Consultation Paper No. 08/2026

Telecom Regulatory Authority of India

Consultation Paper on the Regulatory Framework for Vehicle-to-Everything (V2X) Communication

New Delhi, India

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Written comments on the Consultation Paper are invited from stakeholders by 28.05.2026 and counter-comments by 11.06.2026. The comments and counter-comments may be sent, preferably in electronic form, to Shri Akhilesh Kumar Trivedi, Advisor (Networks, Spectrum and Licensing), TRAI on the email ID advmn@trai.gov.in. Comments and counter-comments received from stakeholders will be posted at the TRAI's website (www.trai.gov.in).

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CHAPTER I: INTRODUCTION

A. Introduction

1.1 India stands at a critical juncture in its development, marked by rapid urbanization, economic expansion, and rising aspirations for mobility and logistics services. The transport sector plays a vital role in enabling this transformation, serving as a catalyst for regional integration, industrial competitiveness, and social inclusion. Today, the transport sector in India is one of the key drivers of the economy of the country.[1] India's automotive industry is a cornerstone of the country's manufacturing and economic growth, contributing 7.1% to India's Gross Domestic Product (GDP) and 49% to manufacturing GDP.[2] Given India's vast geography, spanning 3.28 million square kilometers and a population of over 1.4 billion, mobility is not merely a logistical requirement but a strategic necessity.

1.2 The growing economy and rapid urbanization need a robust urban infrastructure for the growth of the domestic automotive sector. One major component of Smart Cities Mission, announced by the Government of India, is creating and developing an efficient urban mobility and public transport system that provides a variety of transport options.[3] By 2023, the road network in India expanded to 67 lakh km, National Highways to 1.46 Lakh km and the PM Gram Sadak Yojana connected 1.63 lakh habitations, improving last-mile connectivity.[4] Supported by the

[1] Source: https://niti.gov.in/sites/default/files/2026-02/Scenarios-Towards-Viksit-Bharat-and-Net-Zero-Sectoral-Insights-Transport.pdf

[2] Source: https://www.pib.gov.in/PressReleasePage.aspx?PRID=2121826&reg=3&lang=2

[3] Source: https://www.grantthornton.in/globalassets/1.-member-firms/india/assets/pdfs/smart-transportation-report.pdf

[4] Source: https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1993425&reg=3&lang=2

Bharatmala Pariyojana, the road freight market crossed USD 150 billion.[5] The road transport has become the most versatile mode of transportation in India both for freight and passengers, keeping in views its level of penetration in populated area.

1.3 However, today, the road safety is a major concern, not only in India but also globally. According to the Global Status Report on Road Safety (2023) issued by the World Health Organization, there were 1.19 million road traffic deaths in 2021.[6] Vulnerable road users — such as pedestrians, cyclists, and motorcyclists — constitute a significant share of these fatalities. The issue is particularly acute in low-income and middle-income countries, which account for nearly 93% of global road deaths despite possessing only about 60% of the world's vehicles. Exposure to adverse traffic environment is high in India because of the unprecedented rate of motorization and growing urbanization fueled by the high rate of economic growth. As a result, incidents of road accidents, traffic injuries and fatalities have remained high. During the calendar year 2023, road crashes in India claimed about 1.73 lakh lives and caused injuries to 4.63 lakh people.[7]

1.4 The United Nation (UN) Sustainable Development Goals (SDGs) link road transport to safer, sustainable mobility.[8] The aim of SDG 3.6 under Goal 3 (Good Health and Well-Being) is "*by 2030, halve the number of global deaths and injuries from road traffic accidents*'" Further the aim of SDG 11.2 is "*by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those*

[5] https://niti.gov.in/sites/default/files/2026-02/Scenarios-Towards-Viksit-Bharat-and-Net-Zero-Sectoral-Insights-Transport.pdf

[6] https://iris.who.int/server/api/core/bitstreams/ae6918d2-917f-42c4-a926-2d534a333ef3/content

[7] https://morth.nic.in/sites/default/files/Road-Accident-in-India-2023-Publications.pdf

[8] Transforming our world: the 2030 Agenda for Sustainable Development https://sdgs.un.org/2030agenda#:~:text=Goal%203.%20Ensure%20healthy%20lives%20and%20promote

in vulnerable situations, women, children, persons with disabilities and older persons".

1.5 Approximately 92 percent of road accidents are often attributed to failures in human recognition (e.g., driver disregard, insufficient surveillance, and drivers' distraction) and human decision mistakes (e.g., too fast driving, delayed reactions, and misjudging of the safety distance). Moreover, even with the development of various safety-oriented techniques in vehicle, such as anti-locking braking systems (ABS), seatbelts, airbags, and rear-view cameras etc., many people die annually from road traffic accidents. The transport sector also contributes significantly to the country's energy use and emissions, accounting for 20% of energy demand and around 10% of greenhouse gas (GHG) emissions in year 2020.[9] Therefore, the reduction of vehicle accidents and the continuous optimization of transportation system ask urgently to provide a vehicular communication network that enables vehicles to communicate with roadside infrastructure and among them to exchange and share their data, thereby avoiding traffic congestion and leading to the achievement of an Intelligent Transportation system (ITS).[10]

Intelligent Transport System

1.6 The evolution of Intelligent Transport Systems (ITS) spans over 150 years, beginning with rudimentary traffic control and advancing to today's artificial intelligence (AI)-driven networks. The conceptual origins trace back to 1868, when the first traffic control system was implemented in London using gas-powered red and green lights to manage horse-drawn

[9] NITI Ayog, Sectoral Insight: Transport, https://www.niti.gov.in/sites/default/files/2026-02/Scenarios-Towards-Viksit-Bharat-and-Net-Zero-Sectoral-Insights-Transport.pdf

[10] Hussein, N. H., Yaw, C. T., Koh, S. P., Tiong, S. K., & Chong, K. H. (2022). A comprehensive survey on vehicular networking: Communications, applications, challenges, and upcoming research directions. *Ieee Access*, *10*, 86127-86180.

carriages and pedestrians.[11] The development of electric traffic lights in 1912 by police officer Lester Wire in Salt Lake City of the USA marked a crucial advancement, using electricity to power red and green lights with a buzzer to indicate signal changes, eliminating the dangers of gas-powered systems.[12]

1.7 The rapid evolution in Information Technology (IT), sensors, geo-location and communication technologies led to the development of Intelligent Vehicle-Highway Systems (IVHS) for better transportation management. In 1994, this was renamed as Intelligent Transportation System (ITS).[13]

1.8 ITS capabilities have progressively expanded through successive technological waves, beginning with computerized traffic signal control, variable message signs, ramp metering, traffic sensors, and centralized traffic management centers that enabled coordinated, corridor-level operations. This foundation evolved with the integration of information and communication technologies, introducing GPS-based navigation, electronic toll collection, mobile data-driven traffic monitoring, and real-time traveler information services. Subsequent advancements focused on connected and automated mobility, enabled by vehicle automation, and cooperative ITS.

1.9 According to European Telecommunications Standards Institute (ETSI), "*Intelligent Transportation Systems (ITS) aim to provide services relating to different modes of transport and traffic management, enable users to be better informed and make safer, more coordinated and 'smarter' use*

[11] Avcı, İ.; Koca, M. Intelligent Transportation System Technologies, Challenges and Security. Appl. Sci. 2024, 14, 4646. https://doi.org/10.3390/app14114646

[12] https://miovision.com/traffic-signal-technology-evolution/

[13] Rammohan, A. (2023). Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) technology: Current trends, use cases, emerging technologies, standardization bodies, industry analytics and future directions. *Vehicular Communications*, *43*, 100638.

of transport networks. They include advanced telematics and hybrid communications including IP based communications as well as Ad-Hoc direct communication between vehicles and between vehicles and infrastructure."[14]

1.10 As per International Telecommunication Union (ITU), ITS is a system to support transportation of goods and humans with information and communication technologies in order to efficiently and safely use the transport infrastructure and transport means (cars, motorcycles, bicycles, trains, planes, ships, and other) as visualized in the following figure:

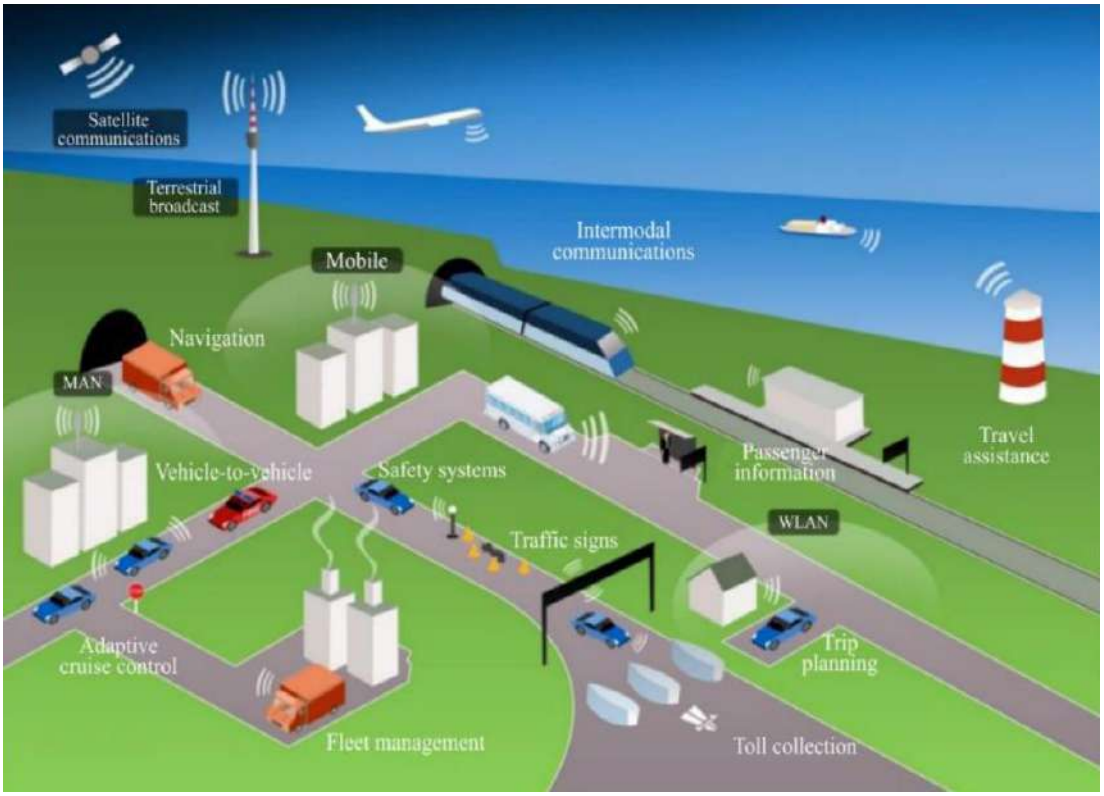


Figure 1.1: Communication technologies and services for ITS (source: ITU-R M.2445-0)[15]

1.11 A core enabler of ITS is Vehicle-to-Everything (V2X) communication

[14] https://www.etsi.org/technologies/automotive-intelligent-transport

[15] https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-Y.2281-201101-I!!PDF-E&type=items

technology. V2X enables vehicles to wirelessly exchange real-time information with every relevant element of their environment. This includes other vehicles (V2V), roadside infrastructure such as traffic signals and toll booths (V2I), vulnerable road users like pedestrians and cyclists (V2P), and the broader cellular network (V2N). V2X technology was traditionally implemented in many parts of the world using the Dedicated Short-Range Communication (DSRC) standard. More recently, the Cellular V2X (C-V2X) standard has been gaining global prominence as the preferred framework for enabling V2X communication.

B. DoT's Reference Dated 01.12.2025

1.12 Department of Telecommunications (DoT), Ministry of Communications, Government of India, through its letter dated 01.12.2025 (**Annexure-I**), requested Telecom Regulatory Authority of India (hereinafter, also referred to as "TRAI", or "the Authority") to give recommendations under clause 11(1)(a) of TRAI Act, 1997 on the regulatory mechanism for Vehicle-to-Everything (V2X). The relevant extract of the reference is reproduced below:

"A Task Force constituted by Ministry of Road Transport and Highways (MoRTH) to give recommendation on industry standards, technical parameters, and frequency usage for Vehicle-to-Everything (V2X)/ Intelligent Transport System (ITS), gave its Part-1 report in May 2025. After examination of the report, DoT has, in-principle, agreed to the following:

i. C-V2X may be adopted as the harmonized Intelligent Transport System (ITS) technology for India.

ii. 30 MHz spectrum (5875-5905 MHz) may be allocated for the initial deployment of C-V2X technology, while the remaining 20 MHz (5905-5925 MHz) may be reserved for future ITS

applications, thereby retaining flexibility for evolving standards and innovations.

iii. *License-exempt use of On-Board Units (OBUs) may be permitted under defined technical conditions, while authorization may be required for Roadside Units (RSUs) to ensure coordinated deployment and effective interference management.*

2. In this context, it is pertinent to refer to IND29 footnote of NFAP-2025, which states that "the frequency band 5875 to 5925 MHz may be used for V2X/ ITS under Mobile service. This does not preclude the use of this frequency bands for other allocated services."

2.1 Further, it is mentioned that First Schedule of the Telecommunication Act, 2023 lists entries eligible for administrative frequency assignment, including the safety and operation of transport systems. Additionally, the DoT charging order dated 11 .12.2023 contains provisions for calculating spectrum charges.

3. However, considering the large-scale impact of ITS on the transport sector of the country, TRAI is requested to provide recommendations on the following, under the terms of clause 11(1)(a) of the TRAI Act, 1997 as amended:

i. *Regulatory mechanism (spectrum assignment, authorization and pricing) for Roadside Units (RSUs);*

ii. *Any other recommendations relevant to the issue."*

1.13 Hereinafter, the DoT's letter dated 01.12.2025 mentioned above shall also be referred to as "the Reference dated 01.12.2025".

1.14 Subsequently, TRAI, through its letter dated 20.02.2026, requested DoT to provide a copy of the DoT's report titled 'Report by the Committee on V2X/ ITS Policy formulation' dated 20.01.2023', any subsequent report (after the Part-I report) of the Task Force constituted by MoRTH, and any other communication received from Ministry of Road Trasport and Highways (MORTH) relevant to the matter. In response, DoT, through its letter dated 05.03.2026, provided a copy of DoT's report by the committee on V2X/ ITS policy formulation dated 20.01.2023, and final report of the Task Force, apart from the communications received from MoRTH related to the matter.

C. The Present Consultation Paper

1.15 In this context, this consultation paper has been prepared to solicit comments from stakeholders on the regulatory mechanism for Vehicle-to-Everything (V2X) communication. This chapter provides an introduction and background information about the subject. Chapter II discusses V2X technologies and global perspective on the matter. Chapter III examines the issues related to the service authorisation framework and assignment of spectrum. Chapter IV discusses the issues related to spectrum charges and other financial conditions. Chapter V summarizes the issues for consultation.

CHAPTER II:
V2X TECHNOLOGIES AND GLOBAL PRACTICES

2.1 This chapter outlines the important aspects of V2X technologies and global practices on the use of V2X technologies.

A. Vehicle-to-Everything (V2X) Ecosystem

2.2 Vehicle-to-everything (V2X) technology enables vehicles to communicate with each other, with other road users such as pedestrians and cyclists, with networks and with roadside infrastructure. Deployments utilizing V2X technologies have demonstrated the safety benefits on a smaller scale. However, to realize the full lifesaving potential of V2X technology will require vehicles and infrastructure to communicate safely, securely and without harmful interference across a variety of devices and platforms."[16]

2.3 Vehicle-to-Everything (V2X) technology has been developed to empower full connectivity, the efficient and accurate information communications among the vehicles and their surrounding vehicles, pedestrians, transportation infrastructure, and network/ cloud infrastructure platforms. On one hand, V2X can improve the driving safety and reduce accident rates by exchanging real-time and effective information about the vehicles and the surrounding environments. The driver (human driver or vehicle controller) can be notified to identify the dangerous situation in advance, which can improve driving safety and reduce accident rates. On the other hand, integrated with Big Data and Artificial Intelligence (AI) and other new technologies, the typical problems such as traffic jams can be solved with the real-time data collection and analysis of vehicles and road

[16] https://unece.org/sites/default/files/2024-6/ITS%20for%20sustainable%20Mobility_E_pdf_web.pdf

infrastructures through V2X by reasonable driving planning from a global perspective.[17]

2.4 In the future, V2X will realize multiple types of communications, such as:

(a) Vehicle-to-Vehicle (V2V): It refers to exchange of information using short-range and/ or direct communications between vehicles located in close proximity to each other.[18]

(b) Vehicle-to-Infrastructure (V2I): It is the exchange of data using short-range and/ or direct communications between a vehicle and roadside infrastructure (e.g. traffic lights).

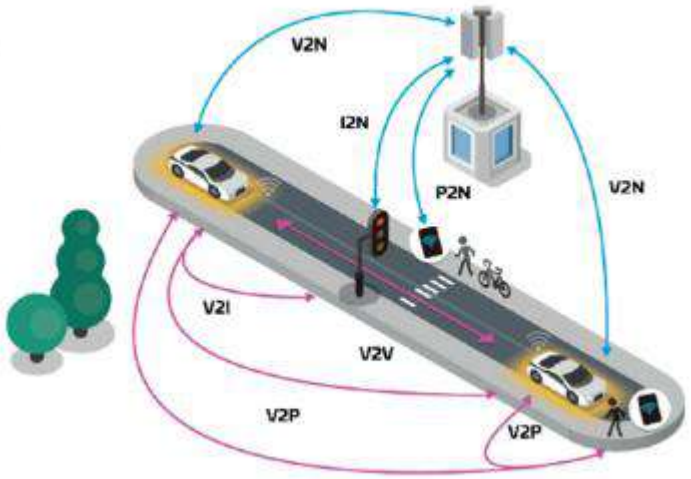
(c) Vehicle-to-Pedestrian (V2P): It is the exchange of information using short-range and/ or direct communications between vehicles and mobile devices carried by a Vulnerable Road User (VRU) such as pedestrian (or cyclist, or pets, or driver/passenger of another vehicle via short-range communication).

(d) Vehicle-to-Network (V2N): It is the exchange of information using long-range communications between a vehicle and mobile network or Internet-based cloud services (e.g. a backend remote server in the network, to obtain additional services such as map updates, fleet-based data collection, and automotive cloud services).

2.5 These interactions, collectively referred to as V2X, are essential for deploying a connected transport network that is dynamically responsive to ever-changing conditions and helps in improving road safety. A pictorial representation of different types of communications in V2X is given below.

[17] Chen, S., Hu, J., Zhao, L., Zhao, R., Fang, J., Shi, Y., & Xu, H. (2023). *Cellular vehicle-to-everything (C-V2X)*. Berlin/Heidelberg, Germany: Springer Nature.

[18] Fallgren, M., Dillinger, M., Mahmoodi, T., Svensson, T., & Wiley, J. (Eds.). (2021). *Cellular V2X for connected automated driving* (Vol. 270, pp. 63-90). Hoboken, NJ, USA: Wiley.



V2V: Vehicle to Vehicle
V2P: Vehicle to Pedestrian
V2I: Vehicle to Infrastructure
P2N: Pedestrian to Network
V2N: Vehicle to Network
I2N: Infrastructure to Network

Figure 2.1: Different types of communications in V2X (Source 5GAA)

2.6 The following figure depicts a block diagram of V2X ecosystem.

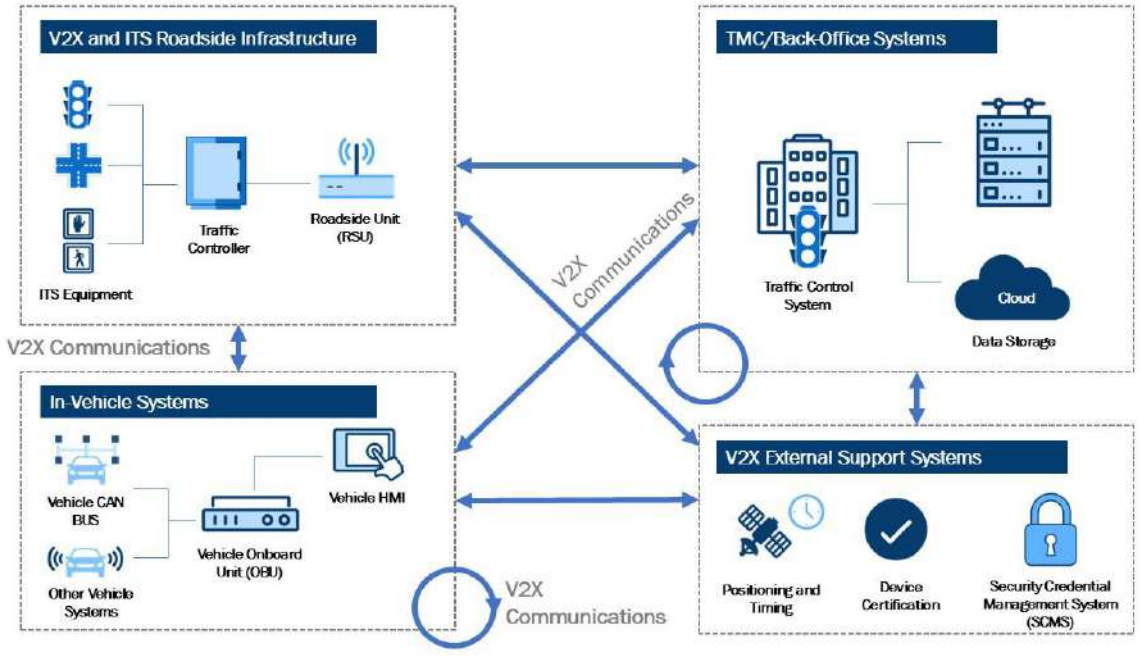


Figure 2.2: V2X Ecosystem (Source: USDOT)

B. Use cases of V2X

(1) Vehicle to Vehicle Communication

2.7 Vehicle-to-vehicle communication (V2V communication) is the wireless transmission of data between motor vehicles. The goal of V2V communication is to prevent accidents by allowing vehicles in transit to send position, speed data and panic information to one another over an ad-hoc mesh network. Depending upon how the technology is implemented, the vehicle's driver may simply receive a warning should there be a risk of an accident or the vehicle itself may take pre-emptive actions such as breaking down to slow down. An illustrative list of potential V2V safety services is given below:

(a) **Control Loss Warning**: The Control Loss Warning (CLW) system is a cooperative safety application designed for connected vehicles[19]. Its purpose is to improve road safety by allowing a vehicle to automatically broadcast a message when it detects that the driver has lost control — for example, due to skidding, hydroplaning, or sudden mechanical failure.

(b) **Pre-crash Actions**: The Pre-crash Actions (PCA) application enables a vehicle to mitigate the injuries in a crash by activating countermeasures in the vehicle when a crash is about to happen.

(c) **Vehicle Emergency Response**: The Vehicle Emergency Response (VER) application provides public safety vehicles with information from connected vehicles involved in a crash. Emergency responders need information about the vehicles involved in a crash to respond safely and effectively to the vehicle crash.

[19] (i) Connected Vehicle (CV). A vehicle is referred to as a CV if V2X radiocommunication equipment is mounted and an Advanced ITS application is supported by using cooperative V2X connectivity.
(ii) Automated Vehicle (AV). A vehicle is referred to as an AV if in-vehicle perception sensors like automotive radar, camera, lidar are mounted and automated driving applications are supported using those sensors only.
(iii) Connected Automated Vehicles (CAV). A vehicle is referred to as a CAV if in-vehicle perception sensors and V2X radiocommunication equipment are mounted and automated driving applications are supported using both in-vehicle perception sensors and cooperative V2X connectivity.
Source: ITU-R M.2534-0

(d) **Panic button**: It alerts the nearby vehicles in case of a panic within the vehicle.

(e) **Motorcycle Approaching Indication**: The Motorcycle Approaching Indication application is intended to warn the driver of a vehicle that a motorcycle is approaching. The motorcycle could be approaching from behind or crossing at an intersection.

(2) Vehicle to Infrastructure Communication

2.8 Vehicle-to-Infrastructure (V2I) Communications for Safety is the wireless exchange of critical safety and operational data between vehicles and roadway infrastructure, intended to avoid motor vehicle crashes, optimize traffic, exchange content, enforce pollution norms. V2I applications include Red Light Violation Warning, Curve Speed Warning, pollution under control check etc. The utility of V2I also enables safety applications designed to avoid or mitigate vehicle crashes, particularly for crash scenarios not addressed by V2V communications alone. An illustrative list of potential V2I safety services is given below:

(a) **Red Light Violation Warning**: The Red-Light Violation Warning (RLVW) application enables a connected vehicle approaching an instrumented signalized intersection to receive information from the infrastructure regarding the signal timing and the geometry of the intersection.

(b) **Curve Speed Warning**: Curve-speed warning (CSW) technology helps drivers to identify potentially dangerous situations if a bend in the road is taken too fast and warn the driver in advance allowing him time to react properly.

(c) **Stop Sign Gap Assist**: The Stop Sign Gap Assist (SSGA) safety application is intended to improve safety at non-signalized intersections where only the minor road has posted stop signs.

(d) **Reduced Speed Zone Warning**: The Reduced Speed Zone

Warning (RSZW) provides connected vehicles which are approaching a reduced speed zone with information on the zone's posted speed limit and/or if the configuration of the roadway is altered (e.g., lane closures, lane shifts).

