The U.S. Department of Transportation

V2X FOR TRANSPORTATION SAFETY

Volpe National Transportation Systems Center

U.S. Department of Transportation

National ITS Reference Architecture

"ARC-IT Version 9.0 is the current release of the National ITS Reference Architecture. ARC-IT Version 9.0 fully defines and upgrades the four architecture views that were initially defined in ARC-IT 8.0, including changes to support vehicle automation content inspired by research results and stakeholder input including the National Dialogue on Highway Automation. Learn more about the most significant enhancements for Version 9.0."*

* https://www.standards.its.dot.gov/LearnAboutStandards/NationalITSArchitecture
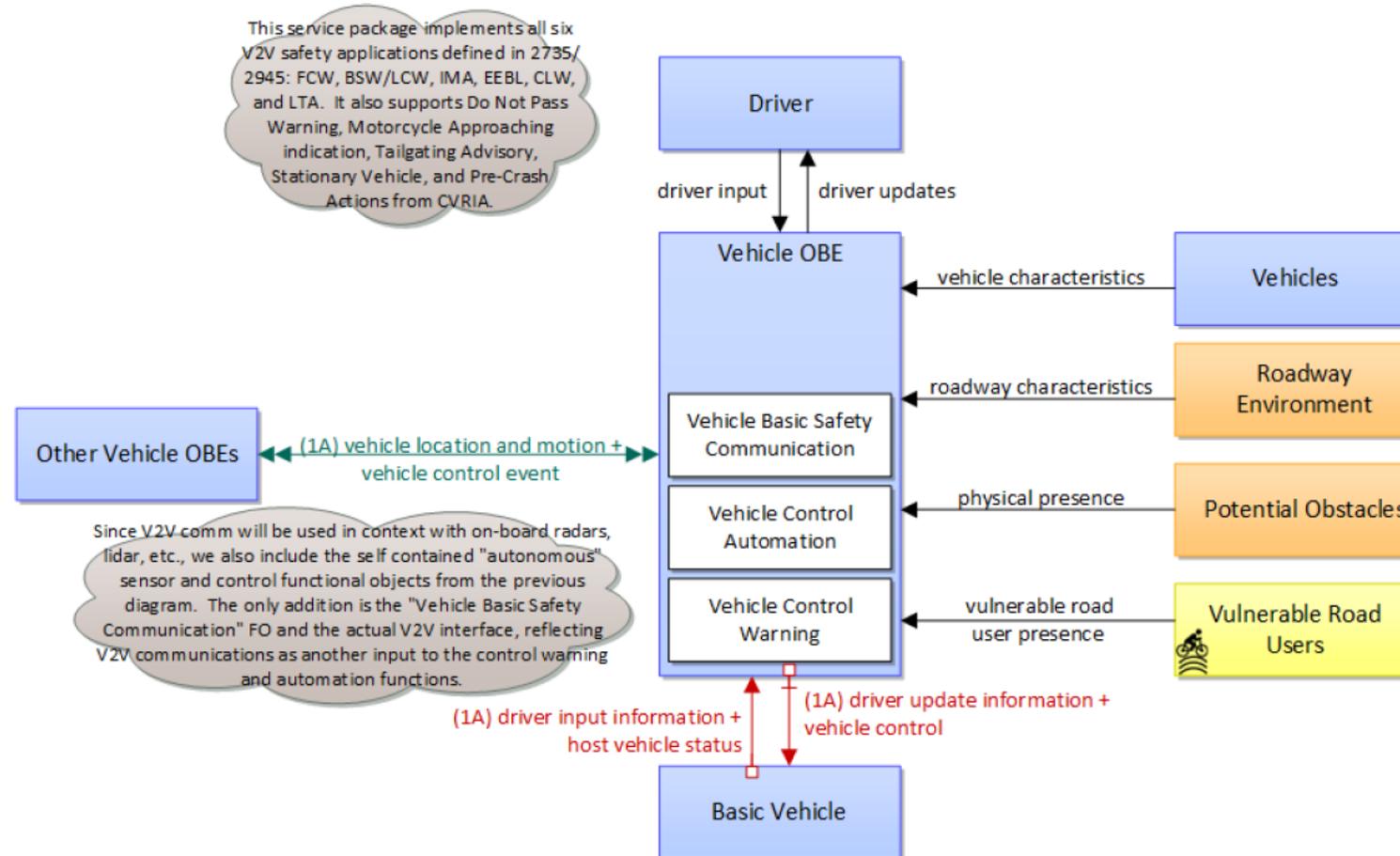
Connected Vehicle - Focus on Safety

