How many of you have used a UTA bus on a state road this week?

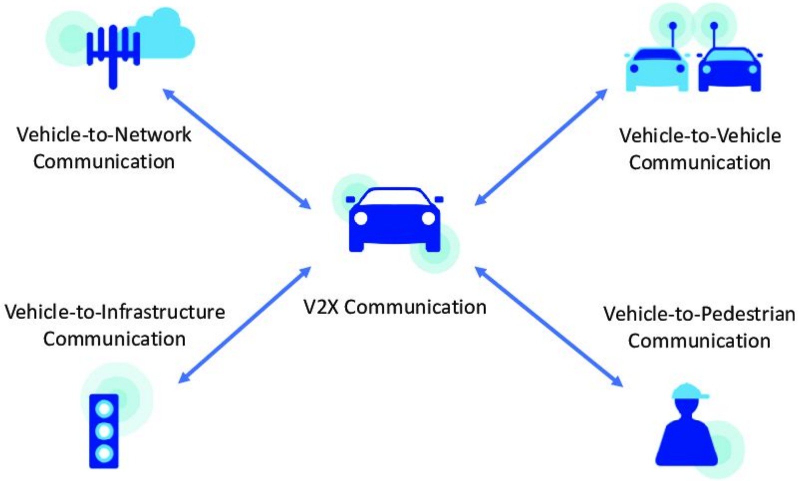
UDOT has several connected vehicle platforms in operation on our roads

Utah Interstate [1]

An Introduction to the Potential of Unregulated Transmissions to Impact V2X Communication

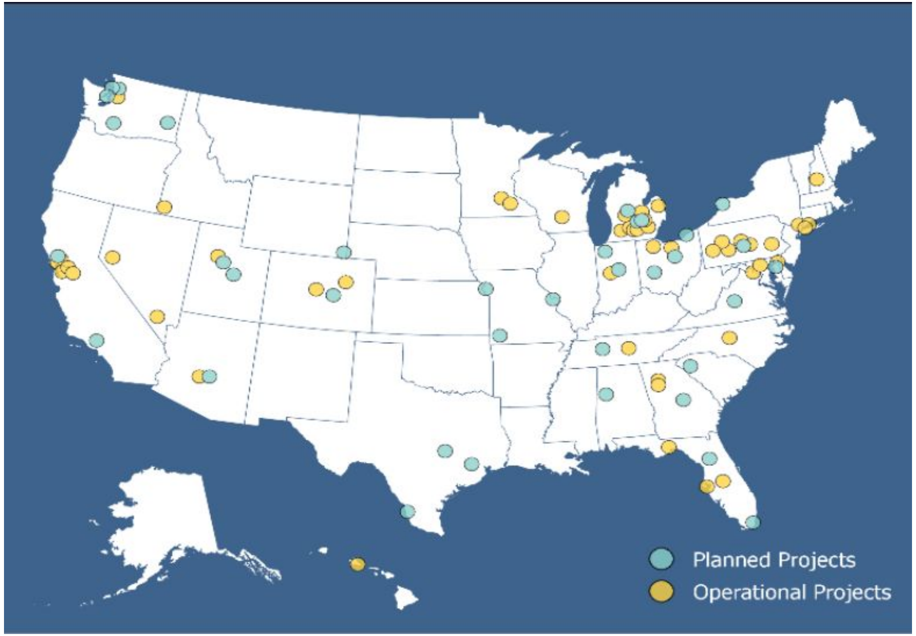
Jacob Bills - Undergraduate Thesis

V2X communication is poised to revolutionize the automotive industry, but a controversial FCC ruling puts its ability to provide connectivity in question.



V2X Connection Types [2]

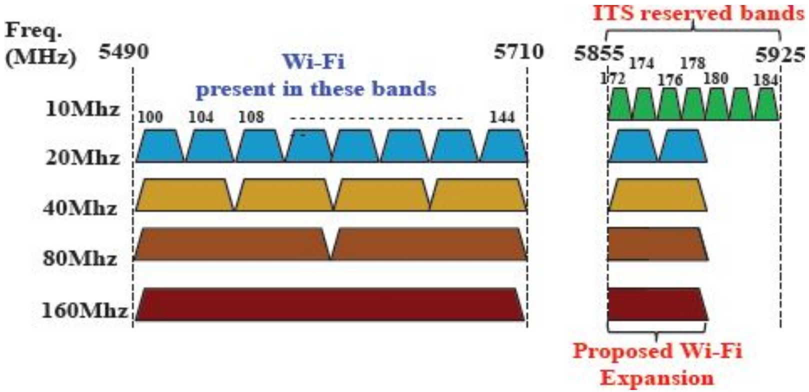
The goal of this project perform OTA performance Tests comparing DSRC & C-V2X operatiting with and without interference at 5.9GHz.