(e) **Spot Weather Information Warning**: The Spot Weather Information Warning (SWIW) application will alert drivers to unsafe conditions or road closure at specific points on the downstream roadway as a result of weather-related impacts, which include, but are not limited to high winds, flood conditions, ice, or fog.

(f) **Stop Sign Violation Warning**: The Stop Sign Violation Warning (SSVW) safety application is intended to improve safety at no signal intersections with posted stop signs by providing warnings to the driver approaching an intersection with no signal.

(g) **Railroad Crossing Violation Warning**: The Railroad Crossing Violation Warning (RCVW) application will alert and/or warn drivers who are approaching an at-grade railroad crossing if they are on a crash-imminent trajectory to collide with a crossing or approaching train.

(h) **Oversize Vehicle Warning**: The Oversize Vehicle Warning (OVW) application uses external measurements taken by the roadside infrastructure, and transmitted to the vehicle, to support in-vehicle determination of whether an alert/warning is necessary. Specifically, the infrastructure data detects and measures the approaching vehicle's height and width.

(3) Vehicle to Pedestrian communication

2.9 Pedestrians, cyclists, and motorized two-wheeler operators are called Vulnerable Road Users (VRUs). Vehicle-to-pedestrian (V2P) directly connects vehicles to pedestrians equipped with compatible mobile devices to issue alerts about potential dangers nearby. V2P communication enables

collision avoidance and other safety protection for vulnerable traffic participants. Safety applications are the V2P crash prevention systems. There may be multiple V2P safety applications that may each address different types of VRU, pre-crash scenarios, and vehicles. There have also been efforts to deploy applications for specific groups of pedestrians and vehicles.[20] The protection of VRUs, and pedestrians in particular, is one of the most relevant use cases for safety applications for the connected vehicles.

(4) Vehicle to Network communication

2.10 V2N uses network-based communication via conventional cellular links between vehicles and the cellular network, enabling vehicle-to-network and vehicle-to-cloud applications such as traffic management services, backend connectivity, and software updates. V2N supports a significantly broader and richer set of use cases than direct PC5-based[21] communications. V2N encompasses communication between the vehicle and the server via 4G/ 5G networks, such as for traffic operations, and road operators can leverage spectrum owned by mobile operators to deliver V2N data exchange in providing traffic management services based on local or aggregated V2V and V2I data. V2N use cases include fleet management, streaming media for entertainment and connectivity for dynamic route management etc.

2.11 The following figure depicts the evolution of the use-cases of V2X in the progressive releases of 3GPP.

20 https://pmc.ncbi.nlm.nih.gov/articles/PMC6359035/?utm

[21] PC5 refers to the 3GPP Proximity Services (ProSe) interface. It is the radio interface used for direct sidelink communication in Cellular Vehicle-to-Everything (C-V2X) technology, allowing vehicles, infrastructure, and pedestrians to communicate directly without needing a cellular network.

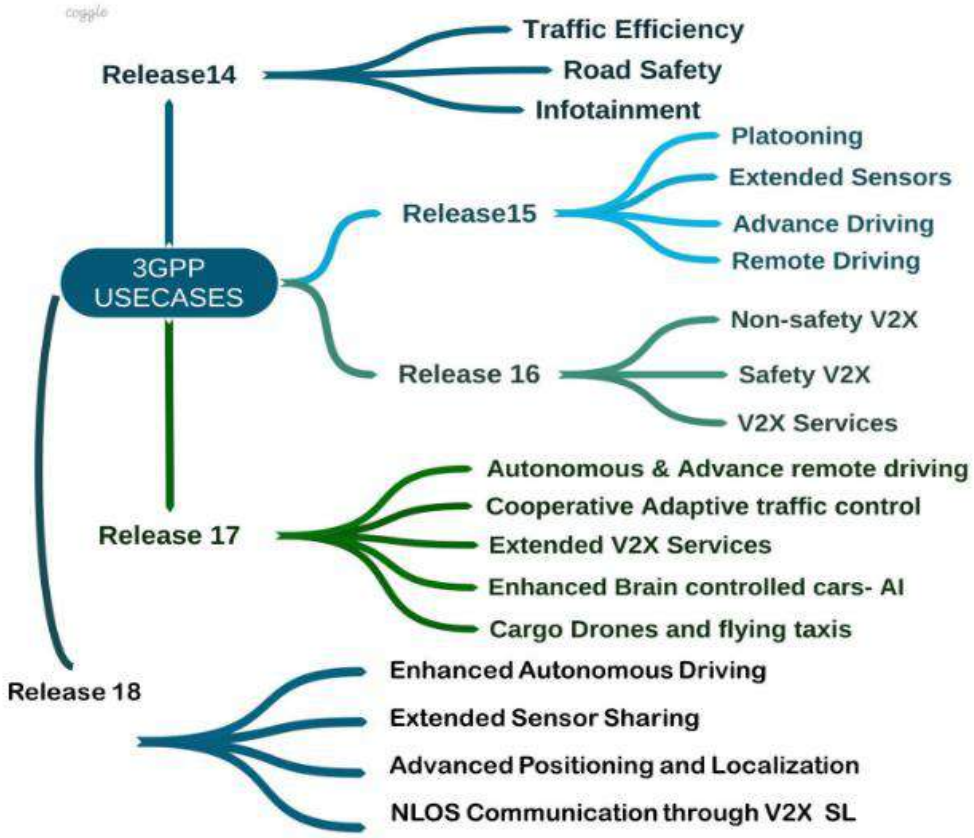


Figure 2.3: Evolution of use cases of C-V2X[22]

C. Types of Connected Vehicle Applications

2.12 There are three main categories for connected vehicle applications:[23]

(a) **Road safety**: These are the applications that assist in the protection of vehicles, their occupants, and other road users. A special case is the protection of Vulnerable Road Users (VRUs), i.e., users not

[22] Pawar, V., Zade, N., Vora, D., Khairnar, V., Oliveira, A., Kotecha, K., & Kulkarni, A. (2024). Intelligent transportation system with 5G vehicle-to-everything (V2X): Architectures, vehicular use cases, emergency vehicles, current challenges, and future directions. *IEEE Access*, *12*, 183937-183960

[23] https://e-archivo.uc3m.es/rest/api/core/bitstreams/a06d6284-2980-4e74-9971-2f1eb590e07f/content

protected by a vehicle body, such as pedestrians, cyclists and motorcyclists.

(b) **Traffic efficiency**: These applications are the ones that improve efficiency in the use of vehicles. These applications can help save fuel, travel time, or make a better use of roads to serve more users with the same infrastructure. In some cases, there is an overlap between this category and the previous one: for example, an application that facilitates vehicles merging onto a road improves both safety and efficiency.

(c) **Others**: Certain applications such as, for example, convenience applications, and access to information or entertainment (infotainment applications).

2.13 The following table depicts different types of V2X communication to support vehicular applications.

Table 2.1: Different types of V2X communications to support vehicular applications[24]

V2X communication types	Category	Example applications
V2V periodic messages	Road Safety	Cooperative collision warning Intersection movement assistance Slow vehicle warning Cooperative glare reduction Collective perception
	Traffic Efficiency	Cooperative Adaptive Cruise Control Platooning
	Convenience	Stolen vehicle alert
V2V event-driven messages	Road Safety	Stationary vehicle warning Emergency electronic brake lights Queue/Traffic jam ahead warning Road condition warning
	Traffic Efficiency	Platooning (braking/join/leave)
V2V bi-directional communication	Road Safety	See-through
	Convenience	Instant messaging
V2V multi-hop	Safety/Efficiency	Coverage extension of ITS messages
V2P periodic messages	Road Safety	Pedestrian collision warning to vehicles Vehicle collision warning to pedestrians
V2I periodic messages	Road Safety	In-vehicle signage Curve speed warning
	Traffic Efficiency	Green Light Optimized Speed Advisory
V2I event-driven messages	Road Safety	Infrastructure based collision warning Warning of vulnerable road user presence Infrastructure based traffic jam ahead warning Infrastructure based road condition warning Roadwork warning
	Traffic Efficiency	Emergency vehicle signal preemption
RSU-relayed messages	Safety/Efficiency	RSUs receive ITS messages and broadcast them to extend their reach RSUs receive ITS messages and send them to a server (e.g., traffic control center)
V2N bi-directional communication	Safety/Efficiency	Dynamic map download and update
	Convenience	Remote driving Media downloading Point of interest notification Payment services Stolen vehicle alert (warn service provider) Secure software updates for vehicles

D. V2X Communication Technologies

2.14 Two alternative access layer technologies for ITS have been defined by the Institute of Electrical and Electronics Engineers (IEEE) and the Third Generation Partnership Project (3GPP), respectively. The first approach is **Dedicated Short Range Communication (DSRC)**, which supports

[24] Soto, I., Calderon, M., Amador, O., & Urueña, M. (2022). A survey on road safety and traffic efficiency vehicular applications based on C-V2X technologies. *Vehicular Communications*, *33*, 100428.

vehicular ad-hoc connectivity Wireless Local Area Network (WLAN) technologies standardized as IEEE 802.11p. The second approach is **Cellular-based V2X (C-V2X)**, standardized by the 3GPP, based on Long-Term Evolution (LTE), also known as LTE-V2X. More recently, New Radio (NR) V2X has been specified in Release 16 (Rel-16) as a complementary access technology defined to better serve sophisticated applications and use cases with more stringent requirements (e.g. platooning, advanced driving, etc.)[25]

2.15 DSRC-based V2X communications provides a number of benefits such as low end-to-end latency, ad-hoc communications and standardized protocols. However, it faces a number of issues such as short-range, large channel access delay and huge capital investments. Thus, despite the deployment of DSRC based V2X in a few countries, the inherent issues of DSRC and the recent growth in cellular technologies have encouraged research and industry communities to investigate cellular technology based V2X communications. Cellular communications such as LTE provide ubiquitous coverage, support very high mobility as well as the high number of vehicles in a cell. Moreover, the introduction of Device-to-Device (D2D) communications further improved spectrum utilization efficiency and system capacity of cellular systems. This motivated organizations like the 3rd Generation Partnership Project (3GPP) to study the feasibility of LTE support for V2X communications.[26]

2.16 The following Table provides a comparison between DSRC and C-V2X technologies.

[25] Garcia-Roger, D., González, E. E., Martín-Sacristán, D., & Monserrat, J. F. (2020). V2X support in 3GPP specifications: From 4G to 5G and beyond. *IEEE access*, *8*, 190946-190963.

[26] Gyawali, S., Xu, S., Qian, Y., & Hu, R. Q. (2020). Challenges and solutions for cellular based V2X communications. *IEEE Communications Surveys & Tutorials*, *23*(1), 222-255.

Table 2.2: Comparison between DSRC and C-V2X

Parameter	DSRC (Dedicated Short-Range Communications)	C-V2X (Cellular Vehicle-to-Everything)
Standardization/Origin	Based on IEEE 802.11p/ WAVE/ ITS-G5 WLAN technology	Based on 3GPP LTE V2X (Rel-14/ 15) and evolving 5G NR V2X (Rel-16+)
Underlying Technology	Wi-Fi-like (802.11p)	Cellular LTE/5G technology with sidelink PC5 & network Uu modes
Operating Frequency	5.9 GHz ITS band	5.9 GHz ITS band for PC5 plus cellular bands for network modes
Communication Mode	Direct (vehicle-to-vehicle & vehicle-to-infrastructure)	Direct + cellular network support (V2V, V2I, V2P via PC5; V2N via cellular)
MAC/Access Scheme	CSMA/CA (carrier sense, contention-based)	Semi-persistent scheduling / cellular resource allocation
Network Dependency	Standalone (no cellular needed)	Can work standalone (PC5) and with cellular infrastructure (Uu)
Evolution Path	802.11p ->new IEEE 802.11bd	3GPP LTE → 5G NR → future 6G

E. 3GPP Specifications for C-V2X

2.17 The support for 3GPP C-V2X was developed by introducing enhancements with evolving 3GPP Releases. LTE V2X is from Release 14 to Release 15, and NR V2X is from Release 16 to the current Release 18 and the future Releases.[27]

2.18 **Rel-14** is the first 3GPP standard introducing 4G enhancements for V2X communications. The technical backbone of Release 14 V2X is the LTE PC5 sidelink interface, evolved from the Device-to-Device (D2D) proximity services work introduced in Releases 12 and 13. The PC5 interface enables direct short-range communication between vehicles and other road users without routing traffic through the network, while the Uu interface connects vehicles to the eNodeB for network-assisted and cloud-based services.

2.19 **Rel-15**, completed in June 2018, introduced enhanced V2X (eV2X), moving beyond Rel-14's broadcast-only model to support unicast and groupcast sidelink communication, enabling coordinated maneuvers between specific vehicles. It refined the PC5 interface with improvements to resource allocation, link adaptation, and a more sophisticated QoS framework that prioritizes message types based on latency and reliability needs.

2.20 **Rel-16**, completed in July 2020, marked a major leap in V2X standardization by introducing NR V2X (New Radio V2X), moving the sidelink from an LTE-based design to a full 5G NR air interface. Rel-16 extends 5G specifications in two broad aspects: i) building up the 5G architecture; ii) offering support for new specific service functionalities, putting a special focus on key selected use cases that are expected to be

[27] https://www.tec.gov.in/pdf/M2M/TR_Technologies%20and%20Standards%20for%20Intelligent%20Transport%20System.pdf

essential for the deployments of industry verticals such as V2X. Rel-16 defines the 5G supporting role for advanced V2X services and vehicle QoS support, as well as coexisting NR and LTE sidelink.[28]

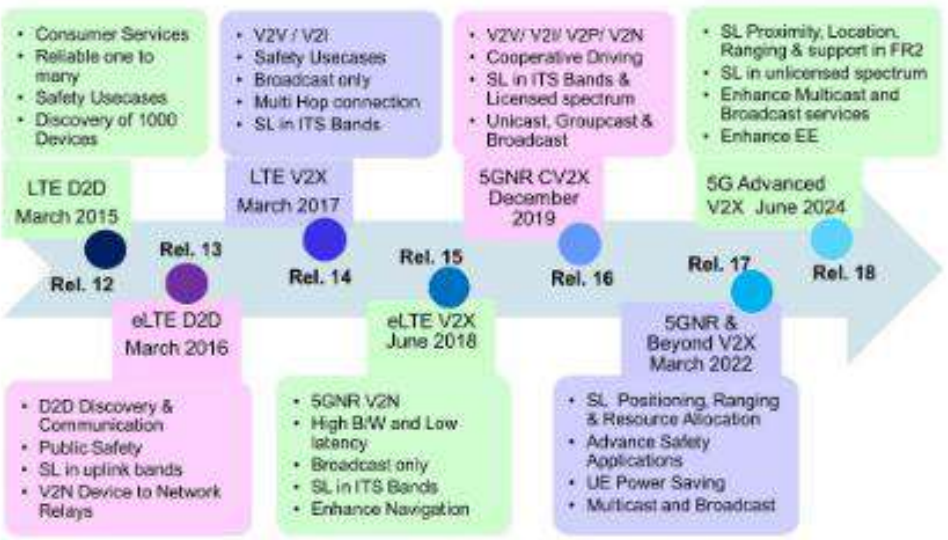
2.21 **In Rel-17**, completed in Q2-2022, 3GPP extends the flexibility of the cellular technologies into an expanding number of vertical industries. 3GPP Release 17 has added further V2X enhancements, e.g., power, efficiency, better latency, enhanced reliability, and improved ranging and positioning.

2.22 **Rel-18:** The 3GPP Release 18, frozen in 2024, essentially matures NR-V2X from a foundational technology (Rel-16) through reliability/power improvements (Rel-17) into a high-throughput, high-precision, and spectrum-flexible platform-critical for the next generation of ADAS and autonomous driving applications. It enhances Side Link (SL) support and brings major enhancements of earlier 4G modules to V2X with SL, proximity, location, ranging, multicast and broadcast services.

2.23 The following figure depicts a summary of the evolution of V2X in various 3GPP releases.

[28] Garcia-Roger, D., González, E. E., Martín-Sacristán, D., & Monserrat, J. F. (2020). V2X support in 3GPP specifications: From 4G to 5G and beyond. *IEEE access*, *8*, 190946-190963.

Table 2.3: Evolution of V2X in 3GPP Releases[29]



2.24 In 3GPP Specifications, V2V and V2I are facilitated using PC5 interface, and V2N operates over the Uu interface. The V2V and V2I communication links use the globally harmonized frequency band at 5.9 GHz, while V2N communication links utilizes existing cellular networks, as further illustrated in the figure below:

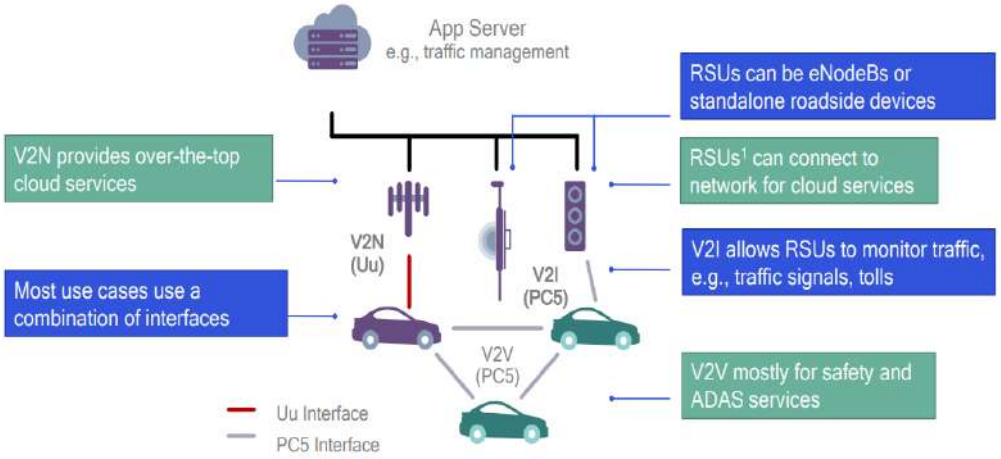


Figure 2.4: V2V, V2I, V2N Interface (Source: TEC 31218:2023)

[29] Pawar, V., Zade, N., Vora, D., Khairnar, V., Oliveira, A., Kotecha, K., & Kulkarni, A. (2024). Intelligent transportation system with 5G vehicle-to-everything (V2X): Architectures, vehicular use cases, emergency vehicles, current challenges, and future directions. *IEEE Access*, *12*, 183937-183960.

2.25 From a system implementation perspective, the key elements of a V2X communication system for ITS comprise of OBUs and RSUs as outlined below:

(a) **On-Board Units (OBUs):** These devices are installed in vehicles to enable communication with other vehicles and infrastructure.

(b) **Roadside Units (RSUs):** These are installed along the roads to facilitate communication between vehicles and transportation infrastructure.

2.26 The integration of these elements forms the backbone of an effective ITS, providing the necessary infrastructure for enhanced safety, real-time traffic management, and improved mobility solutions. A V2X network Architecture diagram is shown as below:

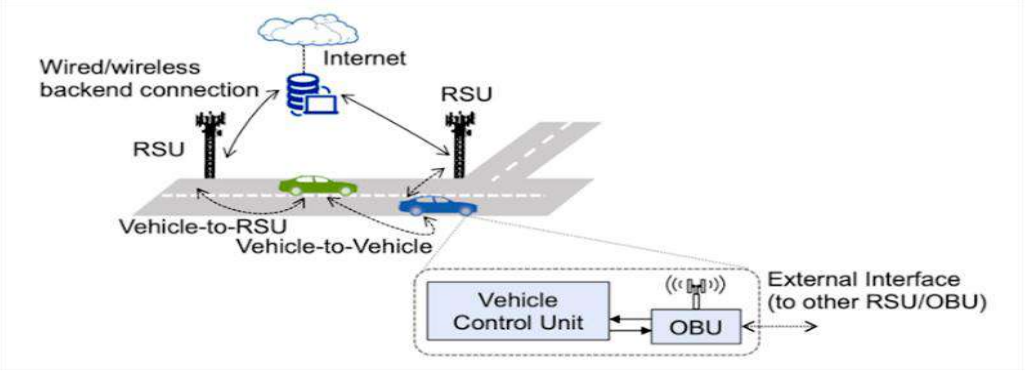


Figure 2.5: Network Architecture of V2X[30]

[30] https://ieeexplore.ieee.org/document/9068410

F. Societal Implications of C-V2X[31]

2.27 The key societal benefits of C-V2X can be understood across the following dimensions:

(a) **Improved Road Safety:** One of the primary motivations for C-V2X research is to enhance road safety. By allowing vehicles to exchange real-time information, such as location, speed, and status, C-V2X enables advanced safety applications like collision avoidance, intersection management, and emergency vehicle warning systems. This technology has the potential to greatly reduce accidents, injuries, and fatalities on the road.

(b) **Increased Traffic Efficiency:** C-V2X technology can significantly improve traffic flow and efficiency. By enabling vehicles to communicate with traffic infrastructure, traffic signals, and other vehicles, C-V2X can optimize traffic patterns, reduce congestion, and enhance overall transportation system performance. This can lead to shorter travel times, reduced fuel consumption, and improved air quality in urban areas.

(c) **Enhanced Autonomous Driving:** C-V2X plays a crucial role in the development of autonomous vehicles. By providing vehicles with real-time situational awareness through communication with other road users and infrastructure, C-V2X can enhance the decision-making capabilities of autonomous vehicles. This application can reduce the travel delay and more importantly it will bring sustainable transportation.

(d) **Integration with Smart Cities:** C-V2X research aligns with the broader concept of smart cities, where various technologies are integrated to create more sustainable and efficient urban

[31] Rammohan, A. (2023). Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) technology: Current trends, use cases, emerging technologies, standardization bodies, industry analytics and future directions. *Vehicular Communications*, *43*, 100638.

environments. C-V2X can be integrated with intelligent transportation systems, smart infrastructure, and other urban mobility solutions to enable seamless communication and coordination. This integration can improve traffic management, public transportation, emergency response, and overall quality of life in cities.

G. Global Perspectives on ITS/ V2X

(1) ITU

2.28 ITU, in its recommendation ITU-R M.2121-1[32] on harmonization of frequency bands for Intelligent Transport Systems in the mobile service, recommended that Administrations should consider using the frequency band 5,850-5,925 MHz, or parts thereof, for current and future ITS applications, highlighting the following benefits of harmonization:

(a) increased potential for transportation operations, especially cross-border;

(b) a broader manufacturing base and increased volume of equipment resulting in economies of scale and expanded equipment availability;

(c) improved spectrum management and planning.

2.29 WTSA Resolution 104[33], adopted at the World Telecommunication Standardization Assembly in New Delhi in October 2024, aims at promoting and strengthening ITU-T standardization activities for vehicular communications, including V2X, ITS, and connected and automated vehicles (CAV). Recalling UN SDGs on road safety, energy efficiency, and sustainable transport, the Resolution recognizes that V2X and ITS will enhance road safety, improve traffic efficiency, reduce carbon emissions,

[32] ITU recommendation ITU-R M.2121-1 https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2121-1-202312-I!!PDF-E.pdf

[33] Resolution 104 – Promoting and strengthening standardization activities for vehicular Communications https://www.itu.int/dms_pub/itu-t/opb/res/T-RES-T.104-2024-PDF-E.pdf

and accelerate digital economic development, particularly in developing countries.

(2) USA

2.30 In October 1999, The Federal Communications Commission (FCC), USA adopted the DSRC Report and Order (FCC 99-305, 14 FCC Rcd 18221), allocating the 5.850–5.925 GHz band on a primary basis to the Mobile Service for use by Dedicated Short Range Communications (DSRC)-based ITS operations.[34] On December 17, 2003, the Commission adopted a Report and Order establishing licensing and service rules for the Dedicated Short Range Communications (DSRC) Service in the ITS Radio Service in the 5.850–5.925 GHz band. The 2003 Report and Order established a two-part licensing regime: vehicle-mounted and portable OBUs were licensed by rule under Part 95 of the Commission's rules, while fixed RSUs were individually licensed under Part 90.

2.31 After 20 years of reserving the entire 5.9 GHz band for DSRC, the FCC in November 2019 released a Notice of Proposed Rulemaking (NPRM) (FCC 19-129, 34 FCC Rcd 12603) under new docket ET Docket No. 19-138, announcing a 'fresh look' at the optimal use of the 75 MHz in the 5.9 GHz band. The NPRM was driven by four converging factors: (1) exponentially growing demand for unlicensed spectrum for next-generation Wi-Fi (IEEE 802.11ax), which could use the 5.9 GHz band as a 'channel extension' to create a continuous 160 MHz block; (2) near-zero deployment of DSRC-based ITS despite 20 years of exclusive spectrum access; (3) recognition that vehicular safety features were increasingly being provided by other technologies (optical cameras, LiDAR, sonar, and emerging C-V2X); and

[34] FCC, Report and Order (FCC 99-305), 'Amendment of Parts 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services,' ET Docket No. 98-95, 14 FCC Rcd 18221 (October 21, 1999).
The report is available at the following URL:https://docs.fcc.gov/public/attachments/FCC-99-305A1.pdf

(4) rising industry and international momentum behind C-V2X as a technically superior alternative.[35]

2.32 On November 20, 2020, the Commission released the 5.9 GHz First Report and Order, Further Notice of Proposed Rulemaking (FNPRM), and Order of Proposed Modification (FCC 20-164, 35 FCC Rcd 13440), adopting the fundamental restructuring of the 5.9 GHz band. The First Report & Order took three major actions:

(a) Band Restructuring: The Commission designated the lower 45 MHz (5.850–5.895 GHz) for unlicensed operations, creating the new U-NII-4 band. Simultaneously, it retained the upper 30 MHz (5.895–5.925 GHz) exclusively for ITS operations. All existing ITS licenses covering the full 75 MHz were modified to permit operation only in the upper 30 MHz portion of the band.