Goal: Achieve a significant reduction in traffic fatalities and serious injuries on all public roads*

Example Objectives*:

- Reduce crashes due to driver errors and limitations
- Reduce crashes due to unexpected congestion
- Reduce secondary crashes
- Reduce the total number of fatalities and severe injuries

* http://www.arc-it.net/html/servicepackages/sp7.html#tab-8

Vehicle-to-Vehicle (V2V) Basic Safety*

This service package implements all six V2V safety applications defined in 2735/2945: FCW, BSW/LCW, IMA, EEBL, CLW, and LTA. It also supports Do Not Pass Warning, Motorcycle Approaching indication, Tailgating Advisory, Stationary Vehicle, and Pre-Crash Actions from CVRIA.

Since V2V comm will be used in context with on-board radars, lidar, etc., we also include the self contained "autonomous" sensor and control functional objects from the previous diagram. The only addition is the "Vehicle Basic Safety Communication" FO and the actual V2V interface, reflecting V2V communications as another input to the control warning and automation functions.

Driver

driver input   driver updates

Vehicle OBE

vehicle characteristics → **Vehicles**

Vehicle Basic Safety Communication

(1A) vehicle location and motion + vehicle control event

Other Vehicle OBEs

roadway characteristics → **Roadway Environment**

Vehicle Control Automation

physical presence → **Potential Obstacles**

Vehicle Control Warning

vulnerable road user presence → **Vulnerable Road Users**

(1A) driver input information + host vehicle status

(1A) driver update information + vehicle control

Basic Vehicle

* http://www.arc-it.net/html/servicepackages/sp7.html#tab-3

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USDOT Pilot Deployments

