# Handheld Firefighter Radio Testing

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### Handheld Radio Testing and the Federal Government

- This report to focus on
  - Federal programs
  - RF testing and audio intelligibility
  - Thermal testing
- Not comprehensive, snapshot of current work
- Part 1: Prior federal work on radio testing
- Part 2: NIST proposal for handheld radio testing
  - Over-the-air lab tests (similar to RF PASS)
    - FDNY
    - NFPA
  - Thermal tests

### Public-Safety Communications Research (PSCR) Program

- A joint effort between NIST/OLES and NTIA/ITS.
  - Public-Safety Audio (and Video) Quality
  - Public-Safety Broadband Communications
  - Project 25 Compliance Assessment Program
- Research, development, testing, and evaluation to foster nationwide communications interoperability.
- Draws on critical requirements provided by public-safety practitioners:
  - Provides insight to wireline and wireless standards committees for voice, data, image, and video communications.



Public Safety Communications Research

U.S. Department of Commerce – Boulder Laboratories

#### **PSCR Public-Safety Broadband Testing**

- 700-MHz Public-Safety Broadband Demonstration Network: Provide manufacturers and first responders a location for early deployment of their systems in a multi-vendor, neutral, host environment.
- Hardware installation completed for three vendors.
- Common test plan for all vendors
  - Physical layer tests to ensure that the submitted equipment will not interfere with other existing 700 MHz LMR, PSCR demonstration systems
  - Messaging/protocol tests
  - Public-safety application tests
  - Basic performance tests

http://www.pscr.gov/projects/broadband/700 mhz\_demo\_net/testing/about\_testing.php



# First Responder Network Authority (FirstNet)



- The Middle Class Tax Relief and Job Creation Act of 2012 created the First Responder Network Authority (FirstNet)
- A single nationwide, interoperable public-safety broadband network.
- An independent authority within NTIA: FirstNet will hold the spectrum license for the network, and is charged with taking "all actions necessary" to build, deploy, and operate the network, in consultation with Federal, State, tribal and local public-safety entities, and other key stakeholders.
- Stems from National Broadband Plan (2010)
- The PSCR standards team recently began directly representing FirstNet.



http://www.ntia.doc.gov/category/firstnet

# Prior Federal Work on Radio Testing: P25 Radios

- DHS Office for Interoperability and Compatibility
- Project 25 Compliance Assessment Program: Baseline Common Air Interference Testing Requirements
- P2P and trunked transmitter and receiver tests:
  - Primarily conducted tests
  - Some over-the-air tests

March 2010. Available on line at:		
http://www.safecomprogram.gov/SiteCollectionDocuments/P25CABCAI	TEST	_REQMarch2010v2.pdf.





# **Testing P25 Radios**

Table 2. Conventional Mode Subscriber Unit Transmitter Tests

Subscriber Unit Transmitter Tests	Method of	Performance
	Measurement [1]	Recommendation [2]
Unwanted Emissions: Adjacent Channel Power Ratio	§2.2.8	§3.2.8
Transmitter Power and Encoder Attack Time	§2.2.12	§3.2.12
Transmitter Throughput Delay	§2.2.14	§3.2.14
Frequency Deviation for C4FM	§2.2.15	§3.2.15
Modulation Fidelity	§2.2.16	§3.2.16
Transient Frequency Behavior	§2.2.18	§3.2.18

Example of test methods

#### This program leverages existing test methods:

- [1] ANSI/TIA-102.CAAA-C, Digital C4FM/CQPSK Transceiver Measurement Methods
- [2] ANSI/TIA-102.CAAB-C, Land Mobile Radio Transceiver Performance Recommendations – Project 25 – Digital Radio Technology, C4FM/CQPSK Modulation
- [3] ANSI/TIA-102.CABC-A, Interoperability Testing for Voice Operation in Trunked Systems
- [4] ANSI/TIA-102.CABC-A-1 Interoperability Testing for Voice Operation in Trunked Systems Addendum – Wide Area Roaming Operation

# Prior Federal Work on Radio Testing: Intelligibility

- Audio-quality tests for the public-safety community, using standard test protocols to assess audio-quality performance of handheld radios.
- This work did not include RF propagation channel impairments.



 David J. Atkinson and Andrew Catellier, "Intelligibility of selected radio systems in the presence of fireground noise: Test plan and results," NTIA Technical Report TR-08-453, June 2008. Available <u>http://www.its.bldrdoc.gov/publications/2490.aspx</u>.