(b) Technology Transition: The Commission required ITS operations in the upper 30 MHz to transition from DSRC to C-V2X, describing this as converting the ITS band to use 'cellular vehicle-to-everything (C-V2X) based technology as the connected mobility platform for implementing the future of ITS communications in the United States. In taking this step, the Commission concluded that 'only a single technology is appropriate' for the ITS band and that C-V2X should be that technology.

(c) DSRC Continuation and Waiver Pathway: Pending finalisation of the transition rules, existing ITS licensees were permitted to continue DSRC-based operations. The Commission simultaneously indicated it would allow operators to seek waivers to begin deploying C-V2X in the upper 30 MHz ahead of the final C-V2X rules.

[35] FCC, Notice of Proposed Rulemaking (FCC 19-129), 'Use of the 5.850-5.925 GHz Band,' ET Docket No. 19-138, 34 FCC Rcd 12603 (November 2019). Available: https://docs.fcc.gov/public/attachments/FCC-19-129A1.pdf

2.33 In November 2024, the FCC adopted Second Report and Order on 5.9 GHz, completing the technical rulemaking for C-V2X in the upper 30 MHz. The Second Report & Order codified C-V2X technical parameters in the Commission's rules; mandated a two-year sunset for existing DSRC operations; declined to mandate a specific 3GPP Release; established a three-tier message priority hierarchy; and addressed questions of additional spectrum and DSRC incumbent reimbursement. Salient points of the Second Report & Order of the FCC on the 5.9 GHz are outlined below:

(a) Channel Bandwidth and Band Plan: The Second Report & Order retained the three existing 10 MHz ITS channels within the upper 30 MHz — 5.895–5.905 GHz, 5.905–5.915 GHz, and 5.915–5.925 GHz — but abandoned the channel number designations that reflected the legacy DSRC band plan. The rules provide flexibility for the industry to use these three channels either separately as 10 MHz channels, in combination as one 20 MHz and one 10 MHz channel, or aggregated as a single 30 MHz channel.

(b) Technical Parameters: Power, Antenna Height, and OOBE: The Second R&O codified updated C-V2X technical requirements for three categories of equipment:

(i) RSU Power and Antenna Height: FCC adopted an EIRP limit for C-V2X RSU as 33dBm. It did not prescribe any limit on the transmitter output power to offer more flexibility for RSU stations to provide reliable service in a given coverage area. The antenna height for RSU is limited to 8 meters at full power and may be as high as 15 meters with a corresponding power.

(ii) OBU Power Limits: For OBUs installed in passenger vehicles, commercial trucks, motorcycles, and other mobile platforms, the Second R&O establishes a maximum Effective Isotropic Radiated Power (EIRP) limit of 33 dBm (approximately 2 watts).

(iii) OOBE Limits: FCC adopted the following conductive OOBE limits outside of the authorized 5.895-5.925 GHz band for all RSUs and OBUs:

- -16 dBm/100 kHz within ± 1 megahertz of the band edges;
- -13 dBm/MHz within ± 1 megahertz to ± 5 megahertz of the band edges;
- -16 dBm/MHz within ± 5 megahertz to ± 30 megahertz of the band edges; and
- -28 dBm/MHz beyond 30 megahertz from the band edges.

(c) 3GPP Technical Standard: With respect to the 3GPP's C-V2X standard, FCC in the Second Report & Order stated, *inter alia*, as below:[36]

"Based on the record before us, we are not incorporating by reference any one particular standard. We encourage industry to develop a consensus concerning 3GPP releases covering C-V2X. We believe this approach is necessary due to the constantly evolving nature of both 3GPP standards and the functionality of C-V2X. As stated by ITE, new testing will undoubtedly lead to changes or enhancements to the applicable standards–and being held to a regulatory ceiling by imposing a particular standard may cap the potential of future C-V2X applications. Our focus in this proceeding is to set objective performance expectations for C-V2X technology but let industry come to a consensus on the technology standard that should be applicable to C-V2X moving forward. Given the broad record support for not incorporating any one particular standard, we will thus provide industry the flexibility to develop a technology standard that fits within the technical bounds prescribed in this Order".

[36] FCC 2nd order and report dated 21.11.2024

(d) Message Priority Hierarchy: The Second Report & Order mandated a three-tier message priority hierarchy for ITS communications in the upper 30 MHz:

(i) Tier 1 — Safety-of-Life Communications (highest priority): Vehicle safety messages, collision avoidance, emergency warnings, and other life-critical V2X transmissions receive absolute network priority.

(ii) Tier 2 — Public Safety Communications: Messages supporting law enforcement, fire, emergency medical services, and other governmental public safety functions.

(iii) Tier 3 — Non-Priority Communications: Commercial, informational, and non-safety operational messages.

The Commission declined to define a formal distinction between 'commercial' and 'non-commercial' communications and also declined to prohibit commercial communications outright — recognising that non-safety commercial services can contribute to overall road safety and ITS ecosystem viability.

(e) Licensing for OBUs and RSUs: Non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5895-5925 MHz band will be issued for a term not to exceed ten years from the date of original issuance or renewal. Frequencies in the 5895-5925 MHz band will not be assigned for the exclusive use of any licensee. Channels are available on a shared basis only for use in accordance with the Commission’s rules. All licensees shall cooperate in the selection and use of channels in order to reduce interference. This includes monitoring for communications in progress and any other measures as may be necessary to minimize interference.

(f) The eligibility criteria and the license term for holding RSU license, as per FCC's Second Report and Order are as follows:

§ 90.388 Eligibility. The following entities are eligible to hold an authorization to operate C-V2X RSUs:

(a) Any territory, possession, state, city, county, town or similar governmental entity.

(b) Any entity meeting the eligibility requirements of § 90.20, 90.33 or 90.35.

§ 90.149 License term.

(b) Non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5895-5925 MHz band … will be issued for a term not to exceed ten years from the date of original issuance or renewal. The registration dates of individual RSUs (see § 90.375, 90.389 of this part) will not change the overall renewal period of the single license."

(g) On-Board Units (OBUs) mounted in vehicles are licensed by rule under FCC Part 95 and communicate with Roadside Units (RSUs) and other OBUs, with portable OBUs also licensed by rule under Part 95. This means no individual FCC license is required to operate an OBU. Each C-V2X OBU that operates or is intended to operate in the 5895-5925 MHz band must be certified in accordance with these rules.

(3) European Union

2.34 The legal foundation for ITS in the EU is Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010, which established the overarching framework for deploying intelligent transport systems in the road transport sector and their interfaces with other transport modes.[37]

[37] EUR-Lex (2010). Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems. OJ L 207, 6.8.2010.

The directive identified priority areas — including optimal use of road, traffic and travel data, continuity of traffic and freight management services, road safety and security, and integration of the vehicle into the transport infrastructure — and empowered the Commission to adopt delegated acts specifying EU-wide requirements within those areas.

2.35 Under this framework, several delegated regulations were subsequently adopted. Delegated Regulation (EU) 2017/1926 addressed EU-wide multimodal travel information services; Delegated Regulation (EU) 2022/670 established requirements for real-time traffic information services; and a 2022 measure addressed safe and secure parking for heavy goods vehicles.[38] The recent legislative development is Directive (EU) 2023/2661, adopted on 22 November 2023. The directive was adopted with the aim of adapting to the emergence of new road mobility options, mobility apps, and connected and automated mobility.[39] It extends the scope of the 2010 framework to encompass cooperative, connected and automated mobility (CCAM) and establishes two provisions of particular significance: first, a legal basis for the EU-wide security credential management system (CCMS) for C-ITS and second, a proportionate legal basis for the processing of personal data for specified ITS and C-ITS services, resolving a long-standing obstacle that had blocked an earlier proposed delegated act on C-ITS in 2019. The directive's priority areas for the development of technical specifications and standards explicitly include road safety and security applications — such as alerts of risks of reduced visibility or of people, animals and debris on the road — as well as ITS services for cooperative, connected and automated mobility.

[38] *EUR-Lex (2022). Commission Delegated Regulation (EU) 2022/670 of 2 February 2022 supplementing Directive 2010/40/EU — Real-time traffic information services. OJ L 122, 25.4.2022.*

[39] *EUR-Lex (2023). Directive (EU) 2023/2661 of the European Parliament and of the Council of 22 November 2023 amending Directive 2010/40/EU. OJ L, 27.11.2023.*

2.36 The specific band plan designates 5,855–5,875 MHz for non-safety road ITS applications, 5,875–5,935 MHz for safety-related ITS, with 5,875–5,915 MHz prioritised for road-ITS applications *(CEPT Report 71, 2019)*. Crucially — and consistent with broader European radio regulation practice — the spectrum is designated on a technology-neutral basis *(CEPT, 2023)*, meaning that both ITS-G5 (based on IEEE 802.11p) and C-V2X (LTE-V2X and its 5G NR-V2X successor) are permitted to operate within the allocated band, subject to non-interference requirements. The following figure depicts the spectrum designations for ITS in Europe.

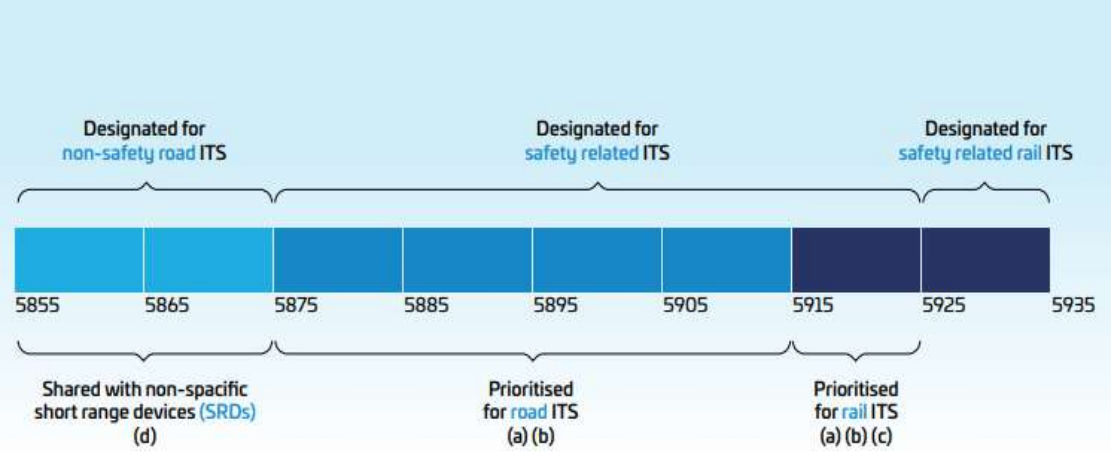


Figure 1: Spectrum designations at 5.9 GHz in Europe. See below for descriptions of (a)-(d).

Figure 2.6: Spectrum designation in Europe[40]

2.37 License Conditions and Authorisation: From an authorisation perspective, the EU harmonised 5.9 GHz frequency band (5,875–5,935 MHz) enables vehicle-to-vehicle connectivity on roads, as well as the operation of radio-controlled urban rail transport. The equipment operating in this band does so under a general authorisation (license-exempt) regime. The OBU/ RSU general authorisation removes a potential barrier to mass-market vehicle deployment.

[40] https://5gaa.org/content/uploads/2021/06/5GAA_S-210019_Position-paper-on-European-deployment-band-configuration-for-C-V2X_final.pdf

(4) United Kingdom

2.38 In the UK, OFCOM is responsible for spectrum management under two Acts of Parliament: the *Communications Act 2003* and the *Wireless Telegraphy Act 2006* (WT Act). Within this framework, the licence-exemption power under section 8(3) of the WT Act is the primary instrument through which ITS and V2X radio equipment — both on-board units (OBUs) in vehicles and roadside units (RSUs) at junctions and highway sites — is authorised to operate without individual licensing.

2.39 The original licence-exempt allocation for safety-related ITS in the UK covered 5,875–5,905 MHz, established by the *Wireless Telegraphy (Intelligent Transport Systems) (Exemption) Regulations 2011* (SI 2011/2949). In May 2022, Ofcom launched a public consultation — *Proposals to amend the authorisation conditions for the use of certain Short-Range Devices* (SRD22-01) — which proposed, among other measures, a 20 MHz extension to the ITS allocation.[41] The most significant outcome of that exercise was confirmed in Ofcom's subsequent *Statement on Short-Range Devices*, in which Ofcom announced it was extending the current spectrum assignment from 5,875 to 5,905 MHz by 20 MHz, to cover 5,875 to 5,925 MHz for safety-related ITS. One element of the CEPT band plan that Ofcom declined to adopt was the 5,925–5,935 MHz sub-band exclusively designated for urban rail ITS.

2.40 Ofcom's Interface Requirement IR 2086 for Intelligent Transport Systems (ITS) in the 5.9 GHz band (5,875-5,925 MHz) is technology-neutral, specifying performance parameters like power limits, channel access etc.[42]

[41] https://www.ofcom.org.uk/spectrum/radio-equipment/authorisation-conditions-for-short-range-devices

[42] https://www.ofcom.org.uk/siteassets/resources/documents/spectrum/interface-requirements/ir_2086.pdf?v=335249

(5) China

2.41 China's Ministry of Industry and Information Technology (MIIT) Document No. 203[43], issued in October 2018, dedicated the 5,905-5,925 MHz band (20 MHz bandwidth) exclusively for direct communication in vehicle-to-everything (V2X) systems, particularly Cellular V2X (C-V2X) for intelligent connected vehicles. The salient points of the document are as below:

(a) *For setting up and using roadside radio equipment in the 5905-5925 MHz band or constructing and operating intelligent transportation systems for Internet of Vehicles, a frequency usage license for 5905-5925 MHz shall, in principle, be obtained by applying to the national radio management authority. After obtaining frequency usage license approval, entities setting up and using roadside radio equipment shall apply to the provincial, autonomous region, or municipal radio management authority in their locality for a radio station license. Roadside radio equipment without a radio station license shall not transmit radio signals and is not protected against harmful radio interference.*

(b) *Setting up and using vehicle-mounted and portable radio equipment in the 5905-5925 MHz band shall be managed in reference to terrestrial public mobile communication terminals, with no need for frequency usage licenses or radio station licenses.*

(c) *To protect the normal operation of existing legitimate radio stations and Internet of Vehicles (intelligent connected vehicles) radio equipment, roadside radio equipment for direct communication of Internet of Vehicles (intelligent connected vehicles) in the 5905-5925 MHz band shall in principle be at least 7 km away from legally used radar stations and 2 km away from satellite earth stations.*

[43] MIIT Interim Regulations on the Management of the 5905-5925MHz Frequency Band for Direct Communication in Vehicle-to-Everything (Intelligent Connected Vehicles) https://www.shanghaiinvest.com/cn/viewfile.php?id=13344

(d) *Before setting up and using roadside radio equipment in the 5905-5925 MHz band, electromagnetic environment testing and interference protection measures shall be conducted to minimize radio interference and eliminate interference hazards to the greatest extent.*

(e) *Radio transmitting equipment for direct communication of Internet of Vehicles (intelligent connected vehicles) produced or imported for sale and use within China shall apply to the national radio management authority for and obtain a radio transmitting equipment type approval certificate in accordance with relevant regulations*

(6) Canada:

2.42 Innovation, Science and Economic Development (ISED) Canada has initiated efforts to deploy C-V2X technology, concentrating on spectrum allocation and technical standards[44]. In December 2022, ISED designated the 5,895-5,925 MHz range exclusively for Intelligent Transportation Systems using C-V2X technology. Particularly, -

(a) Decision (D8): ISED will allow ITS OBUs to operate under a licence-exempt (no protection, no-interference) basis in the 5,895-5,925 MHz band.

(b) Decision (D9): ISED will implement a spectrum licence approach for ITS RSUs in the 5,895-5,925 MHz band.

(c) Decision (D10): A licensing framework for RSU deployments in the 5895-5925 MHz band will be determined through a future consultation.

[44] https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/learn-more/key-documents/decision-technical-and-policy-framework-radio-local-area-networks-devices-5850-5895-mhz-band-and

(7) Japan:

2.43 Japan is among the world's most advanced adopters of Intelligent Transportation Systems (ITS), with a national V2X communications program spanning over two decades of structured government-industry collaboration. The national ITS architecture is overseen jointly by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of Internal Affairs and Communications (MIC), with additional coordination from the National Police Agency (NPA) for traffic signal integration applications.[45]

2.44 Japan introduced ETC using 5.8 GHz active DSRC as a core ITS communication infrastructure, later upgraded to ETC2.0 for highspeed, high capacity bidirectional communication with roadside "ITS spots." ETC2.0 supports electronic toll collection plus added services such as traffic information and cooperative driving support via V2I communication. The 760 MHz ITS band (755.5–764.5 MHz) is allocated to "ITS Connect," which provides safety and signal information using V2V, V2I and Infrastructure-to-Infrastructure (I2I) communications.

2.45 In its 2020 revision of the Frequency Action Plan, Japan's Ministry of Internal Affairs and Communications (MIC) developed a tangible plan towards the opening of 5.9 GHz spectrum to V2X for next-generation ITS. The Frequency Reorganization Action Plan (FY2023 version), announced by Japan's Ministry of Internal Affairs and Communications (MIC) in December 2023, aims to secure the 5.9 GHz band (5,888 to 5,925 MHz) for Vehicle-to-Everything (V2X) systems, with a target of completing frequency assignment by FY2026.[46]

[45] Ministry of Land, Infrastructure, Transport and Tourism (MLIT). ITS Basic Plan 2023. Tokyo: MLIT, 2023. Available at: https://www.mlit.go.jp/road/ITS/

[46] https://www.tele.soumu.go.jp/e/adm/freq/search/actionplan/actionplan2023.pdf

(8) Australia:

2.46 The Australian Communications and Media Authority (ACMA) has allocated 70 MHz of spectrum in the 5.855–5.925 GHz band for ITS operations. The ACMA framework supports vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-person (V2P), and general V2X communications. ITS and V2X operations in Australia are authorized under the Radiocommunications (Intelligent Transport Systems) Class License 2017.[47] Under this license, operators do not require individual licenses or pay fees to access the spectrum. This class license allows for operating intelligent transport systems (ITS) station. An ITS station uses wireless technology to communicate from vehicle to person, vehicle to vehicle and vehicle to structure.[48] The license mandates compliance with international technical standards, particularly ETSI EN 302 571, which defines the maximum effective isotropically radiated power (EIRP), antenna characteristics, and modulation parameters for ITS equipment. This ensures interoperability and alignment with internationally recognized technical norms.

(9) South Korea:

2.47 South Korea's Ministry of Science and ICT (MSIT) and Ministry of Land, Infrastructure and Transport (MOLIT) finalized the frequency allocation plan for next-generation Cooperative Intelligent Transport Systems (C-ITS)/V2X pilot projects on March 16, 2022, designating the 70 MHz band from 5,855 to 5,925 MHz for ITS applications.[49]

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[47] Radiocommunications (Intelligent Transport Systems) Class License 2017
https://www.legislation.gov.au/F2018L00026/latest/text

[48] https://www.acma.gov.au/licences/intelligent-transport-systems-class-licence

[49]https://smartcity.go.kr/en/2022/03/16/%EA%B3%BC%EA%B8%B0%EC%A0%95%ED%86%B5%EB%B6%80EC%B0%A8%EC%84%B8%EB%8C%80%EC%A7%80%EB%8A%A5%ED%98%95%EA%B5%90%ED%86%B5%EC%B2%B4%EA%B3%84c-its-%EC%8B%9C%EB%B2%94%EC%82%AC%EC%97%85-%EC%A3%BC%ED%8C%8C/
MSIT confirms frequency allocation plan for next-generation intelligent transportation system (C-ITS) pilot project

2.48 In December 2023, South Korea adopted LTE-V2X as its primary vehicle communication technology, moving away from Dedicated Short-Range Communications (DSRC). This aligns with trends in the U.S. and China. Following the December 2023 C-V2X decision, MSIT revised the band plan substantially. The updated technical regulation standard, published in June 2024, re-designates the allocation as: 5.855–5.875 GHz (20 MHz) for LTE-V2X, and 5.875–5.925 GHz (50 MHz) reserved for future study, anticipated to accommodate NR-V2X and advanced cooperative driving applications. Critically, the revised standard mandates that all DSRC operations must cease by June 2027, establishing a firm sunset for the legacy WAVE infrastructure.[50]

2.49 In South Korea, ITS roadside communication infrastructure is regulated as base-station radio equipment, while vehicle communication devices are treated as land mobile station equipment. The National Radio Research Agency technical standards explicitly identify "transmitter/receiver equipment of base stations" and "transmitter/receiver equipment of land mobile stations" for Intelligent Transport Systems operating in the 5855–5875 MHz band.

2.50 The regulatory treatment of V2X devices in south Korea distinguishes between roadside infrastructure and vehicle equipment. Under the Radio Waves Act, a radio station refers to a facility installed to transmit or receive radio waves, and establishing such a station requires authorization from the Ministry of Science and ICT. Accordingly, roadside units (RSUs) used for Intelligent Transport Systems are treated as base-station radio equipment, and their installation and operation require radio station authorization along with compliance with technical standards issued by the National Radio Research Agency. In contrast, on-board units (OBUs)

[50] Summarised in 5GAA, C-V2X in Action, https://5gaa.org/c-v2x-in-action/

installed in vehicles are classified as transmitter/receiver equipment of land mobile stations, meaning they are regulated primarily through equipment conformity assessment and certification rather than individual station licensing.[51]

2.51 The present global V2X landscape and country position is summarized in the table below:

Table 2.4: V2X global landscape

Country	Band (MHz)	Technology	OBU License	RSU License
Europe	5855 – 5875 (ITS G5B: non-safety) 5875 – 5905 (ITS G5A: road safety) 5905 – 5925 (ITS G5C: future extension)	From driving DSRC to technology neutral	License Exempt	License Exempt
United States	5895 – 5925, 30 MHz (LTE-V2X)	Transit from DSRC to C-V2X, two-year sunset for DSRC (Dec 2026)	No individual licensing (FCC Part 95)	Licensed (FCC Part 90)
Canada	5895-5925 MHz (for ITS)	C-V2X technology	License Exempt	Licensed
China	5905 – 5925 (LTE-V2X), 20 MHz	C-V2X	License Exempt	Licensed
South Korea	5855 – 5875 (LTE-V2X) 5875 – 5895 (Guard band)	Pilot trial with DSRC, but formally chose LTE-V2X in 2023	License Exempt	Licensed

[51] https://elaw.klri.re.kr/eng_service/lawView.do?hseq=7179&lang=ENG&utm_

	5895 – 5925 (DSRC)			
Australia	5855 – 5925, 70 MHz	Spectrum-neutral and tech-neutral	Class License	Class License
Japan	755.5 – 764.5 (DSRC) 5770 – 5850 (reserved for ETC/ DSRC) 5855-5925 (C-V2X, planning)	Production in DSRC, also doing trials in C-V2X		

2.52 The following chapter examines the issues related to the service authorisation framework and assignment of spectrum for V2X communication.

CHAPTER III: EXAMINATION OF ISSUES RELATED TO THE SERVICE AUTHORISATION FRAMEWORK AND ASSIGNMENT OF SPECTRUM

A. Committee constituted by DoT for V2X/ ITS Policy Formulation

3.1 A committee was constituted by DoT to recommend the overall policy requirement including spectrum requirement for the introduction of roll out of V2X in the country. The committee was chaired by Wireless Advisor, WPC of DoT and represented by DoT, TEC, C-DoT, C-DAC, IAFI, SIAM, COAI, Qualcomm, SMEV and Zero-Sum ITS Solutions India Pvt Ltd. The Terms of Reference of the committee were as below:

(a) To study the international developments towards adoption of ITS/ V2X;

(b) To study the overall requirements including policy interventions, to start deployment of the ITS/ V2X in the country;

(c) To study the spectrum requirement for introduction/ roll-out of ITS/ V2X in the country.

3.2 Through its report dated 20.01.2023 (**Annexure-II**), the committee recommended the following:

"13 Recommendations of the Committee

The ITS/ V2X is critical to road-safety and reducing the carbon footprint. As different standards are either planned or under operation in different geographies of the world, the issue of compatibility/ interoperability of all the vehicles on the road and the road-side infrastructure is an important consideration in choice of the technology for V2X in Indian scenario. Adoption of a harmonized technology option would have advantages of an evolved ecosystem avoiding major challenge in implementation.

In view of the above facts and the deliberations carried out by the committee, the following could be important considerations in the choice of a V2X/ ITS system in our country –

13.1. ***Technological options for V2X in India:*** *The two major competing technologies for the implementation of V2X are C-V2X (Cellular based V2X technology, which is a globally harmonized technology) and DSRC (where there are multiple country specific modification of the IEEE 802.11 p standard). In India there are no legacy V2X implementations and hence the requirement for the backward compatibility for the newly adopted system does not arise. Further, any proposed V2X technology must be universally adopted so that the benefits of "economies of scale" can be reaped. C-V2X has gained momentum both domestically and internationally through its ability to achieve greater network effects and can leverage cellular networks to reduce infrastructure costs. It also promises a more efficient and effective use of the spectrum. While the NFAP designated Dedicated Short-Range Communications (DSRC) services for ITS services more than a decade. ago (NFAP 2011, IND 71), DSRC has not been meaningfully adopted or deployed, and this critical spectrum has largely been unused. Moreover, In India, demonstration trials were carried out for both cellular based and noncellular based technologies as mentioned in para 7 above.*

However, taking into consideration the requirements from the Automobile associations and in view of the evolving V2X/ITS standards worldwide, the committee foresee that CV2X deployment of ITS services will dominate in future. Therefore, the Committee recommends that C-V2X standards may be given preference over DSRC standards.

