

Spectrum Policies for Connected Vehicles

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What are Connected Vehicles?

- Connected vehicles refers to wireless communications
 - From vehicle to vehicle (V2V)
 - From vehicle to roadside infrastructure (V2I)
 - From vehicles to everything (V2X)
- Spectrum policies remain unclear
 - With ongoing disagreements between Federal Communications Commission (FCC) and Dept. of Transportation (DOT)

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A Time of Change

- Note: these slides were produced in Oct. 2020
- The FCC may or may not vote to change policy with respect to Intelligent Transportation Systems spectrum in its last Open Meetings of 2020
 - Nov. 18 and Dec. 10, 2020

CMU Research Will Address Issues of Spectrum & Infrastructure for V2X

- This talk is about whether spectrum should be exclusive to V2X, or shared with unlicensed devices.
- A policy should address this and other issues, including
 - How much spectrum should be allocated?
 - With infrastructure provided by whom?
 - Using which technology for V2X?
 - At which frequencies?
 - Under centralized or decentralized control?
 - If centralized, by whom?
 - With what rules for each channel?
 - With what protection from adjacent channels? *And more*

Spectrum Sharing Model

- Divide V2X traffic into separate bands for
 - Safety-critical and latency-sensitive
 - e.g. crash avoidance
 - QoS measures include latency, loss rate
 - Non-safety-critical or non-latency-sensitive
 - Primary QoS measure is throughput
- Let non-safety-critical V2X share with unlicensed devices

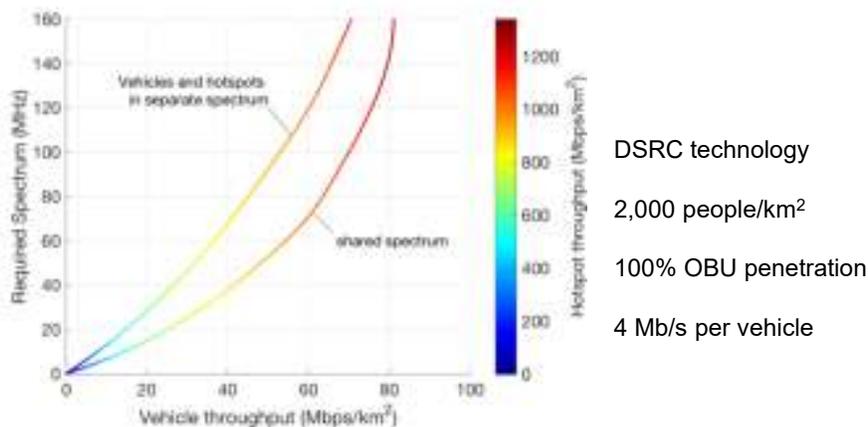
Spectrum accessible for ITS	
Exclusively for safety-critical V2X	non-safety-critical V2X traffic AND unlicensed devices (Wi-Fi) share as equals

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Total spectrum: separate vs shared band



- More spectrum is needed in separate bands, when compared to shared spectrum
- Spectrum more efficiently used if shared rather than separate

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Conclusions

- Co-equal spectrum sharing is effective for non-safety-critical DSRC communications
 - There is a bit of degradation when spectrum is shared between DSRC and Wi-Fi
 - Especially outdoor Wi-Fi
 - But can support given throughputs in far less spectrum with sharing
- We should consider allowing unlicensed into ITS band *and* allowing V2X in unlicensed band
- (May not suffice for traffic that is both safety-critical and latency-sensitive)

Breaking the Policy Impasse

- We need better analysis, but analysis is not enough
- Current process in U.S. is broken.
 - U.S. can fall behind in connected (and autonomous?) vehicles
- We have proposed a new approach
 - Interagency task force to establish a *coherent shared vision*
 - Federal agencies include White House, FCC, DoT, NTIA, NSF, NIST
 - Reps from state & local government, auto industry, telecom industry, consumer groups, privacy groups, crazy professors
 - Begin by re-examining objectives and intended applications

For Further Info

- For more info on how V2X traffic can share spectrum, see
 - Alexandre Ligo & Jon M. Peha, "Spectrum for V2X: Allocation and Sharing," *IEEE Trans. on Cognitive Communications and Networking*.
 - https://users.ece.cmu.edu/~peha/spectrum_for_V2X.pdf
- For more info on how an interagency task force could advance the policies, see
 - Jon M. Peha, *Leading the Way: A National Task Force on Connected Vehicles*, Day One Project, Federation of American Scientists, 2020.
 - <https://www.dayoneproject.org/post/leading-the-way-a-national-task-force-on-connected-vehicles>