Measurement Results for Radar and Wireless System Coexistence at 3.5 GHz

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Sponsored by NSWC Dahlgren Division

Wireless @ Virginia Tech

THE HUME CENTER

Overview

- Preliminary 3.5 GHz Radar-Communications Compatibility Tests
- Cognitive Navy Radars and 3.5 GHz Spectrum Sharing

Jeffrey H. Reed

PRELIMINARY 3.5 GHZ RADAR-COMMUNICATIONS COMPATIBILITY TESTS

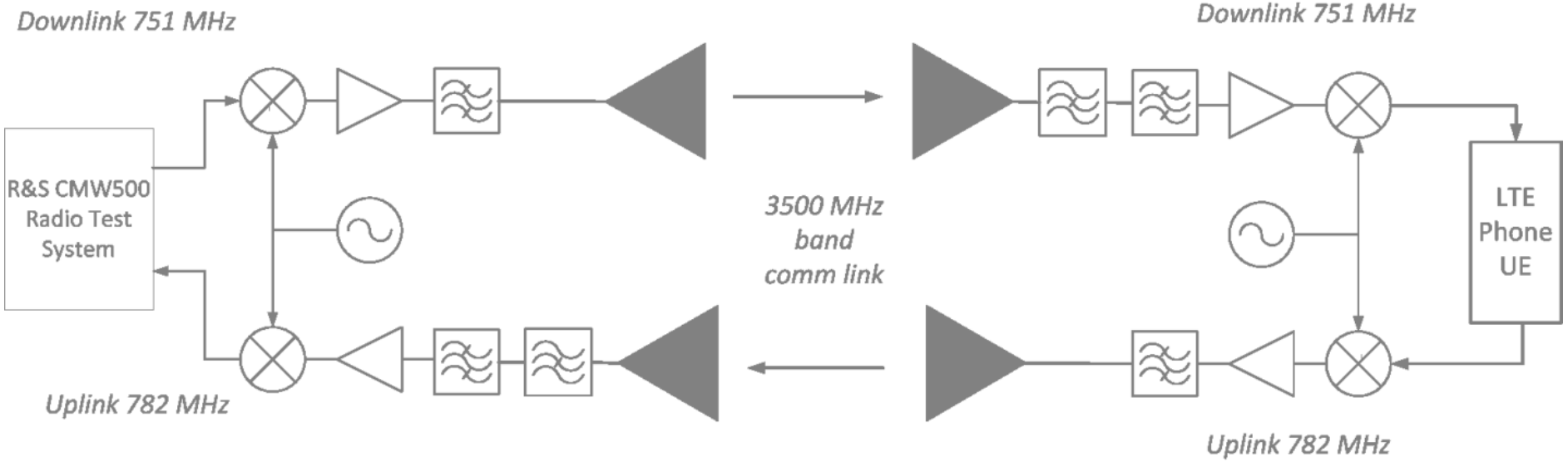
Overview of Tests

- LTE communication at 3550-3650 MHz in presence of Naval radar
- Location: Eastern Shore of VA
- Emphasis on proof-of-concept (existence proof)

Equipment Used

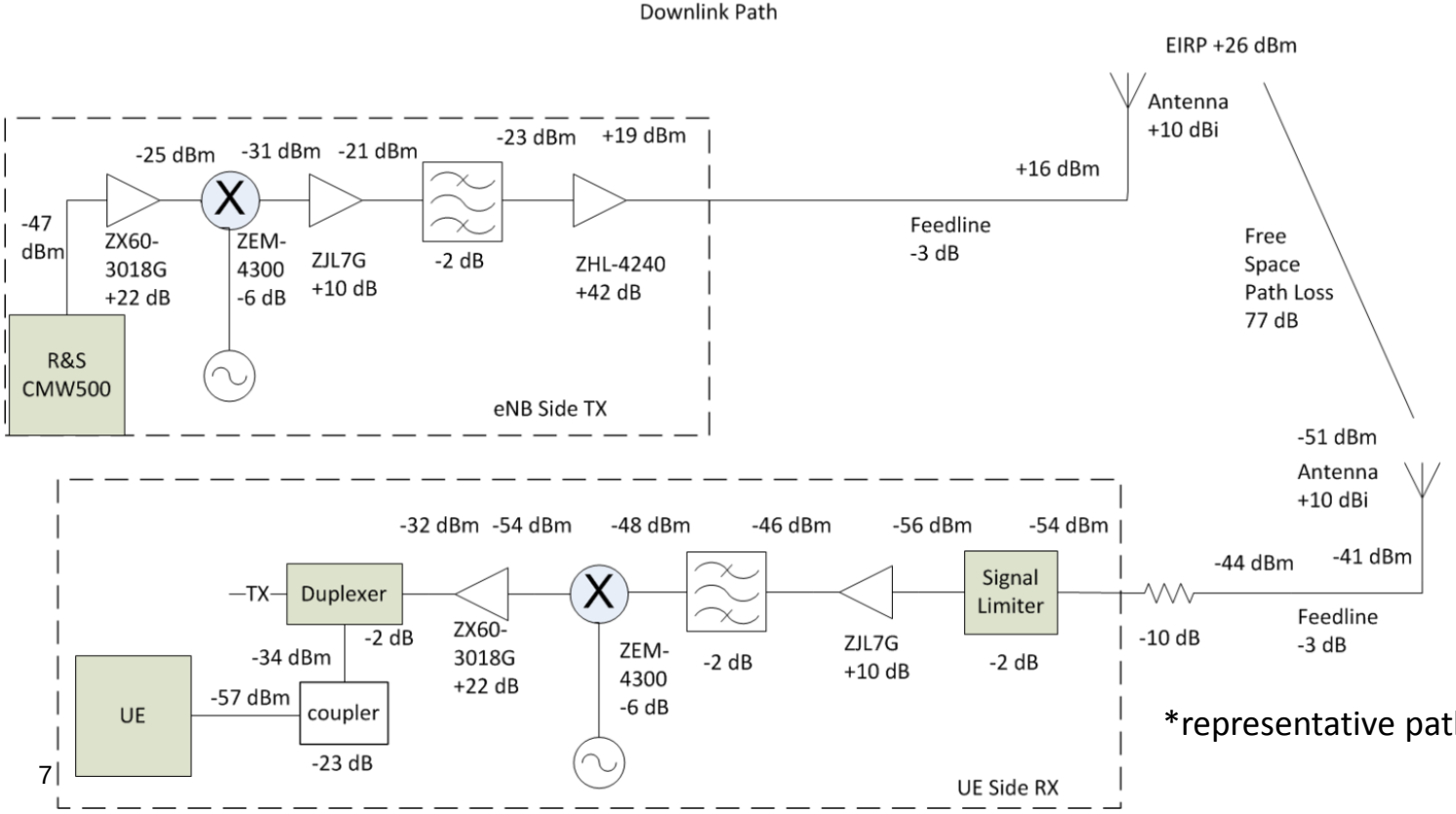
- Rhode & Schwarz CMW500 as eNodeB
- Commercial LTE User Equipment
  - UE in shielded enclosure
  - Dipole affixed to UE as coupler
- Custom frequency translators
  - 700 MHz to/from 3550 MHz
- Broad-beam directional antennas
  - C-band TVRO feed horns
  - adjustable linear polarization