13.2. ***Frequency bands for V2X in India:***

i. Spectrum in Mid-Band (1 - 6 GHz):

The frequency band 5 875-5 925 MHz (50 MHz) has already been identified for V2X Technologies/ Intelligent Transport Systems in NFAP 2022. The

same may be recommended for C-V2X technology as a harmonized standard. The higher part of ITS band i.e. 5905 - 5 925 MHz (20.0 MHz) may be reserved for basic-safety related use cases and lower part of the band i.e. 5 875 - 5 905 MHz (30 .0 MHz) may be reserved for the advanced use cases.

ii. Spectrum in sub 1 GHz Band:

Further, to cater to any requirement in the sub-1 GHz band, 10 MHz may be suitably considered in the sub 1-GHz IMT bands at a later stage based on any future requirements. Sub 1 GHz is vital for V2V and V2I communication in dense urban landscapes where the range and penetration of sub 1 GHz band is higher with low latency, especially in the area of V2I communication with Traffic Signal infrastructure.

13.3. ***Other allied frequency requirements for V2X in India:***

Besides the 5.9 GHz band, the two other frequency bands i.e., 24.05-24.25 GHz and 76-81 GHz, are also important for ITS applications. The 24.05-24.25 GHz band is already delicensed as per GSR 104 7(E) dated 18.10.2018 for Transport and traffic telematics devices. The frequency band 76-77 GHz has already been delicensed vide GSR No.699(E) dated 16.09.2015. The Committee recommends that frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

13.4. ***Other recommendations***

i. Constitution of a Committee comprising of various stakeholders for coordination and implementation of ITS in India.
ii. Companies working in ITS technology may be encouraged to conduct experiment in our local condition for confidence building. It would help in its early implementation."

B. Task Force constituted by Ministry of Road Transport and Highways (MoRTH)

3.3 In September 2024, MoRTH established a Task Force for the development and implementation of Intelligent Transportation Systems (ITS) in the country, with specific focus on Vehicle to Everything (V2X). The task force was represented by members from DoT, Ministry of Road Transport and Highways (MoRTH), National Highways Authority of India (NHAI), C-DAC, Society of Indian Automobile Manufacturers (SIAM), Automotive Research Association of India (ARAI), International Centre for Automotive Technology in India (ICAT), Cellular Operator Association of India (COAI), 5G Automotive Association (5GAA), ITS India Forum, Qualcomm, Zero-Sum ITS Solutions India Pvt Ltd and IDEMIA. The mandate of the Task Force was as follows:

(a) Recommendations of Automotive Industry Standards and regulations related to Intelligent Transportation Systems, and rollout of communication between vehicle to anything (V2X).

(b) Recommendations/suggestions on vehicle-to-vehicle and vehicle-to-infrastructure communication, use of 5.875 — 5.925 GHz frequency in the Intelligent Transportation System.

(c) Recommendations/suggestions on various radio frequency levels and delicensing frequency bands to the Department of Telecommunications (DoT).

3.4 The Task Force gave its Part-1 of the report in May 2025 and made the following recommendations (Part-1 report of the task force is enclosed with the DoT reference dated 01.12.2025 (**Annexure-I**)):

(a) The Task Force recommends adopting the V2X/ITS frequency range of 5.9 GHz (5.875-5.925 GHz), which has already been considered for V2X technologies/ Intelligent Transport System in the NFAP-2022,

recognizing it as the spectrum band for enhancing road safety and reducing road fatalities.

(b) The Task Force acknowledges the recommendation of para 13.2(i) of the DoT report titled Report by the Committee on V2X/ ITS Policy formulation dated 20.01.2023 to identify harmonized technology. To ensure that vehicles and infrastructure can seamlessly interoperate to achieve the goal of road safety, this Task Force recommends the frequency range of 5.875-5.925 GHz for the use of C-V2X technology.

(c) The Task Force recommends setting transmission power limits with a maximum e.i.r.p. of 4W for both On-Board Units (OBUs) and Roadside Units (RSUs), with a conducted power output of 200mW (23 dBm) over a bandwidth of 20 MHz or higher for RSUs. Additionally, the Task Force advises adhering to the out-of-band emission limits outlined in the table below for both OBUs and RSUs.

Table 3.1: out-of-band emission limits for both OBUs and RSUs

Offset frequency from the end of the occupied frequency bandwidth	Reference value (average power)	Resolution bandwidth
± 0-1 MHz	-16 dBm	100kHz
± 1-5 MHz	-13 dBm	1 MHz
± 5-30 MHz	-16 dBm	1 MHz
± 30 MHz and beyond	-28 dBm	1 MHz

(d) The Task Force recommends that within the frequency range of 5.875-5.925 GHz, OBUs of vehicles using C-V2X technology should

not require individual licenses or authorizations. This would allow OBUs to be easily installed in all types of vehicles, promoting widespread adoption and accessibility for individual users.

(e) The Task Force recommends a licensing framework to be applied for RSUs with appropriate spectrum charges to ensure proper deployment maintenance, and operation in the low-power, short-range spectrum. The State Government or any authority authorized in this behalf by the State Government or National Highways Authority of India (NHAI) or any other road owning agencies will be better suited to handle oversight and authorization for RSU installation to ensure that RSUs are correctly located, functional, and meet all necessary safety and operational standards.

3.5 The Task Force submitted its final report in January 2026 (**Annexure-III**). The final report of the Task Force includes recommendations on Automotive Industry Standards and regulations related to ITS stack, cybersecurity framework and rollout of V2X communication in India and is in addition to part-I of the report mentioned above. The main recommendations are as follows:

"Regulatory measures and implementation:

8.1 It is recommended that adequate regulatory measures including certification and testing are initiated by MoRTH, towards adoption of C-V2X, ITS stack and security services framework for India.

8.2 Industry, specially OEMs must be encouraged to implement Day-0 use cases on priority and ensure that the learnings are properly documented for development of the guidelines by the competent authority for uniform C-V2X implementation at Pan-India level.

8.3 It is recommended to expedite the allocation of the frequency spectrum so that Day-0 use cases i.e. V2V use cases for V2X implementation and scalable pilot projects may be undertaken

immediately in urban centres and selected national highways and later expanded to state highways and rural areas. This will help identify and address technical and regulatory challenges prior to large-scale pan India deployment.

8.4 It is recommended to establish a centralized authority for inter-state operations of ITS/ C-V2X, along with a centralized platform to implement ITS/ C-V2X services, ensuring inter-state harmonization and interoperability.

ITS Radio and Stack Standardrzation:

8.5 For ITS Stack, based on wider ecosystem consultation and consensus, ETSI TC ITS stack may be adopted for V2X/ ITS implementation in the country. Adoption of corresponding ETSI standard as National Standard may be taken up by the appropriate standardisation body in India (e.g. TSDSI; TEC).

ITS Security Services Standardization:

8.6 For Security services, a harmonized approach based on ETSI TS 102 941, which is derived from IEEE 1609.2, should be adopted to ensure PKI Root of Trust and scalability. This includes the possibility of either having a separate and dedicated national ITS root CA [para 7.3.5 (A)] or alternatively, consideration for a coexistence framework wherein the national root CA (X. 509) countersigns the ITS certificates [para 7.3.5 (C)].

8.7 The standardization of the national security framework may be implemented by the concerned competent authority i.e. CCA, for harmonized security services architecture for V2X/ITS in India.

V2X Implementation Standards:

8.8 The certification of radio equipment (OBU and RSU) may be undertaken by competent authority i.e. TEC, DoT to ensure the C-V2X radios comply with emission limits and essential requirements established by the DOT for wireless emissions, EMI/EMC, communication security, etc. in the harmonized band (5.9 GHz).

8.9 The standardization of automotive related implementation may be

undertaken by agencies designated by MoRTH, to ensure that the C-V2X system reliably provides the functionality related to safety in a vehicle and roadside infrastructure.

8.10 Consideration of C-V2X test cases in future revisions of Bharat NCAP with robust BNCAP evaluation protocol at appropriate stage when ecosystem is developed.

Pilot Proiects

8.11 Pilot tests should be conducted in controlled environments before large-scale rollout and deployment should begin in high-priority zones such as metropolitan cities, highways and accident-prone areas and scale up based on results.

Task Force continuity

8.12 This ITS Task Force, being an inter-disciplinary group of experts involving several diverse stakeholders in single platform, is recommended to continue its function as an expert group to ensure evaluation of pilot projects on ITS and to provide time to time recommendations throughout the journey of implementation of ITS in India. The Task Force shall continue to guide and supervise the pilots throughout their lifecycle and the outcomes shall be reported to MoRTH for making informed policy decisions and determine the implementation strategies for phased large-scale deployment."

C. DoT's reference dated 01.12.2025 to TRAI

3.6 On 01.12.2025, DoT sent a reference to TRAI on regulatory mechanism for Vehicle-to-Everything (V2X). Through the reference, DoT stated as below:

"A Task Force constituted by Ministry of Road Transport and Highways (MoRTH) to give recommendations on industry standards, technical parameters, and frequency usage for Vehicle-to-Everything (V2X)/ Intelligent Transport System (ITS), gave its Part-1 report in May 2025.

After examination of the report, DoT, has, in-principle, agreed to the following:

i. *C-V2X may be adopted as the harmonized Intelligent Transport System (ITS) technology for India.*

ii. *30 MHz spectrum (5875-5905 MHz) may be allocated for the initial deployment of C-V2X technology, while the remaining 20 MHz (5905-5925 MHz) may be reserved for future ITS applications, thereby retaining flexibility for evolving standards and innovations.*

iii. *License-exempt use of On-Board Units (OBUs) may be permitted under defined technical conditions, while authorization may be required for Roadside Units (RSUs) to ensure coordinated deployment and effective interference management.*

2. In this context, it is pertinent to refer to IND29 footnote of NFAP-2025, which states that "the frequency band 5875 to 5925 MHz may be used for V2X/ ITS under Mobile Service. This does not preclude the use of this frequency bands for other allocated services.

2.1. Further, it is mentioned that First Schedule of the Telecommunications Act, 2023 lists entities eligible for administrative frequency assignment, including the safety and operation of transport systems. Additionally, the DoT charging order dated 11.12.2023 contains provisions for calculating spectrum charges.

3. However, considering the large-scale impact of ITS on the transport sector of the country, TRAI is requested to provide recommendations on the following, under the terms of clause 11(1)(a) of the TRAI Act, 1997 as amended:

(i) Regulatory mechanism (spectrum assignment, authorization and pricing) for Roadside Units (RSUs);

(ii) Any other recommendations relevant to the issue."

D. Regulatory Mechanism for Road Side Units (RSUs)

(1) The Telecommunications Act, 2023 (Authorisation)

3.7 In December 2023, the Parliament passed the Telecommunications Act, 2023[52]. The purpose of the Act is to amend and consolidate the laws concerning the development, expansion, and operation of telecommunication services and telecommunication networks, assignment of spectrum, and related matters.[53] Section 3 of the Telecommunications Act, 2023 gives the Central Government the power to grant authorisation. Section 3 of the Telecommunications Act, 2023 is reproduced below:

"3(1) Any person intending to —
(a) provide telecommunication services;
(b) establish, operate, maintain or expand telecommunication network; or
(c) possess radio equipment,
shall obtain an authorisation from the Central Government, subject to such terms and conditions, including fees or charges, as may be prescribed.

(2) The Central Government may while making rules under sub-section (1) provide for different terms and conditions of authorisation for different types of telecommunication services, telecommunication network or radio equipment.

(3) The Central Government, if it determines that it is necessary in the public interest so to do, may provide exemption from the requirement of

[52] The Telecommunications Act, 2023 is available at the URL: https://egazette.gov.in/WriteReadData/2023/250880.pdf

[53] Section 60 (1) of the Telecommunications Act, 2023 provides as below:
"Subject to the other provisions of this section, the enactments namely, the Indian Telegraph Act, 1885, and the Indian Wireless Telegraphy Act, 1933, are hereby repealed."

authorisation under sub-section (1), in such manner as may be prescribed.

(4) Any exemption granted prior to the appointed day under the Indian Telegraph Act, 1885 or the Indian Wireless Telegraphy Act, 1933 shall continue under this Act, unless otherwise notified by the Central Government.

(5) Any authorised entity may undertake any merger, demerger or acquisition, or other forms of restructuring, subject to any law for the time being in force and any authorised entity that emerges pursuant to such process, shall comply with the terms and conditions, including fees and charges, applicable to the original authorised entity, and such other terms and conditions, as may be prescribed.

(6) A license, registration, permission, by whatever name called, granted prior to the appointed day under the Indian Telegraph Act, 1885 or the Indian Wireless Telegraphy Act, 1933, in respect of provision of telecommunication services or telecommunication network—
(a) where a definite validity period is given, shall be entitled to continue to operate under the terms and conditions and for the duration as specified under such license or registration or permission, or to migrate to such terms and conditions of the relevant authorisation, as may be prescribed; or
(b) where a definite validity period is not given, shall be entitled to continue to operate on the terms and conditions of such licence or registration or permission for a period of five years from the appointed day, or to migrate to such terms and conditions of the relevant authorisation, as may be prescribed.

(7) Any authorised entity which provides such telecommunication services as may be notified by the Central Government, shall identify the person to whom it provides telecommunication services through use of any verifiable biometric based identification as may be prescribed.

(8) The Central Government may, subject to such terms and conditions, including fees or charges as may be prescribed, allot telecommunication identifiers for use by authorised entities.

(9) The Central Government may allow use of telecommunication identifiers allotted by international bodies which are recognised by the Central Government from time to time."

(2) TRAI's Recommendations on the Framework for Service Authorisations to be Granted Under the Telecommunications Act, 2023

3.8 On 21.06.2024, DoT sent a reference to TRAI under Section 11(1)(a) of the TRAI Act, 1997 and requested TRAI to provide its recommendations on terms and conditions, including fees and charges, for the authorisations to provide telecommunication services as per the provisions of the Telecommunications Act, 2023. In this regard, after following a comprehensive consultation with stakeholders, the Authority sent its recommendations on the Framework for Service Authorisations to be Granted Under the Telecommunications Act, 2023 to the Government.

3.9 Through these recommendations, TRAI recommended, *inter-alia*, that service authorisations under Section 3(1)(a) of the Telecommunications Act, 2023 should be grouped into three categories viz. "Main", "Auxiliary" and "Captive" service authorisations. TRAI defined the category "Auxiliary service authorisation" as "service authorisations (other than Captive

services), which are not used for the delivery of services to public at large or have very light touch regulatory oversight in the present regime …".

3.10 After considering the TRAI's recommendations dated 18.09.2024 on 'terms and conditions, including fees and charges, for the Authorisations to provide telecommunication services as per the provisions of the Telecommunications Act, 2023'; DoT, in September 2025, issued the following draft rules for seeking objections or suggestions of stakeholders:

(a) Draft of the Telecommunication (Authorisation for Provision of Main Telecommunication Services) Rules, 2025 issued on 05.09.2025;
(b) Draft of the Telecommunication (Authorisation for Provision of Miscellaneous Telecommunication Services) Rules, 2025 issued on 09.09.2025; and
(c) Draft of the Telecommunication (Authorisation for Provision of Captive Telecommunication Services) Rules, 2025 issued on 10.09.2025

3.11 DoT, in its draft rules, has chosen the term "miscellaneous service authorisation" in place of the term "auxiliary service authorisation" (recommended by TRAI).

3.12 Through its Reference dated 01.12.2025, DoT has mentioned that "[l]*icense-exempt use of On-Board Units (OBUs) may be permitted under defined technical conditions, while authorization may be required for Roadside Units (RSUs) to ensure coordinated deployment and effective interference management.*" Specifically, DoT has requested TRAI to provide recommendations on '*[r]egulatory mechanism (spectrum assignment, authorization and pricing) for Roadside Units (RSUs)*."

3.13 In a letter dated 20.11.2025 addressed to DoT (**Annexure-IV**), MoRTH *inter-alia* stated that:

".....2. It is noted that the National Frequency Allocation Plan (NFAP-2025) has earmarked 5875-5925 MHz (50 MHz) for Intelligent Transport System (V2X) use. In view of DoT's observation, it is proposed that V2V communication within the frequency range 5875-5905 (30 MHz) may be initiated, as this would improve braking, fuel efficiency and driving behaviour. Accordingly, necessary steps for implementation of V2V communication in this frequency band may be initiated immediately.

3. The Vehicle-to-Infrastructure (V2I) or Road-side Units (RSUs) may be rolled out subsequently based on key learnings from pitot deployments. The authorization for RSUs will be restricted to Central or State Governments or any other agencies authorized by them."

3.14 The following aspects may be inferred from the DoT's reference dated 01.12.2025, read with the MoRTH's letter dated 20.11.2025:

(a) DoT has envisaged license-exempt usage of On-Board Units (OBUs). Therefore, for Vehicle-to-Vehicle (V2V) communication, which involves communication between OBUs, no authorisation under the Telecommunications Act, 2023 would be required. MoRTH has envisaged that V2V communication may be initiated immediately.

(b) DoT has envisaged that "*authorization may be required for Roadside Units (RSUs) to ensure coordinated deployment and effective interference management*." Therefore, for providing Vehicle-to-Infrastructure (V2I) communication, which involves communication between RSUs and OBUs, authorisation under the Telecommunications Act, 2023 would be required. MoRTH has envisaged that the authorization for RSUs will be restricted to Central or State Governments or any other agencies authorized by them.

3.15 The proposed authorization for RSUs, or the authorization to operate RSUs, essentially, means authorisation to provide V2I communication service to OBUs installed in vehicles by using RSUs. DoT has sought, *inter alia*, the

recommendations of TRAI on the regulatory mechanism for RSUs. In this regard, in the present consultation paper, the Authority would solicit inputs from stakeholders on the framework for the authorisation to provide V2I communication service.

3.16 Before proceeding to examine the specific issues on the matter, it would be worthwhile to peruse the global perspective on licensing the operation of RSUs/ provision of V2I communication service.

E. Global Perspective on licensing the operation of RSUs

(1) USA

3.17 Title 47 of the Code of Federal Regulations (47 CFR) contains the U.S. Federal regulations for telecommunications, administered by the Federal Communications Commission (FCC). It governs broadcasting, cable services, and radio frequency (RF) devices, including mandatory, authorized, and unlicensed spectrum use. As per part 90 of 47 CFR revised by 2nd order and report, *non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5895-5925 MHz band under subpart M of this part will be issued for a term not to exceed ten years from the date of original issuance or renewal*.

3.18 Frequencies in the 5895-5925 MHz band will not be assigned for the exclusive use of any licensee. Channels are available on a shared basis only for use in accordance with the Commission's rules. All licensees shall cooperate in the selection and use of channels in order to reduce interference. This includes monitoring for communications in progress and any other measures as may be necessary to minimize interference.

3.19 The eligibility criteria and the license term for holding RSU license, as per FCC 2nd report and order are as follows:

*"**§ 90.388 Eligibility**. The following entities are eligible to hold an authorization to operate C-V2X RSUs:*

(a) Any territory, possession, state, city, county, town or similar governmental entity.

(b) Any entity meeting the eligibility requirements of § 90.20, 90.33 or 90.35.

***§ 90.149 License term**.*

** * (b) Non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5895-5925 MHz band under subpart M of this part will be issued for a term not to exceed ten years from the date of original issuance or renewal. The registration dates of individual RSUs (see § 90.375, 90.389 of this part) will not change the overall renewal period of the single license."*

3.20 On-Board Units (OBUs) mounted in vehicles are licensed by rule under FCC Part 95 and communicate with Roadside Units (RSUs) and other OBUs, with portable OBUs also licensed by rule under Part 95. This means no individual FCC license is required to operate an OBU. Each C-V2X OBU that operates or is intended to operate in the 5895-5925 MHz band must be certified in accordance with these rules.

(2) China

3.21 China's Ministry of Industry and Information Technology (MIIT) Document No. 203[54], issued in October 2018, dedicated the 5905-5925 MHz band (20 MHz bandwidth) exclusively for direct communication in vehicle-to-

[54] MIIT Interim Regulations on the Management of the 5905-5925MHz Frequency Band for Direct Communication in Vehicle-to-Everything (Intelligent Connected Vehicles)
https://www.shanghaiinvest.com/cn/viewfile.php?id=13344

everything (V2X) systems, particularly Cellular V2X (C-V2X) for intelligent connected vehicles.

3.22 In China, the use of the 5905–5925 MHz band for Internet of Vehicles (IoV) communications is regulated by the Ministry of Industry and Information Technology (MIIT). Entities that set up roadside units (RSUs) must first obtain a frequency usage license from the national radio management authority and then apply for a local radio station license before transmitting. Equipment operating without these licenses cannot legally transmit and will not be protected from interference. By contrast, vehicle-mounted and portable IoV devices (OBUs) are managed like mobile communication terminals and do not require any frequency or station license. To prevent harmful interference, RSUs must generally be located at least seven kilometers from radar stations and two kilometers from satellite earth stations. Before deployment, operators are required to conduct electromagnetic environment testing and implement interference protection measures. Furthermore, all IoV transmitting devices produced or imported for use within China must receive type approval from the Ministry of Industry and Information Technology (MIIT) to ensure compliance with technical standards.

(3) European Union (EU):

3.23 EU harmonised 5.9 GHz frequency band (5,875–5,935 MHz) enables vehicle-to-vehicle connectivity on roads, as well as the operation of radio-controlled urban rail transport. The equipment operating in this band does so under a general authorisation (licence-exempt) regime.

(4) Canada:

3.24 Innovation, Science and Economic Development (ISED) Canada has initiated regulatory measures to support the deployment of Cellular Vehicle-to-Everything (C-V2X) technology, focusing on spectrum allocation and technical standards. In December 2022, ISED designated the 5895–5925 MHz frequency range exclusively for Intelligent Transportation Systems (ITS) using C-V2X technology. Under this framework, ISED decided that ITS On-Board Units (OBUs) will operate on a licence-exempt basis with no interference protection, while ITS Roadside Units (RSUs) will be subjected to spectrum licensing requirements. Furthermore, ISED announced that a detailed licensing framework for RSU deployments in the 5895–5925 MHz band will be developed through a future public consultation.

3.25 The international practice for requirement for license for OBU/ RSU is summarized as follows:

Table 3.2: License requirements for OBUs/RSUs: Global Scenario

Region	Country	OBU	OBU Licensing condition	RSU	RSU Licensing condition
Region 1	Europe[55]	License-exempt	No individual licensing	License-exempt	
Region 2	USA[56]	Licensed-by-Rule	No individual licensing (FCC Part 95)	Licensed	Eligibility: Any territory state, city, country, town or similar governmental entity or any other entity meeting the eligibility requirements
	Canada[57]	License-	No	Licensed	

[55] https://docdb.cept.org/download/4869

[56] https://docs.fcc.gov/public/attachments/FCC-24-123A1.pdf

[57] https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/devices-and-equipment/radio-equipment-standards/radio-standards-specifications-rss/rss-252-intelligent-transportation-systems-dedicated-short-

		exempt	individual licensing		
Region 3	Australia[58]	Class License	No individual licensing	Class License	No individual licensing
	China	License-exempt	No individual licensing	Licensed	Administratively assigned to RSU operator (typically govt. road/ transport)
	Korea	License-exempt	No individual licensing	Licensed	Administratively assigned to RSU operator (typically govt. road/ transport)

3.26 In this context, the Authority solicits input of stakeholders on the following questions:

Issues for consultation:

Q1. Whether there is a need to introduce an authorisation for vehicle-to-infrastructure (V2I) communication service under Section 3(1)(a) of the Telecommunications Act, 2023? If yes, please provide input with respect to the following aspects:

(a) Eligibility conditions for the authorisation;

(b) Period of validity of the authorisation and conditions for its renewal;

(c) Service area of the authorisation;

(d) Scope of service of the authorisation;

(e) Technical, operating, security related conditions etc. of the authorisation;

(f) Any other related aspect.

Kindly provide a detailed response with justification.

range-communications-dsrc-board-unit-obu

[58] https://www.acma.gov.au/licences/intelligent-transport-systems-class-licence

Q2. In case your reply to Q1 is no, what should be the mechanism for enabling, facilitating and regulating vehicle-to-infrastructure (V2I) communication service in India? Kindly provide a detailed response with justification.

Q3. Any other suggestions relevant to the authorisation for vehicle-to-infrastructure (V2I) communication service may be submitted with proper explanation and justification.

F. Selection of C-V2X standard/Technology

3.27 DoT, through its reference dated 01.12.2025 has informed that, it has agreed, in-principle, that C-V2X may be adopted as the harmonized Intelligent Transport System (ITS) technology for India. Cellular V2X is an umbrella term comprising all 3GPP standardized vehicle-to-everything communication technologies for connected and automated mobility, providing one unified solution for V2V, V2I, V2P, and V2N operation. It enables direct and network-assisted communication between vehicles, infrastructure, pedestrians, and backend systems to improve road safety, traffic efficiency, and support automated driving. C-V2X has evolved in two stages:

(i) LTE-V2X: Introduced in 3GPP Release 14/15, optimised for immediate road-safety use cases.