US DSRC Deployments [3]

Project Objective

We aim to quantify the impact of recent rule changes by the FCC on existing V2X technologies in ITS spectrum.



WiFi & ITS spectrum sharing in 5.7–5.9GHz band [4]

Related Works

- Cheng et al.[5] made use of computer simulations to determine the effect of WiFi on DSRC with and without Detect & Vacate technologies. Their research showed up to a 30% performance reduction at distances greater than 70m.
- Choi et al.[6] conducted similar experiments as Cheng, but made use of SDRs and an attenuator matrix. This resulted in similar results, but they claimed it would not impact DSRC operations meaningfully.
- Mavromatis et al.[7] conducted a test that brought operational DSRC to existing 2.4 and 5GHz WiFi channels. They reported a nearly 30% performance drop when operating on the 5GHz channel as opposed to the dedicated DSRC channels.
- Fang et al.[8] examined the impacts of China allowing vehicle based WiFi adjacent to C-V2X's dedicated spectrum. They showed C-V2X remained robust up to 465m.

Challenges Involved

Hardware Challenges

- Ensure realistic OTA environment that is comparable to standard conditions
- Keep interference levels consistent at 5.9GHz, ensure power levels scale at higher frequency
- Ensure we are working within vendor specified radio parameters.

Software Challenges

- Be able to decode and process DSRC and C-V2X communication with tools like wireshark, tshark, or pyshark
- Construct testing framework within the existing and propriety firmware on radio devices

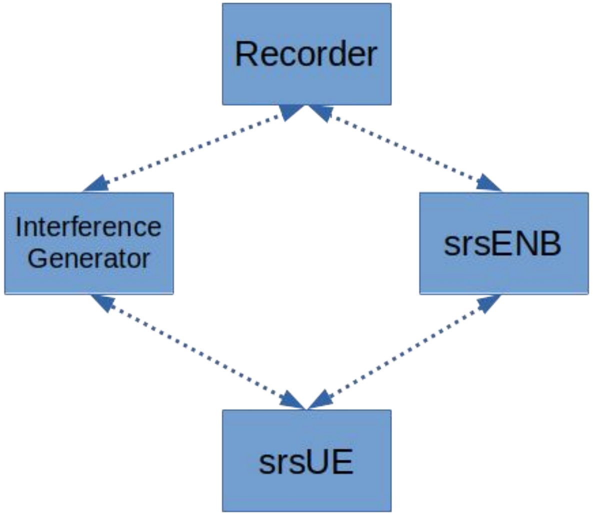
Materials List

Major project components are being provided by POWDER or UDOT

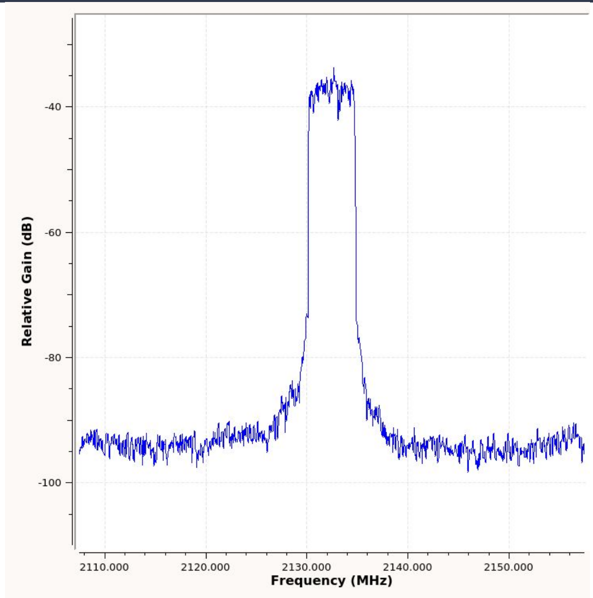
Item	Quantity	Provided By
USRP B210 SDR	4	POWDER
Attenuation Matrix	1	POWDER
DSRC On Board Unit	1	UDOT
DSRC Road Side Unit	1	UDOT
C-V2X On Board Unit	1	UDOT
C-V2X Road Side Unit	1	UDOT
WiFi 6E AP	1	POWDER
WiFi 6E Client	1	POWDER

