones

3. Open Discussion – Rashmi Doshi

4. Test Demonstrations
    a. RF Characterization Measurements – Dusmantha Tennakoon
    b. Benchtop Interference Susceptibility Tests – Steve Jones
    c. Interference Mitigation Tests – Reza Biazaran

DSRC- UNII-4 Open House Attendee List (29)

Friday October 21, 2016, Laboratory Division, FCC

Name	Organization	Group	Signature
Michael Schagrin	Global Automakers (ctr)	1	
John Kuzin	Qualcomm	1	
Justin McNew	JMC Rota Inc.	1	
Brian Gallagher	DENSO Inc.	1	
Ms. Megumi Suzuki	Subaru	1	
Bill Graff	TUV Rheinland of North America	1	
Danielle Pineres	NCTA	1	
Andy Scott	NCTA	1	
Paul Caritj	Harris, Wiltshire & Grannis LLP	1	
Austin Bonner	Harris, Wiltshire & Grannis LLP	1	
Michael Cammisa	Association of Global Automakers	2	
Steve VanSickle	CAMP	2	
Ehsan Moradi-Pari	Honda R&D Americas, Inc.	2	
John Kenney	Toyota	2	John B. Kenney
Mary Brown	Cisco	2	
David Case	Cisco	2	
Will Otero	Alliance of Automobile Manufacturers	2	
Bud Zaouk	KEA Technologies, Inc.	2	
Neeraj Dalal	KEA Technologies, Inc.	2	N DALAL
Ken Leonard	DoT, ITS PO	3	
Kevin Gay	DoT, ITS PO	3	
Tom Schaffnit	DoT, VOLPE	3	
Jason Conley	OmniAir Consortium	3	

DSRC- UNII-4 Open House Attendee List

Friday October 21, 2016, Laboratory Division, FCC

Name	Organization	Group	Signature
Rajesh Gangadhar	Charter Communications	3	
Praveen Srivastava	Charter Communications	3	
Audrey Connors	Charter Communications	3	
Hariharan Krishnan	GM	3	
Radhika Bhat	Mintz Law firm	3	
Michael Lewis	DLA Piper LLP	3	
Roy MILLER	SQUIRE PATTON	1	

U-NII-4-to-DSRC EMC Test Plan

Open House
FCC/OET/LAB/TRB

October 21, 2016

Agenda

- Introduction – Rashmi Doshi
- U-NII-4-to-DSRC EMC Test and Measurement Plan Overview – Steve Jones
- Open Discussion – Rashmi Doshi
- Test Demonstrations
  - RF Characterization Measurements – Dusmantha Tennakoon
  - Benchtop Interference Susceptibility Tests – Steve Jones
  - Interference Mitigation Tests – Reza Biazaran

Introduction

- Public Notice (PN) FCC-16-68 released on June 1, 2016.
- PN included an initial general test plan.
- Comments and Reply Comments to the PN and prototype devices submitted for testing have provided information in the development of a more detailed test plan.
- The following slides give an overview of the plan for performing tests and measurements to obtain the requisite data to evaluate sharing proposals.

Test Scope

- Information provided to the record alludes to potential sharing between unlicensed local area network (LAN) applications and DSRC operations.
- This plan is specific to assessing compatibility between these types of operations.
  - Other possible DSRC interference sources, including non-standard unlicensed operations, are not considered within the scope of this effort.

Test Scope (2/4)

- A DSRC radio contains two discrete radios, one dedicated to broadcast and reception of public safety messages, and the second for use in peer-to-peer communications.
- To maintain a manageable test scope, only basic safety message (BSM) traffic is being considered in this effort.
  - BSM considered to be representative of most DSRC safety messaging in terms of packet structure and length.
  - Ongoing discussion of what constitutes safety-related messaging, but general agreement that BSM's represent fundamental safety aspect of DSRC.

Test Scope (3/4)

- Modulation-Coding Schemes (MCS)
  - DSRC and proposed U-NII-4 devices operate under the IEEE 802.11 standard and have ability to dynamically assign one of many available MCS combinations depending on prevailing channel conditions.
  - Practical considerations applied to reduce the number of MCS combinations for the current test effort
  - DSRC BSM's use MCS 1 (QPSK with ½ coding) and this will be the combination employed in testing.
  - U-NII-4 devices not likely to utilize higher order modulation schemes in a DSRC environment, so consideration will be limited to MCS 0 and 2 (BPSK with ½ coding and QPSK with ¾ coding, respectively).

Test Scope (4/4)

- Multiple Input Multiple Output (MIMO)
  - The IEEE 802.11ac standard provides for MIMO operations that are likely to employed by proposed U-NII-4 devices.
  - However, due to time constraints, only a single spatial stream will be considered for the proposed U-NII-4 devices.

