



5.9 GHz

Transportation

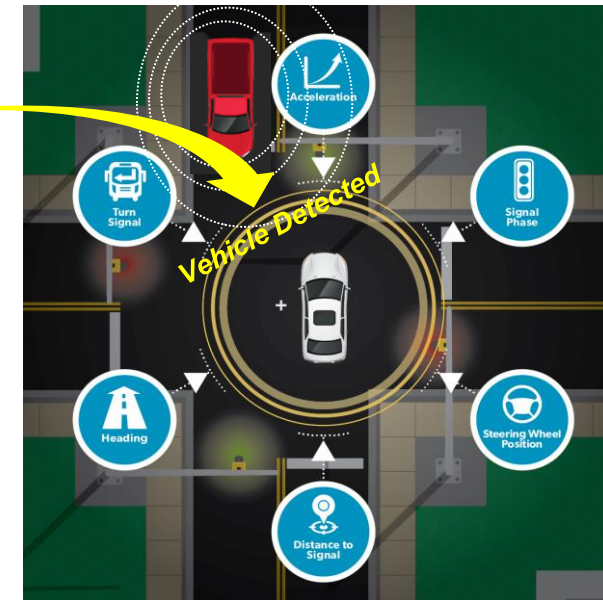
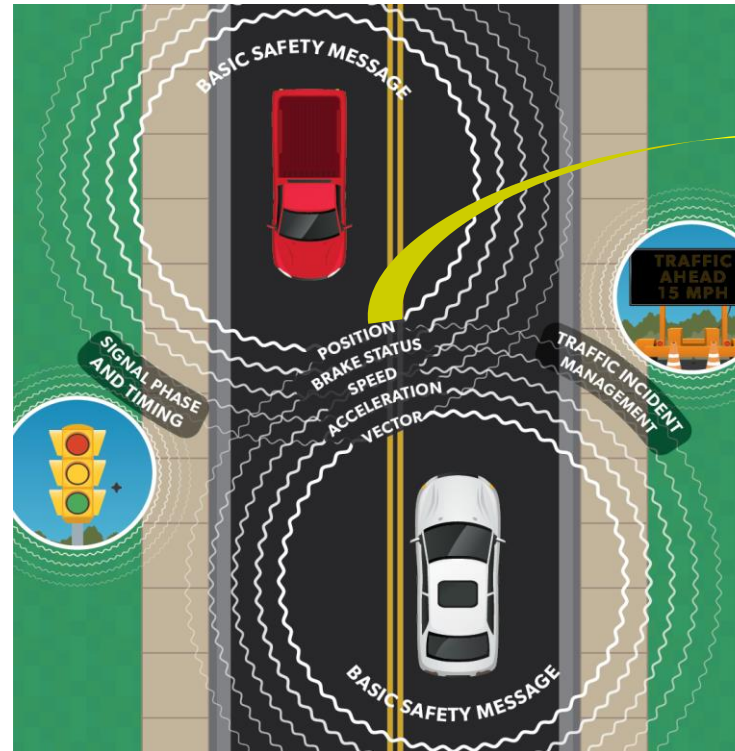
Safety Band

Testing

Criticality of Spectrum Availability With No Interference



- ▶ The **“Safety Band” allocation is critical for transportation safety** → supports the vision of advancing toward a fully connected and automated transportation system.
- ▶ The **band plan is tailored to meet transportation needs** → sharing the band could compromise the speed at which V2V/V2x information is received, putting lives at risk.
- ▶ **Over 37,000 deaths on our Nation’s roads every year** → it is critical that efforts to free up additional spectrum do not come at the expense of saving lives.

