



Spectrum Sharing Testing

Dr. Jeffrey Reed, Willis G. Worcester Professor

Wireless@Virginia Tech

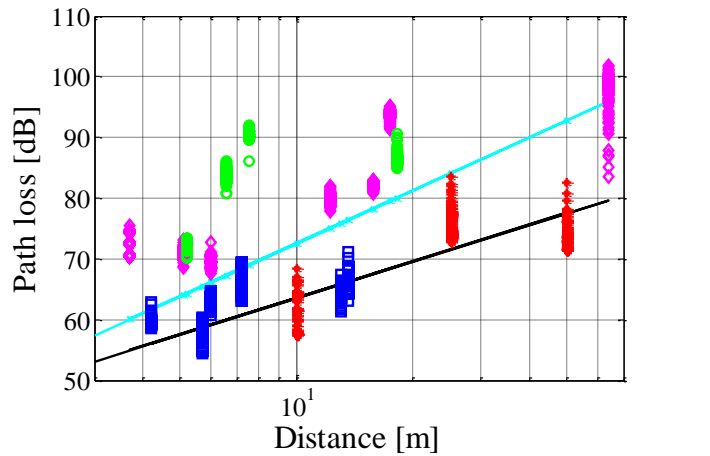
reedjh@vt.edu



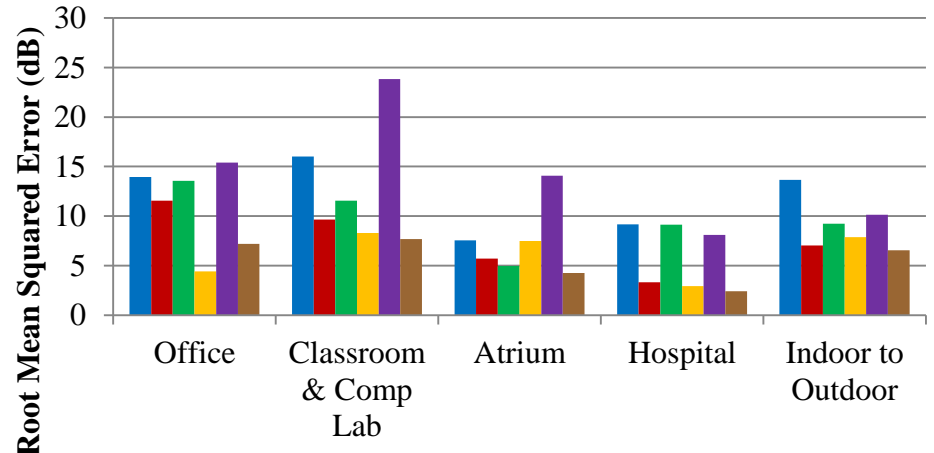
Presentation Overview

- Some background research
- Some initial thoughts on measurement needs from an R&D perspective

3.5 GHz Indoor Propagation Study



- Recorded path loss measurements in traditional office environment
- Floor adds **~15 dB of attenuation**
- Heavy walls add **~10-20 dB of attenuation**
- Path loss exponent ranges from **2.4 – 3.1**



- Partition-based models (COST MW and MWF) have the best performance (**~5 dB of RMSE**) and **outperform log-distance model**
- M.2135 model may suffice for 'back of the envelope' path loss prediction LOS environments

Researchers: S. Ha, T. Yang, C. Dietrich, J. Reed

SPN-43 LTE Field Test at PAX River

• Experiment

- TD-LTE system operating with interference from in-band radar in 3550-3650MHz band
- Measurements at varying frequency offsets from radar operating frequency
- Block Error Rate and Throughput used as metrics for LTE performance