Test Samples

- Several parties for 5.9 GHz expansion have provided prototype U-NII-4 devices for testing in response to the Public Notice.
- Some parties have also provided DSRC devices to support the test effort, but these are not all fully-capable devices (e.g., some are only preamble generators).
- We are working with DOT to acquire additional representative DSRC radios to support the test effort.
- A detailed list of the test sample devices currently in our possession is provided in the test plan.
  - 8 U-NII-4 prototype devices
  - 6 DSRC devices

Phase I Testing: FCC Laboratory Tests

- Phase I testing has been divided into three discrete components:
  - RF Characterization Measurements
  - Benchtop Interference Susceptibility Tests
  - Interference Mitigation Tests
- Each of these components is discussed in the subsequent slides.

Component 1: RF Characterization Measurements

- Measurement Objectives
  - To quantify and determine parameter consistency among the various test samples.
  - To aid in obtaining an understanding of the operational capabilities of the sample devices.
  - To identify any potential bugs or glitches prior to use in subsequent testing.
- Characterization Measurements to be Performed with U-NII-4 Prototype Devices
  - Measure occupied bandwidth (OBW) and emission spectra (fundamental and out-of-band/spurious emissions)
    - Measurements for each supported modulation scheme.
    - Measurements for 20, 40, and 80 MHz channel bandwidths
      - Prototypes provided do not support 160 MHz channel BW
    - Only one spatial stream examined per device.

Component 1: RF Characterization Measurements (2/2)

- Characterization Measurements to be Performed for DSRC Transmitters
  - Measure OBW and emission spectra for 10 MHz DSRC channel bandwidth.
- Characterization Measurements to be Performed for DSRC Receivers
  - Measure minimum receiver sensitivity.
    - Quantify receiver sensitivity applying a standard methodology (i.e., received signal level associated with a 10% PER).
- Compare measured emission spectra (U-NII-4 and DSRC) to applicable IEEE 802.11 emission mask.

Component 2: Benchtop Interference Susceptibility Tests

- Test Objective
  - To produce data regarding potential impact to reception of DSRC BSM's introduced by unmitigated (i.e., native CCA-CS only) co-channel and adjacent-channel U-NII-4 transmissions.
- Approach
  - Basic approach is to introduce a U-NII-4 (undesired) signal to a functioning DSRC broadcast link while observing and recording the effect on typical network performance indicators as the undesired signal is incrementally increased.

Component 2: Benchtop Interference Susceptibility Tests (2/7)

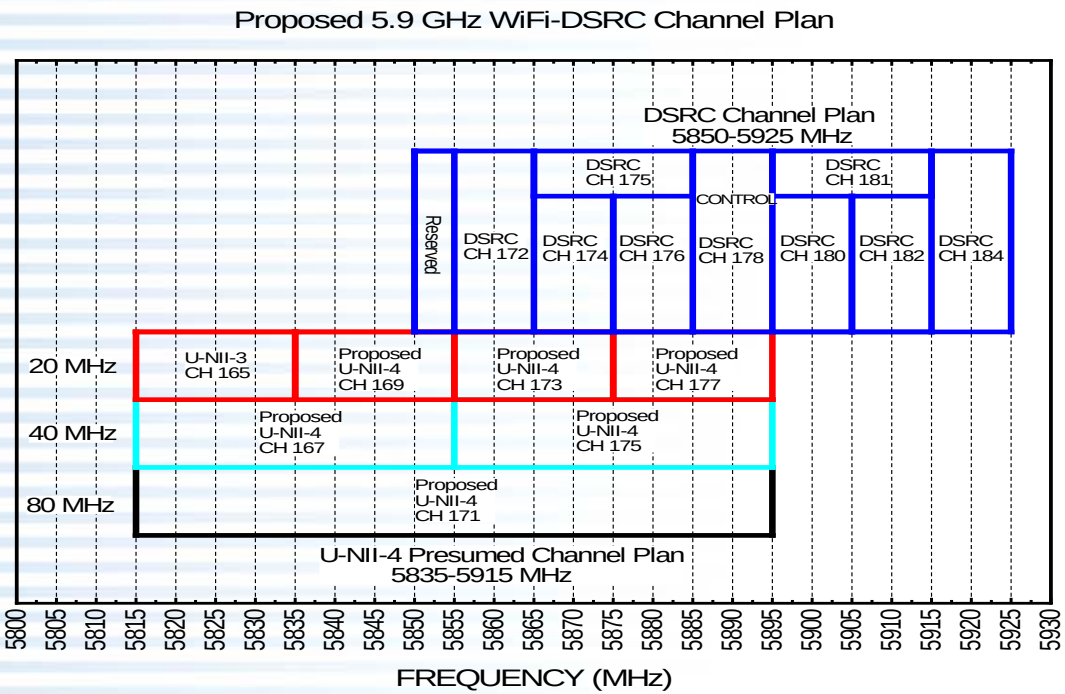
- Test Metrics
  - The following network performance parameters will serve as the fundamental metrics for the interference susceptibility tests:
    - Packet Error Rate (PER)
    - Data Throughput
    - Network Latency or Delay
    - Packet Delay Variation (aka, Jitter)
  - These parameters will be monitored and recorded during testing utilizing a commercial network analysis software tool.