(ii) NR-V2X: Introduced in 3GPP Release 16 onwards, designed to support advanced cooperative and automated driving functions.

3.28 The compatibility and coexistence between LTE-V2X and NR-V2X represents a critical consideration in the evolution of cellular vehicular communications, with 3GPP adopting a complementary rather than replacement strategy. As a main design principle, NR is not designed to be backward compatible with LTE, and similarly NR V2X is not backward

compatible with LTE C-V2X.[59] LTE-V2X and NR-V2X use different radio waveforms, numerologies, and sidelink designs. An LTE-V2X device may not directly decode NR-V2X sidelink transmissions, and vice versa. There may be issues in the message exchange between the OBUs and between OBU & RSUs of different 3GPP standards.

3.29 It needs to be examined which of the 3GPP C-V2X standard Release 14 (LTE V2X) or Release 16 (NR V2X) should be adopted in India; whether Release 14 (LTE V2X) should be adopted initially with an eventual transition to Release 16; or whether there is no need to specially specify either standard for adoption.

3.30 TEC released a report on 'Technologies and Standards for Intelligent Transport System (TEC 31218:2023)' in October 2023.[60] On Standards related aspects, it has recommended the following:

"(i) As discussed in earlier sections, access layer standards for ITS should be based on 3GPP C-V2X for harmonized ecosystem, interoperability, long-term roadmap, and wider usage of ITS applications.

(ii) Develop TEC Specifications related to testing and certification for OBU and RSU.

(iii) For the non-access layer, the automotive ecosystem needs to converge on using a common ITS stack to enable wider application support and full interoperability across various end-users, vehicle manufacturers and road side unit implementations. This will facilitate integration of the V2X services with a national ITS digital platform….."

[59] https://www.itskrs.its.dot.gov/success-strategies/snapshot/vehicle-everything-v2x-communications

[60] https://www.tec.gov.in/pdf/M2M/TR_Technologies%20and%20Standards%20for%20Intelligent%20Transport%20System.pdf

3.31 As regards the 3GPP's C-V2X standard, FCC in its 2nd order and report stated *inter alia* as below:[61]

"Based on the record before us, we are not incorporating by reference any one particular standard. We encourage industry to develop a consensus concerning 3GPP releases covering C-V2X. We believe this approach is necessary due to the constantly evolving nature of both 3GPP standards and the functionality of C-V2X. As stated by ITE, new testing will undoubtedly lead to changes or enhancements to the applicable standards–and being held to a regulatory ceiling by imposing a particular standard may cap the potential of future C-V2X applications. Our focus in this proceeding is to set objective performance expectations for C-V2X technology but let industry come to a consensus on the technology standard that should be applicable to C-V2X moving forward. ***Given the broad record support for not incorporating any one particular standard, we will thus provide industry the flexibility to develop a technology standard that fits within the technical bounds prescribed in this Order****".*

3.32 In December 2023. South Korea adopted LTE-V2X as its primary vehicle communication technology, moving away from Dedicated Short-Range Communications (DSRC).

3.33 China has actively deployed LTE-V2X (PC5-based) as the foundational V2X technology, with the Ministry of Industry and Information Technology (MIIT) allocating 20 MHz in the 5905–5925 MHz band for LTE-V2X. China is prioritizing LTE-V2X for basic safety applications while preparing NR-V2X for evolved services requiring higher reliability and throughput

3.34 In this context, the Authority solicits inputs of stakeholders on the following

[61] FCC 2nd order and report dated 21.11.2024

question:

Issue for consultation:

Q4. Whether a specific technology (such as LTE-based C-V2X, NR-based C-V2X etc.) should be prescribed for the implementation of C-V2X in India? If yes, which technology should be adopted for the implementation of C-V2X? If no, in what manner, the issues related to inter-operability between different technologies should be addressed? Kindly provide a detailed response with justification.

G. Certification for OBUs/RSUs

3.35 Section 19 of the Telecommunications Act, 2023, part of the "Standards, Public Safety, National Security and Protection of Telecommunication Networks" chapter, empowers the Central Government to notify standards and conformity assessment measures for telecommunication equipment, services, network security, encryption, and data processing. The provisions of Section 19 are reproduced below:

"19. The Central Government may notify standards and conformity assessment measures in respect of—
(a) telecommunication equipment, telecommunication identifiers and telecommunication network;
(b) telecommunication services, in consonance with any regulations notified by the Telecom Regulatory Authority of India from time to time;
(c) manufacture, import, distribution and sale of telecommunication equipment;
(d) telecommunication security, including identification, analysis and prevention of intrusion in telecommunication services and

telecommunication networks;

(e) cyber security for telecommunication services and telecommunication networks; and

(f) encryption and data processing in telecommunication."

3.36 Telecommunications (Framework to Notify Standards, Conformity Assessment and Certification) Rules, 2025 prescribe for Certificate of Conformity Assessment in respect of Telecommunication Equipment as defined in Telecommunications Act 2023. As per Rule 8:

"8. Compliance obligations. – (1) Every person to which a notified standard applies, shall ensure that the details of such standard, including the Certificate of Conformity Assessment, is displayed in such manner as may be specified by the Appropriate Authority.

(1) No telecommunication equipment to which a standard applies, shall be sold or deployed in any telecommunication network, or otherwise be used in India, unless it has a valid Certificate of Conformity Assessment."

3.37 TRAI in its recommendations on the Issues Related to Critical Services in the M2M Sector, and the Transfer of Ownership of M2M SIMs dated 22.04.2025 has recommended the following:

"….The Authority recommends that the M2M communication modules embedded/ plugged in all IoT devices (which are capable of being connected to telecommunication networks) deployed in the critical sectors identified by National Critical Information Infrastructure Protection Centre (NCIIPC), Government of India should be notified under the framework of Mandatory Testing & Certification of Telecommunication Equipment (MTCTE) in a phased manner. IoT devices deployed in the remaining

sectors may be notified under MTCTE at a subsequent stage…."

3.38 With respect to the gazette notification on 'Testing and Certification of Telegraph' dated 05.09.2017, Telecom Engineering Center (TEC), in October 2018, issued 'Procedure for Mandatory Testing & Certification of Telecommunication Equipment'.[62] The procedure has been amended from time to time. The salient features of the amended Procedure for Mandatory Testing & Certification of Telecommunication Equipment (MTCTE) issued by TEC are given below:[63]

(a) Mandatory Testing & Certification' means testing and certification of Telecom/ related ICT Equipment as per the prescribed procedure.

(b) The scope of certification covers all types of telecom/ related ICT equipment to be sold in India for being used or that may be used for telecommunication. The effective dates for certification becoming mandatory for different products will be notified by the Government separately.

(c) The objective of testing and certification:
   (i) that any telecommunication equipment does not degrade performance of the existing network to which it is connected;
   (ii) safety of the end users;
   (iii) security of telecommunication networks;
   (iv) protection of users and general public by ensuring that radio frequency emissions from equipment do not exceed prescribed standards;
   (v) that Telecommunication Equipment complies with the relevant National and International Regulatory Standards and requirements.

[62] Source: https://tec.gov.in/mandatory-testing-and-certification-of-telecom-equipments-mtcte

[63] Source: https://tec.gov.in/pdf/MTCTE/Amend%20MTCTE%20Procedure%20cl%2017%202.pd

(d) Any Original Equipment Manufacturer (OEM)/ Authorised Indian Representative (AIR) who wishes to sell or import any telecom equipment in India, shall have to obtain Certificate from TEC for the notified telecom equipment.

(e) Only complete-in-itself, standalone, independent equipment are tested and certified under MTCTE. Equipment modules/ components are not covered by MTCTE. Further combinations of independent equipment made to form systems are not certified under MTCTE. Instead, each independent equipment should be certified separately.

(f) The equipment needs to be tested in TEC designated Conformity Assessment Bodies (CABs). As a relaxation, test reports/ results from any lab accredited by accreditation bodies under International Laboratory Accreditation Cooperation (ILAC) may be accepted except for those parameters of Essential Requirements (ERs) which are mandatorily to be tested in Indian CABs.

(g) The Essential Requirements (ERs) to be compiled for the purpose of certification under MTCTE will include the following:

(i) EMI/ EMC as prescribed by TEC
(ii) Safety as prescribed by TEC
(iii) Technical requirements as prescribed by TEC
(iv) Security requirements as mandated by DoT HQ/ NCCS, Bengaluru from time to time
(v) Other requirements as notified by TEC/ DoT HQ/ any Government agency from time to time.

3.39 As regards the testing and certification OBU and RSUs, TEC in its report on 'Technologies and Standards for Intelligent Transport System (TEC

31218:2023)' released in October 2023,[64] recommended to develop TEC Specifications related to testing and certification for OBU and RSU.

H. Global perspective:

(1) USA:

3.40 FCC, in the 2nd order report and order dated 21.11.2024, specified *inter alia* as below:

"§ 95.3202 OBU transmitter certification.

(a) Each C-V2X OBU that operates or is intended to operate in the 5895-5925 MHz band must be certified in accordance with this subpart and subpart J of part 2 of this chapter.
(b) A grant of equipment certification for this subpart will not be issued for any C-V2X OBU transmitter type that fails to comply with all of the applicable rules in this subpart."

(2) Canada:

3.41 ISED's RSS-252 standard, Issue 2 (May 2023)[65], certifies license-exempt C-V2X devices in the 5895-5925 MHz band. It sets technical parameters for C-V2X on-board units to ensure compliance and interoperability in Canada's ITS framework. The instructions provided in this document regarding certification requirement is reproduced below:
"…
2.2 Certification requirements

[64] https://www.tec.gov.in/pdf/M2M/TR_Technologies%20and%20Standards%20for%20Intelligent%20Transport%20System.pdf
[65] https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/devices-and-equipment/radio-equipment-standards/radio-standards-specifications-rss/rss-252-intelligent-transportation-systems-dedicated-short-range-communications-dsrc-board-unit-obu

Equipment covered by this standard is classified as Category I and shall be certified. Either a Technical Acceptance Certificate (TAC) issued by ISED's Certification and Engineering Bureau or a certificate issued by a recognized certification body (CB) is required.

…

2.4 RSS-Gen compliance

In addition to the requirements specified in this standard, equipment being certified under this standard shall also comply with the applicable requirements set out in RSS-Gen, General Requirements for Compliance of Radio Apparatus."

(3) Australia:

3.42 Certification & Compliance (OBU/RSU) —

Australian Communications and Media Authority (ACMA) Class Licence Conditions[66]

ITS Class Licence requires equipment to operate only within assigned power levels to avoid interference with other services Licence requires adherence to electromagnetic compatibility (EMC) standards referenced in EN 302 571 (harmonised ITS standard). This instrument authorises a person to operate an ITS station subject to the following conditions:

(a) the ITS station must be operated:
   (i) on a frequency, or within a range of frequencies, greater than 5855 MHz and not greater than 5925 MHz; and
   (ii) at a radiated power that does not exceed a maximum EIRP of 23 dBm/MHz;

(b) the ITS station must not be operated within 70 kilometres of the Murchison Radioastronomy Observatory located at latitude 26° 42'

[66] https://www.acma.gov.au/licences/intelligent-transport-systems-class-licence

15" south, longitude 116° 39' 32" east;

(c) the ITS station must comply with ETSI Standard EN 302 571; and

(d) the ITS station must comply with section 7 of this instrument.

(4) China:

3.43 With respect to the radio transmitting equipment for direct communication of Internet of Vehicles (intelligent connected vehicles) produced or imported for sale and use within China, the entities shall apply to the national radio management authority and obtain a radio transmitting equipment type approval certificate in accordance with relevant regulations.

3.44 In this context, the Authority solicits inputs from stakeholders on the following questions:

Issue for consultation:

Q5. Whether there is a need to bring road-side units (RSUs) and on-board units (OBUs) under the regime of Mandatory Testing Certification of Telecom Equipment (MTCTE)? If no, in what manner, Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC), safety, technical and security requirements prescribed by TEC/ DoT may be ensured? Kindly provide a detailed response with justification.

I. ITS/V2X Stack and Security/ Authentication/ Privacy Protection mechanism for OBUs/ RSUs

(1) ITS Stack:

3.45 The ITS / V2X stack is a standardized, layered communication framework that enables real-time information exchange between vehicles, roadside infrastructure, pedestrians, and cellular networks. For the Access layer, DoT has already agreed, in-principle, for the C-V2X standard. A Reference Architecture for ITS stack is provided in the Figure below:

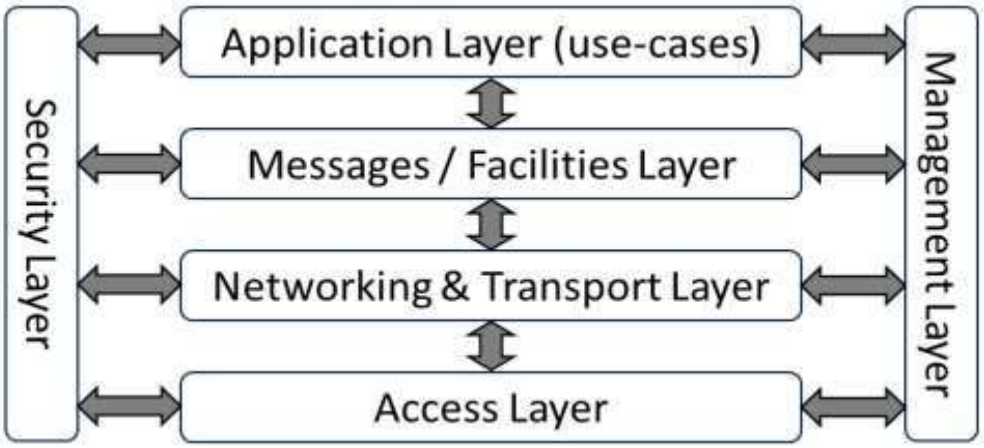


Figure 3.1: Reference Architecture for ITS stack[67]

3.46 The automotive industry, through SAE International, ETSI, and IEEE, have done considerable work in defining the Applications, the message/ facilities layer, security services and the Transport/ networking layers. C-V2X leverages all of the existing standards in these layers, and just replaces the PHY and the MAC[68] (commonly called the Access layers) from 3GPP to provide the end-to-end solution. A reference for 3GPP C-V2X standards is shown below:

[67] TEC Technical Report on Technologies and Standards for ITS

[68] PHY stands for Physical Layer and MAC stands for Media Access Control

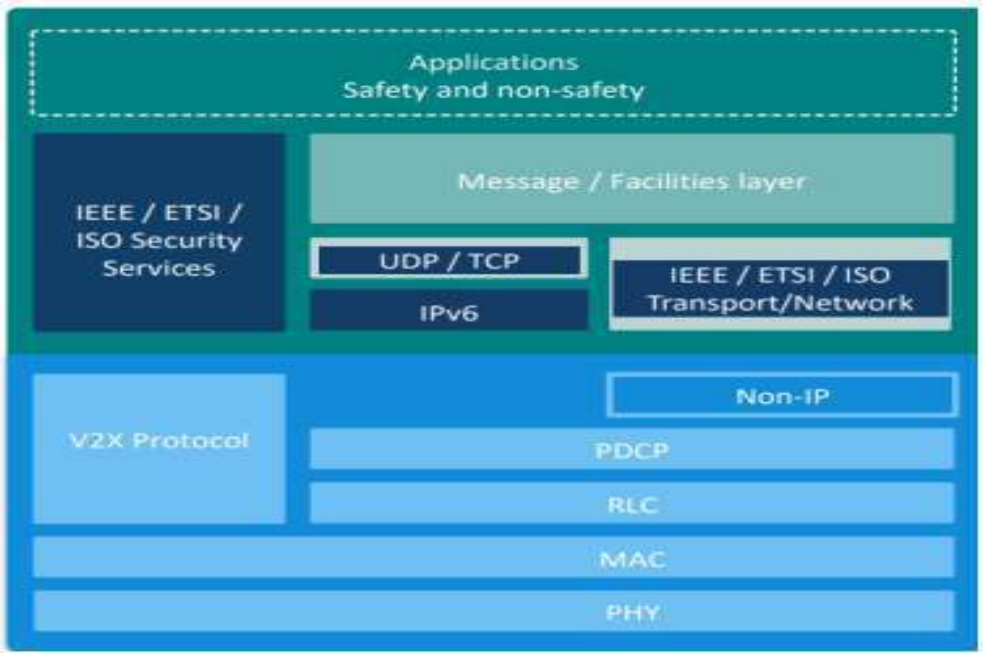


Figure 3.2: C-V2X Protocol Stack[69]

3.47 Higher layer technologies for V2X above the access layer, pertinent to CAVs, are provided by set of standards such as ETSI ITS, CEN, IEEE 1609, SAE, CCSA and China-SAE.[70] These standards for the ITS stack may not be interoperable. There may be a need for India to adopt an appropriate standard for higher layer which may be most suitable for India's requirements. For higher layer, largely two options are under discussion globally, ETSI (Europe) and IEEE WAVE/SAE (United States).

(2) Security/ Authentication/ Privacy Protection mechanism for OBUs/ RSUs

3.48 ITS/V2X communications enable real-time exchange of safety-critical information among vehicles, roadside infrastructure, pedestrians, and networks. These systems support applications such as collision avoidance, emergency braking, and traffic efficiency. Given their safety-of-life nature and reliance on open wireless communication environments, robust

[69] TEC Technical Report on Technologies and Standards for ITS

[70] Rep. ITU-R M.2534-0

security and privacy frameworks are essential to ensure safe, reliable, and trusted deployment at scale.

3.49 Security and privacy in ITS/V2X are critical because of the direct impact of these systems on road safety. V2X messages influence driving decisions in real time; therefore, any compromise - such as false collision warnings, spoofed/ delayed vehicle messages, or suppression of critical alerts - can result in accidents or fatalities, unsafe vehicle behavior, loss of trust in the system, exposure of vehicle movement patterns, and broader risks to personal data and public safety. Furthermore, V2X communication is inherently broadcast-based, with vehicles transmitting frequent messages to surrounding entities. This exposes the system to various cyber threats, including spoofing, replay attacks, Sybil attacks, and message tampering, making strong authentication and integrity protection indispensable.

3.50 Privacy is equally critical in ITS/ V2X systems due to the continuous broadcasting of vehicle data. Messages typically include location, speed, direction, and timing information, which can be used to track individual vehicles over time. Without adequate safeguards, this could enable persistent surveillance, profiling of user behavior, and misuse of personal data. Such risks raise significant concerns from both regulatory and societal perspectives, particularly in the context of data protection and individual privacy rights.

3.51 ITU has also recognized the security and privacy issues in V2X/ITS. ITU X.1372 groups main security risks in V2X into seven categories: confidentiality, integrity, availability, non-repudiation, authenticity, accountability, and authorization as given below:

- **Threats to confidentiality**: Unauthorized parties may access V2X messages or related data.
- **Threats to integrity**: Messages or data may be altered, forged, or corrupted in transit.

- **Threats to availability**: V2X services or channels may be disrupted or denied, affecting safety-critical communications.
- **Threats to non-repudiation**: A sender may later deny having sent a message, creating dispute or legal uncertainty.
- **Threats to authenticity**: Receivers may be unable to verify that a message truly came from the claimed sender.
- **Threats to accountability**: Actions or messages may not be traceable to the responsible entity, weakening auditability.
- **Threats to authorization**: An entity may perform actions or access functions without proper permission.

3.52 The following table outlines the security requirements for V2X communication:

Table 3.3: Security requirements for V2X communication[71]

	V2V warning propagation	V2V platooning communication	V2V beaconing	V2I warning	V2V/V2I information exchange	V2D communication	V2P communication
Confidentiality (general)	–	O	–	–	O	O	O
Confidentiality (PII)	O	O	O	▲	O	O	O
Integrity	O	O	O	O	O	O	O
Availability	O	O	O	O	O	▲	O
Non-repudiation	O	O	O	O	O	O	O
Authenticity	O	▲	O	O	O	O	O
Accountability	O	O	O	O	O	O	O
Authorization	–	O	–	–	O	O	–

O: Required, –: Not required, ▲: partially required

3.53 There is a need for the establishment of trust in a fully automated and time-sensitive environment. Vehicles must be able to verify the authenticity of received messages instantaneously, without human intervention. This necessitates the use of cryptographic trust frameworks, typically based on Public Key Infrastructure (PKI). The authentication

[71] ITU-T X.1372

requirements in the V2X context is different from other applications as it is required to be done within milliseconds. Further, V2X systems should incorporate specific privacy-preserving mechanisms. These may include the use of pseudonym certificates—temporary, frequently changing digital identities that prevent long-term tracking of vehicles etc.

3.54 There may be a need for a Root of Trust in ITS/V2X to create a verifiable trust anchor so that vehicles and roadside units can authenticate messages, enforce permissions, and reject spoofed or unauthorized traffic. Without that anchor, V2X messages may not be reliably tied to a trusted certificate chain. The Root of Trust in V2X systems is established through a Public Key Infrastructure (PKI) hierarchy. At the apex of this hierarchy is the Root Certificate Authority (Root CA), which serves as the ultimate trust anchor. The Root CA issues certificates to subordinate entities, such as Enrollment Certificate Authorities and Authorization Certificate Authorities, which in turn issue certificates to end devices, including vehicles and roadside units. This hierarchical trust chain ensures that any message received in the network can be cryptographically verified back to a trusted origin. The vehicular PKI is distinguished from the conventional PKI in several aspects. The most important aspect is using pseudonyms in order to protect the exposure of a vehicle's location related to the owner's location.

3.55 The Information Technology Act, 2000 in India recognizes the legal sanctity of digital signatures that are based on asymmetric cryptosystems. Digital signatures are hence treated on par with handwritten signatures. Within the confines of the IT Act, the Controller of Certifying Authorities (CCA) is authorized to license and regulate the working of Certifying Authorities in the Country. The CCA is therefore a statutory organization, appointed by the Central Government for promoting the growth of ecommerce and e-governance, through the use of digital signatures. The

CCA has established the Root Certifying Authority of India (RCAI) under section 18(b) of the IT Act to digitally sign the public keys of Certifying Authorities (CA) in the country. The CCA certifies the public keys of CAs using its own private key, which enables users in the cyberspace to verify that a given certificate is issued by a licensed CA. The CCA also maintains a Repository of Digital Certificates, which contains all the certificates issued to the CAs in the country. At present, the CCA recognizes the ITU-T X.509 format of digital certificates as an accepted standard in the country and issues CA certificates, adhering to this standard.[72]

3.56 There is a need for C-V2X devices to adhere to security frameworks supported by global standards, to ensure interoperability and compliance. IEEE 1609.2 and ETSI ITS security are the two main V2X security stacks that have been specified by IEEE and ETSI respectively. IEEE 1609.2 defines security services for application and management messages in vehicular environments, including secure message formats, processing rules, and administrative functions needed to support the security core. It is the foundational security standard for DSRC/WAVE-style V2X deployments and is closely tied to certificate-based message signing and verification.[73] ETSI's ITS security framework is centered on TS 103 097 for secure data structures, header formats, and certificate formats, plus TS 102 941 for trust and privacy management and security credential management. ETSI explicitly emphasizes PKI, trust anchors, enrollment credentials, revocation, and trust information lists, with a Root CA acting as the trust anchor.[74] Further, the architectural details of IEEE 1609.2 and ETSI ITS security standards and their comparison may be seen in the final report of the task force enclosed as Annexure III**.**

[72] Report of the Task Force constituted by MoRTH- (Annexure-IV of this Consultation Paper)

[73] https://standards.ieee.org/ieee/1609.2/6038/

[74]https://www.etsi.org/deliver/etsi_ts/103000_103099/103097/02.01.01_60/ts_103097v020101p.pdf

3.57 The PKI framework specified by both ETSI and IEEE standards are inherently based on the IEEE 1609.2 definition of the certificate format. However, in India, since CCA recognizes ITU-T X.509 certificate as the standard, incorporating the IEEE 1609.2 certificate format cannot be directly achieved due to incompatibility between the standards. Further, there are no global standards that seek to resolve and develop a coexistence framework for certificates belonging to different trust models. Such a facility would require system level customization, rendering the solutions globally non-compatible. The task force in its report has proposed a few PKI based trust architectures for developing a bridged framework to ensure global interoperability and standards alignment. The final report of the task force is enclosed as Annexure III.

3.58 As detailed in Para 3.5, the task force constituted by MoRTH, in its final report, has recommended that for security services, a harmonized approach based on ETSI TS 102 941, which is derived from IEEE 1609.2, should be adopted to ensure PKI Root of Trust and scalability. This includes the possibility of either having a separate and dedicated national ITS root CA or alternatively, consideration for a coexistence framework wherein the national root CA (X. 509) countersigns the ITS certificates. The standardization of the national security framework may be implemented by the concerned competent authority i.e. CCA, for harmonized security services architecture for V2X/1TS in India.