Prototype

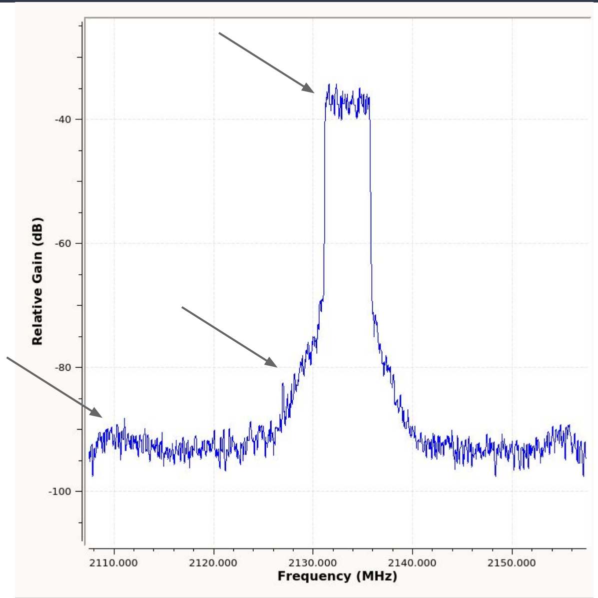
We have used GNU Radio to capture and replay active LTE links using SDRs and srsLTE in the PhantomNet testbed.