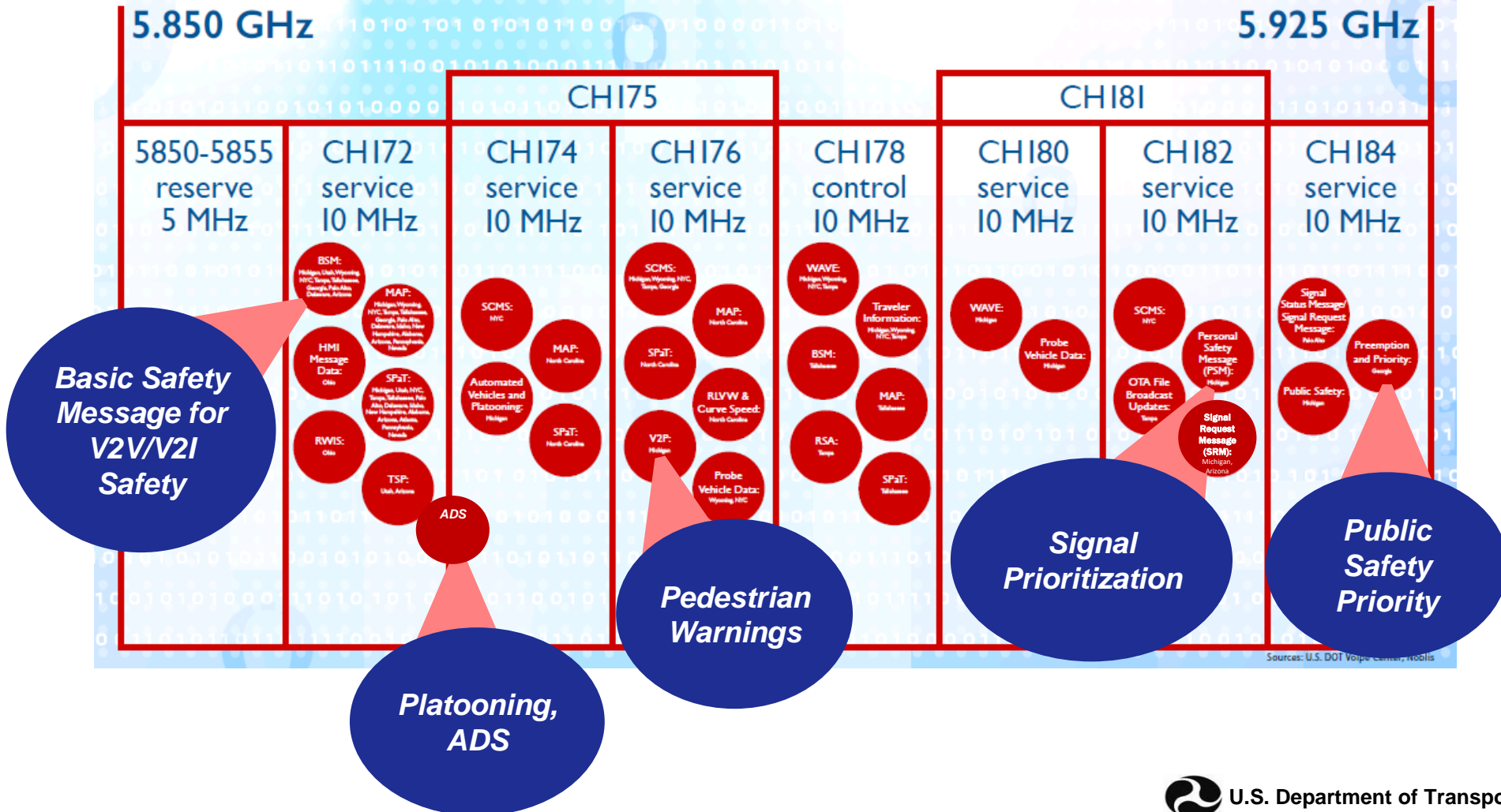


5.9 GHz Safety Band In Use Today

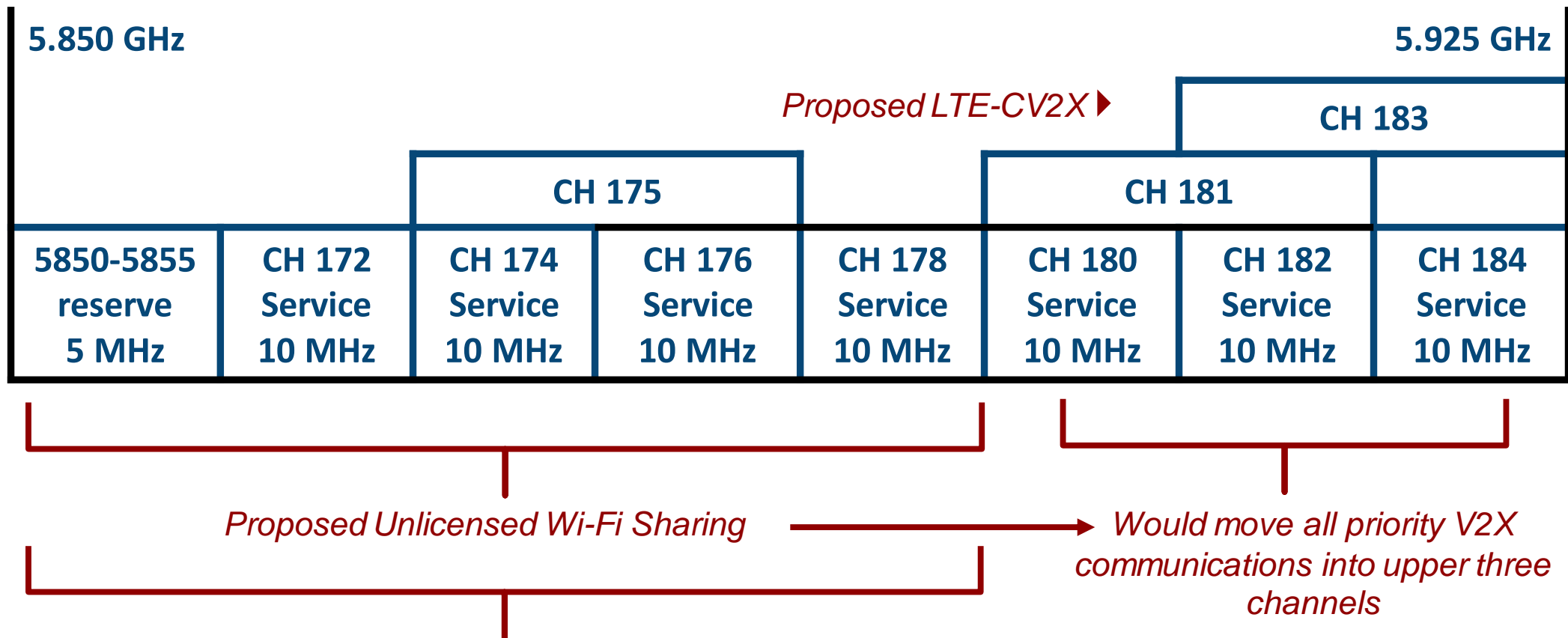


Experimental trials of LTE-CV2X

5.9GHz Spectrum Use Today



Safety Band Research and Test Program



*Also proposed detect-and-vacate Sharing;
leaves priority V2X communications in
place throughout the band*



Phase 2 DSRC-UNII Sharing Testing Plan



Can DSRC continue to provide safety-critical messages in the presence of unlicensed national information infrastructure (UNII-4) devices?

Assess three types of interference:

- Interference at DSRC receiver that leads to corrupted or no messages received
- Interference at DSRC transmitter that suppresses message transmission
- Adjacent/n-adjacent channel interference



Can UNII-4 devices effectively share the Safety Band with DSRC by mitigating potential interference to DSRC operations using the proposed sharing techniques?

- Re-channelization
- Detect & Vacate





Performance indicators

- Packet Error Rate (PER)
- Data Throughput
- Network Latency or Delay
- Packet Delay Variation (aka, “Jitter”)

Specific to Re-Channelization of the Band for DSRC & Unlicensed Wi-Fi

- **Detection Threshold:** Point at which the probability of detecting DSRC signal is equal to or greater than target percentage (90th percentile).
