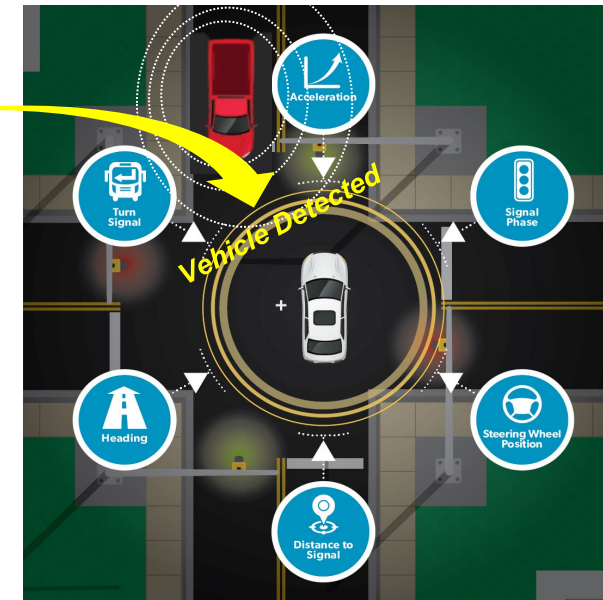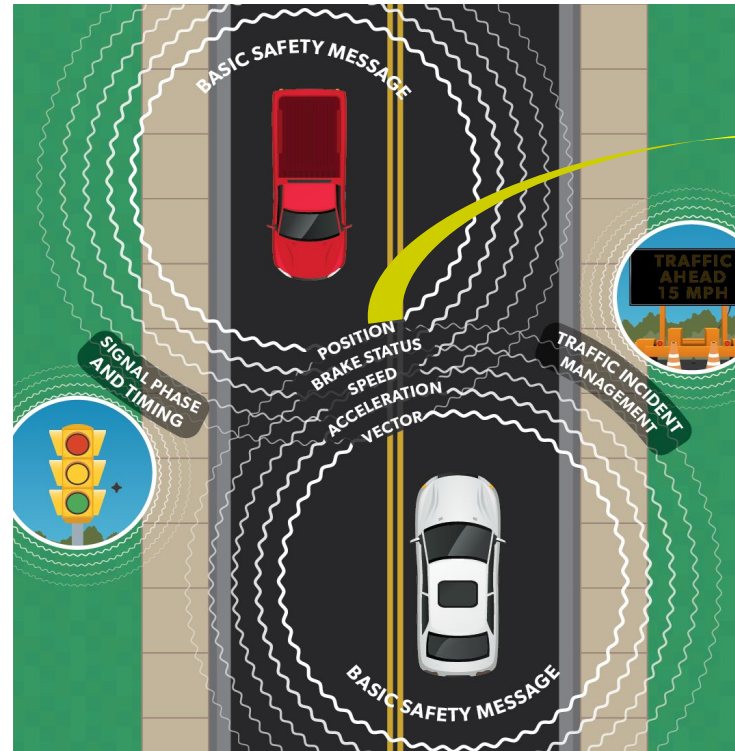# 5.9 GHz