# Intelligibility Tests of Public-Safety Radios

- Modified Rhyming Test (MRT) similar words spoken in phrases ("Select the word cat {hat, bat, ...}").
  - Utilized in NFPA 1981.
  - With and without mask.
  - 54,000 sentences for each subject!
- Sound-isolated chambers with torso simulators, background noise.
- Radio vocoders assessed.
  - Digital and analog radios





#### Intelligibility Tests of Public-Safety Radios Mean Opini Listening

- P25/VoLTE (Voice over LTE): LTE is to be used in (FirstNet)
- Test speech quality for two speech coders:
  - Multi-band excitation (MBE, low data rate, P25)
  - Adaptive multi-rate (AMR, higher data rate, LTE)
- Automated (not subjective) testing: PESQ algorithm processes digital speech recordings.
  - No background noise
  - Perfect channel
  - March 2013

http://www.safecomprogram.gov/library/Lists/Library/Attachments/34 1/P25-VoLTE%20Technical%20Report\_Final.pdf

Mean Opinion Score, Listening Quality, Objective (MOS-LQO)



# Prior Federal Work on Radio Testing: Thermal

- Tests of handheld radios under I (100 °C for 25 mins.) and Class III (260 °C for 5 mins.) conditions
- Support for NFPA 1221.
- Analog radios plus speaker microphone on cable

Testing of Portable Radios in a Fire Fighting Environment <sup>W. D. Davis</sup> M. K. Donnelly M. J. Selepak	
W. D. Davis M. K. Donnelly M. J. Selepak	

- W.D. David, M.K. Donnelly, and M.J Selepak, "Testing of portable radios in a fire fighting environment," NIST Technical Note1477, Aug. 2006. Available on line.
- <u>See also: M.K. Donnelly, W.D. Davis, J.R. Lawson and M.J. Selepak, "Thermal Environment for</u> <u>Electronic Equipment Used by First Responders," NIST internal Report 1474, Dec. 2006.</u>



# **Thermal Testing of Handheld Firefighter Radios**

- Tested alone and inside turn-out gear
- Signal level monitored through cable to spectrum analyzer (no antenna): no damage to radio evident
- When antenna attached: some damage



Test	Radio	Temp	Time Soak	Survive	Notes
		(°C)	(min)	Soak	
Antenna	A	260	5	Yes*	Slight melting on antenna
Antenna	В	260	5	Yes*	Antenna bent over
Increased velocity	В	260	5	Yes	Air velocity at 2 m/s for this
					test
Rotated 90	В	260	5	Yes	No damage to radio evident
degrees					
Speaker/	C	260	5	No	Speaker/mic failure – standard
Microphone					mic
<i>6</i> .	C	260	5	No	Speaker/mic failure – rugged
					mic

Table 3	Testing	inside	Turnout	Coat ]	Pocket,	Variations
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### NIST Proposal: Performance-Based Testing of Handheld Radios

#### **Goal: Standardized test methods for firefighter radios**

- RF performance tests
  - Attenuation (path loss)
  - Interference
  - Audio impairments (sirens, fireground noise, PASS, etc.)
- Thermal tests
  - Survivability
  - RF link under thermal conditions

### Radio Testing: Audio and RF Impairments

- PASS alarms: "go" or "no-go"
- Radios: Voice quality subjective assessment
- Phase I: Subjective assessment of radios in the field
  - Representative RF and AF impairments
  - Group of firefighters rates audio
- Phase II: Find methods to connect audio quality to objective measures
  - RF signal level or distortion
  - AF signal level or distortion (STIPA, PESQ)
  - Develop lab-based tests from these measures

# Phase I Field Test: Radio Performance

Compare path loss to radio performance

- NYU Poly assesses audio quality
  - Representative environments
  - Representative background noise
  - Simulated two-way conversation between IC and FF
    - Firefighters are test subjects
    - Specific, common phrases (unknown to listener)
    - Wearing appropriate gear (e.g., face masks)
  - Audio quality is rated by listener

### Field Test 2: Path Loss

Compare path loss to radio performance

- NIST measures path loss in same environments
  - Similar to data collected for RF PASS tests



Measured path-loss data (cdfs) from four levels in the NYC subway

# Compare Radio Performance to Path Loss

- NYU Poly and NIST process data
- Extract key parameters for labbased testing
- Develop tests similar to RF PASS tests
  - Attenuation
  - Interference
  - Multipath
- Rating by firefighters



# Phase I, Part 2: Thermal Tests

- Expose radios to Class 1 and Class 3 thermal tests (100 °C for 25 mins., and 260 °C for 5 mins.)
- Monitor RF signal level during heat exposure
- Results published in NIST Technical Note



# Phase II Audio Quality Metrics

- NYU Poly researchers study relationship between audio and RF impairments and ratings of radios
- Extract key parameters
- Develop objective audio-quality metrics that could be used in lab-based tests
- With NIST, incorporate into RF test procedures

# **Seeking Support**

- FDNY Foundation: small possibility of funding field tests
- NFPA Fire Protection Research Foundation (Casey Grant): DHS grants, consortium of manufacturers
- DHS Office of Standards: unlikely due to sequestration
- Other ideas?