



5.9 GHz

Transportation

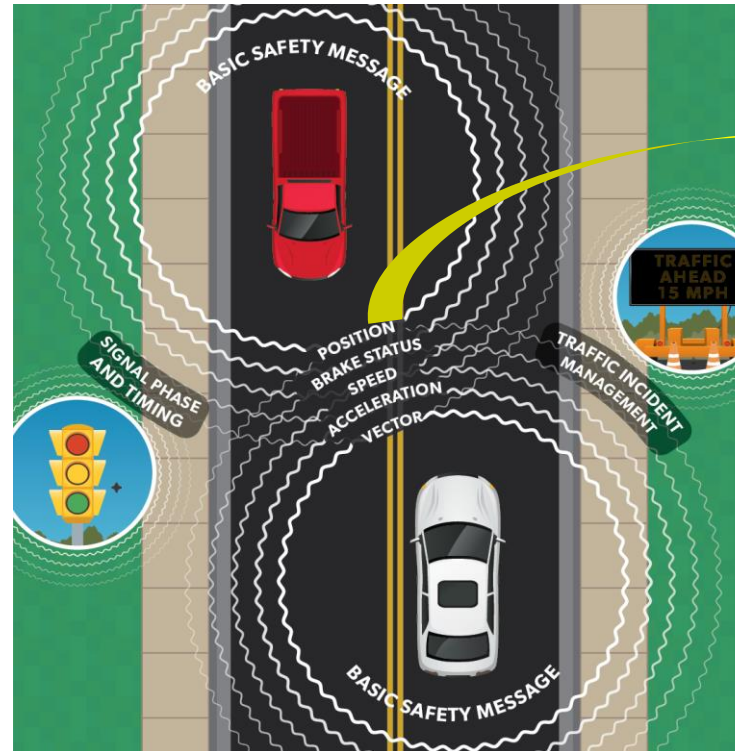
Safety Band

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.