"The U.S. Department of Transportation (USDOT) is supporting the advancement of connected vehicle technology with a pilot deployment program that is uncovering what barriers remain and how to address them, documenting lessons learned, and serving as a template assisting other early CV technology deployments. The USDOT awarded cooperative agreements collectively worth more than $45 million to three pilot sites being led by the New York City Department of Transportation (NYCDOT); the Tampa Hillsborough Expressway Authority (THEA); and the Wyoming Department of Transportation (WYDOT) to implement a suite of connected vehicle applications and technologies tailored to meet their region's unique transportation needs, ranging from dense urban grid networks to isolated high-plains interstates."*
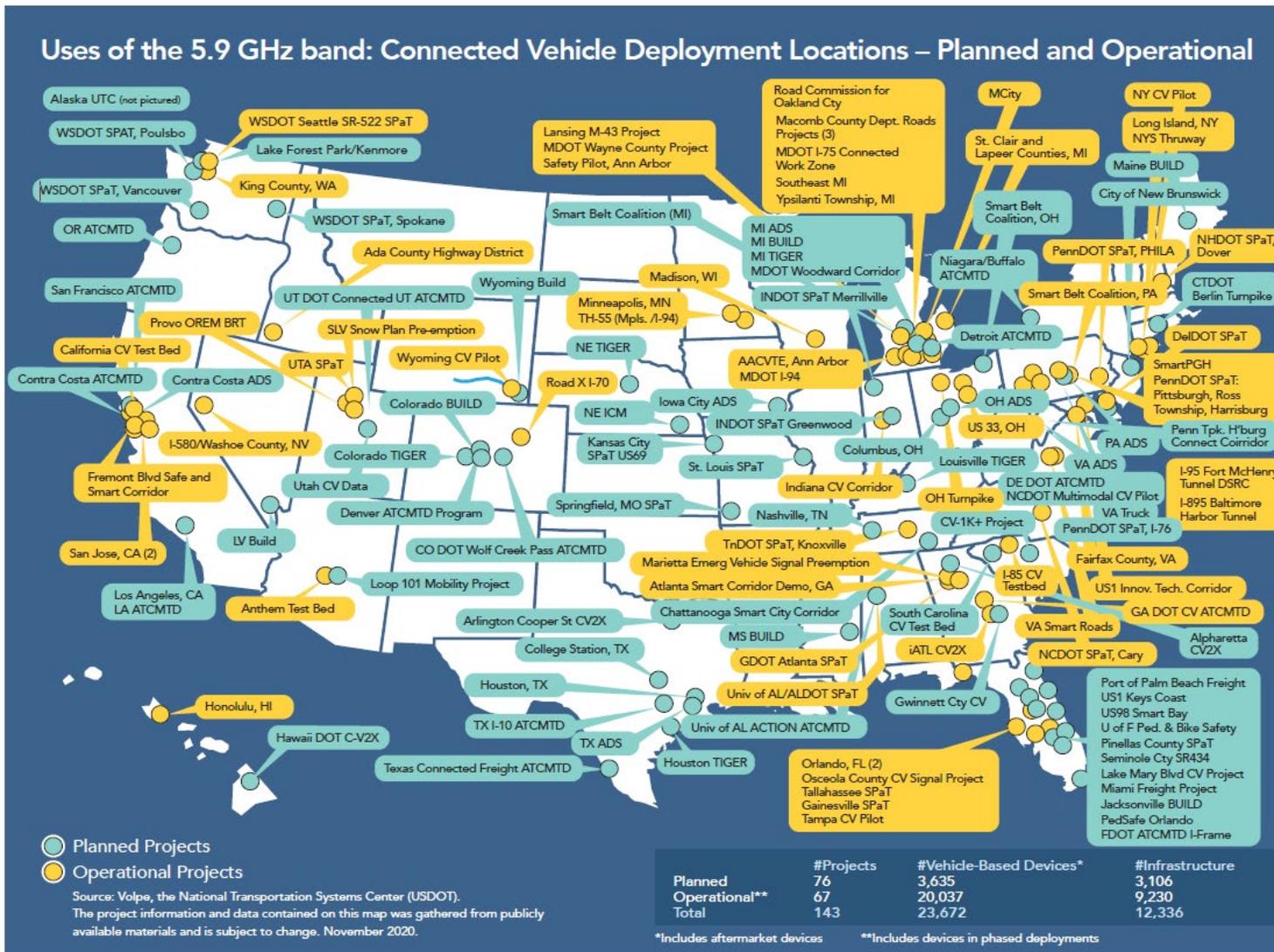
* https://www.its.dot.gov/pilots/

V2X is being deployed by State and local governments throughout the United States

Uses of the 5.9 GHz band: Connected Vehicle Deployment Locations – Planned and Operational

There are currently **143 planned or operational connected vehicle deployment locations in the U.S.,** all of which use the Safety Band.

**More than 18,000** vehicles are deployed with aftermarket V2X communications devices.

Over 6,000 infrastructure V2X devices have been installed at the roadside in **25 states.**

	#Projects	#Vehicle-Based Devices*	#Infrastructure
Planned	76	3,635	3,106
Operational**	67	20,037	9,230
Total	143	23,672	12,336

*Includes aftermarket devices   **Includes devices in phased deployments

Source: Volpe, the National Transportation Systems Center (USDOT). The project information and data contained on this map was gathered from publicly available materials and is subject to change. November 2020.

What is Direct V2X ?