- **(Received) Packet Completion Rate (PCR):** Ratio of the number of successfully received DSRC packets to number of transmitted DSRC packets.
- **(Transmitted) Packet Completion Rate (PCR):** Ratio of the number of DSRC packets placed in the transmit queue to number of successfully transmitted DSRC packets.
- **Inter Arrival Time (of Received Packets) (IAT):** Time between two successive received DSRC packets.
- **Inter Departure Time (of Transmitted Packets) (IDT):** Time between two successive DSRC transmitted packets.



► Specific to Detect & Vacate with DSRC & Unlicensed Wi-Fi

- **Detection Threshold** at which point probability of detecting DSRC preamble is equal to or greater than certain percentage (90th percentile).
- **Channel-Move Time** or the time between detection of DSRC preamble and start of IEEE 802.11 transmission in a backup channel.
- **(Received) Packet Completion Rate (PCR):** The ratio of the number of successfully received packets to number of transmitted packets.
- **(Transmitted) Packet Completion Rate (PCR):** The ratio of the number of packets placed in transmit queue to the number of successfully transmitted packets.
- **Inter Arrival Time (of Received Packets) (IAT):** The time between two successive received packets.
- **Inter Departure Time (of Transmitted Packets) (IDT):** The time between two successive transmitted packets.