3.59 Practices adopted by USA, European Union, China, and South Korea with respect to the security framework for ITS are outlined below:

(a) In the United States, the security framework is built around the Security Credential Management System (SCMS), a distributed PKI architecture designed to ensure strong privacy protections. Trust is distributed across multiple entities, including Enrollment Certificate Authorities and Authorization Certificate Authorities,

ensuring that no single entity can link a vehicle's identity to its communications. The system relies on short-lived pseudonym certificates, which are rotated frequently to prevent tracking while maintaining trust. It also incorporates misbehavior detection and certificate revocation to exclude compromised devices.[75]

(b) The European Union adopts a harmonized ETSI-based trust framework, primarily defined by ETSI TS 102 941[76] and ETSI TS 103 097[77]. This framework enables interoperability across member states by establishing a common trust model, including enrollment and authorization authorities and standardized certificate lifecycle management. Vehicles use pseudonym-based authorization tickets that are periodically rotated to preserve privacy while ensuring secure communication. The framework also includes misbehavior detection and revocation mechanisms.

(c) China has developed a highly centralized and sovereign V2X security architecture aligned with its national Cellular V2X (C-V2X) deployment strategy. Its framework, defined through national standards such as YD/T 3957-2021 and driven by CCSA/CAICT, implements a Chinese Security Credential Management System (C-SCMS) with Government-controlled root certificate authorities and a nationally managed trust framework. Unlike US/EU systems, China adopts domestic cryptographic algorithms (SM2/SM3/SM4) instead of global ECC curves, while still maintaining core features such as pseudonym certificates and message authentication.[78]

(d) South Korea's V2X security architectures rely on PKI-based certificate systems aligned with IEEE 1609.2, supporting authentication, integrity,

[75] A Security Credential Management System for V2X Communications https://arxiv.org/abs/1802.05323

[76] https://www.etsi.org/deliver/etsi_ts/102900_102999/102941/02.02.01_60/ts_102941v020201p.pdf

[77] https://www.etsi.org/deliver/etsi_ts/103000_103099/103097/01.03.01_60/ts_103097v010301p.pdf

[78] https://uraeus.io/resources/v2x-security-monitoring/

and privacy in vehicular networks.[79]

3.60 In this context, the Authority solicits inputs from stakeholders on the following questions:

Issues for consultation:

Q6. To ensure inter-operability among different RSUs/ OBUs, whether there is a need to standardize the layered communication framework (stack) for higher layers (other than the access layer in which C-V2X will be used) of Intelligent Transportation System (ITS)? If yes, which standard for ITS stack and security should be adopted? Specifically, whether the ETSI standard for ITS stack and security, as recommended by the Task Force on Intelligent Transportation System for the use of 5.9 GHz (mentioned at para 3.5 of this consultation paper) should be adopted? If no, in what manner, inter-operability among different RSUs/ OBUs can be ensured? Kindly provide a detailed response with justification.

Q7. Whether there is a need for prescribing a security framework for ITS/ C-V2X in India? If yes, -

(a) What should be the security framework for ITS/ C- V2X?

(b) Which agency [such as Controller of Certifying Authorities (CCA), Ministry of Electronics & Information Technology (MeitY)] should implement the Public Key Infrastructure (PKI) framework for ITS/ C-V2X in India?

[79] https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE02407400

(c) How to ensure coexistence of V2X PKI certificates with the legacy PKI mechanism in India i.e. based on X.509, operated by Root Certifying Authority of India (RCAI)?

Please provide a detailed response with justifications.

J. Spectrum Assignment

3.61 DoT in its reference dated 01.12.2025 has mentioned, *inter alia*, as below*:*

"

…

iii. License-exempt use of on-Board Units (OBUs) may be permitted under defined technical conditions, while authorisation may be required for Roadside Units (RSUs) to ensure coordination deployment and effective interference management.

2. In this context, it is pertinent to refer to IND29 footnote of NFAP-2025, which states that "the frequency band 5875 to 5925 MHz may be used for V2X/ITS under Mobile service. This does not preclude the use of this frequency bands for other allocated services".

…"

(1) National Frequency Allocation Plan 2025 (NFAP-2025)

3.62 The Department of Telecommunications (DoT), Ministry of Communications, released the National Frequency Allocation Plan 2025[80] (NFAP-2025) — a key policy document that governs the management and allocation of radio-frequency spectrum in India. NFAP-2025 has come into effect from 30.12.2025.

[80] NFAP-2025 is available at the following URL: https://www.dot.gov.in/static/uploads/2026/02/b110cdc386d3a4e41c8483d7ffd7c410.pdf

3.63 The NFAP-2025 provides the allocation of radio-frequency spectrum to various radio-communication services in the frequency range from 8.3 kHz to 3000 GHz. It serves as an essential reference for spectrum managers, wireless operators, and telecom equipment manufacturers.

3.64 The IND29 footnote of NFAP-2025 states that "*the frequency band 5875 to 5925 MHz may be used for V2X/ITS under Mobile service. This does not preclude the use of this frequency bands for other allocated services*".[81]

(2) The Telecommunications Act, 2023 (Assignment of Spectrum)

3.65 As per Section 4 of the Telecommunications Act, 2023, the Central Government shall assign spectrum for telecommunication through auction except for entries listed in the 'First Schedule' for which assignment shall be done by administrative process. Section 4 of the Telecommunications Act, 2023 is reproduced below:

"4(1) The Central Government, being the owner of the spectrum on behalf of the people, shall assign the spectrum in accordance with this Act, and may notify a National Frequency Allocation Plan from time to time.
(2) Any person intending to use spectrum shall require an assignment from the Central Government.
(3) The Central Government may prescribe such terms and conditions as may be applicable, for such assignment of spectrum, including the frequency range, methodology for pricing, price, fees and charges, payment mechanism, duration and procedure for the same.
(4) The Central Government shall assign spectrum for telecommunication through auction except for entries listed in the ***First Schedule for which assignment shall be done by***

[81] https://www.dot.gov.in/static/uploads/2026/02/b110cdc386d3a4e41c8483d7ffd7c410.pdf

administrative process.

Explanation.—For the purposes of this sub-section,—

(a) "administrative process" means assignment of spectrum without holding an auction;

(b) "auction" means a bid process for assignment of spectrum.

(5)(a) The Central Government may, by notification, amend the First Schedule for assignment of spectrum—

(i) in order to serve public interest; or

(ii) in order to perform government function; or

(iii) in cases where auction of spectrum is not the preferred mode of assignment due to technical or economic reasons.

(b) The notification referred to in clause (a) shall be laid before each House of Parliament.

(6) The Central Government, if it determines that it is necessary in the public interest so to do, may exempt,—

(a) from the requirement of assignment under sub-section (2), in such manner as may be prescribed; and

(b) by notification, specific usages within specified frequencies and parameters, from the requirements of sub-section (2).

(7) Any exemption with respect to use of spectrum granted under the Indian Telegraph Act, 1885 and the Indian Wireless Telegraphy Act, 1933 prior to the appointed day, shall continue under this Act, unless otherwise notified by the Central Government.

(8) Any spectrum assigned through the administrative process prior to the appointed day, shall continue to be valid on the terms and conditions on which it had been assigned, for a period of five years from the appointed day, or the date of expiry of such assignment, whichever is earlier.

(9) Any spectrum assigned through auction prior to the appointed day, shall continue to be valid on the terms and conditions on which it had been assigned.

5. *The Central Government may, to enable more efficient use of spectrum, re-farm or harmonise any frequency range assigned under section 4, subject to such terms and conditions, as may be prescribed.*

   Explanation.—For the purposes of this section,—

   (a) "harmonisation" means rearrangement of a frequency range;

   (b) "re-farming" means repurposing of a frequency range for a different use, other than that for which it is used by an existing assignee.

6. *The Central Government may enable the utilisation of the spectrum in a flexible, liberalised and technologically neutral manner, subject to such terms and conditions, including applicable fees and charges, as may be prescribed.*

7. *(1) The Central Government may, to promote optimal use of the available spectrum, assign a particular part of a spectrum that has already been assigned to an entity, known as the primary assignee, to one or more additional entities, known as the secondary assignees, where such secondary assignment does not cause harmful interference in the use of the relevant part of the spectrum by the primary assignee, subject to such terms and conditions as may be prescribed.*

   (2) The Central Government may, notwithstanding anything contained in any other law for the time being in force, after providing a reasonable opportunity of being heard to the assignee concerned, determines that any assigned spectrum has remained unutilised for insufficient reasons for such period as may be prescribed, terminate such assignment, or a part of such assignment, or prescribe further terms and conditions relating to spectrum utilisation.

8. *(1) The Central Government may establish by notification, such monitoring and enforcement mechanism as it may deem fit to ensure adherence to terms and conditions of spectrum utilisation and enable interference-free use of the assigned spectrum.*

   (2) The Central Government may permit the sharing, trading, leasing

and surrender of assigned spectrum, subject to the terms and conditions, including applicable fees or charges, as may be prescribed.

9. No person shall be entitled to the refund of any fees or charges paid in respect of or under an authorisation or assignment granted under this Act, if such authorisation or assignment is suspended, curtailed, revoked or varied."

3.66 The First Schedule of Telecommunications Act, 2023 is reproduced below:

"The First Schedule"

[See sections 4 (4), (5) and 57(1)]

ASSIGNMENT OF SPECTRUM THROUGH ADMINISTRATIVE PROCESS

1. National security and defence.

2. Law enforcement and crime prevention.

3. Public broadcasting services.

4. Disaster management, safeguarding life and property.

5. Promoting scientific research, resource development, and exploration.

6. ***Safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems.***

7. Conservation of natural resources and wildlife.

8. Meteorological department and weather forecasting.

9. Internationally recognised dedicated bands for amateur stations, navigation, telemetry, and other like usages.

10. Use by Central Government, State Governments, or their entities or other authorised entities for safety and operations of mines, ports and oil exploration and such other activities where the use of spectrum is primarily for supporting the safety and operations.

11. Public Mobile Radio Trunking Services.

12. Radio backhaul for telecommunication services.

Explanation.—The term "radio backhaul" shall mean the use of radio frequency only to interconnect telecommunication equipment, other than the customer equipment in telecommunication networks.

13. Community Radio Stations.

14. In-flight and maritime connectivity.

15. Space research and application, launch vehicle operations and ground station for satellite control.

16. Certain satellite-based services such as: Teleports, Television channels, Direct To Home, Headend In The Sky, Digital Satellite News Gathering, Very Small Aperture Terminal, Global Mobile Personal Communication by Satellites, National Long Distance, International Long Distance, Mobile Satellite Service in L and S bands.

17. Use by Central Government, State Governments or their authorised agencies for telecommunication services.

18. Bharat Sanchar Nigam Limited (BSNL) and Mahanagar Telephone Nigam Limited (MTNL).

19. Testing, trial, experimental, demonstration purposes for enabling implementation of new technologies, including for creation of one or more Regulatory Sandboxes."

3.67 As may be seen from the above, the entry 6 of the First Schedule of Telecommunications Act, 2023 is 'Safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems'. Accordingly, the assignment of spectrum for V2I communication service for safety and operation of roads will be through administrative process.

(3) Frequency bands for ITS

3.68 DoT, in the Reference dated 01.12.2025, has mentioned, *inter-alia*, that

"30 MHz spectrum (5,875-5,905 MHz) may be allocated for the initial deployment of C-V2X technology, while the remaining 20 MHz (5,905-5,925 MHz) may be reserved for future ITS applications, thereby retaining flexibility for evolving standards and innovations."

3.69 ITU, in its recommendation ITU-R M.2121-1[82] on harmonization of frequency bands for Intelligent Transport Systems in the mobile service, recommended that Administrations should consider using the frequency band 5,850-5,925 MHz, or parts thereof, for current and future ITS applications, highlighting the following benefits of harmonization:

(i) increased potential for transportation operations, especially cross-border,

(ii) a broader manufacturing base and increased volume of equipment resulting in economies of scale and expanded equipment availability

(iii) improved spectrum management and planning;

3.70 5GAA, an automotive and mobile industry association, in its white paper on 'A visionary roadmap for advanced driving use cases, connectivity technologies, and radio spectrum needs' released in September 2020[83], recommends that national administrations make the entire globally harmonised 5855-5925 MHz band available for use by ITS communications between road users and roadside ITS infrastructure, as supported by the PC5 interface of C-V2X. The 5GAA report also highlights the need for additional spectrum for cellular network-based communications for use by mobile operators in delivering advanced driving capabilities in rural and urban environments.

[82] ITU recommendation ITU-R M.2121-1 https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2121-1-202312-I!!PDF-E.pdf

[83] https://5gaa.org/content/uploads/2020/09/A-Visionary-Roadmap-for-Advanced-Driving-Use-Cases-Connectivity-Technologies-and-Radio-Spectrum-Needs.pdf

3.71 A global snapshot of spectrum targeted or allocated to ITS is depicted in following table[84]:

Table 3.4: Examples of frequency usage for evolving ITS withing Regions[85]

Region 1	
Country or Group	**Frequency bands**
CEPT	5 855-5 925 MHz
United Arab Emirates	5 855-5 925 MHz
Region 2	
Country or Group	**Frequency bands**
Brazil	5 855-5 925 MHz
Canada	5 895-5 925 MHz
United States	5 895-5 925 MHz
Region 3	
Country or Group	**Frequency bands**
Australia	5 855-5 925 MHz
China	5 905-5 925 MHz
India	5 875-5 925 MHz
Japan	755.5-764.5 MHz 5 770-5 850 MHz
Korea	5 855-5 925 MHz
Singapore	5 855-5 925 MHz

(4) International Scenario for V2X Spectrum

United States:

3.72 In November 2024, Federal Communications Commission (FCC) adopted final rules on cellular vehicle-to-everything (C-V2X) technology through the Second Report and Order[86] on the Use of the 5.850-5.925 GHz Band. Through this decision, FCC further addressed the transition of 5.9 GHz ITS operations from Dedicated Short-Range Communications (DSRC)-based technology to C-V2X-based technology and established a two-year

84 https://www.tec.gov.in/pdf/M2M/TR_Technologies%20and%20Standards%20for%20Intelligent%20Transport%20System.pdf

85 https://www.itu.int/rec/R-REC-M.2121-1-202312-I/en

86 https://docs.fcc.gov/public/attachments/FCC-24-123A1.pdf

sunsetting window for DSRC operations till December 2026.

3.73 Under the FCCs rules, the upper 30 MHz of the 5.9 GHz band (5.895-5.925 GHz) is preserved for ITS, particularly Cellular Vehicle-to-Everything (C-V2X) technology, partitioning the band into three, 10 MHz bandwidths: (i) 5.895-5.905 GHz, (ii) 5.905-5.915 GHz, and (iii) 5.915-5.925 GHz bands, for individual or combined use.

Canada:

3.74 In December 2022, ISED designated the 5895–5925 MHz frequency range exclusively for Intelligent Transportation Systems (ITS) using C-V2X technology. Under this framework, ISED decided that ITS On-Board Units (OBUs) will operate on a licence-exempt basis with no interference protection, while ITS Roadside Units (RSUs) will be subjected to spectrum licensing requirements. Furthermore, ISED announced that a detailed licensing framework for RSU deployments in the 5895–5925 MHz band will be developed through a future public consultation.

China:

3.75 China's Ministry of Industry and Information Technology (MIIT), via its Radio Administration Bureau (National Radio Office), issued Guo Wu Ban Han No. 113 on December 18, 2024, optimizing V2X direct communication channels in the 5905-5925 MHz band to boost industry growth. Building on the 2018 MIIT No. 203 regulations that allocated a 20 MHz bandwidth for C-V2X, the notice introduces flexible 10 MHz or 20 MHz options: vehicle-mounted/portable units can use 5905-5915 MHz (10 MHz) or 5905-5925 MHz (20 MHz), while roadside units can operate on 5915-5925 MHz (10 MHz) or the full 20 MHz band. This adjustment provides flexibility in spectrum utilization while continuing the dedicated 20 MHz V2X band

allocation (5905–5925 MHz) established under earlier regulations.[87]

Europe:

3.76 European Conference of Postal and Telecommunications Administrations (CEPT) designated 5,855–5,875 MHz for non-safety road ITS applications, 5,875–5,935 MHz for safety-related ITS, with 5,875–5,915 MHz prioritised for road-ITS applications on a technology-neutral basis[88].

Japan:

3.77 As discussed earlier in para 2.44 and 2.45, Japan is currently using two main bands for V2X/ITS, with an additional one under development as followings:

(i) **760 MHz band**: 755.5–764.5 MHz is assigned for "ITS Connect" safety-related V2V/V2I communications (9 MHz channel).

(ii) **5.8 GHz band**: 5770–5850 MHz is allocated for ITS applications (ETC and related services).

(iii) **5.9 GHz band**: Japan is preparing to allocate 5895–5925 MHz (up to 30 MHz) for V2X to support automated driving, with frequency reorganization and migration of existing systems aiming for allocation by FY2026.

Australia:

3.78 The Australian Communications and Media Authority (ACMA) has allocated 70 MHz of spectrum in the 5.855–5.925 GHz band for ITS operations. ITS and V2X operations in Australia are authorized under the

[87] https://www.miit.gov.cn/jgsj/wgj/gzdt/art/2024/art_6994e7ba117f48efa518a135a0f4d439.html

[88] https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2444-1-2023-PDF-E.pdf

Radiocommunications (Intelligent Transport Systems) Class License 2017[89]. Under this license, operators do not require individual licenses or pay fees to access the spectrum. The license mandates compliance with international technical standards, particularly ETSI EN 302 571, which defines the maximum effective isotropically radiated power (EIRP), antenna characteristics, and modulation parameters for ITS equipment. This ensures interoperability and alignment with internationally recognized technical norms.

South Korea:

3.79 South Korea's Ministry of Science and ICT (MSIT) and Ministry of Land, Infrastructure and Transport (MOLIT) finalized the frequency allocation plan for next-generation Cooperative Intelligent Transport Systems (C-ITS)/V2X pilot projects on March 16, 2022, designating the 70 MHz band from 5,855 to 5,925 MHz for ITS applications.[90]

3.80 The present global V2X landscape and country position is summarized in the table below:

Table 3.5: Spectrum assignment for V2X: Global Scenario

Country	Band (MHz)	Technology
China	5905 – 5925 (LTE-V2X), 20 MHz	C-V2X
United States	5895 – 5925, 30 MHz (LTE-V2X)	Transit from DSRC to C-V2X, two-year sunset for DSRC (Dec 2026)

[89] Radiocommunications (Intelligent Transport Systems) Class License 2017
https://www.legislation.gov.au/F2018L00026/latest/text

[90]https://smartcity.go.kr/en/2022/03/16/%EA%B3%BC%EA%B8%B0%EC%A0%95%ED%86%B5%EB%B6%80EC%B0%A8%EC%84%B8%EB%8C%80%EC%A7%80%EB%8A%A5%ED%98%95%EA%B5%90%ED%86%B5%EC%B2%B4%EA%B3%84c-its-%EC%8B%9C%EB%B2%94%EC%82%AC%EC%97%85-%EC%A3%BC%ED%8C%8C/
MSIT confirms frequency allocation plan for next-generation intelligent transportation system (C-ITS) pilot project

South Korea	5855 – 5875 (LTE-V2X) 5875 – 5925 (Future use)	Pilot trial with DSRC, but formally chose LTE-V2X in 2023
Europe	5855 – 5875 (ITS G5B: non-safety) 5875 – 5905 (ITS G5A: road safety) 5905 – 5925 (ITS G5C: future extension)	From driving DSRC to technology neutral
Australia	5855 – 5925, 70 MHz	Spectrum-neutral and tech-neutral
Japan	755.5 – 764.5 (DSRC) 5770 – 5850 (reserved for ETC/ DSRC) 5855-5925 (C-V2X, planning)	Production in DSRC, also doing trials in C-V2X

(5) Block of V2X spectrum for assignment:

3.81 As per DoT reference dated 01.12.2025, 30 MHz spectrum (5875-5905 MHz) may be allocated for the initial deployment of C-V2X technology, while the remaining 20 MHz (5905-5925 MHz) may be reserved for future ITS applications. It is to be seen whether this entire 30 MHz spectrum may be assigned for ITS operation or certain bandwidth within this range be earmarked for "safety applications" and "non safety applications" separately, or may be divided in the different carriers.

3.82 As per the FCC 2nd report and order dated 21.11.2024, 30 MHz (5.895-5.925 GHz) has been reserved for ITS service using C-V2X technology. As regard the channel bandwidth FCC has stated that:

"Given our preference for a light touch to minimize disruption to ongoing transition activities, we will continue to provide for 10-megahertz channel bandwidths, resulting in three channels : 5.895-5.905 GHz, 5.905-5.915 GHz, and 5.915-5.925 GHz, respectively. We will allow users to combine the 10-megahertz channels into 20 megahertz contiguous channels or a single 30-megahertz channel without restriction, thus accommodating

various ITS applications and services".[91]

3.83 In EU 5,855–5,875 MHz is reserved for non-safety road-ITS and short-range devices on a non-interference basis, 5,875–5,925 MHz serves as the primary safety-related ITS band for both road and urban rail applications, and 5,925–5,935 MHz is available for rail-ITS only.

3.84 In China, the vehicle-mounted/ portable units can use 5905-5915 MHz (10 MHz) or 5905-5925 MHz (20 MHz), while roadside units can operate on 5915-5925 MHz (10 MHz) or the full 20 MHz band.

3.85 It is to be examined as to whether the spectrum of 30 MHz (5,875-5,905 MHz) under consideration in India, is to be divided in blocks for assignment or different bandwidth out of this 30 MHz is to be reserved for safety and non-safety application or for V2V and V2I communication.

(6) Period of Spectrum Assignment, roll out obligation and Surrender of Spectrum:

3.86 As discussed in para 3.67, the safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems, falls under the first schedule of the Telecommunications Act, 2023. The spectrum for such purposes shall be assigned administratively.

3.87 It is to be examined for how much period the spectrum for V2I communication service should be assigned. Further, there may be cases where an authorised entity gets the spectrum assigned but does not start the operation. V2I communication service is a safety critical service, it may not be in public interest, if even after the assignment of spectrum, the

[91] FCC 2nd report and order dated 21.11.2024

authorised agency delays the roll-out of service or does not roll-out at all.

3.88 TRAI, while submitting recommendation on 'Method of allocation of spectrum for Public Mobile Radio Trunking Service (PMRTS) including auction, as a transparent mechanism' on 20.07.2018 and 'Response to the Back Reference dated 21.07.2025 received from DoT on these Recommendations' dated 30.09.2025, recommended the following:

> *"2.6.11……the Authority recommends that, at this stage, the maximum period of validity of spectrum assignment to PMRTS operators should be five years. Based on a review after five years, the Government may consider renewing the spectrum assignment to PMRTS operators for a further period of maximum five years.*
>
> *2.6.12 Further, as mentioned above in this section, the Authority does not agree with the DoT's view that spectrum assignment on administrative basis should be issued for a maximum period of five years for all candidate services. The Authority recommends that the maximum period of validity of spectrum assignment on administrative basis should depend upon on the type of service."*

3.89 As regard the period of license for RSUs, the FCC Second Report and Order states that: *"Non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5,895-5,925 MHz band under subpart M of this part will be issued for a term not to exceed ten years from the date of original issuance or renewal."*

3.90 Regarding the roll out obligations, FCC Second Report and Order states that:

"Intelligent Transportation Systems radio service Roadside Units (RSUs) under subpart M of this part in the 5895-5925 MHz band must be placed in operation within 12 months from the effective date of registration (see

§§ 90.375, 90.389 of this part) or the authority to operate the RSUs cancels automatically (see § 1.955 of this chapter)".

3.91 Similarly, after the assignment of spectrum, the authorised entity may not be interested in starting of the services or entity ceased the operation. There may also be other scenarios where the authorised entity wants to surrender the assigned spectrum. As the spectrum is a scarce resource, there should be enabling regulatory provisions for the surrender of spectrum so that other interested entity may be assigned the spectrum and provide services. The mechanism for the surrender of spectrum needs to be examined.

(7) Spectrum assignment in exclusive/ non-exclusive manner/ Interference management:

3.92 The authorized entities can be one or more than one in a service area. If there are more than one authorized entity in a common geographical area, the mechanism for simultaneous use of spectrum by the Authorised entities needs to be examined. If the spectrum is to be divided among the entities in an exclusive manner, it is to be seen how much minimum spectrum needs to be assigned to each authorized entity. In case the complete spectrum band of 30 MHz is to be shared among all the authorised entities, there may be chances of interference among the RF signal emanating from RSUs of different entities. It is to be examined how the interference management may be done through geographical separation or any other means.

3.93 In USA, RSU/OBU licenses are issued on a non-exclusive basis. As per FCC 2nd report and order dated 21.11.2024:

"(1) If a dispute arises concerning non-priority communications, the licensee of the later-registered RSU must accommodate the operation of

the early registered RSU, i.e., interference protection rights are date-sensitive, based on the date that the RSU is first registered (see § 90.389) and the later registered
RSU must modify its operations to resolve the dispute in accordance with paragraph (c)(2) of this section.

(2) For purposes of this paragraph (c), objectionable interference will be considered to exist when the Commission receives a complaint and the difference in signal strength between the earlier-registered RSU and the later-registered RSU is 18 dB or less (co-channel). Later-registered RSUs causing objectionable interference must correct the interference immediately unless written consent is obtained from the licensee of the earlier-registered RSU.

(8) Approval mechanism for deploying the RSUs

3.94 For setting up any wireless communication infrastructure which uses radio frequencies, such as telecom towers, the Standing Advisory Committee on Frequency Allocation (SACFA) clearance is required. The SACFA clearance is issued by the Wireless Planning and Coordination (WPC) Wing of the Department of Telecommunications and is mandatory for the establishment of wireless communication infrastructure in India, including telecom towers, base transceiver stations, and radio antennas. SACFA approval ensures that the proposed infrastructure meets regulatory standards, including:

(a) **Frequency Allocation Compliance**: Ensures that the frequency spectrum to be used does not interfere with other radio services and adheres to the country's spectrum allocation policies.