- Direct communications between devices (no cellular network needed)

- Vehicles can communicate directly:

  - with each other (vehicle-to-vehicle, V2V)

  - with roadside infrastructure— (vehicle-to-infrastructure, V2I)

  - and with portable devices such as those used by pedestrians (vehicle-to-pedestrian, V2P)

- ITU-R Working Party 5A prepares reports and recommendations on direct V2X
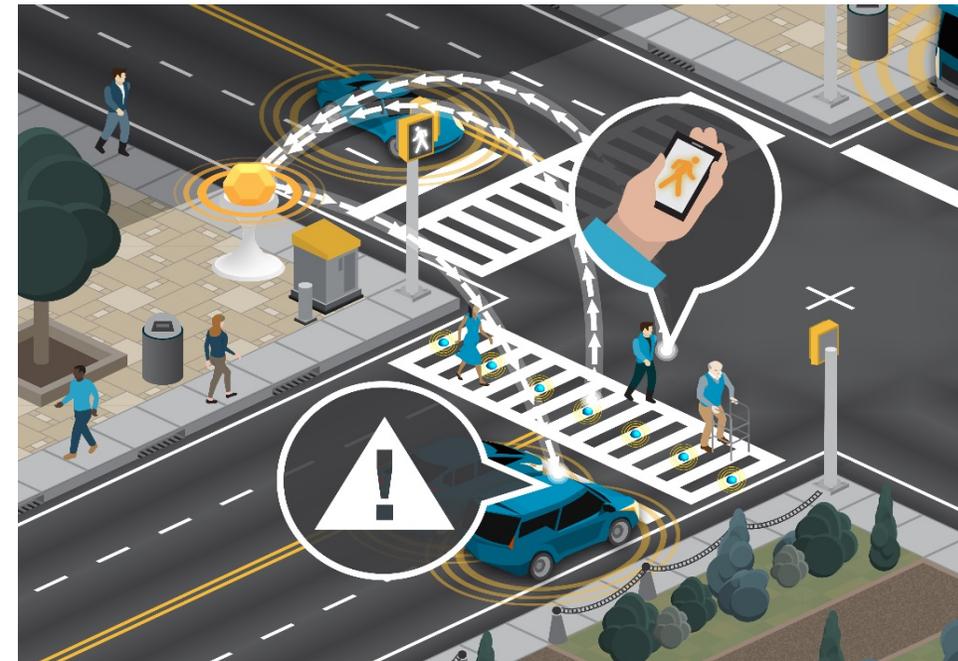
What is Cellular Network V2X ?

- Communications with server based applications, for example:
  - Ride sharing applications
  - Internet navigation applications
  - Edge computing

- Indirect communications between devices (through cellular network – e.g., P2N2V)

- Direct communications between devices (managed by cellular network)

- ITU-R Working Party 5D prepares reports and recommendations on cellular network V2X
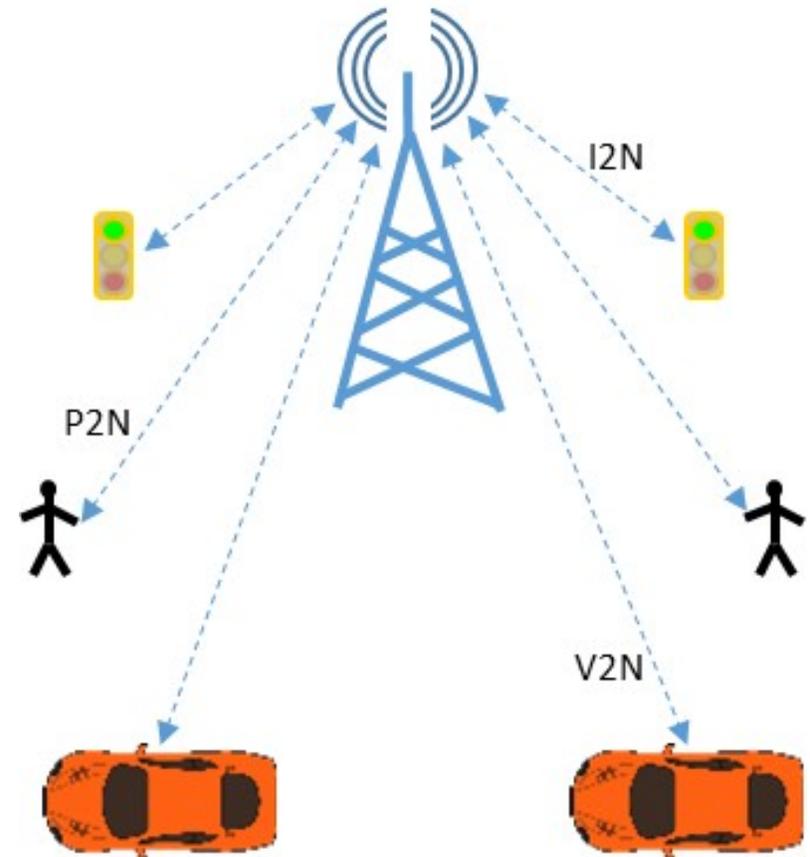
Direct V2X for V2V Safety Communications