Hardware Configuration



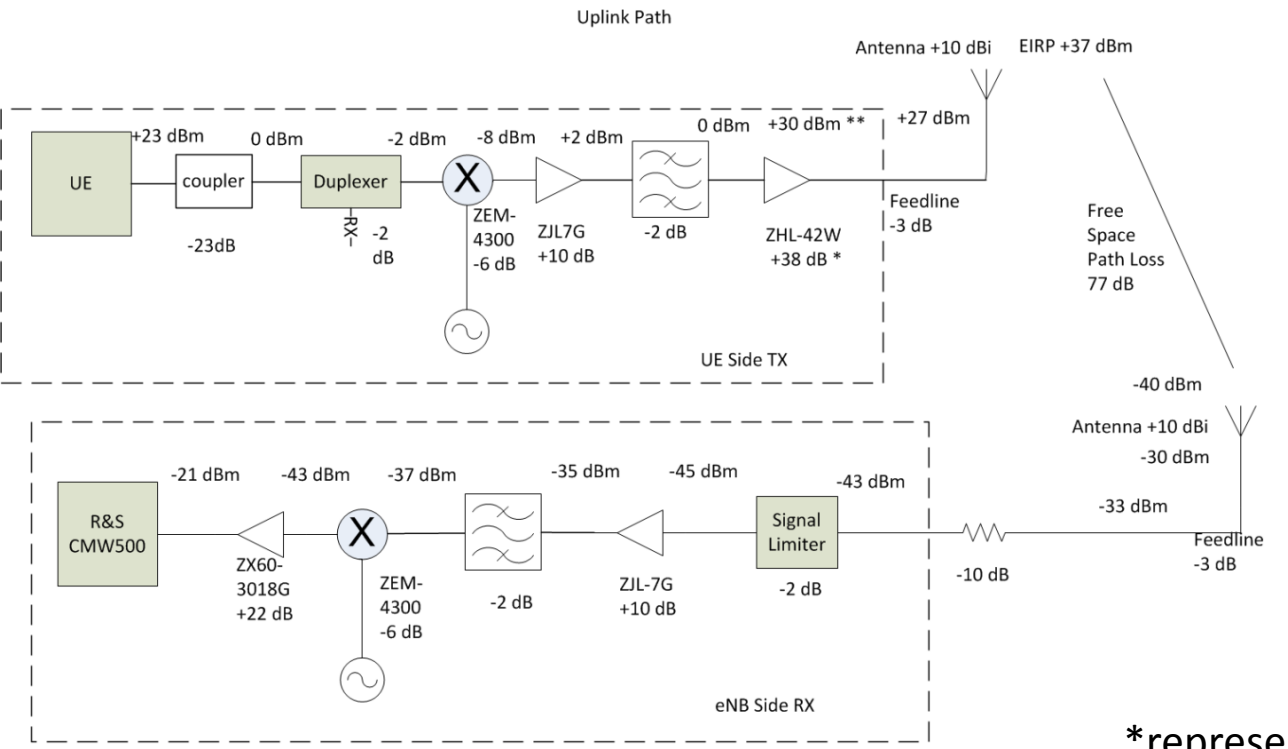
- Power limiters added to protect translator
- Interference was within filter passband
- Step attenuator used on downlink