(b) **Aviation Safety**: Checks for compliance with height restrictions

and safety guidelines laid out by the Ministry of Civil Aviation to avoid interference with aircraft navigation.

3.95 The SACFA clearance process involves consultation with various Government bodies, including the Ministry of Civil Aviation, Ministry of Defence, and other agencies, to assess the suitability and safety of the site. Applicants must provide details about the proposed site location, equipment specifications, and intended frequency use. SACFA applications are classified into the following four major categories, depending on the nature of the installation and the type of service being deployed. These categories help streamline the process for tower/mast installations and ensure proper frequency coordination, safety, and compliance.

(a) Mast Height Category

(i) Purpose: To obtain clearance for setting up new masts or towers, primarily based on their height and location.

(ii) Sub-Categories:

- Mast Height (Broadcast Service) – For broadcast towers used in radio or TV transmission.
- Mast Height (VSAT) – For Very Small Aperture Terminal (VSAT) earth stations used in satellite communication.
- Mast Height (General) – For general telecom applications (e.g., cellular towers, microwave links).

(iii) Use Case: Most commonly used for new tower or mast installations by telecom service providers, broadcasters, or satellite operators.

(b) Full Siting Category

(i) Purpose: For locations that require detailed inter-agency coordination, including defence, aviation, and other regulatory authorities.

(ii) When Required:

- Installation of high-power or large antenna systems
- Sites near airports, defence zones, or sensitive areas
- Usage of new or uncoordinated frequency bands
- Installations involving international border proximity or restricted zones

(iii) It ensures:

- National security compliance through coordination with the Ministry of Defence (MoD).
- Aviation safety, with checks by the Airports Authority of India (AAI).
- Interference management through technical vetting by the Wireless Planning & Coordination (WPC) wing.
- Geographic impact assessment, especially in proximity to defence/air traffic zones.

(iv) Use Case: Used for satellite uplink stations, large broadcasting stations, and installations near airports or military installations.

(c) Exemption Category

(i) Purpose: The Exemption Category under SACFA is for wireless installations that do not require full SACFA clearance, due to their low risk, low power, or indoor deployment characteristics. These setups are considered non-critical in terms of frequency interference, national security, or aviation safety.

(ii) Commonly Exempted Installations:

- Indoor antennas (e.g., Wi-Fi access points)
- Low-powered devices or short-range wireless installations
- Small cell deployment under defined height/power limits

(d) Additional Antenna Category

(i) Purpose: The Additional Antenna Category is used when a

telecom operator or infrastructure provider wants to install new antennas on a site or tower that has already received SACFA clearance. This ensures that any modification or expansion of the existing infrastructure complies with the DoT's regulations for frequency usage, interference management, and structural safety.

(ii) Why it is Needed:

- To facilitate network upgrades (e.g., 4G to 5G, MIMO additions)
- To allow multiple operators to share the existing towers (infrastructure sharing)
- To add new frequencies or sectors to improve coverage or capacity
- To maintain updated records of antenna parameters for each site.

(iii) Use Case: Used when operators upgrade from 4G to 5G, or add antennas to existing towers for coverage enhancement.[92]

3.96 As regard the approval mechanism in USA, it is stated in the FCC 2nd report and order dated 21.11.2024 that:

"§ 90.389 RSU license areas and registrations.

(a) Roadside Units (RSUs) in the 5895-5925 MHz band are licensed on the basis of non-exclusive geographic areas. Governmental applicants will be issued a geographic area license based on the geopolitical area encompassing the legal jurisdiction of the entity. All other applicants will be issued a geographic area license for their proposed area of operation based on county(s), state(s) or nationwide.

[92] SACFA clearance https://eservices.dot.gov.in/sacfa-standing-advisory-committee-frequency-allocation-clearance

(b) Applicants who are approved in accordance with FCC Form 601 will be granted non-exclusive licenses for the channel(s) corresponding to their intended operations (see § 90.386). Such licenses serve as a prerequisite of registering individual RSUs located within the licensed geographic area described in paragraph (a) of this section. Licensees must register each RSU in the Universal Licensing System (ULS) before operating such RSU. RSU registrations are subject, inter alia, to the requirements of § 1.923 of this chapter as applicable (antenna structure registration, environmental concerns, international coordination, and quiet zones). Additionally, RSUs at locations subject to NTIA coordination (see § 90.387(b)) may not begin operation until NTIA approval is received. Registrations are not effective until the Commission posts them on the ULS. It is the licensee's responsibility to delete from the ULS registration database any RSUs that have been discontinued.

(c) Licensees must operate each C-V2X RSU in accordance with the Commission's rules and the registration data posted on the ULS for such C-V2X RSU.

3.97 As RSU is a wireless communication equipment, which uses radio frequencies, the requirement for SACFA-type approval mechanism or a reporting system with GIS based database, needs to be examined.

3.98 In this context, the Authority solicits inputs from stakeholders on the following questions:

Issues for consultation:

Q8. What should be the regulatory framework for the assignment of frequency spectrum to the entities holding the proposed V2I communication service authorisation? Specifically, -

(a) Whether there is a need for partitioning the 30 MHz spectrum (5,875-5,905 MHz) for specific applications such as "safety applications" and "operational applications (non-safety applications)"?

(b) In case more than one authorised entity has to operate in the same geographical area, what should be the mechanism for simultaneous use of the spectrum? Specifically, whether the spectrum should be divided amongst the authorised entities in an exclusive manner, or should the authorised entities utilize the spectrum in a shared manner?

(c) If your response to part (b) is "in an exclusive manner", what should be the minimum quantity of spectrum to be assigned to each entity holding the proposed V2I communication service authorisation? If your response to part (b) is "in a shared manner", whether there is a need to prescribe a mechanism for interference management?

(d) For interference management, whether there is a need to prescribe –

(i) minimum directionality of road-side unit (RSU), or

(ii) protection distance between the RSUs, or

(iii) maximum antenna height for RSUs?

If yes, what should be such parameter(s)?

(e) Whether there is need to mandate a mechanism for obtaining prior approval (analogous to SACFA clearance) for the establishment of RSUs by the entities holding the proposed

V2I communication service authorisation? If no, in what manner, the establishment of RSUs should be regulated?

(f) For avoiding (i) interference between RSUs, (ii) interference between RSUs and OBUs, and (iii) interference between OBUs, whether the radiated power limits for OBUs and RSUs and OOBE limits, recommended by the Task Force on Intelligent Transportation System for the use of 5.9 GHz (mentioned at para 3.4 of this consultation paper) should be adopted? If no, what should be the radiated power limits for OBUs and RSUs and OOBE limits?

(g) What should be the maximum period of assignment of spectrum to the entities holding the proposed V2I communication service authorisation?

(h) Whether there is a need to prescribe roll-out obligations associated with the assignment of spectrum to the entities holding the proposed V2I communication service authorisation?

(i) Whether there is a need to introduce a provision for the surrender of frequency spectrum?

Kindly provide a detailed response with justification.

Q9. Whether there is a need for prescribing timelines for processing the applications for the assignment of spectrum to the entities holding the proposed V2I communication service authorisation? Kindly provide a detailed response with justification.

Q10. Whether there are any other suggestions related to assignment of spectrum to the entities holding the proposed V2I communication service authorisation? Please provide a detailed response with justification.

Q11. Any other issues/ suggestions relevant to the regulatory framework for V2X communication may be submitted with proper explanation and justification.

3.99 The following chapter discusses the issues related to spectrum charges and other financial conditions related to the proposed V2X communication service authorisation.

CHAPTER IV: ISSUES RELATED TO SPECTRUM CHARGES AND OTHER FINANCIAL CONDITIONS

A. Background

4.1 The Department of Telecommunications (DoT), vide its reference dated 01.12.2025, has sought recommendations on the regulatory mechanism for Vehicle-to-Everything (V2X), including spectrum assignment, authorization and pricing for RSUs along with any other recommendation relevant to the issue. As discussed in the preceding chapters, V2X technologies are expected to play a critical role in enhancing road safety, improving traffic efficiency, and enabling Intelligent Transport Systems (ITS). In this context, the formulation of an appropriate financial framework assumes significance, as it directly influences the pace of deployment and overall viability of V2X ecosystems in the country.

4.2 The DoT Reference further provides that 30 MHz of spectrum (5875-5905 MHz) may be allocated to initial deployment of C-V2X technology. In this context, entry 6 of the First Schedule of Telecommunications Act, 2023 regarding 'Safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems' provides for administrative assignment of spectrum. Given that V2X technology is expected to be intrinsically linked to safety-critical use cases such as collision avoidance, emergency warnings, and traffic management, the spectrum (5875-5925 MHz) will be assigned through an administrative process. Therefore, the financial conditions governing administrative assignment of spectrum need to be aligned with the broader policy objective of facilitating widespread adoption of V2X technology while ensuring efficient spectrum utilization.

4.3 As highlighted in Chapter II, the proposed V2X framework consists of two main components namely On-Board Units (OBUs) and Roadside Units

(RSUs). OBUs, being embedded within the vehicles and operating at low power over short ranges, are contemplated to function under a license-exempt regime. RSUs are expected to be deployed along road networks and require coordinated operation to ensure interoperability and avoid interference. As per DoT Reference and the MoRTH Committee Report, the entities deploying and operating RSUs are envisaged to be brought under an authorization framework. The Chapter III discussed about the V2I Communication service authorisation framework for the entities deploying the RSUs. Accordingly, this chapter deals with the determination of appropriate spectrum charges and related financial conditions for the proposed V2I communication service authorisation.

4.4 The financial conditions for V2I communication service authorised entities, need to take into account multiple considerations, including the safety related use case and public welfare-oriented nature of V2X services, the need to encourage early-stage investments, and the evolving nature of the technology ecosystem. Calibrated financial conditions with rationalized charges and simplified compliance requirements could promote innovation in the V2X ecosystem and accelerate the deployment of V2X infrastructure in the country.

4.5 In addition, international experience suggests that financial models for V2X technology deployment have generally prioritized ecosystem development over revenue generation. Many jurisdictions have adopted minimal or no spectrum charges, particularly for safety-related applications, while ensuring that regulatory oversight is maintained through technical and operational conditions. In this backdrop, given the safety-critical and public welfare-oriented nature of V2X services, the determination of spectrum charges and other financial conditions for V2I communication service authorised entities need to be examined so as to strike a balance between C-V2X ecosystem development and efficient spectrum utilization. This is particularly important in the context of

promoting early adoption and ensuring that financial conditions do not impede the rollout of V2I infrastructure & services in the country.

4.6 Spectrum-related financial considerations also extend to the identification of the appropriate revenue base for V2I communication service authorised entities under the proposed V2I communication service authorisation framework. Unlike traditional telecommunications services, V2X technologies are not expected to generate direct revenue streams, especially from safety-related use cases. Therefore, definitions of concepts such as Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) for V2I communication service authorised entities require careful deliberation to ensure clarity, fairness, and ease of compliance.

4.7 The discussion about financial conditions pertains to the following categories:

(i) Spectrum Charges for RSUs

(ii) Definition of GR/ApGR/AGR ;

(iii) Other financial conditions including:

a. Entry Fees;

b. Application processing Fees;

c. Bank Guarantees;

d. Minimum Equity & net worth; and

e. Authorisation Fees

B. Spectrum Charges

4.8 Spectrum charges constitute a critical element of the overall financial framework governing V2X technology deployments and have a direct bearing on the scale at which V2X infrastructure is rolled out. The manner in which such charges are determined influences investment decisions, and the pace of adoption of V2X technologies. Therefore, the design of an appropriate spectrum charging mechanism assumes considerable importance in the present context.

4.9 The Task Force constituted by Ministry of Road Transport and Highways and the DoT Reference dated 01.12.2025, as discussed in section B and C of Chapter III, had prescribed that RSUs be brought under an appropriate Authorisation framework. In this context, the entry 6 of the First Schedule of Telecommunications Act, 2023 under 'Safety and operation of roads, railways, metro, regional rail, inland waterways, airports, ports, pipelines, shipping, and other transport systems' provide for administrative assignment of spectrum. Accordingly, as discussed in Chapter III, the assignment of spectrum for Vehicle-to-Infrastructure (V2I) communication service for safety and operation of roads will be through administrative process.

4.10 Roadside Units (RSUs) form a critical component of the V2X ecosystem, functioning as communication infrastructure deployed along roadways to enable Vehicle-to-Infrastructure (V2I) interactions. These units are typically installed at strategic locations such as highways, intersections, toll plazas, and urban corridors to facilitate real-time data exchange between vehicles and the surrounding environment. Through such interactions, RSUs can support a wide range of applications, including traffic management, collision avoidance, congestion mitigation, and dissemination of safety alerts, thereby contributing significantly to the overall efficiency and safety of transport systems. On-Board Units (OBUs)

are embedded within vehicles and operate in a largely decentralized manner. On the other hand, deployment of RSUs is expected to require coordinated planning to cover highways, urban intersections, high-traffic corridors etc. and to avoid the interference.

4.11 Further, as discussed in Chapter III, the assignment of spectrum to a V2I communication service authorised entity, whether on an exclusive or shared non-exclusive basis, has direct implications for the determination of spectrum charges. Any spectrum pricing framework must therefore reflect the underlying nature of such assignment. Importantly, international experience within the V2X ecosystem indicates a clear policy preference for non-exclusive spectrum assignment in order to maximize overall spectrum efficiency and utilization. Such non-exclusive assignment of spectrum is reflected in minimal or no spectrum charges for V2I communication services, particularly where the spectrum is designated for license-exempt use or for public safety applications.

4.12 V2I communication service authorised entities deploying and managing RSUs are crucial parts of the V2X ecosystem for the stated purposes viz. road safety, traffic efficiency etc. Unlike conventional telecom services, RSU-based deployments are primarily aimed at enabling road safety and traffic efficiency and could not be associated with clearly identifiable revenue streams. At the same time, such deployments are expected to be carried out at scale across highways, urban intersections, and other high-traffic corridors, and is likely to involve multiple ministries/ agencies for implementation. In this context, the appropriate framework for levy of spectrum charges requires careful consideration of the nature of use, deployment characteristics, and overall policy objectives.

4.13 It is noted that the services under the proposed V2I communication service authorisation fall within the broader category of road safety and operation of transport systems. In this context, the determination of

spectrum charges requires consideration of factors beyond conventional commercial principles. In the Indian context, specific conditions as noted by the task force constituted by MoRTH, such as poor traffic management, inadequate infrastructure, driver error, adverse weather conditions etc. could have a direct bearing on the design of the spectrum charging framework. Accordingly, the approach to spectrum charging for such applications need to be context-specific, taking into account public safety objectives, affordability considerations, and the requirement to facilitate widespread adoption.

(1) Determination of Spectrum Charges for Administratively Assigned Spectrum to V2I communication service authorised entities

4.14 For spectrum assigned administratively under the First Schedule of Telecommunication Act, 2023, the Order dated 11.12.2023 (**Annexure V**) issued by the Wireless Planning and Coordination (WPC) Wing, Department of Telecommunications can be referred. The said order contains provisions for calculation of spectrum charges for all users to whom radio frequency assignment is made through administrative process. As spectrum to the V2I communication service authorised entities will be assigned administratively, the said order could provide reference in determination of appropriate spectrum charges.

4.15 The said Order provides for spectrum charges to be levied on a formula-based methodology, comprising license fee and royalty charges, applicable across different radiocommunication services. The Order further provides that such charges are determined based on the nature of the service, technical characteristics (including bandwidth and coverage), and operational parameters, and are generally applicable on an annual basis.

4.16 The Order dated 11.12.2023 further classifies spectrum usage into multiple categories of radiocommunication services, inter alia, Land Mobile Service (Schedule II) and Maritime Mobile service (Schedule III). V2X (Vehicle-to-Everything) technology involves exchange of information between vehicular units (OBUs), roadside infrastructure (RSUs), and network-based entities. Such systems could exhibit characteristics of both mobile and fixed elements, with OBUs functioning as mobile stations and RSUs as fixed/base stations within a defined coverage area.

4.17 The Land Mobile Service, as described in the Order dated 11.12.2023, encompasses networks comprising "one or more base stations, mobile stations, or any combinations thereof," and includes both fixed-site and area-based operations, with charging determined on the basis of coverage area, bandwidth, and frequency band characteristics. Given that V2I deployments could typically involve localized or corridor-based communication (e.g., along roads, urban intersections, or highways), and may scale to district or state-wide coverage, reference could be drawn from the Land Mobile Service category.

4.18 Further, Maritime Mobile Services prescribed in the said Order can be examined to assess whether relevant insights can be drawn for the calculation of spectrum charges for the proposed V2I communication service authorisation. Under the maritime mobile service, frequencies are largely assigned on a non-exclusive basis within a regulatory framework that prioritizes safety-critical communications. Spectrum charges for the maritime mobile service is structured as fixed annual royalties based on technical parameters such as bandwidth, rather than market-based valuation, and certain distress and safety frequencies are exempted to ensure unrestricted access. While V2X encompasses a broader set of use cases, its safety-critical applications share similarities with maritime mobile service in terms of their public safety objectives and the need for high reliability and widespread accessibility. To this extent, the maritime

mobile service reflects an administrative, cost-recovery-oriented approach to spectrum pricing rather than revenue maximization. In this context, the spectrum charging methodologies applicable to Maritime Mobile Service and Land Mobile Service, as prescribed in the DoT Order dated 11.12.2023, could be examined to assess their reference for the proposed V2I communication service authorisation.

(2) International experiences on Assignment and Pricing of spectrum used in V2X

4.19 Internationally, the spectrum in the 5.9 GHz band for Intelligent Transport Systems (ITS) and Vehicle-to-Everything (V2X) communications is assigned in a manner that reflects its public safety and non-commercial character. Across jurisdictions, the dominant approach is to assign such spectrum through administrative or license-exempt frameworks, with pricing methodologies aligned to cost-recovery principles or zero-fee regimes. International experiences from some of the jurisdictions are discussed below:

(a)United States

4.20 In the United States, spectrum in the 5.9 GHz band for Intelligent Transport Systems (ITS) is assigned under a non-exclusive, site-based licensing framework administered by the Federal Communications Commission (FCC). Under this framework, spectrum access is granted without exclusive rights, and multiple users may operate subject to technical conditions.

4.21 In the United States, the deployment of Vehicle-to-Everything (V2X) technologies in the 5.9 GHz band is currently progressing through a transitional regulatory framework, led by the Federal Communications Commission. As the regulatory regime shifts from Dedicated Short-Range

Communications (DSRC) to Cellular V2X (C-V2X), the FCC has enabled early-stage deployments through flexible mechanisms rather than relying solely on a finalized licensing structure.[93] This approach has allowed stakeholders to initiate real-world deployments while the broader regulatory framework continues to evolve.

4.22 A key mechanism supporting such deployments is the use of experimental licenses, which have been granted by the FCC to facilitate testing and pilot implementation of C-V2X technologies. These licenses have been used by industry participants, research institutions, and public authorities to conduct field trials and demonstrate V2X use cases under real-world conditions. Evidence from national-level deployment planning documents indicates that implementing agencies continue to rely on experimental licensing to advance projects and meet deployment timelines, highlighting their role not only in laboratory testing but also in practical, on-ground deployment scenarios. [94]

4.23 In parallel, the FCC has also utilized regulatory waivers to support early deployment of C-V2X technologies. These waivers permit entities to operate within the 5.9 GHz band under specified technical conditions, even before the full implementation of finalized service rules. Through this approach, the FCC has enabled a number of pilot and pre-commercial deployments, thereby ensuring continuity of innovation and avoiding delays associated with regulatory transition. The use of waivers has been particularly important in facilitating the migration from DSRC-based systems to C-V2X, allowing stakeholders to deploy next-generation technologies while maintaining regulatory oversight.[95]

[93] https://docs.fcc.gov/public/attachments/FCC-20-164A1.pdf

[94] https://itsa.org/wp-content/uploads/2023/04/V2XDeploymentPlan-1.pdf

[95] https://www.dwt.com/blogs/broadband-advisor/2023/05/fcc-connected-vehicles-c-v2x

(b) Australia

4.24 In Australia, spectrum in the 5.9 GHz band for Intelligent Transport Systems (ITS), including Vehicle-to-Everything (V2X) communications, is assigned under a class licensing framework administered by the Australian Communications and Media Authority (ACMA). Under this framework, the relevant band is reserved for ITS applications and is made available for use without the requirement for individual spectrum licences. Specifically, ACMA has issued an ITS class licence, which permits the operation of radiocommunications transmitters for ITS purposes, including DSRC and Cellular V2X technologies, subject to compliance with prescribed technical standards. Users operating under this framework are not required to apply for individual licences, nor are they required to pay spectrum access fees, provided that they adhere to equipment and operational requirements.[96]

(c) UK

4.25 In the UK, OFCOM is responsible for spectrum management under two Acts of Parliament: The Communications Act 2003 and the Wireless Telegraphy Act 2006 (WT Act). Within this framework, the licence-exemption power under section 8(3) of the WT Act is the primary instrument through which ITS and V2X radio equipment both on-board units (OBUs) in vehicles and roadside units (RSUs) at junctions and highway sites is authorised to operate without individual licensing. Accordingly, such operations are carried out under a licence-exempt framework, no spectrum licence is granted and, therefore, no spectrum charges or royalty fees are applicable in the United Kingdom. Instead, the deployment of V2X technologies has been supported through

[96] Australian Communications and Media Authority (ACMA), *Radiocommunications (Intelligent Transport Systems) Class Licence 2017*, available at: https://www.acma.gov.au/licences/intelligent-transport-systems-class-licence

government-funded programmes and pilot-based initiatives. For instance, the UK Government has funded multiple V2X innovation projects, including programmes with total funding of over £11 million and additional allocations of approximately £4.8 million for pilot deployments.[97] Individual projects under these programmes typically involve costs ranging from £150,000 to £300,000 and are implemented through collaborative arrangements between industry participants and public authorities.

4.26 Furthermore, real-world V2X deployments in the UK have been carried out through public-private partnerships, involving telecom operators, infrastructure providers, and transport authorities, with costs primarily associated with infrastructure deployment, system integration, and testing.

(d)Canada

4.27 In Canada, Innovation, Science and Economic Development Canada (ISED), through its decision on the 5850-5925 MHz band, has designated the 5895-5925 MHz portion for Intelligent Transport Systems (ITS), including V2X applications. The decision indicates that spectrum access in this band is to be governed under a structured regulatory framework, including the use of spectrum licensing mechanisms. Under the spectrum licensing framework, licences are issued by the competent authority to authorize the use of specified frequencies within a defined geographic area and are subject to applicable terms and conditions. Such licences enable the licensee to establish and modify radiocommunication networks within the authorized area, while ensuring compliance with technical and operational requirements. Further, spectrum licences are assigned based

[97] https://www.gov.uk/government/publications/v2x-innovation-programme-successful-projects/v2x-innovation-programme-phase-2-successful-projects

on defined service areas and are subject to applicable spectrum fees, as determined by the Government from time to time.

(e) Other Countries

4.28 In addition to the above, as noted in Chapter III, China has adopted a differentiated licensing framework for V2X in the 5905-5925 MHz band, wherein RSUs are subject to frequency usage and radio station licences, while OBUs operate on a licence-exempt basis. Similarly, in South Korea, RSUs are administratively assigned spectrum under a licensed framework, whereas OBUs are kept licence-exempt. While no explicit provisions relating to spectrum charging could be identified in either jurisdiction, the requirement of licensing for RSUs indicates that spectrum access is subject to regulatory control through formal administrative mechanisms. Such licensing frameworks, in general, are associated with the levy of administrative fees or spectrum usage charges, even where these are not separately specified.

4.29 However, it has also been observed that, despite the presence of defined licensing structures, there is limited publicly available information on the applicable pricing methodologies, quantum of charges, or principles governing spectrum valuation for V2X technology in these jurisdictions. This could be an indication that, at present, regulatory approaches are primarily focused on enabling deployment and ensuring technical coordination, with spectrum charging not being distinctly articulated as a standalone policy component.

4.30 It can be observed that many countries have adopted minimal or no spectrum charges for V2X communications, particularly where the spectrum is designated for license-exempt use or for public safety applications. Further, in most jurisdictions, OBUs operate under a license-exempt regime, consequently no authorisation fees or spectrum charges

are levied. Even in cases where RSUs are subjected to licensing, charges are often kept low and structured in a manner that does not impede deployment. Such approaches have facilitated the gradual expansion of V2I infrastructure. The emphasis in international deployment of V2X have generally been on ensuring technical compliance, interoperability, and efficient spectrum use, rather than imposing significant financial burdens. This approach recognizes that the long-term benefits of V2X deployment, in terms of safety and efficiency, outweigh the potential short-term revenue gains from spectrum charges. It is also observed that in several jurisdictions, governments have actively supported V2X deployment through funding initiatives, pilot projects, and policy incentives. In such cases, the imposition of high spectrum charges would be counterproductive and could undermine broader policy objectives.