- Current deployments use direct V2X for V2V safety communications, due to:
  - Over two decades of research, development and testing
  - Dedicated spectrum
  - Low latency inherent in broadcast mode of operation
  - Interoperability by design
  - Privacy / non-trackability by design
  - No cellular network subscription or coverage required

Importance of International Recommendations and Standards

Examples:

- Harmonization of Spectrum
  - Recommendation ITU-R M.2121 - Harmonization of frequency bands for Intelligent Transport Systems in the mobile service
  - "recommends that, taking into account considering h), Administrations should consider using the frequency band 5 850-5 925 MHz, or parts thereof, for current and future ITS applications"

- V2X Radio Interface Technologies
  - Recommendation ITU-R M.2084 - Radio interface standards of vehicle-to-vehicle and vehicle-to-infrastructure two-way communications for Intelligent Transport System applications
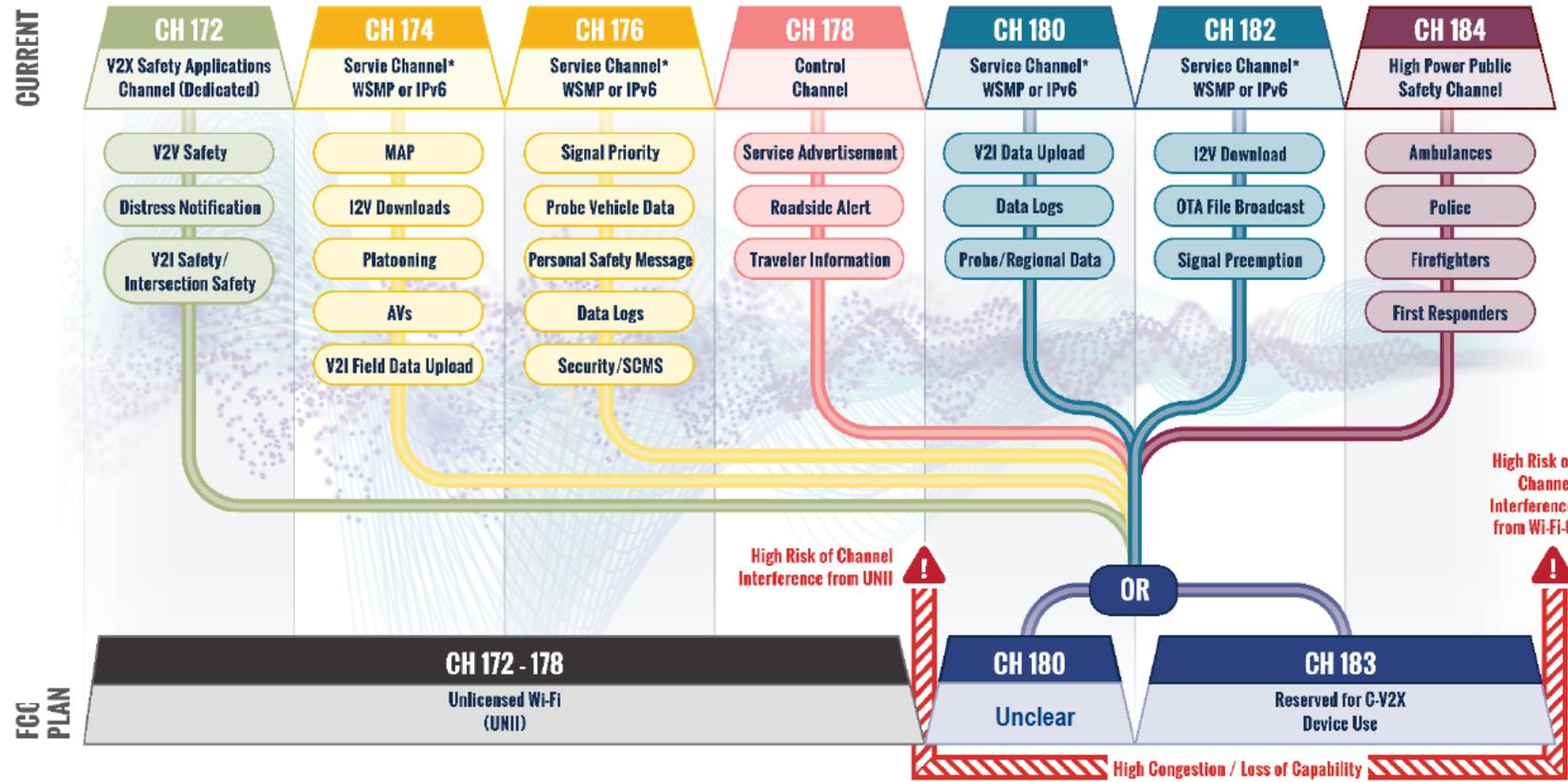 - Facilitates global marketplace and supports interoperability