Downlink*



*representative path loss shown

Uplink*

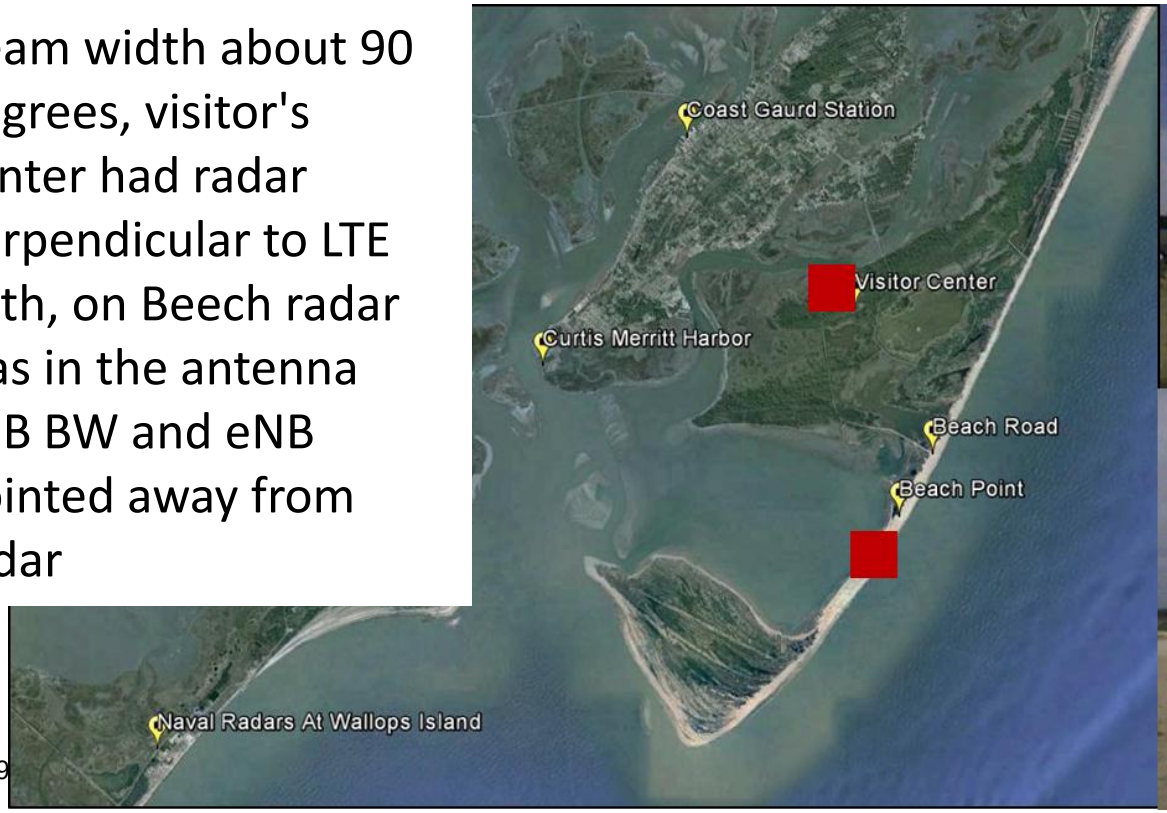


*representative path loss shown

*Nominal uncompressed gain.
** Estimated due to amplifier compression.

Measurement Locations (■)

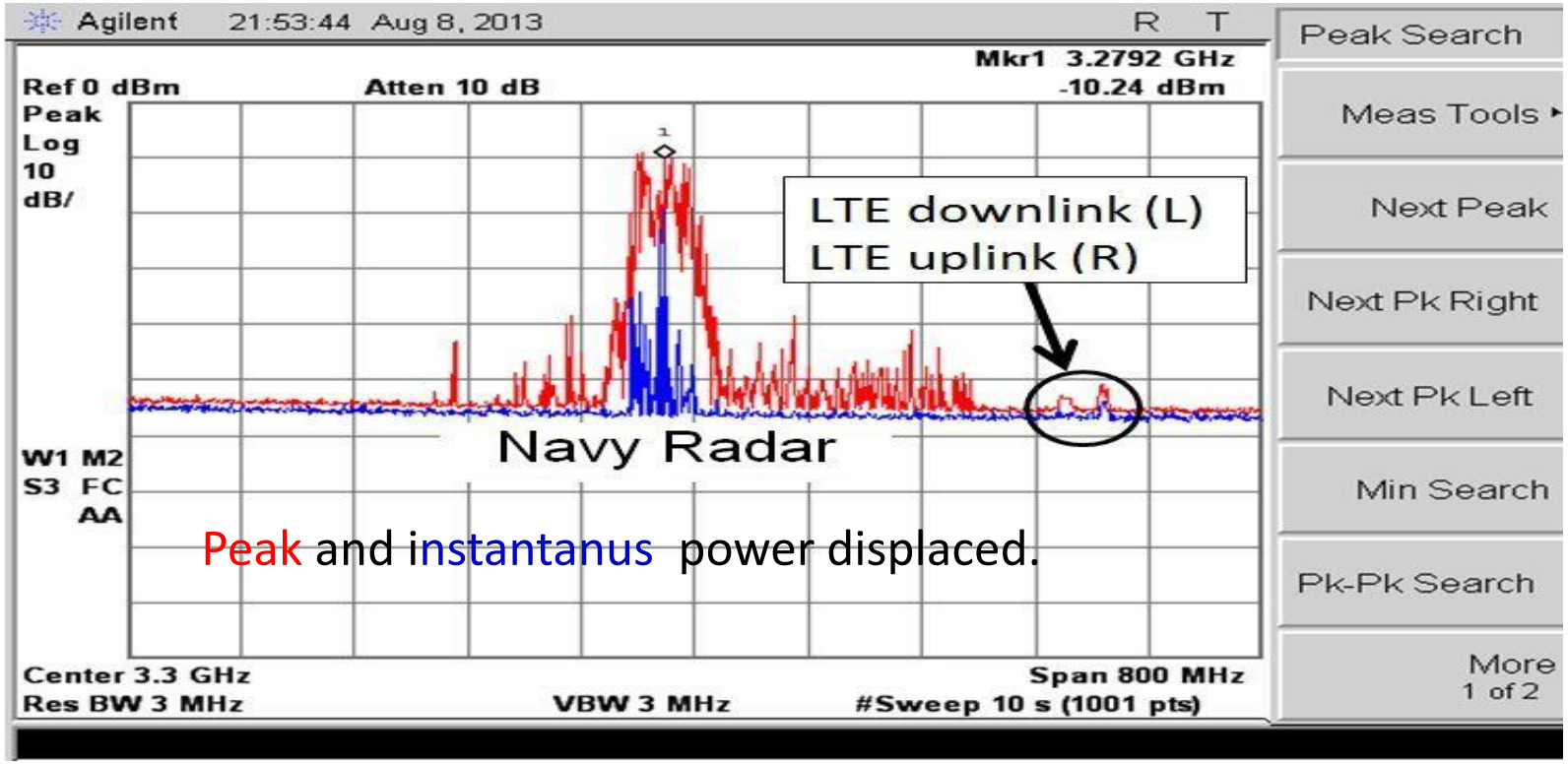
Beam width about 90 degrees, visitor's center had radar perpendicular to LTE path, on Beech radar was in the antenna 3dB BW and eNB pointed away from radar



