



5.9 GHz

Transportation

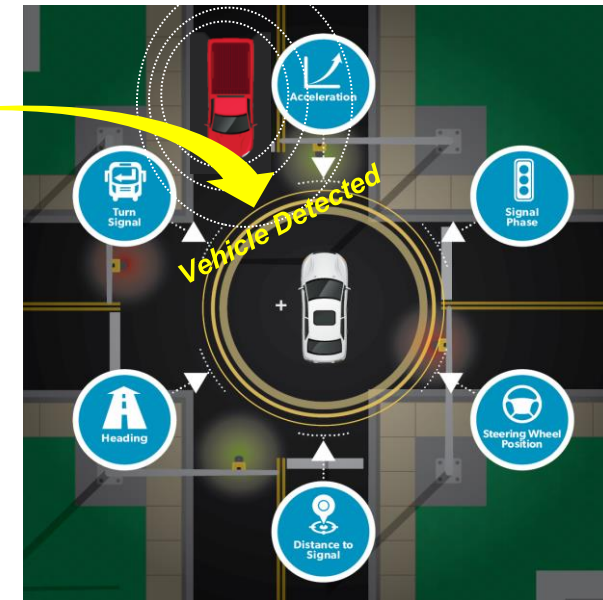
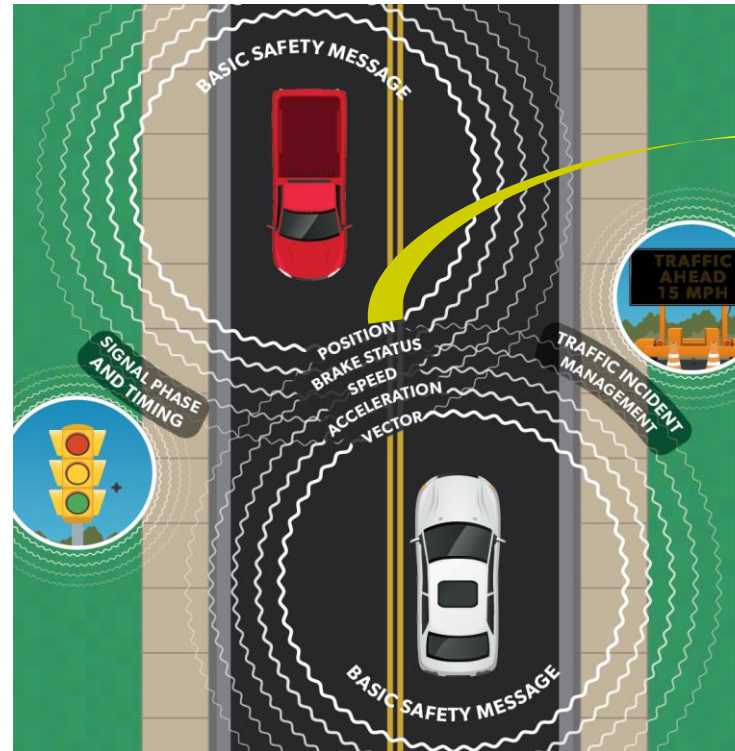
Safety Band

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.