Worldwide V2X Spectrum Allocations

*https://www.transportation.gov/sites/dot.gov/files/2021-01/SPECTRUM%20GRAPH%2012JAN2021e.pdf
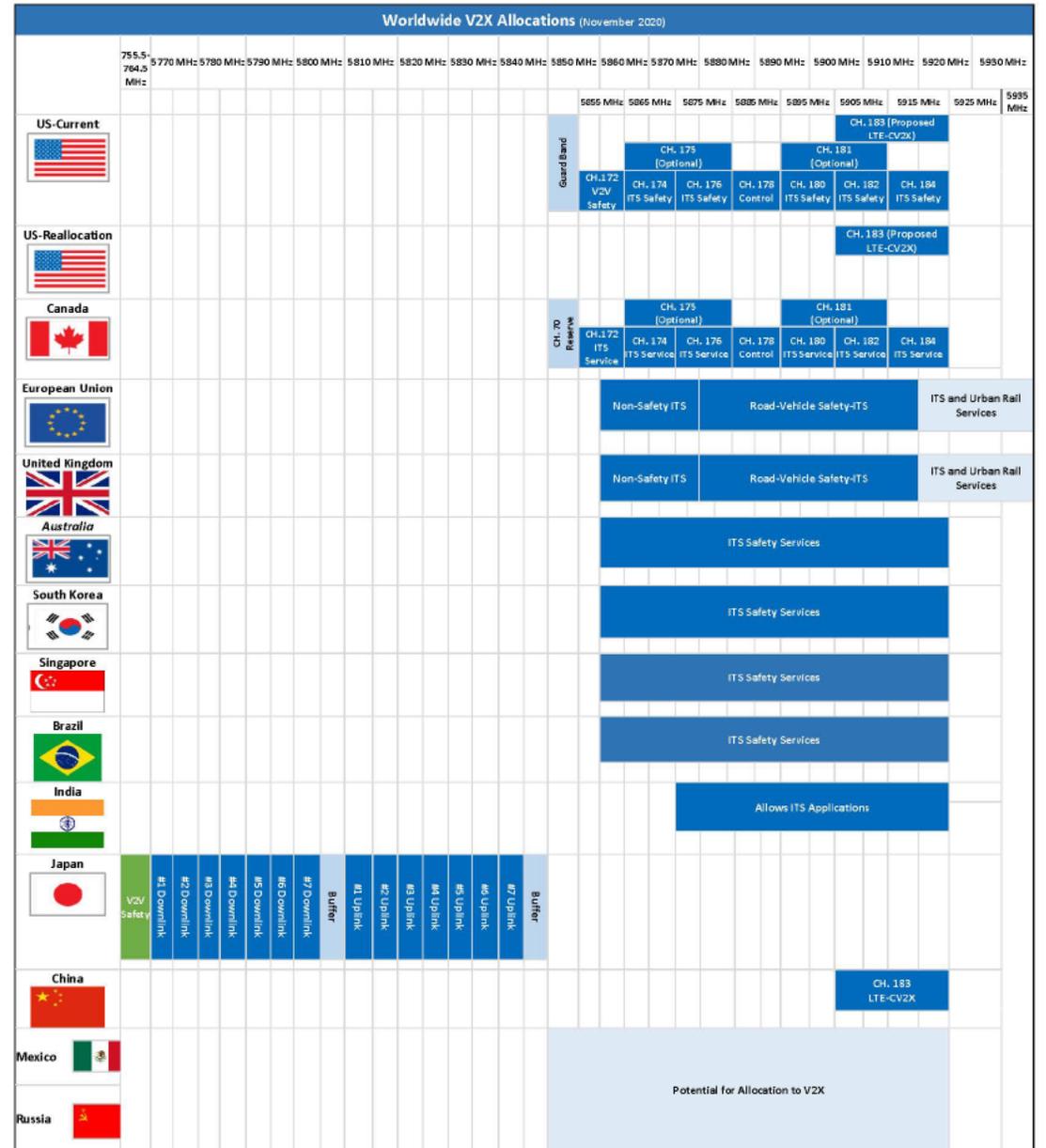
IMPACT OF COMPRESSING THE 5.9 GHZ SAFETY BAND CHANNELS