Test Conditions

File numbers	Location	LTE Path Distance	Path Loss est.	DL Resource Blocks	DL Mod.	UL Resource Blocks	UL Mod.
1-91	Visitors Center	25m	72 dB	16	QPSK	16	QPSK
92	Beach	45m	77 dB	16	QPSK	16	QPSK
93-172	Beach	45m	77 dB	50	64 QAM	16	16 QAM

LTE and Radar Spectra

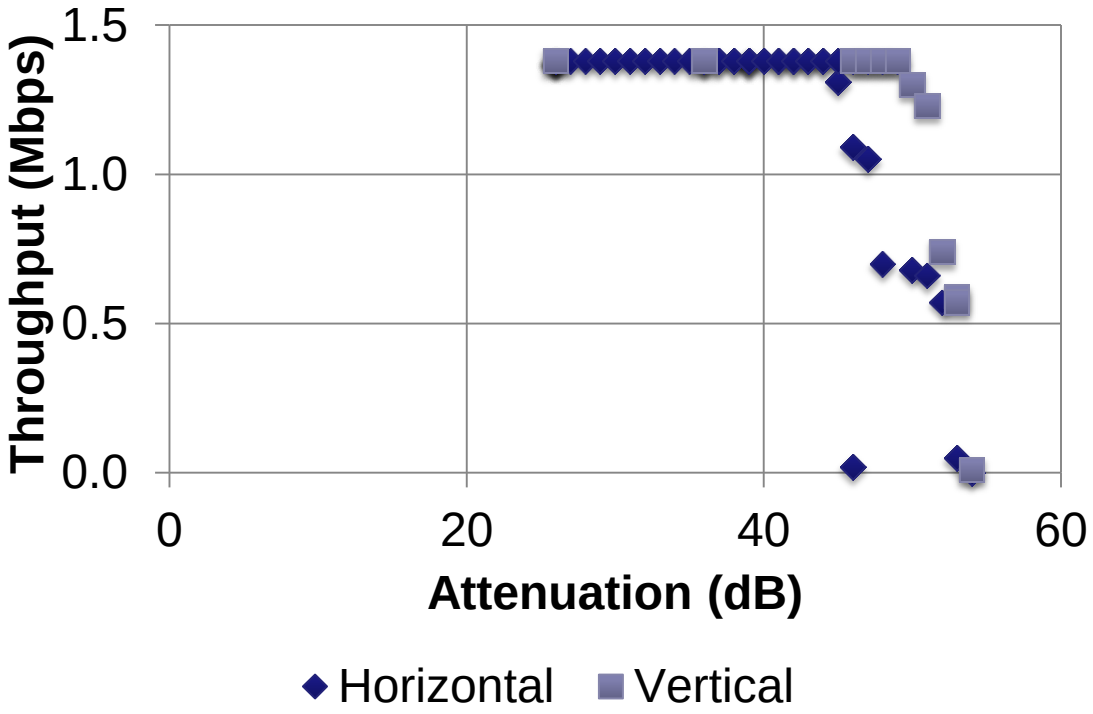


LTE Statistics Collected

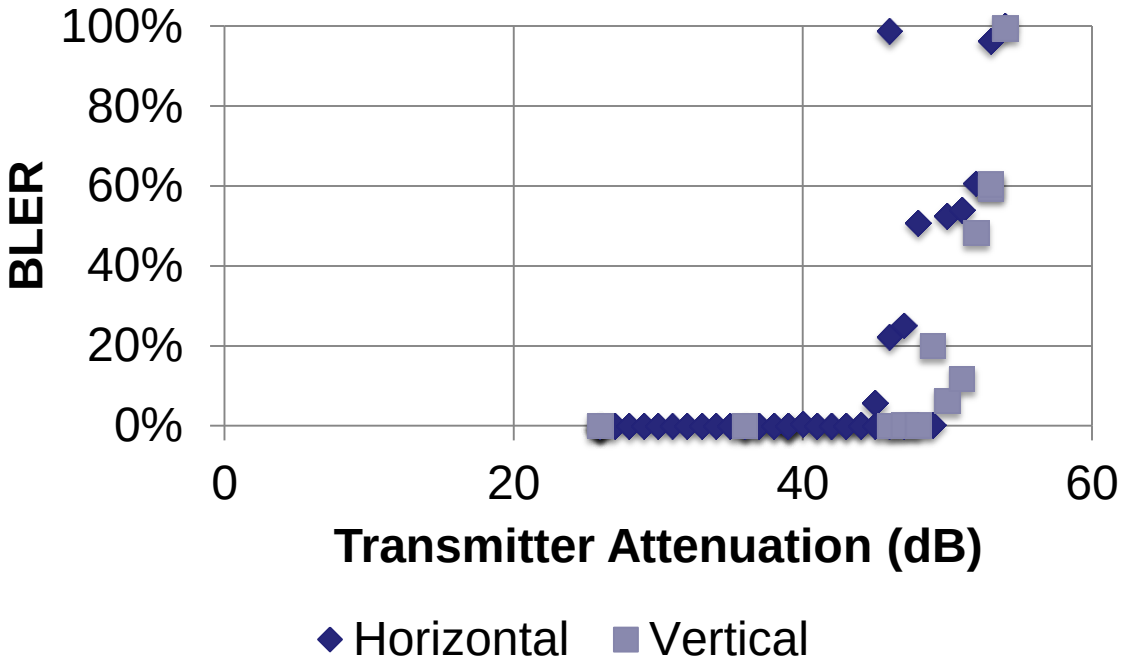
- ACKs: packet acknowledgments
- NACKs: negative acknowledgments
- DTX: discontinuous transmit, UE did not recognize that a packet was sent
- BLER: Block Error Rate
- CQI: Channel quality indication
- UE Status: e.g., Attached, Connected
- Throughput