# Transportation

# Safety Band

# Testing

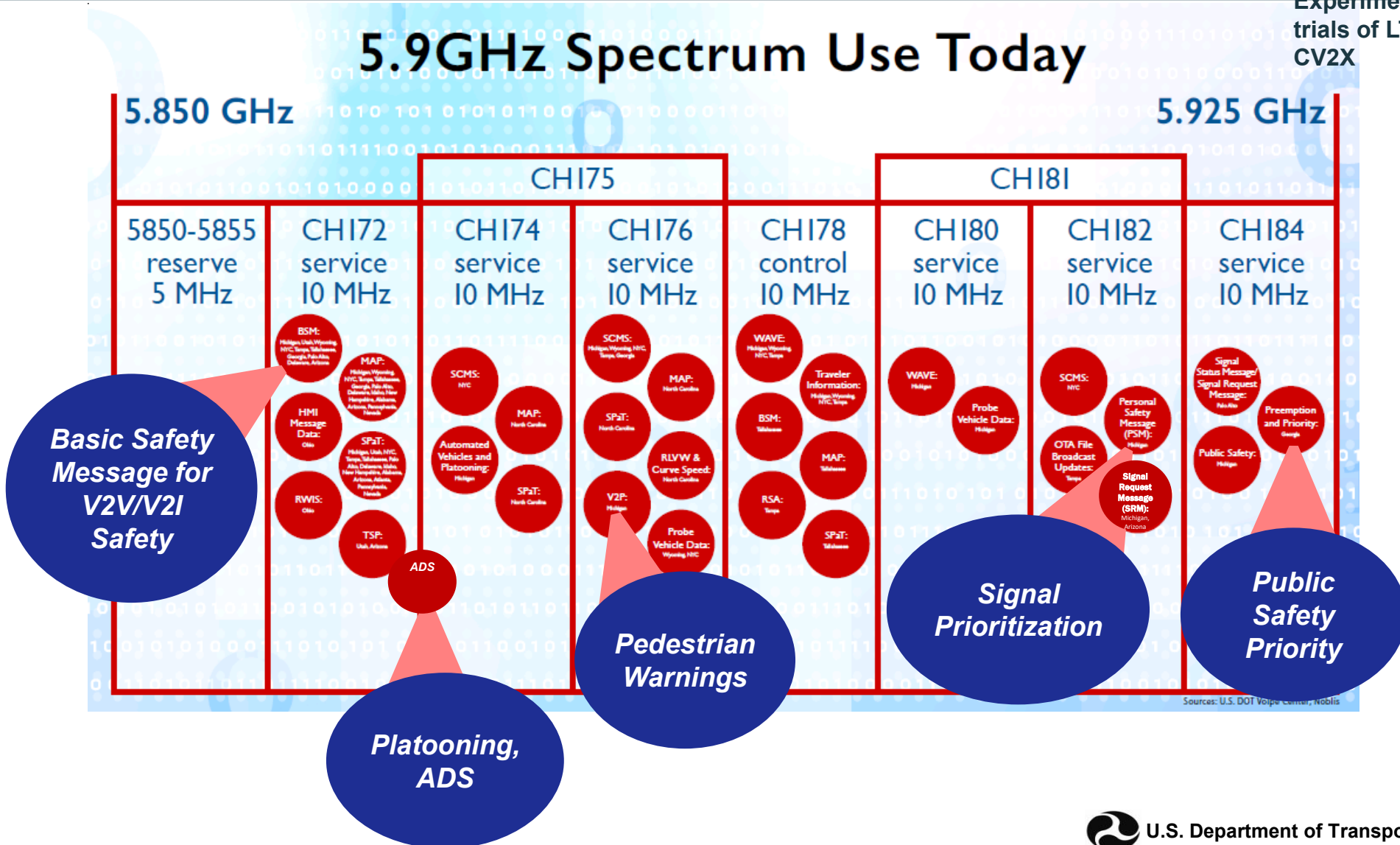# Criticality of Spectrum Availability With No Interference

▶ **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

5.850 GHz — 5.925 GHz

| 5850-5855 reserve 5 MHz | CH172 service 10 MHz | CH174 service 10 MHz | CH176 service 10 MHz | CH178 control 10 MHz | CH180 service 10 MHz | CH182 service 10 MHz | CH184 service 10 MHz |

CH175 spans CH174 and CH176. CH181 spans CH180 and CH182.

Callouts:
- **Basic Safety Message for V2V/V2I Safety**
- **Platooning, ADS**
- **Pedestrian Warnings**
- **Signal Prioritization**
- **Public Safety Priority**

Sources: U.S. DOT Volpe Center, Noblis

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# Safety Band Research and Test Program



5.850 GHz — 5.925 GHz

Proposed LTE-CV2X ▶

CH 183

CH 175

CH 181

| 5850-5855 reserve 5 MHz | CH 172 Service 10 MHz | CH 174 Service 10 MHz | CH 176 Service 10 MHz | CH 178 Service 10 MHz | CH 180 Service 10 MHz | CH 182 Service 10 MHz | CH 184 Service 10 MHz |