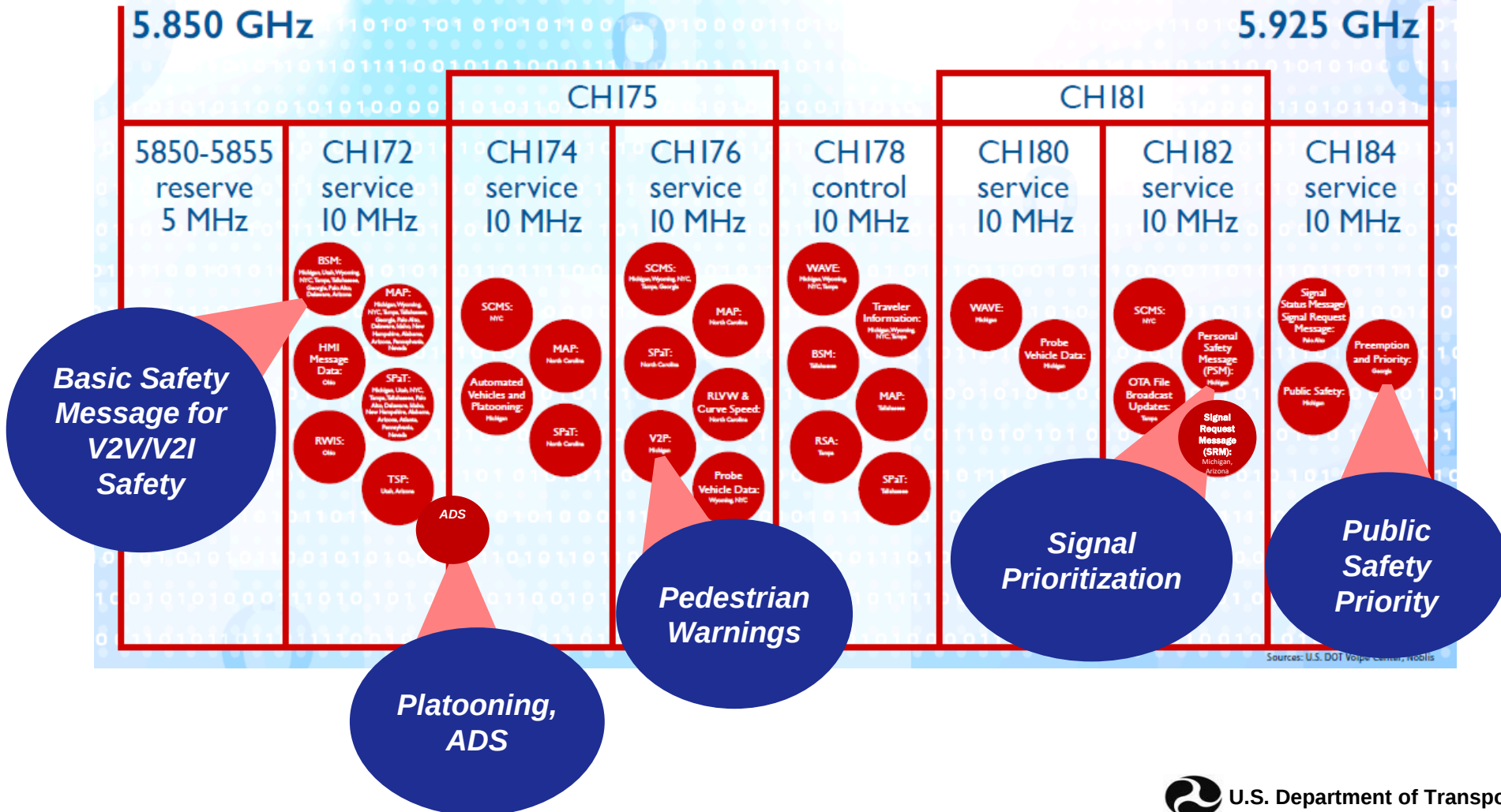


# 5.9 GHz Safety Band In Use Today

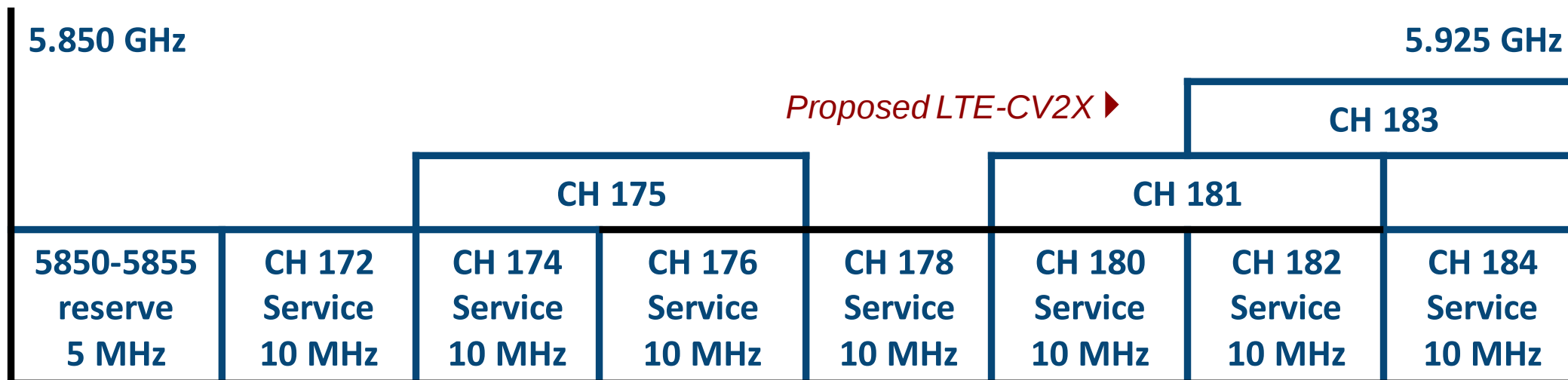


Experimental trials of LTE-CV2X

## 5.9GHz Spectrum Use Today



# Safety Band Research and Test Program



*Proposed Unlicensed Wi-Fi Sharing*

*Would move all priority V2X communications into upper three channels*

*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

**\*\*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    |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Rechannelization             |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Detect & Vacate              |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| LTE-CV2X Testing             |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Basic Performance for Safety |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Scalability                  |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Application Testing          |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Interoperability             |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| Analysis                     |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
| 5G V2X                       |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |
|                              |      |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |

PHASE 2  
START:  
8.07.2019

LTE-CV2X  
START:  
8.23.2019

# For More Information



## For Information:

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



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