CMW500 Downlink Screen

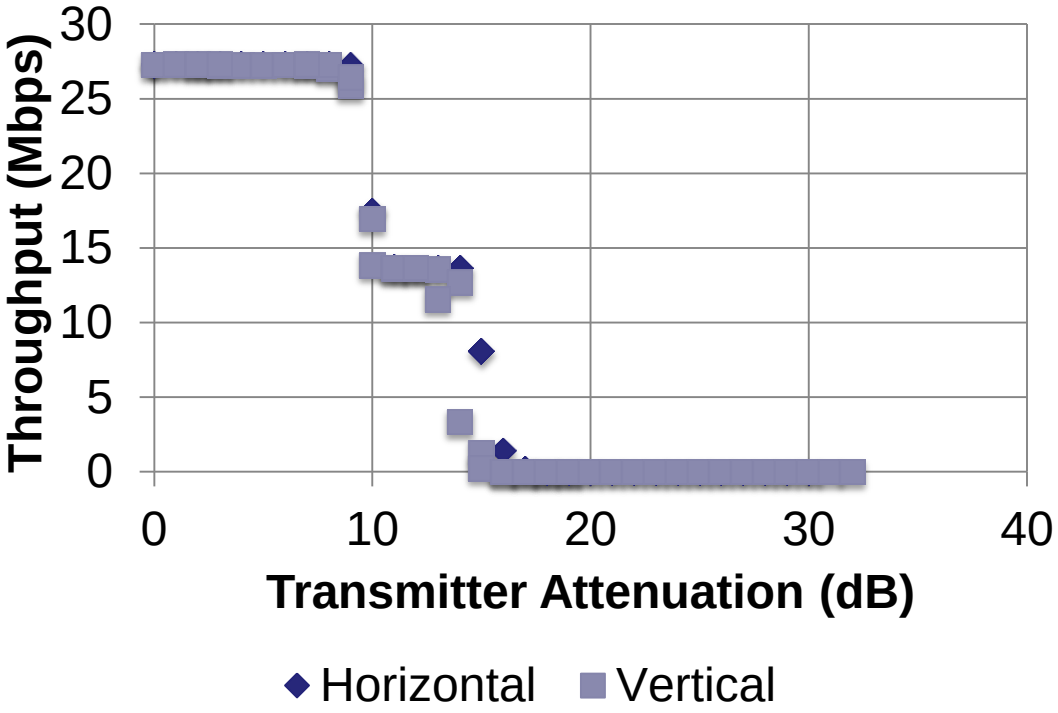
Downlink Throughput at Visitor Center (BPSK, Radar Active)



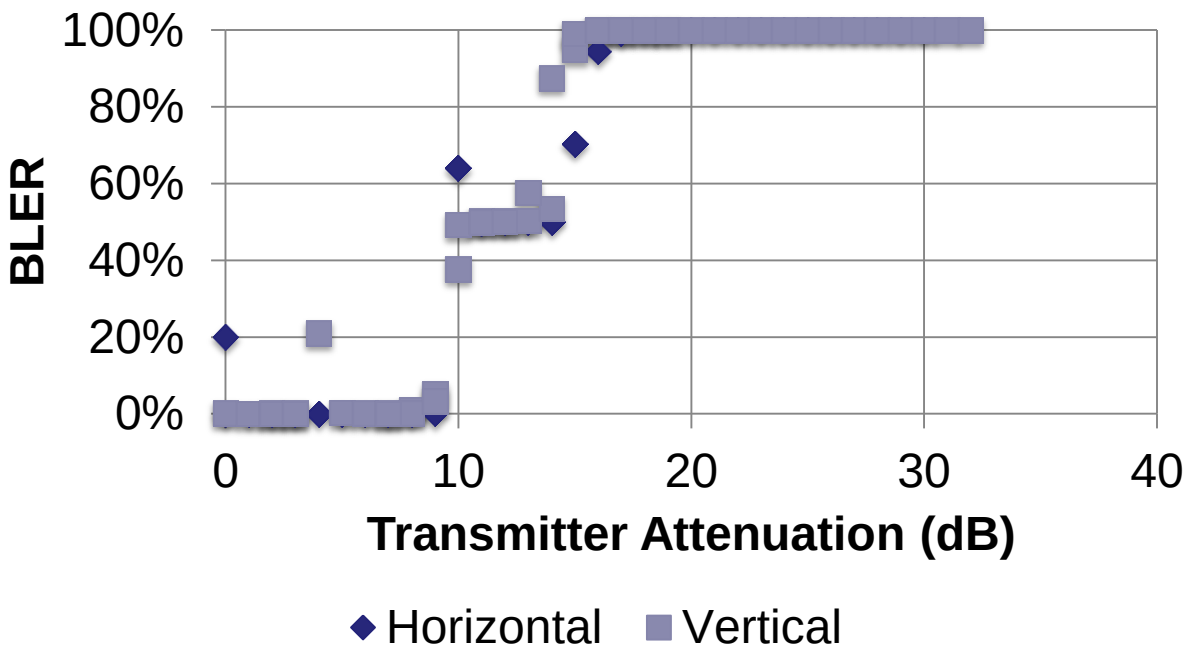
Downlink BLER at Visitor Center (BPSK, Radar Active)