Proposed Unlicensed Wi-Fi Sharing

Would move all priority V2X communications into upper three channels
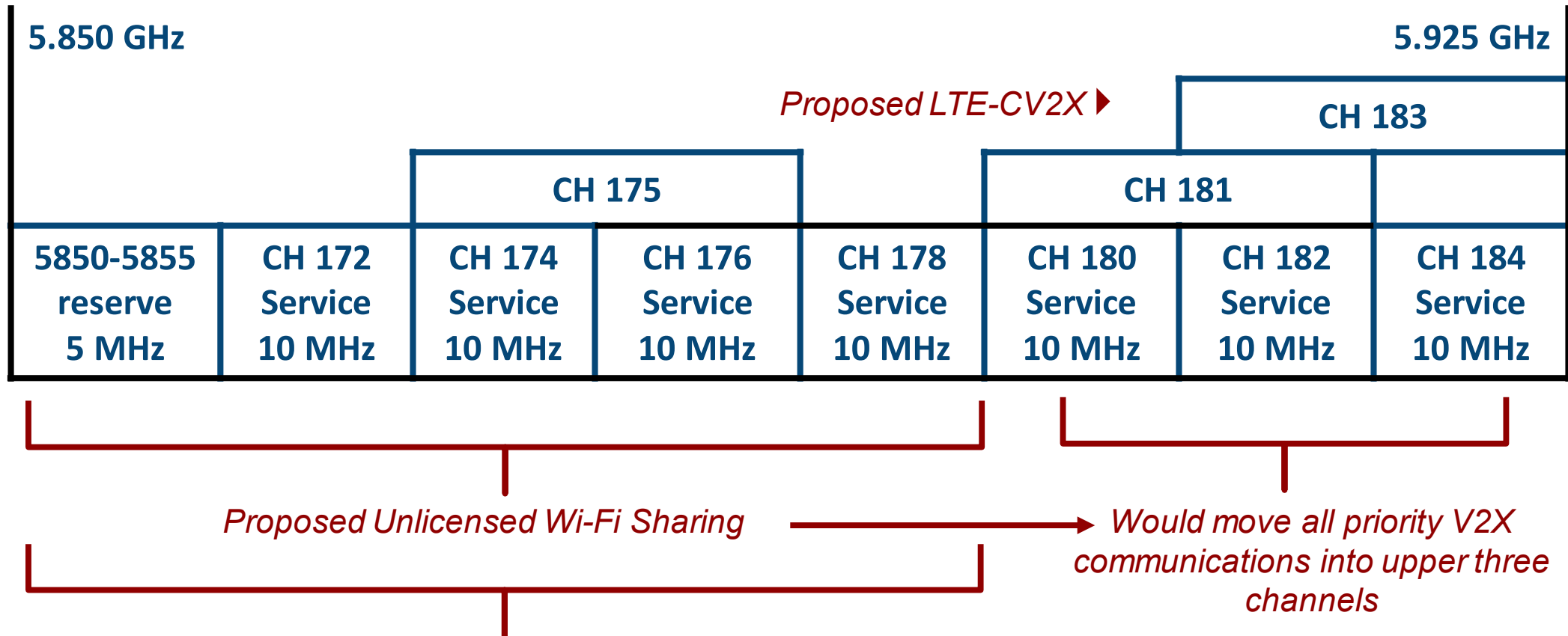
Also proposed detect-and-vacate Sharing; leaves priority V2X communications in place throughout the band

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# 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

# Test Metrics

▶ **Performance indicators**

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

▶ **Specific to <u>Re-Channelization</u> 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.

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# Test Metrics

► **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

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▶ **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

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# 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 | | |

**Research / Data Collection**

**Phase II Spectrum Sharing**

PHASE 2 START: 8.07.2019

**Rechannelization** — Lab-RC1 | Interference Testing--still working out device issues | RC1-Test Track & Small-Scale Field

Lab-RC2 | RC2-Test Track & Small-Scale Field

**Phase 3 Naturalistic Environment Testing (if necessary)** ▶

**Detect & Vacate** — Lab D&V Test | D&V-Test Track & Small-Scale Field

**LTE-CV2X Testing**

LTE-CV2X START:

**Basic Performance for Safety** — Device Ops | LAB testing + Validating Industry Results

**Scalability- Lab** — Lab simulations-validate Industry simulations

**Application Testing** — Test Plan Dev. | Installation | V2I application testing

**Scalability & Congestion - Field Interoperability Testing** — Acquisition of Commercial Prototypes for Interoperability / Scalability / Congestion | Acq. Of test site/track | Interoperability/ Congestion and Scalability Testing

**Naturalistic Environment Testing (if necessary)** ▶

**5G V2X** — Request for 5G prototype devices | Anticipate 5G New Radio Prototypes expected to be available for testing

Lab | Small-Scale Field ▶

I= Interim   D= draft   F = Final

date line

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# 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;

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