TEST PROCEDURE OVERVIEW



▶ **Adjacent Channel with DSRC in Upper Band**

- UNII-4 in 20MHz, 40MHz, 80MHz, 160MHz channels
- DSRC in 10MHz channel (Ch 180)

▶ **N-Adjacent Channel with DSRC in Upper Band**

- UNII-4 in 20MHz, 40MHz, 80MHz, 160MHz channels
- DSRC in 10MHz channels

▶ **Adjacent Channel with DSRC in Lower Band**

- UNII-4 in 20MHz and 40MHz channels
- DSRC in 20MHz channel

▶ **N-Adjacent Channel with DSRC in Lower Band**

- UNII-4 in 20MHz and 40MHz channels
- DSRC in 20MHz channel

USDOT's LTE-CV2X Testing Framework



▶ **Operations and Safety Performance tests** to assess LTE-CV2X capability to support crash-imminent V2V/V2I safety applications

▶ **Interference tests** to identify whether there is interference and the magnitude and impacts:

- LTE-CV2X with DSRC
- LTE-CV2X and unlicensed Wi-Fi above the band
- Sensitivity of LTE-CV2X technology to other/existing forms of interference?

▶ **Scalability tests** to measure the consistency of performance as increasing numbers of LTE-CV2X devices are added

▶ **Interoperability tests** at the chipset, radio, applications levels for interoperability among different device vendors and chipset manufacturers. Can all makes and models “hear and understand” one another?

▶ **System Dynamics and Congestion testing** to assess how LTE-CV2X technology performs in complex, highly dynamic and congested transportation scenarios with varying conditions as well as a range of environmental effects

▶ **Validation tests** to ensure that the laboratory, field testing and industry simulation and test results are able to be validated.



US DOT's Testing Progress & 5G Efforts



▶ **DSRC-UNII-4 Sharing Testing with Phase 2 has begun:**

- First rechannelization devices in testing
- Working to gain access to additional rechannelization devices + detect-and-vacate devices

▶ **LTE-CV2X Testing has begun**

- First devices received in Summer 2019 and set-up for testing at end of August.
- Testing on operability and interference underway
- Working with development platforms; receiving commercial-prototypes and will add them to the testing

▶ **5G:**

- Monitoring of transportation use cases and device specifications
- Seeking to acquire 5G prototypes (appear to be available in Asia for testing as of this past Fall)
- Assessing 5G's security to meet transportation needs



Planned Test Schedule

****NOTE: This Roadmap is updated regularly and reflects schedule changes due to external factors (such as the pandemic).**

	2019							2020												2021																			
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D								
Research / Data Collection																																							
Phase II Spectrum Sharing	PHASE 2 START: 8.07.2019																																						
Rechannalization				Lab	Interference Testing										Small-Scale Field Testing					Phase 3 (If Phase 2 Successful) Naturalistic Environment																			
Detect & Vacate										Lab	Interference Testing					Small-Scale Field Testing					Phase 3 (If Phase 2 Successful) Naturalistic Environment																		
LTE-CV2X Testing	LTE-CV2X START: 8.23.2019																																						
Basic Performance for Safety				Device Operations Testing	LAB testing (validating industry results)															Phase 3 (If Phase 2 Successful) Naturalistic Environment																			
Scalability				Lab simulations (validating industry results)										Test track congestion testing																									
Application Testing				Test Plan Dev.										V2I application testing																									
Interoperability				Device Acquisition for testing					Broad Agency Announcement (BAA) for hundreds of devices & Acq. of test site(s)/track(s)					Interoperability/Congestion and Scalability Testing																									
5G V2X																						5G New Radio Prototypes expected to be available for procurement/testing																	
																						Lab										Small-Scale Field Testing →							

For More Information



For Information:

- <https://www.transportation.gov/content/safety-band>
- <https://www.its.dot.gov>



Contacts for Testing New Communications Technologies

- Jim Arnold, USDOT Spectrum Engineer;
James.A.Arnold@dot.gov
- Jonathan Walker, Division Chief,
Knowledge Transfer and Policy, ITS Joint
Program Office;
Jonathan.B.Walker@dot.gov