Downlink Throughput at Beach (64 QAM, Radar Active)



Downlink BLER at Beach (64 QAM, Radar Active)



Conclusion

- Communication is possible in the presence of operating Naval radars under certain operating conditions
- Power for the LTE system can overcome the radar
- Additional work is needed to provide a detailed feasibility assessment for LTE communication in the 3550-3650 MHz band

Future Work

- Bench-top testing using pulse interference with various PRF and pulse width combinations
- Receiver improvements, e.g., band-reject filters
- Field measurements with longer transmit-receive paths

Future Work

- Use of omnidirectional antennas
- Experimentation with DSA to increase robustness of low-SNR links
- Tests with additional radars that operate in or near the 3500 MHz band
- Use stop band filters
- Study of implications for use of the band further from coast / radar locations

Acknowledgments

Thanks for assistance during the project and measurements from:

- Bernie Ulfers (NSWCDD)
- Daniel Togni, Richard Canning and Braden Eggerl (Rhode & Schwarz)
- Advice in measurements from Peter Stanforth (Spectrum Bridge) and David Gurney (Motorola Solutions)

T. Charles Clancy, PhD

COGNITIVE NAVY RADARS AND 3.5 GHZ SPECTRUM SHARING

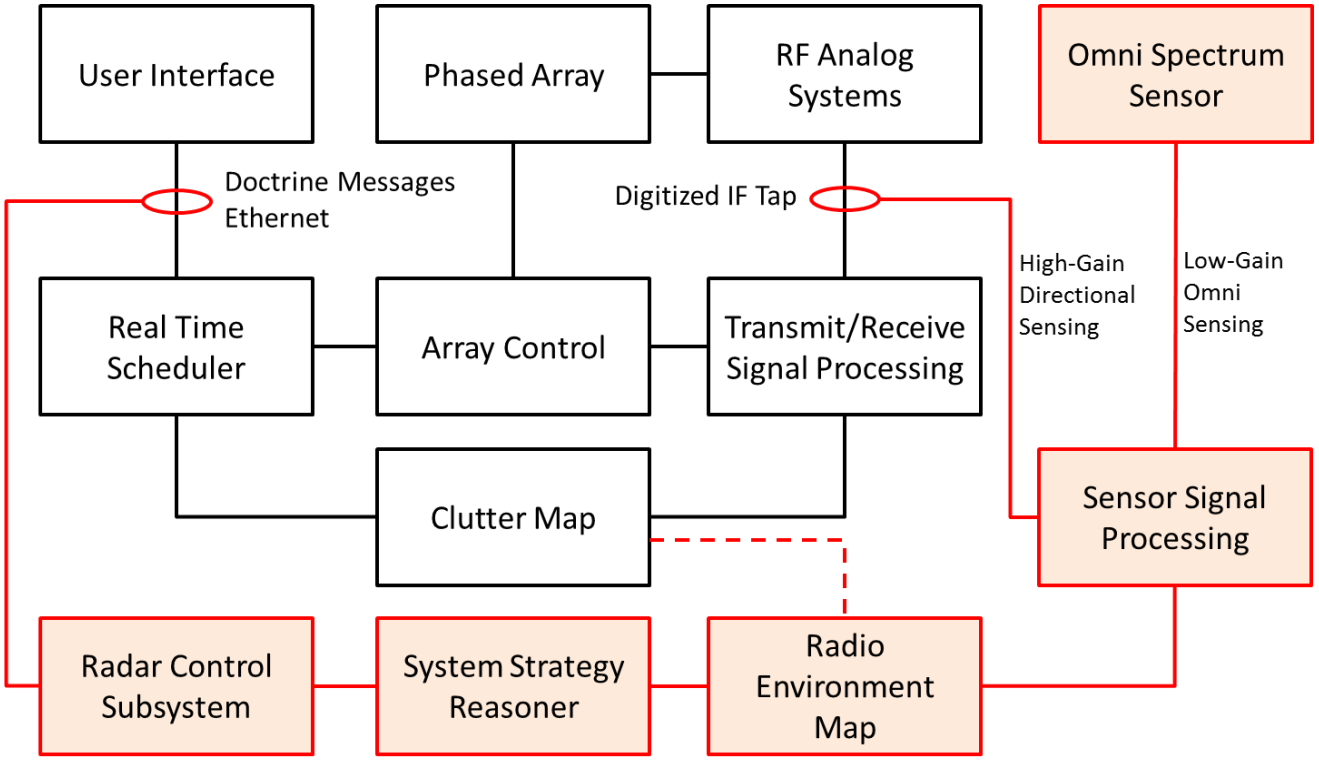
Cognitive Radar Project

Add intelligence to a legacy radar to reduce its impact on WiMAX and LTE infrastructure operating in the 3550 to 3650 MHz frequency band

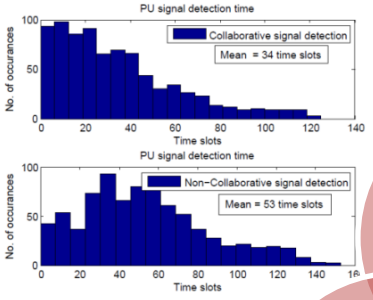
Goal: Fall 2014 field trial demonstrating closed-loop control of Naval radar system to demonstrate reduced impact on WiMAX base stations