The Federal Communications Commission decided to compress the 75 MHz Safety Band into 30 MHz

CURRENT

CH 172	CH 174	CH 176	CH 178	CH 180	CH 182	CH 184
V2X Safety Applications Channel (Dedicated)	Servie Channel* WSMP or IPv6	Service Channel* WSMP or IPv6	Control Channel	Service Channel* WSMP or IPv6	Service Channel* WSMP or IPv6	High Power Public Safety Channel
V2V Safety	MAP	Signal Priority	Service Advertisement	V2I Data Upload	I2V Download	Ambulances
Distress Notification	I2V Downloads	Probe Vehicle Data	Roadside Alert	Data Logs	OTA File Broadcast	Police
V2I Safety/ Intersection Safety	Platooning	Personal Safety Message	Traveler Information	Probe/Regional Data	Signal Preemption	Firefighters
	AVs	Data Logs				First Responders
	V2I Field Data Upload	Security/SCMS				

High Risk of Channel Interference from UNII ⚠

High Risk of Channel Interference from Wi-Fi-6 ⚠

OR

FCC PLAN

CH 172 - 178	CH 180	CH 183
Unlicensed Wi-Fi (UNII)	Unclear	Reserved for C-V2X Device Use

High Congestion / Loss of Capability

ACRONYMS

AV: Automated Vehicle

C-V2X: Cellular Vehicle to Everything

DSRC: Dedicated Short-Range Communications

I2V: Infrastructure to Vehicle

IPv6: Internet Protocol version 6

OTA: Over the Air

SCMS: Security Credential Management System

UNII Unlicensed National Information Infrastructure

V2I: Vehicle to Infrastructure

V2V: Vehicle to Vehicle

V2X: Vehicle to Everything

WSMP: WAVE Short Message Protocol

Intelligent Transportation Systems Joint Program Office

U.S. Department of Transportation

For More Information

Technical Contacts:

ITS Joint Program Office

Jonathan B. Walker, P.E., Ph.D.
Chief of Policy, Architecture, and Knowledge Transfer

Federal Highway Administration

John Harding

Connected/Automated Vehicles and Emerging Technologies Team Leader, Office of Operations

National Highway Traffic Safety Administration

Bob Kreeb

Chief of Electronic Systems Safety Division

OST-R/Volpe National Transportation Systems Center

Suzanne Sloan

Principal Technical Advisor, Technology Innovation and Policy

Tom Schaffnit

Operations Research Analyst, Technology Innovation and Policy

Visit the US DOT Safety Band website:

www.transportation.gov/content/safety-band