FFTs of actual LTE link and Replay

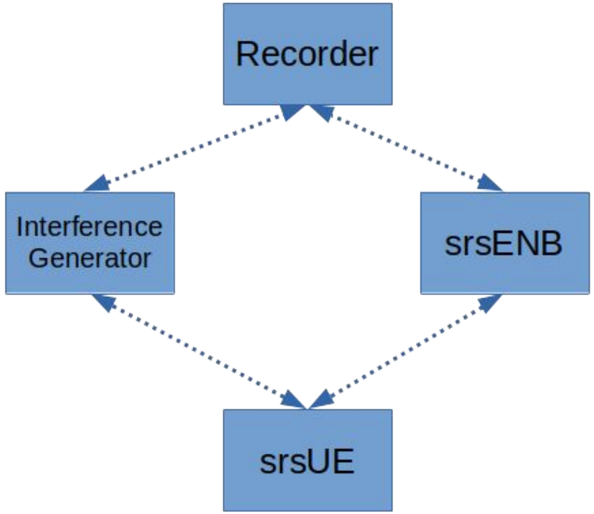


Active srsLTE link centered at 2132.5MHz

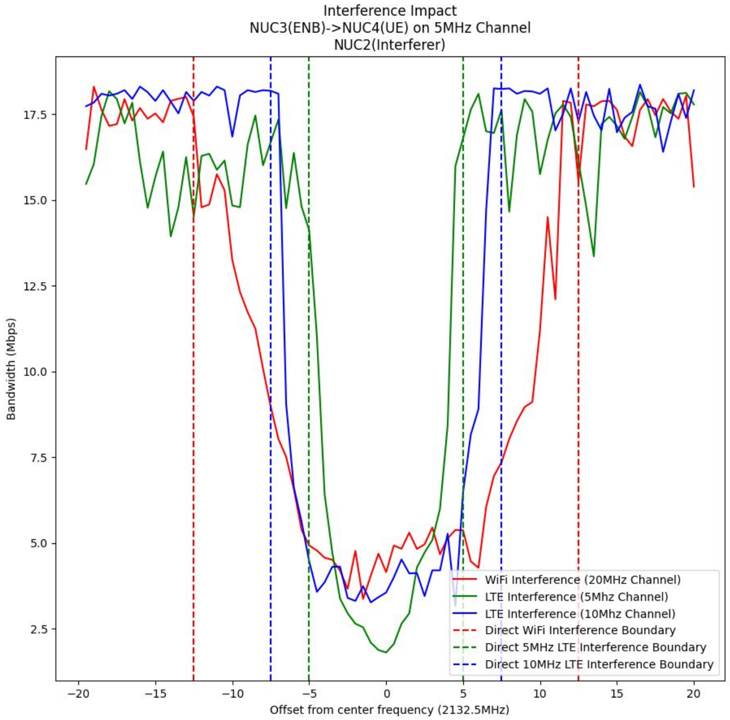


Replayed LTE link centered at 2132.5MHz

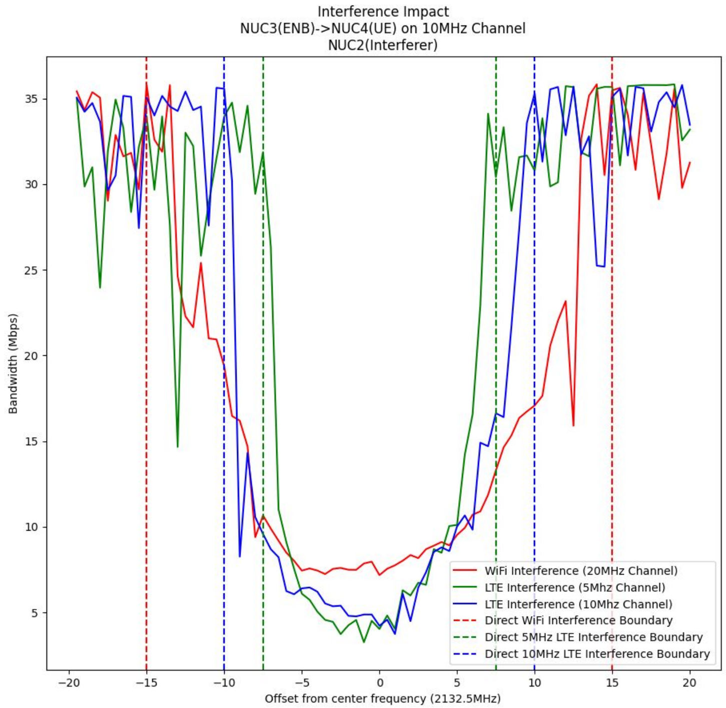
Using this consistent interference source we conducted a proof of concept interference test with srsLTE in PhantomNet.



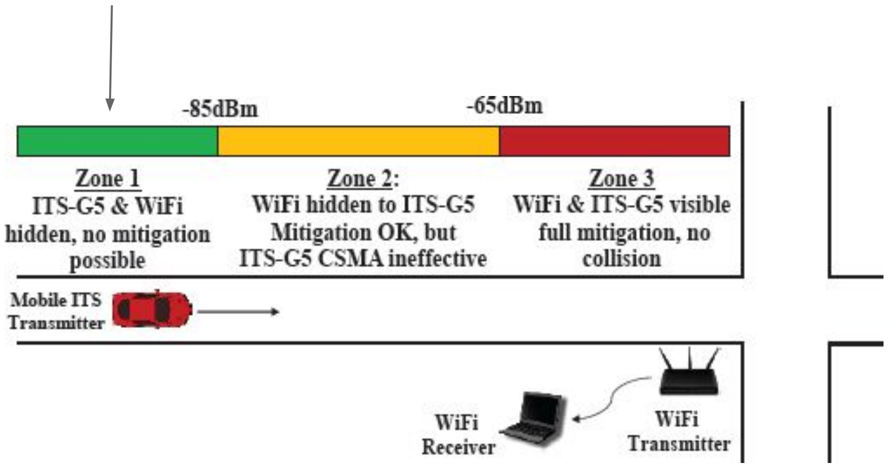
Interference testing on 5 MHz LTE link



Interference testing on 10 MHz LTE link



These initial tests indicate there is a potential for adjacent unregulated transmissions to impact V2X connectivity.