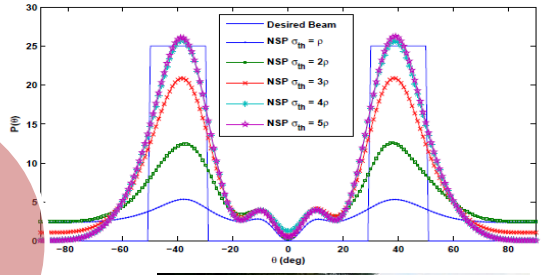
Cognitive Radar Project

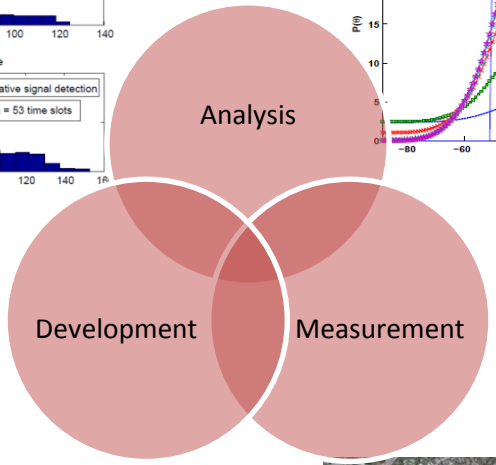
High-Level Integration Strategy

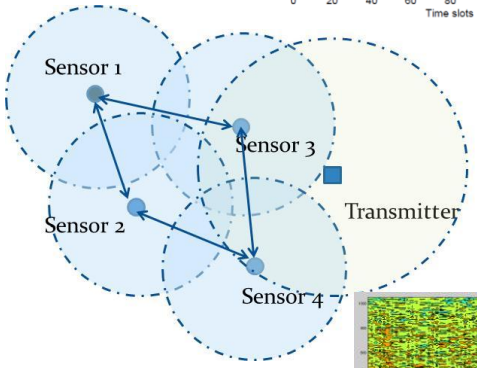


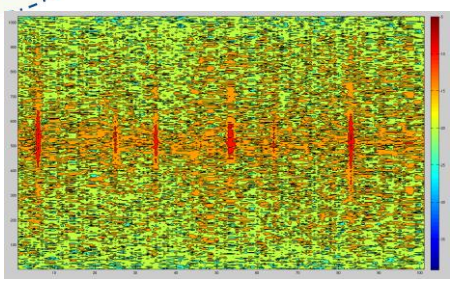
Broad Areas of Research



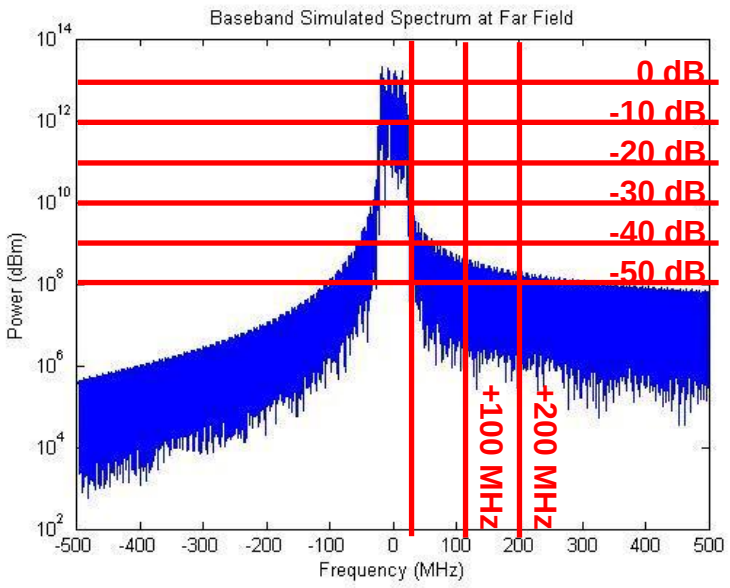






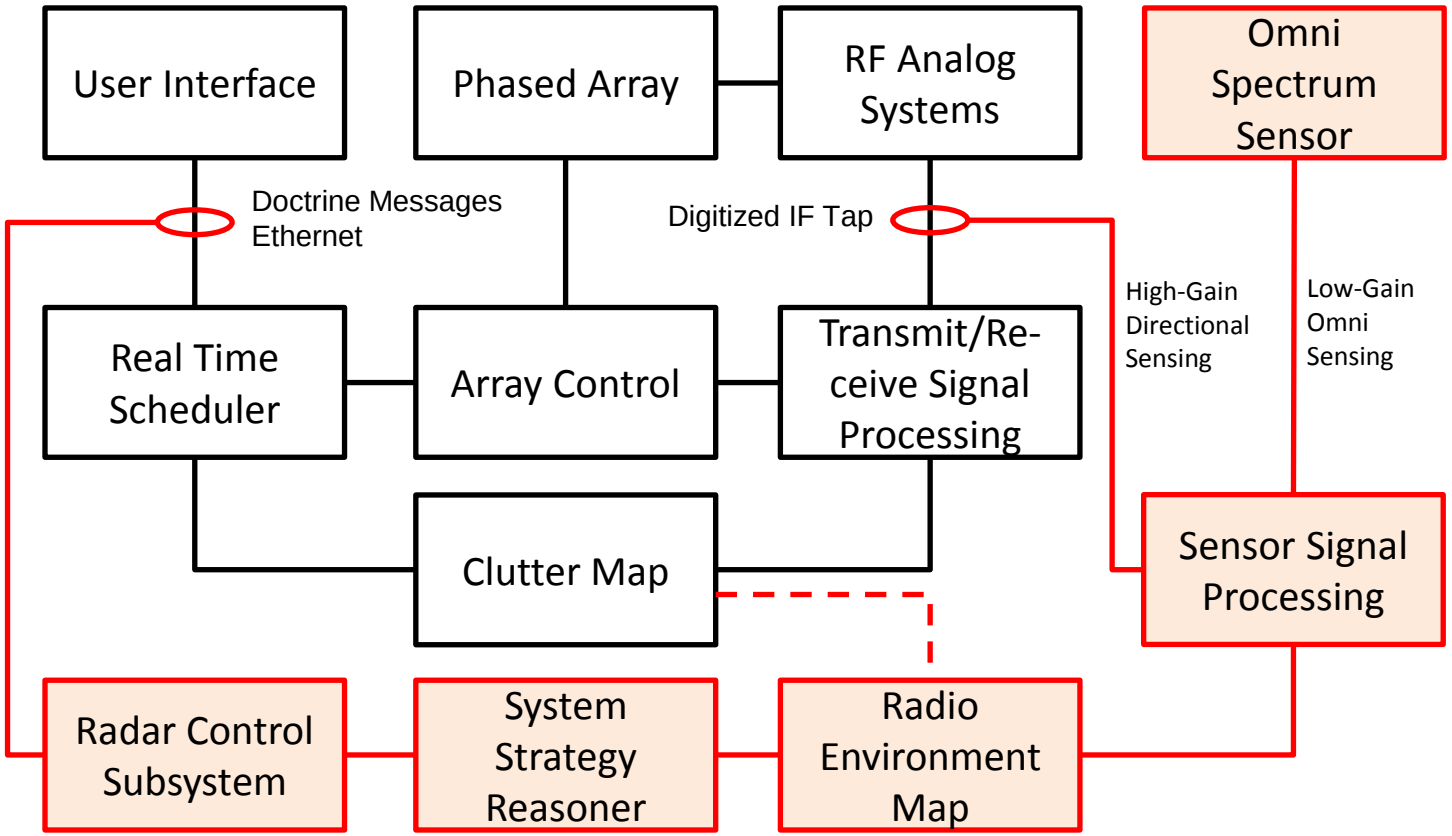


Radar Spectral Mask



MATLAB-based waveform model based on measurements from Navy radars collected in partnership with NSWC Dahlgren

Radar Integration



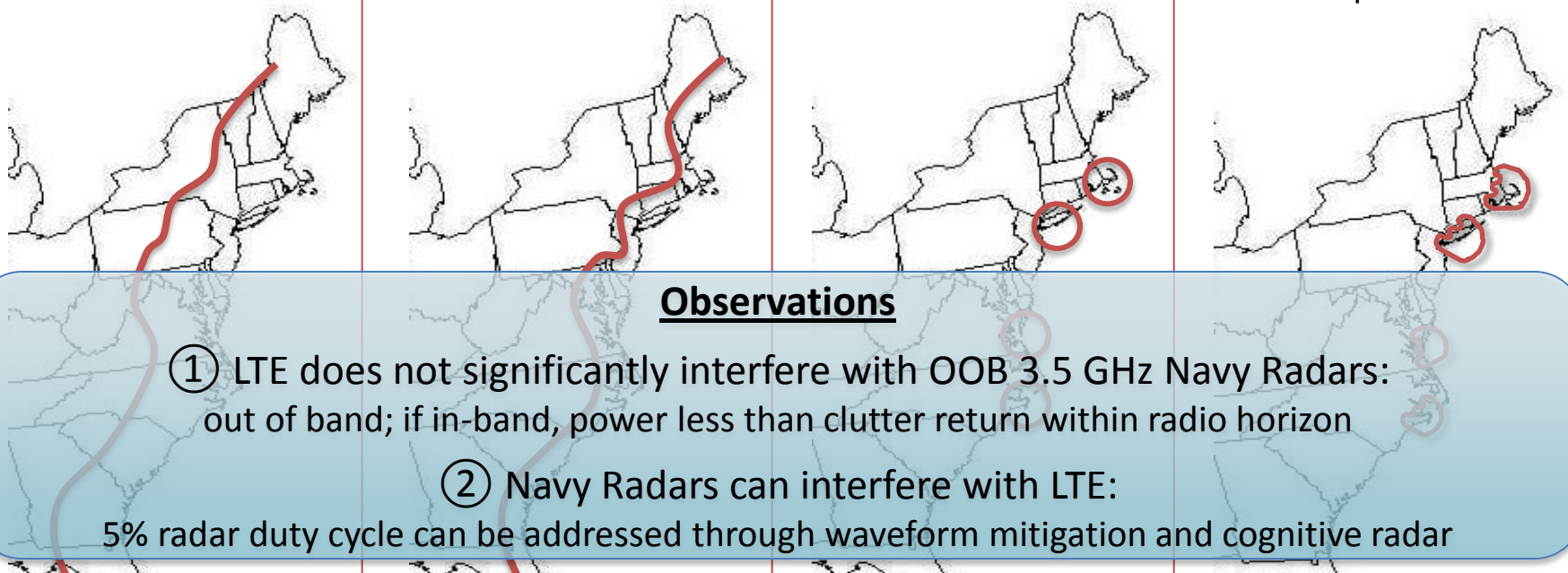
Impact on 3.5 GHz Exclusion Zones

275km Exclusion Zone
NTIA/CSMAC Value

65km Exclusion Zone
Radio Horizon
LTE (100m) → Radar (30m)

65km Exclusion Zone
Radio Horizon for
Specific Ship Locations

Exclusion Zone
Known Tower, Propagation,
& Ship Location



Observations

① LTE does not significantly interfere with OOB 3.5 GHz Navy Radars:
out of band; if in-band, power less than clutter return within radio horizon

② Navy Radars can interfere with LTE:
5% radar duty cycle can be addressed through waveform mitigation and cognitive radar