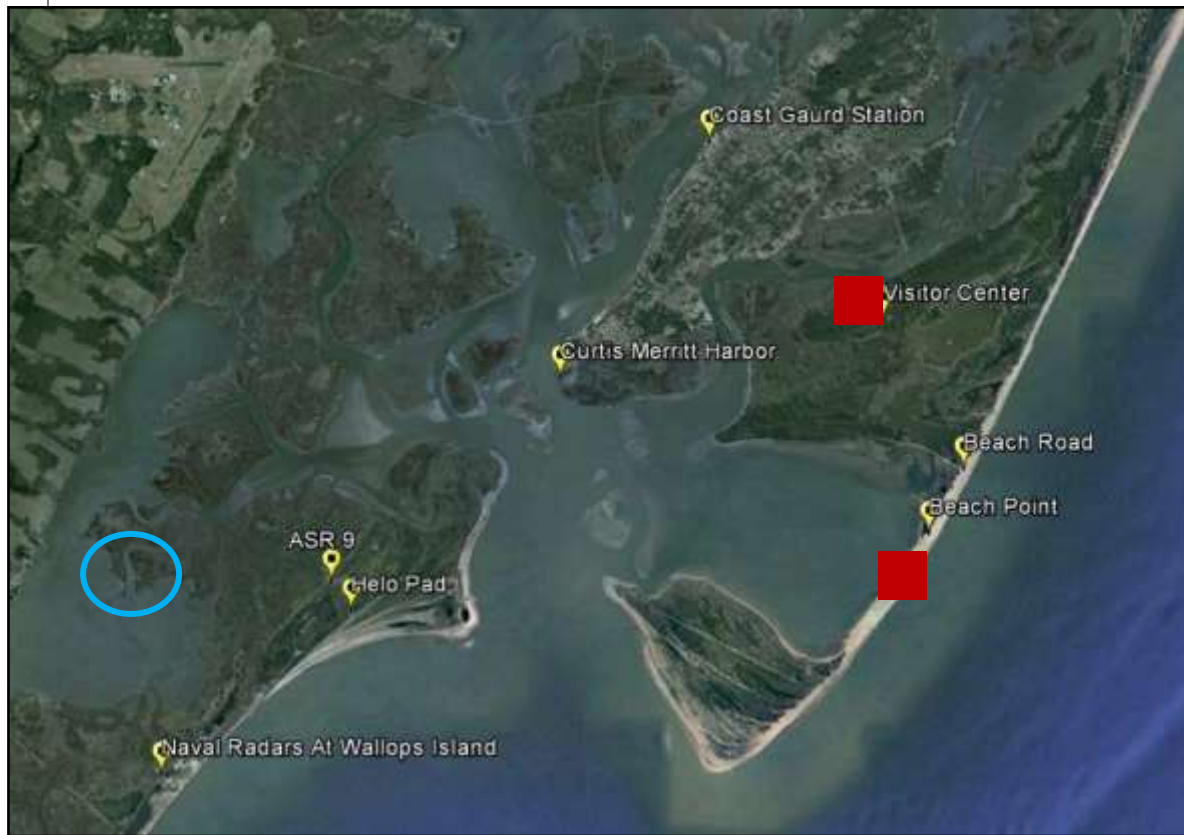
• Highlights

- Confirmed non-co-channel operation at 1.25km (radar LOS) and co-channel operation at 4km (non-LOS)
- Detection of incumbent radar operations at 70km
- Determined that permanent fixed exclusion zones as proposed in FNPRM are likely **unnecessary**





More Measurements at Wallops



Beam width about 90 degrees, visitor's center had radar perpendicular to LTE path, on Beech radar was in the antenna 3dB BW and eNB pointed away from radar



Preliminary Testing Summary

- Communication is possible in the presence of operating Naval radars under certain operating conditions
- Key is to operate at high power than usual microcellular operation or keep path link short
- Should power be position dependent?
- Better filter would help.
- Much additional work is needed to provide a detailed feasibility assessment for LTE communication in the 3550-3650 MHz band.

Characterizing LTE Vulnerabilities

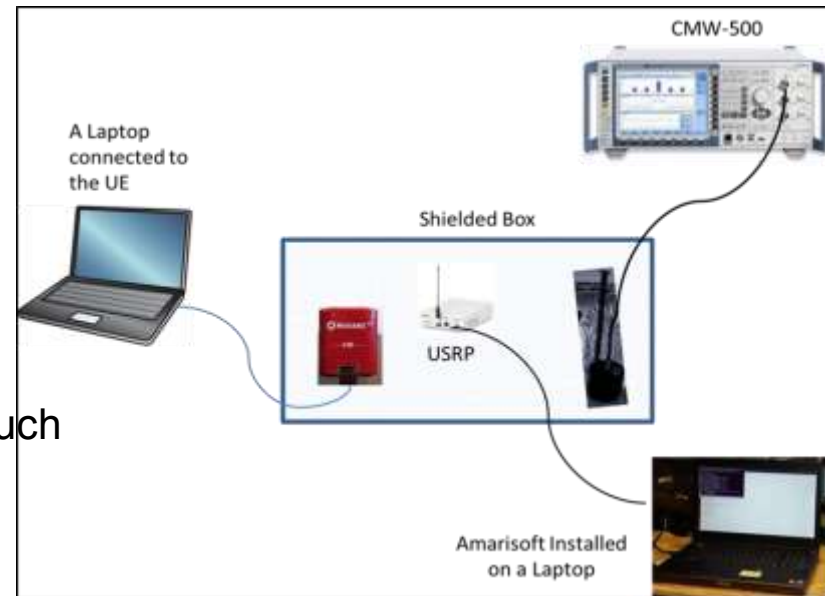
Objectives

- Characterize vulnerabilities of LTE to interference and spoofing
- Develop testbed to demonstrate effects
- Propose mitigation techniques