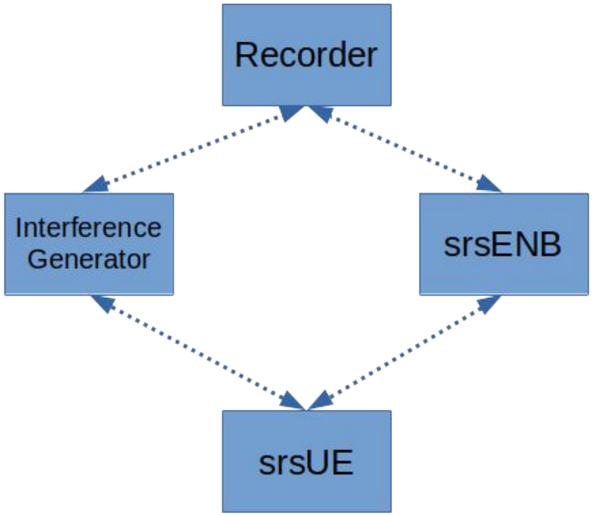
Connectivity Zones [4]

Execution Plan / Next Steps

Milestones 1 & 2

1) Finish initial testing and ensure the interference generation is consistent.

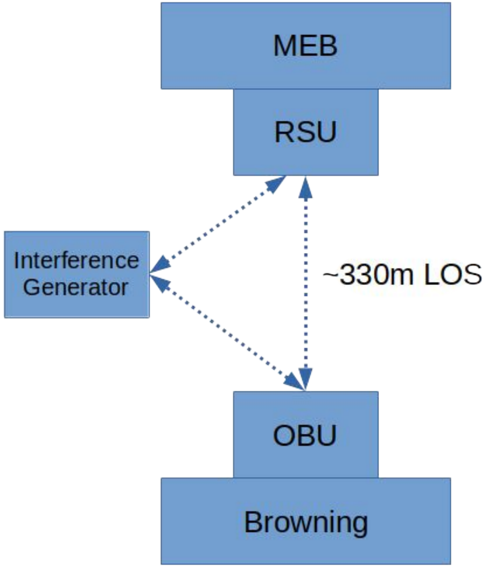
2) Develop testing methodologies to record interference impacts. Run the DSRC tests in an over the air environment in campus.



Milestone 3 & 4

3) Analyze the impacts of the initial tests and refine methodologies. Make a presentation to UDOT showing the results of the initial phase.

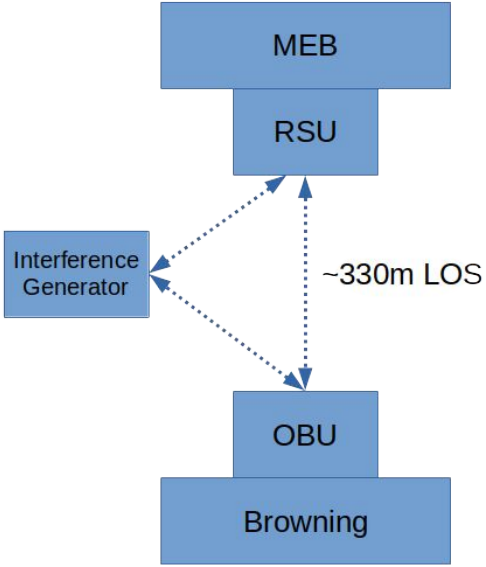
4) Integrate C-V2X equipment into the Powder platform and ensure basic functionality.



Milestone 5 & 6

5) Run refined methodologies on C-V2X hardware in an OTA environment on campus.

6) Compile and analyze results from C-V2X tests and compare them to DSRC results.



Questions?

Citations

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[3] CONGRESSIONAL RESEARCH SERVICE (CRS), “Smart Cars and Trucks: Spectrum Use for Vehicle Safety,” Dec. 2018

[4] I. Khan and J. Härri, "Can IEEE 802.11p and Wi-Fi coexist in the 5.9GHz ITS band ?," 2017 IEEE 18th International Symposium on A World of Wireless, Mobile and Multimedia Networks (WoWMoM), Macau, 2017, pp. 1-6, doi: 10.1109/WoWMoM.2017.7974358.

[5] B. Cheng, H. Lu, A. Rostami, M. Gruteser and J. B. Kenney, "Impact of 5.9 GHz spectrum sharing on DSRC performance," 2017 IEEE Vehicular Networking Conference (VNC), Torino, 2017, pp. 215-222, doi: 10.1109/VNC.2017.8275636.

[6] J. Choi, V. Marojevic, R. Nealy, J. H. Reed and C. B. Dietrich, "DSRC and IEEE 802.11ac Adjacent Channel Interference Assessment for the 5.9 GHz Band," 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), Kuala Lumpur, Malaysia, 2019, pp. 1-5, doi: 10.1109/VTCSpring.2019.8746433.

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