Component 2: Benchtop Interference Susceptibility Tests (3/7)

- Baseline Testing
  - Establish a conducted DSRC communications link, in which priority messages (BSMs) are broadcast and received.
  - Attenuate the DSRC transmitted signal power level to attain a predetermined link margin at the receiver.
  - Measure and record baseline values for the identified test metrics under a “no interference” condition.
  - Repeat the baseline measurements for additional link margin assumptions.

Component 2: Benchtop Interference Susceptibility Tests (4/7)

- Test Channels
  - The figure below depicts the DSRC channel plan overlaid with the proposed U-NII-4/Wi-Fi channel plan.



Component 2: Benchtop Interference Susceptibility Tests (5/7)

- Proposed channel 177 (CF=5885 MHz) will be used for testing DSRC BSM susceptibility to a 20-MHz U-NII-4 signal.
  - Channel 177 selected so as to facilitate examination of:
    - co-channel interactions with DSRC channels 176 and 178,
    - first adjacent-channel interactions with DSRC channels 174 and 180,
    - second adjacent-channel interactions with DSRC channels 172 and 182, and
    - Third adjacent-channel interactions with DSRC channel 184.

Component 2: Benchtop Interference Susceptibility Tests (6/7)

- Similarly, susceptibility tests performed for 40 and 80 MHz channel BWs will utilize proposed U-NII-4 channels 175 (CF=5875 MHz) and 171 (CF=5855 MHz), respectively.
- Will utilize a commercial signal suite hosted on a vector signal generator (no CCA) to simulate a U-NII-4 signal to produce one data set that can be used for comparative purposes.

Component 2: Benchtop Interference Susceptibility Tests (7/7)

- Network Loading Conditions
  - Previous tests assume one-on-one potential interference interactions (i.e., ignores influence of network loading).
  - The susceptibility tests will be repeated with multiple DSRC devices used to generate simultaneous BSM packets to simulate network loading conditions.
    - The amount of network loading that can be achieved will be determined by the available number of DSRC devices.

Interference Mitigation Tests

- Interference Mitigation Proposals
  - Three distinct mitigation strategies proposed for enhancing compatibility between proposed U-NII-4 transmissions and DSRC BSM reception.
  - One of these proposals is specific to WAN applications and is considered beyond the scope of this effort.
- The two mitigation proposals under consideration are:
  - The "*re-channelization*" approach
  - The "*detect and vacate*" proposal.
  - Both are intended to preclude co-channel interactions with DSRC receivers.

Interference Mitigation Proposals: "*Re-channelization*" Approach

- Relies on re-channelizing the DSRC frequency band such that all DSRC priority and control messaging is performed on the upper three 10-MHz channels (i.e., DSRC channels 180, 182, and 184), that would continue to be exclusive to DSRC operations.
- Proposes to move the channel currently dedicated to Public-Safety V2V messaging (i.e., channel 172) onto one of the three upper channels above 5895 MHz.
- The lower 45 MHz of the DSRC spectrum (i.e., DSRC channels 172, 174, 176, 178, and the guard band) would be made available for shared use by DSRC and U-NII-4.
  - Reconfigure lower four 10-MHz DSRC channels into two 20-MHz channels to enable use of existing 802.11ac CCA-CS techniques.
  - Proposes use of a priority channel access scheme using Enhanced Distributed Channel Access (EDCA).

Interference Mitigation Proposals: "*Detect and Vacate*" Approach

- PN and some commenters also refer to this approach as "*Detect and Avoid*".
- Proposes detecting and identifying DSRC message traffic present in the lower five DSRC channels (DSRC channels 172, 174, 176, 178, and 180) and to immediately <u>vacate</u> transmission in the 5825-5925 MHz band upon a positive detection.
  - Proposed detection threshold of -85 dBm/10-MHz on DSRC channels 172, 174, 176, and 178 (lower 40 MHz) and -65 dBm/10-MHz in channel 180 (via digital image reflection).
  - Identification of DSRC signal through demodulation and recognition of unique preamble training symbols.

Component 3: Interference Mitigation Tests

- Re-channelization Mitigation Proposal
  - Since this approach, particularly the proposed message prioritization scheme using EDCA, is not implemented in the current U-NII-4 prototype devices, direct testing is not practical.
    - If the devices can be upgraded, we will revisit this test
  - However, data acquired in previous (Component 2) tests can be used to assess some aspects of the proposal.
- Detect and Vacate Proposal
  - Initial conducted tests will be performed to determine detection reliability at threshold levels and the time required to vacate the band.

Component 3: Interference Mitigation Tests (2/2)

- Detect and Vacate Proposal (continued)
  - Conducted tests will be repeated with AWGN introduced into channel while observing effect on detection reliability at the threshold level.
  - Subsequent tests will be performed using over-the-air (OTA) signals (i.e., radiated test configuration).
  - General approach to these tests is to attenuate DSRC signal level at U-NII-4 device while recording the detection success rate over enough trials to obtain a statistically significant representative data sample.

Additional Information

- The PN and the detailed test plan are accessible at:

  https://www.fcc.gov/oet/unii-4banddevice

- Updates and additional test schedules will be published on the website

Questions?