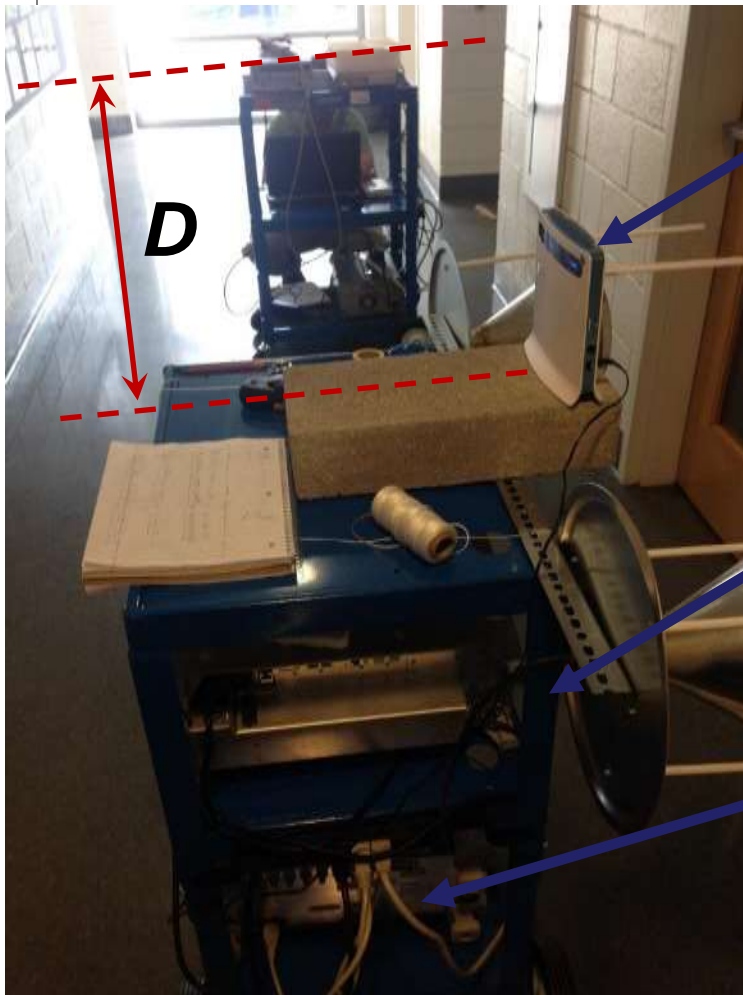
Highlights

- Short duration pulses didn't impact system much
- CW tended to have a more negative impact
- LTE control channel spoofer
- Demonstrated effectiveness to cause *Denial of Service* for the UEs
- Mitigation techniques proposed to protect LTE systems against these attacks

LTE Control Channel Spoofing Testbed



Experiment Setup: TD-LTE Sys.



□ User Equipment

- Huawei Repeater Bridge (CPE B593s-42)
- $f_c = 3.5$ GHz
- Support up to 20-MHz Cell BW
- 1 main + 1 diversity antennas

□ eNB

- R&S CMW500

□ Spectrum Analyzer

- Tektronix RSA3408A

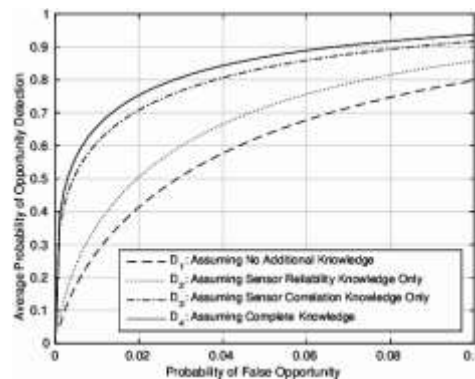
Heterogeneous Collaborative Sensing Using CORNET