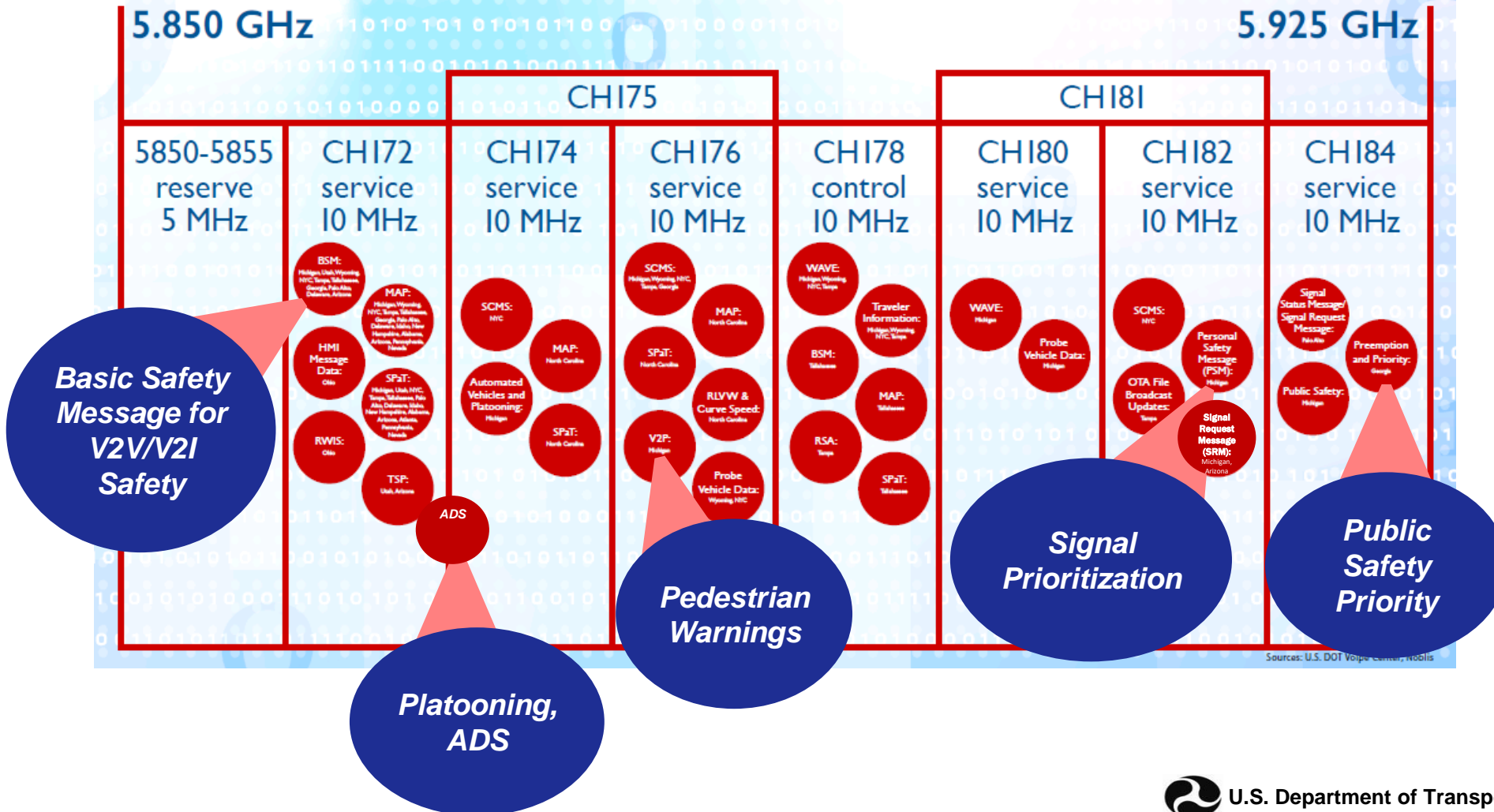


5.9 GHz Safety Band In Use Today

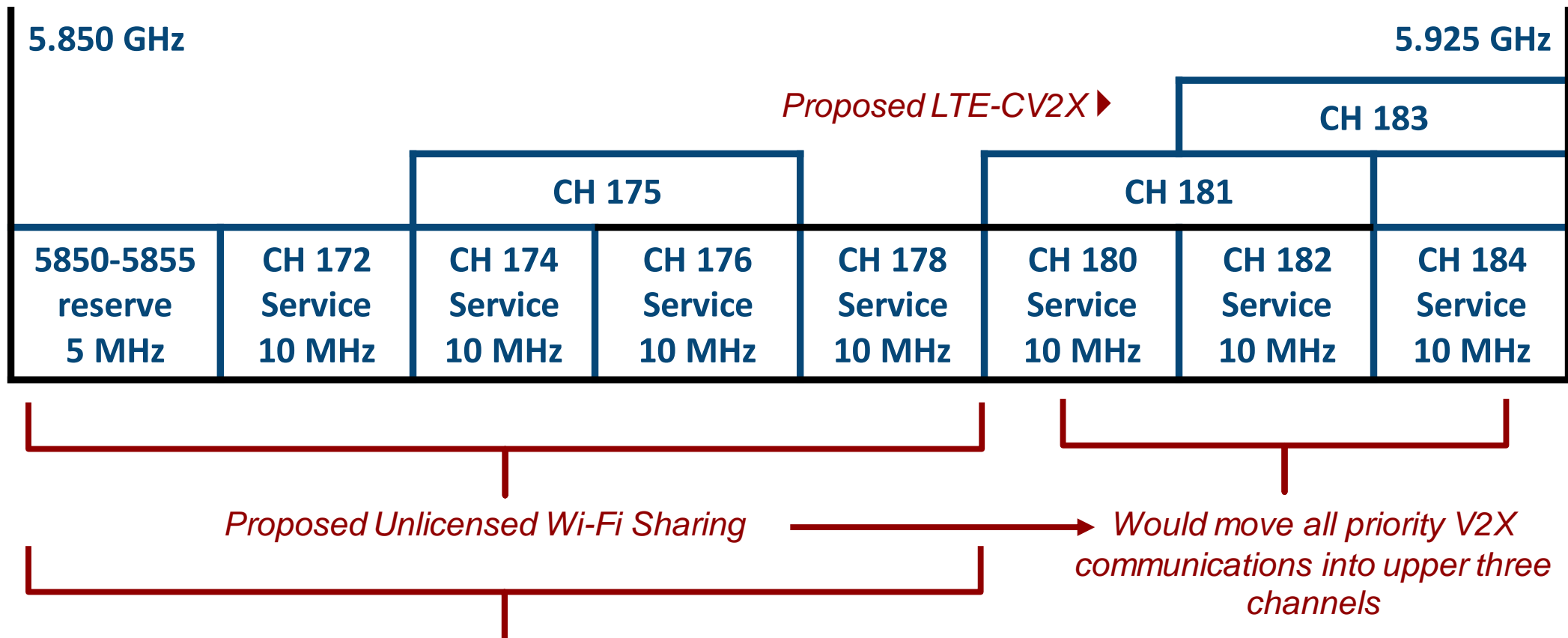


Experimental trials of LTE-CV2X

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

	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																														
Rechannelization																															
Detect & Vacate																															
LTE-CV2X Testing	LTE-CV2X START: 8.23.2019																														
Basic Performance for Sa																															
Scalability																															
Application Testing																															
Interoperability																															
Analysis																															
5G V2X																															

For More Information



For Information:

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



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