- Objectives

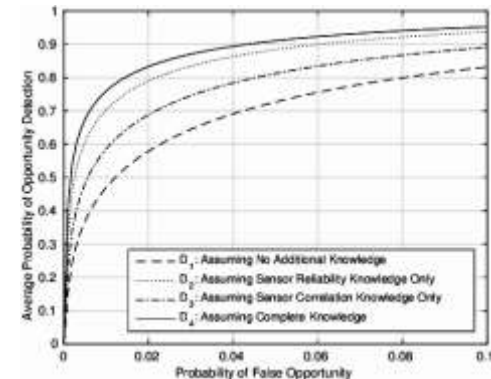
- Consider sensor reliability and correlation information in collaborative sensing algorithms
- Intelligent sensor selection based on these considerations

- Highlights

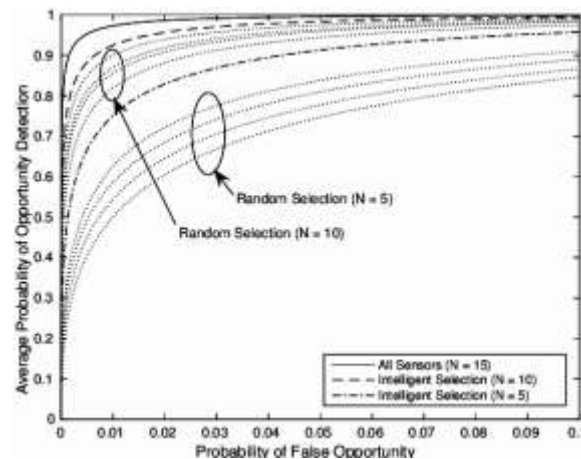
- Developed algorithm outperforms prior work considering one or neither of these effects
- Intelligent sensor selection provides natural trade-off between overhead and performance



Given a sensor correlation dominated environment



Given a sensor reliability dominated environment

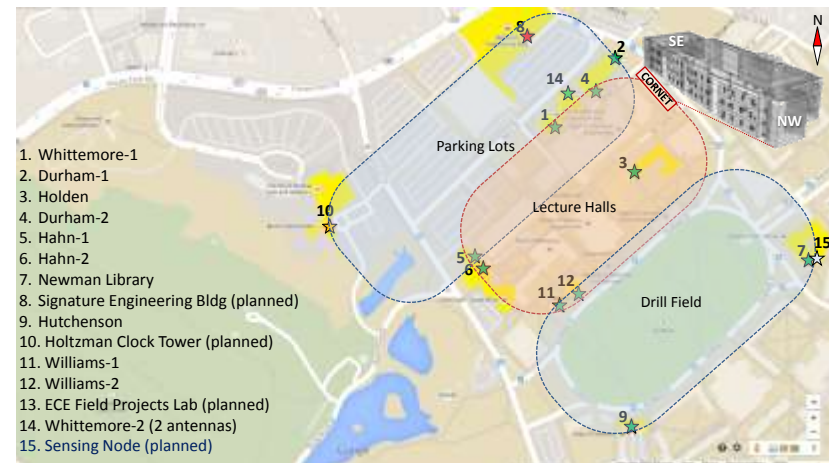


Researchers: W. Headley, V. Chavali, C. da Silva



CORNET

- Objectives
 - Supplement wireless research and education
 - Wireless@VT facility for R&D proposals
- Highlights
 - 60+ SDR nodes across campus
 - ARO-DURIP grant for LTE-CORNET
 - NSF-IUSE 2-year grant
 - Appears in:
 - SDR Forum/WinnComm Annual Report
 - WSRD Testbed Information Portal
 - ACROPOLIS Catalogue (EU-FP7-NoE)



Researchers: V. Marojevic, R. Nealy, C. Dietrich, J. Park, J. Reed



Some Thoughts about Measurements and Spectrum Sharing 1/3

- New metrics needed
 - Harmful interference
 - Statistical availability of spectrum on a probabilistic basis
 - Information assurance/privacy
 - Receiver performance



Some Thoughts about Measurements and Spectrum Sharing 2/3

- Quantifying impact on higher layers
 - Inform industry
 - Information Assurance Ramifications
 - Vagueness of standards
- Still plenty of basic propagation measurements needed
 - Vector Channels
 - Interference measurements to make models
 - Low flying UAS



Some Thoughts about Measurements and Spectrum Sharing 2/3

- Processes are important for uniform and repeatable experiments
 - NIST/NTIA contribution
 - Teach academia and industry
- Metrics for the SAS?
- Dealing with the bureaucracy