4.31 While the technical and regulatory frameworks for V2X spectrum assignment and pricing may be informed by international practices, the Indian context presents a distinct set of deployment challenges and policy considerations that require careful examination. First, the effectiveness of V2X applications, particularly safety-critical use-cases, is contingent upon predictability and compliance in road user behaviour. India's traffic environment is marked by heterogeneous mix of vehicles and varying adherence to traffic rules. These factors could potentially present context specific challenges in adoption of V2X ecosystem in India. Second, infrastructure readiness remains an important constraint. The deployment of V2X applications/ systems, especially those relying on Roadside Units (RSUs), requires supporting infrastructure such as reliable power supply and could require integration with existing traffic management systems. In several regions, particularly outside major urban centres, such infrastructure may be limited or absent, thereby increasing the cost and complexity of deployment. Third, the traffic density and load conditions in India are typically higher in urban areas, which could have implications

for spectrum usage efficiency, interference management, and overall system performance. Use of V2X technology to cater to urban areas with higher density could necessitate more robust and scalable V2X technology-based communication mechanisms, thereby influencing spectrum requirements and charging frameworks.

4.32 Further, the primary policy objective for V2X deployment in India is likely to be road safety and traffic management, given the high incidence of road accidents and congestion. Large-scale deployment of RSUs, could involve significant capital and operational expenditure. In this context, it seems especially relevant, that any spectrum charging framework that imposes high or recurring costs could act as a barrier to adoption, particularly in the absence of clear revenue streams.

4.33 In addition, considerations of scalability and future-proofing are relevant. V2X technologies are expected to evolve with advancements in 5G and beyond, enabling new use-cases such as autonomous driving and advanced traffic coordination. Spectrum assignment and pricing frameworks must therefore be flexible enough to accommodate technological evolution without requiring frequent regulatory restructuring. In the case of V2X technology, spectrum is not merely a commercial resource but also an enabler of safety-critical services. Applications of V2X technology such as collision avoidance, emergency vehicle warnings, and traffic signal coordination rely on reliable and low-latency communication. Accordingly, the determination of spectrum charges needs to reflect the unique and evolving nature of these services and their broader societal benefits.

4.34 One of the defining characteristics of V2X technology is the significant public safety and societal benefits associated with V2I deployments. These systems have the potential to reduce road accidents, improve traffic efficiency, and enhance emergency response mechanisms. In this

context, a case could be made to consider such safety related use-cases in the valuation framework of spectrum used by RSUs under V2I communication service authorisation.

4.35 Given these characteristics of V2I communication services, it is necessary to propose a spectrum charging mechanism that takes into account the technical, operational, and societal aspects of V2I communication services. A differentiated charging framework could be appropriate in this context. As discussed in Chapter III, an important consideration is that whether entire 30 MHz spectrum may be assigned for ITS operation or certain bandwidth within this range be earmarked for "safety applications" and "non safety applications" separately or may be divided in the different carriers. In view of this, different categories of use-cases could be subjected to different levels of spectrum charges. For instance, safety-related use cases could be subject to minimal or no charges, while commercial or value-added services operating over the same infrastructure could attract higher charges. Such differentiated charging framework could ensure context specific spectrum pricing while maintaining incentives for innovation.

4.36 In the Indian context, where V2X deployment is yet to commence, adopting a facilitative and forward-looking spectrum charging framework is particularly important. At the same time, such a framework must promote efficient spectrum utilization and prevent misuse. Given the need for widespread and rapid deployment of V2X infrastructure, it is necessary to carefully examine the appropriateness of spectrum charges. This is especially relevant considering the likely public nature of entities responsible for deploying and managing RSUs, which could warrant a calibrated spectrum charging approach. Appropriate safeguards, including technical conditions and compliance requirements, can be incorporated to ensure responsible usage without imposing excessive financial burden.

4.37 Therefore, spectrum charges for V2I communication service authorised entities for the use of spectrum in the frequency band of 5,875-5,905 MHz, needs to be designed in a manner that supports ecosystem growth, encourages innovation, and facilitates widespread deployment, while ensuring efficient spectrum management. A calibrated approach, informed by both domestic priorities and global best practices, could be essential in achieving these objectives. Considering the above discussion regarding spectrum charges, the Authority solicits the views of stakeholders on the following set of questions:

Issues for consultation:

Q12. In view of the public welfare-oriented nature of V2X applications and the need to encourage the deployment of such infrastructure and services, should there be spectrum charges levied on spectrum assigned to the V2I communication service authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q13. If answer to Q12 is affirmative, whether the spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation should be determined based on the spectrum charging methodology prescribed by the Department of Telecommunications (DoT) vide its order dated 11.12.2023? If yes, then which of the radiocommunication services specified in the said order, should be taken as basis for calculation of spectrum Charges? Please provide detailed justification in support of your response.

Q14. If answer to Q12 is affirmative, whether the spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation should be levied as a percentage of Adjusted Gross Revenue (AGR)? If yes, are there any specific operational/ non-operational revenue items that should be included in/ excluded from AGR for the purpose of determination of spectrum charges? Please provide your response with detailed justification.

Q15. If response to questions 13 and 14 is negative, then what should be the appropriate methodology for determination of spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q16. For spectrum assigned to the V2I communication service authorised entities under the proposed V2I communication service authorisation, what should be the appropriate payment terms for spectrum charges, if any? Please provide your response with detailed justification.

C. Definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR) and Adjusted Gross Revenue (AGR)

4.38 The concept of revenue in the context of the V2X technology is expected to differ significantly from that in traditional telecommunications services. Conventional telecom operations are largely based on direct revenue streams such as subscriber fees, usage charges, and value-added services. In contrast, V2X ecosystems could be characterized by a mix of direct and indirect value generation mechanisms, many of which may not

translate into clearly identifiable revenue streams. A significant proportion of V2X applications, particularly those related to safety, are not expected to generate any direct revenue. For instance, applications such as collision warnings, emergency vehicle alerts, and hazard notifications are primarily designed to enhance road safety and public welfare. These services could be typically provided as part of a broader V2X system and could not be monetized on a standalone basis.

4.39 Further, since the authorisation under consideration here is V2I communication service authorisation, which is likely to be granted to public entities such as city bodies, highway authorities etc., the functioning of many V2I communication service authorised entities may be non-commercial in nature, without any sources of revenue.

4.40 In addition to safety-related applications, several V2I communication service use cases could involve indirect or ancillary revenue streams. These could include services such as traffic analytics, fleet management solutions, predictive maintenance, and data-driven insights for urban planning. In such cases, the revenue may not arise directly from the use of V2I services but rather from value-added services built on top of the V2I infrastructure. Given these likely direct and indirect sources of revenue, existing definitions for Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) could not be used without inclusion or exclusion of V2I communication service specific items for sources of revenue. The existing definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) have historically evolved in the context of licensed telecom operators with well-defined revenue streams, and adapting such existing definitions to the proposed V2I communication service authorisation could therefore require detailed examination.

4.41 In view of the foregoing, there is a need to revisit and suitably adapt the definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) to align with the specific characteristics of the proposed V2I communication service authorisation. This would require clearly identifying the potential sources of revenue, if any, that could be included within the scope of GR. One other issue in this regard is the determination of whether the revenue base should encompass all revenues accruing to a V2I communication service authorised entity or be restricted only to those directly attributable to V2I services. As was prescribed for all communications licenses through the Telecom Reforms 2021 as well as in the Draft Rules, inclusion of non-service/ non-telecom revenues for charging of government levies such as Authorisation Fee/ Spectrum charges has been clearly done away with.

4.42 As envisaged presently, a significant proportion of V2X applications are oriented towards public safety and are not expected to generate any significant direct revenue streams. The inclusion of such activities within the revenue base would not be appropriate and could necessitate differential treatment vis-à-vis commercial services such as data monetization or fleet management. The multi-stakeholder nature of the V2X ecosystem further complicates revenue attribution, thereby necessitating clear and consistent guidelines for apportionment of revenue among various entities such as RSU operators, OBU and RSU manufacturers, application developers, certifying agencies, system integrators, vehicle manufacturers, and government agencies involved in provisioning of V2I services.

4.43 From a regulatory perspective, it is essential that the definitions of GR, ApGR, and AGR remain simple, transparent, and easy to implement, while incorporating adequate safeguards to prevent misreporting or underreporting. Given the evolving nature of V2X technologies and

business models, the framework should also retain sufficient flexibility to accommodate emerging revenue streams without creating ambiguity.

4.44 Considering the above discussion regarding appropriate definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR) and Adjusted Gross Revenue (AGR), the Authority solicits the views of stakeholders on the following set of questions:

Issues for consultation:

Q17. What are the potential sources of revenue, if any, for an V2I communication service authorised entity under the proposed V2I communication service authorisation? Please provide your response with detailed justification.

Q18. What should be the definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) for V2I communication service authorised entity under the proposed V2I communication service authorisation? Further, what should be the relevant items of revenue, exclusions and deductions and consequent definitions of GR, AGR and ApGR? Please provide your response with detailed justification.

Q19. What revenue components should be included in, or excluded from, the computation of Gross Revenue (GR), Applicable Gross Revenue (ApGR) and Adjusted Gross Revenue (AGR) for the purpose of determining authorisation fees or spectrum charges for the proposed V2I communication service authorisation? Please provide your response with detailed justification.

Q20. Whether revenue derived from safety-related V2X services under the proposed V2I communication service authorisation should be excluded from the computation of AGR, in view of their public interest and non-commercial nature? Please provide your response with detailed justification.

D. Other Financial Conditions

4.45 Apart from definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) & Spectrum Charges, other financial conditions assume particular significance for granting the proposed V2I communication service authorisation. Such conditions, inter alia, include entry fee, authorisation fee, bank guarantees, minimum equity and net worth requirements, and application processing fees. These financial provisions serve both as eligibility criteria and as signalling mechanisms to ensure that only serious, credible, and technically capable entities participate in the provisioning and operation of V2I infrastructure, including deployment of RSUs. At the same time, these financial conditions must be calibrated carefully so as not to create undue barriers to entry. With regard to such financial conditions, there generally has to be an appropriate balance between facilitating participation and ensuring financial robustness, so as to promote investment, innovation, and the orderly growth. However, since V2I service authorisation is likely to be granted to public entities such as city bodies, highway authorities etc, as has been done across countries, the concerns of level of participation, competition, entry barriers etc do not hold as much relevance.

4.46 Accordingly, the financial aspects relating to entry fees, bank guarantee, minimum equity and minimum networth, application processing fees and rate of authorisation fees are covered in the paragraphs below.

(1) Entry Fee

4.47 The entry fee under the proposed V2I communication service authorisation assumes importance as an initial commitment from V2I service authorised entities seeking to participate in the deployment and operation of RSUs. Such a fee could serve as a signalling mechanism to ensure that only serious and credible applicants enter the ecosystem, thereby promoting an orderly and structured market environment. However, considering that V2I services are yet to be deployed and business models remain with uncertain revenue streams, it is important to examine the appropriate level of entry fee that is reasonable and non-prohibitive so as not to discourage participation. Further, since V2I communication service authorisation is likely to be granted to public entities such as city bodies, highway authorities etc., entry criteria to encourage participation or competition is not a significant concern. However, private entities could also be considered for allotment of V2I communication service authorisation, especially for non-safety related V2X applications.

4.48 A balanced approach could therefore be envisaged, wherein the entry fee reflects the need for commitment and administrative cost recovery, while also facilitating wider participation, fostering innovation, and supporting the gradual growth of the V2X ecosystem. In this context, the Authority solicits the views of stakeholders on the following question:

Issue for Consultation:

Q21. What should be the appropriate entry fee for V2I communication service authorised entities under the proposed V2I

communication service authorisation? Please provide detailed justification in support of your response.

(2) Bank Guarantee

4.49 Bank guarantees under the proposed V2I communication service authorisation could be envisaged as an important financial safeguard to ensure compliance with authorisation conditions including technical and operational conditions and timely discharge of financial obligations, including any applicable spectrum-related dues. An appropriate level of Bank guarantees is expected to promote technical, operational and financial discipline among the V2I communication service authorised entities. However, the need for widespread and rapid deployment of V2I infrastructure as well as the public welfare orientation of V2I communication service also has to be kept in mind. Also, considering the likely public nature of entities deploying and managing RSUs, necessity and level of such guarantee commitments need careful assessment.

4.50 In this context, the Authority solicits the views of stakeholders on the following question:

Issue for consultation:

Q22. What should be the appropriate terms and conditions for bank guarantees for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

(3) Minimum Equity and Minimum Net Worth

4.51 Minimum equity and minimum net worth requirements under the proposed V2I communication service authorisation are significant to ensure that only financially sound and credible entities participate in the deployment and operation of V2I infrastructure. Such requirements serve as an important eligibility criterion, reflecting the financial capacity of an entity to undertake investments, sustain operations, and meet long-term obligations in a technologically evolving ecosystem.

4.52 For scalable deployment of V2I communication services and the need to encourage innovation and participation, an appropriate level of Minimum equity and minimum net worth requirements is to be examined. Further, since the proposed V2I communication service authorisation is likely to be granted to public entities such as city bodies, highway authorities etc., minimum equity and networth criteria may not be particularly relevant in such cases.

4.53 In this context, the Authority solicits the views of stakeholders on the following question:

Issue for consultation:

Q23. What should be the applicable minimum equity and minimum net worth requirements for authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

(4) Application Processing Fee

4.54 In the context of the proposed V2I communication service authorisation, the determination of an appropriate application processing fee is an important consideration. An application processing fee needs to be levied based on well-defined principles, including the need to recover administrative costs as well as to deter non-serious applications. In this context, the Authority solicits the views of stakeholders on the following question:

Issue for consultation:

Q24. What should be the applicable application processing fee for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

(5) Authorisation Fee

4.55 In the context of the proposed V2I communication service authorisation, for determination of appropriate authorisation fee, draft rules on Miscellaneous Telecommunication Services Authorisations notified by DoT vide Gazette notification dated 09.09.2025 could be referred, in line with discussion at Para 3.9 of Chapter III. Amongst the Auxiliary/ Miscellaneous services, the draft rules regarding Machine to Machine (M2M) service authorisation, In-Flight and Maritime Connectivity (IFMC) service authorisation and Aeronautical Data Communication service authorisation, as contained in the Gazette Notification dated 09.09.2025, is reproduced below for reference:

A. Fee and Charges prescribed for Machine to Machine (M2M) Service Authorisation:

"Fee and charges

There shall be no authorisation fee to be paid by the authorised entity."

B. Fee and Charges prescribed for In-Flight and Maritime Connectivity (IFMC) service authorisation:

"Fee and charges

(1) An authorised entity shall pay an annual authorisation fee of one rupee, payable to the Central Government from the effective date of authorisation: Provided that the authorised entity shall pay the authorisation fee for the entire duration of the authorisation, in advance, at the time of grant of authorisation.

(2) The revenue earned by the other authorised entity with whom an agreement has been entered into under sub rule (3) of rule 66, from the entity authorised to provide IFMC service, shall be included in the AGR of such other authorised entity."

C. Fee and Charges prescribed for Aeronautical Data Communication Service Authorisation:

"Fee and Charges

An authorised entity shall pay an annual authorisation fee of one rupee, payable to the Central Government from the effective date of authorisation: Provided that the authorised entity shall pay the authorisation fee for the entire duration of the authorisation, in advance, at the time of grant of authorisation."

4.56 It is noted from above that the Authorisation fee for multiple authorisations has been prescribed as nominal/nil in the draft rules on Miscellaneous Telecommunication Services Authorisations notified by DoT vide Gazette notification dated 09.09.2025. The relevant observation, forming the basis for the draft rules, as contained in Recommendation dated 18.09.2024 is stated below:

"Auxiliary service authorisation includes all other existing service authorisations (other than Captive services), which are not used for the delivery of service to public at large or have very light touch regulatory oversight in the present regime, unless specifically exempted from the requirement of service authorisation."

4.57 A similar approach could be followed for the proposed V2I communication service authorisation, in view of the public welfare-oriented nature of V2X applications and considering multiple factors including safety-related use cases and the need to encourage early-stage investments. Such an approach could promote innovation in the V2X ecosystem and accelerate the deployment of V2I infrastructure in the country.

4.58 In this context, the Authority solicits the views of stakeholders on the following question:

Issue for consultation:

Q25. What should be the applicable rate of authorisation fee for proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

4.59 The sections above have examined various financial aspects under the proposed V2I communication service authorisation, including spectrum

charges, payment terms, definitions of GR/ApGR/AGR, as well as other financial conditions such as authorisation fee, entry fee, bank guarantees, application processing fee, and minimum equity/net worth requirements. In addition to these, stakeholders' views are solicited on whether any other financial terms and conditions may be considered necessary for V2I communication service authorised entities under the proposed V2I communication service authorisation. In this context, the Authority solicits the views of stakeholders on the following question:

Issue for consultation:

Q26. Apart from the financial provisions discussed earlier, are there any other financial terms and conditions that should be made applicable for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

4.60 The following chapter lists the issues for consultation.

CHAPTER V: ISSUES FOR CONSULTATION

Stakeholders are requested to provide detailed responses to the following questions:

Q1. Whether there is a need to introduce an authorisation for vehicle-to-infrastructure (V2I) communication service under Section 3(1)(a) of the Telecommunications Act, 2023? If yes, please provide input with respect to the following aspects:

(a) Eligibility conditions for the authorisation;

(b) Period of validity of the authorisation and conditions for its renewal;

(c) Service area of the authorisation;

(d) Scope of service of the authorisation;

(e) Technical, operating, security related conditions etc. of the authorisation;

(f) Any other related aspect.

Kindly provide a detailed response with justification.

Q2. In case your reply to Q1 is no, what should be the mechanism for enabling, facilitating and regulating vehicle-to-infrastructure (V2I) communication service in India? Kindly provide a detailed response with justification.

Q3. Any other suggestions relevant to the authorisation for vehicle-to-infrastructure (V2I) communication service may be submitted with proper explanation and justification.

Q4. Whether a specific technology (such as LTE-based C-V2X, NR-based C-V2X etc.) should be prescribed for the implementation of

C-V2X in India? If yes, which technology should be adopted for the implementation of C-V2X? If no, in what manner, the issues related to inter-operability between different technologies should be addressed? Kindly provide a detailed response with justification.

Q5. Whether there is a need to bring road-side units (RSUs) and on-board units (OBUs) under the regime of Mandatory Testing Certification of Telecom Equipment (MTCTE)? If no, in what manner, Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC), safety, technical and security requirements prescribed by TEC/ DoT may be ensured? Kindly provide a detailed response with justification.

Q6. To ensure inter-operability among different RSUs/ OBUs, whether there is a need to standardize the layered communication framework (stack) for higher layers (other than the access layer in which C-V2X will be used) of Intelligent Transportation System (ITS)? If yes, which standard for ITS stack and security should be adopted? Specifically, whether the ETSI standard for ITS stack and security, as recommended by the Task Force on Intelligent Transportation System for the use of 5.9 GHz (mentioned at para 3.5 of this consultation paper) should be adopted? If no, in what manner, inter-operability among different RSUs/ OBUs can be ensured? Kindly provide a detailed response with justification.

Q7. Whether there is a need for prescribing a security framework for ITS/ C-V2X in India? If yes, -

(a) What should be the security framework for ITS/ C- V2X?

(b) Which agency [such as Controller of Certifying

Authorities (CCA), Ministry of Electronics & Information Technology (MeitY)] should implement the Public Key Infrastructure (PKI) framework for ITS/ C-V2X in India?

(c) How to ensure coexistence of V2X PKI certificates with the legacy PKI mechanism in India i.e. based on X.509, operated by Root Certifying Authority of India (RCAI)?

Please provide a detailed response with justifications.

Q8. What should be the regulatory framework for the assignment of frequency spectrum to the entities holding the proposed V2I communication service authorisation? Specifically, -

(a) Whether there is a need for partitioning the 30 MHz spectrum (5,875-5,905 MHz) for specific applications such as "safety applications" and "operational applications (non-safety applications)"?

(b) In case more than one authorised entity has to operate in the same geographical area, what should be the mechanism for simultaneous use of the spectrum? Specifically, whether the spectrum should be divided amongst the authorised entities in an exclusive manner, or should the authorised entities utilize the spectrum in a shared manner?

(c) If your response to part (b) is "in an exclusive manner", what should be the minimum quantity of spectrum to be assigned to each entity holding the proposed V2I communication service authorisation? If your response to part (b) is "in a shared manner", whether there is a need to prescribe a mechanism for interference management?

(d) For interference management, whether there is a need to prescribe –

(i) minimum directionality of road-side unit (RSU), or

(ii) protection distance between the RSUs, or

(iii) maximum antenna height for RSUs?

If yes, what should be such parameter(s)?

(e) Whether there is need to mandate a mechanism for obtaining prior approval (analogous to SACFA clearance) for the establishment of RSUs by the entities holding the proposed V2I communication service authorisation? If no, in what manner, the establishment of RSUs should be regulated?

(f) For avoiding (i) interference between RSUs, (ii) interference between RSUs and OBUs, and (iii) interference between OBUs, whether the radiated power limits for OBUs and RSUs and OOBE limits, recommended by the Task Force on Intelligent Transportation System for the use of 5.9 GHz (mentioned at para 3.4 of this consultation paper) should be adopted? If no, what should be the radiated power limits for OBUs and RSUs and OOBE limits?

(g) What should be the maximum period of assignment of spectrum to the entities holding the proposed V2I communication service authorisation?

(h) Whether there is a need to prescribe roll-out obligations associated with the assignment of spectrum to the entities holding the proposed V2I communication service authorisation?

(i) Whether there is a need to introduce a provision for the surrender of frequency spectrum?

Kindly provide a detailed response with justification.

Q9. Whether there is a need for prescribing timelines for processing the applications for the assignment of spectrum to the entities holding the proposed V2I communication service authorisation? Kindly provide a detailed response with justification.

Q10. Whether there are any other suggestions related to assignment of spectrum to the entities holding the proposed V2I communication service authorisation? Please provide a detailed response with justification.

Q11. Any other issues/ suggestions relevant to the regulatory framework for V2X communication may be submitted with proper explanation and justification.

Q12. In view of the public welfare-oriented nature of V2X applications and the need to encourage the deployment of such infrastructure and services, should there be spectrum charges levied on spectrum assigned to the V2I communication service authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q13. If answer to Q12 is affirmative, whether the spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation should be determined based on the spectrum charging methodology prescribed by the Department of Telecommunications (DoT) vide its order dated 11.12.2023? If yes, then which of the radiocommunication services specified in the said order, should be taken as basis for calculation of spectrum Charges? Please provide detailed justification in support of your response.

Q14. If answer to Q12 is affirmative, whether the spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation should be levied as a percentage of Adjusted Gross Revenue (AGR)? If yes,

are there any specific operational/ non-operational revenue items that should be included in/ excluded from AGR for the purpose of determination of spectrum charges? Please provide your response with detailed justification.

Q15. If response to questions 13 and 14 is negative, then what should be the appropriate methodology for determination of spectrum charges for the V2I communication service authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q16. For spectrum assigned to the V2I communication service authorised entities under the proposed V2I communication service authorisation, what should be the appropriate payment terms for spectrum charges, if any? Please provide your response with detailed justification.

Q17. What are the potential sources of revenue, if any, for an V2I communication service authorised entity under the proposed V2I communication service authorisation? Please provide your response with detailed justification.

Q18. What should be the definitions of Gross Revenue (GR), Applicable Gross Revenue (ApGR), and Adjusted Gross Revenue (AGR) for V2I communication service authorised entity under the proposed V2I communication service authorisation? Further, what should be the relevant items of revenue, exclusions and deductions and consequent definitions of GR, AGR and ApGR? Please provide your response with detailed justification.

Q19. What revenue components should be included in, or excluded from, the computation of Gross Revenue (GR), Applicable Gross Revenue (ApGR) and Adjusted Gross Revenue (AGR) for the purpose of determining authorisation fees or spectrum charges for the proposed V2I communication service authorisation? Please provide your response with detailed justification.

Q20. Whether revenue derived from safety-related V2X services under the proposed V2I communication service authorisation should be excluded from the computation of AGR, in view of their public interest and non-commercial nature? Please provide your response with detailed justification.

Q21. What should be the appropriate entry fee for V2I communication service authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q22. What should be the appropriate terms and conditions for bank guarantees for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q23. What should be the applicable minimum equity and minimum net worth requirements for authorised entities under the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q24. What should be the applicable application processing fee for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q25. What should be the applicable rate of authorisation fee for proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Q26. Apart from the financial provisions discussed earlier, are there any other financial terms and conditions that should be made applicable for the proposed V2I communication service authorisation? Please provide detailed justification in support of your response.

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning & Coordination Wing

6th Floor, Sanchar Bhawan,
20, Ashoka Road, New Delhi 110001

No. R-11018/02/2022-PP **Date: 01.12.2025**

To,
The Secretary,
Telecom Regulatory Authority of India
G/90, Nauroji Nagar Market,
Block G, Block F, Nauroji Nagar,
New Delhi 110029.

Subject: Reference to TRAI on regulatory mechanism for Vehicle-to-Everything (V2X) – reg.

Sir,

A Task Force constituted by Ministry of Road Transport and Highways (MoRTH) to give recommendation on industry standards, technical parameters, and frequency usage for Vehicle-to-Everything (V2X) / Intelligent Transport System (ITS), gave its Part-1 report in May 2025. After examination of the report, DoT has, in-principle, agreed to the following:

i. C-V2X may be adopted as the harmonized Intelligent Transport System (ITS) technology for India.
ii. 30 MHz spectrum (5875–5905 MHz) may be allocated for the initial deployment of C-V2X technology, while the remaining 20 MHz (5905–5925 MHz) may be reserved for future ITS applications, thereby retaining flexibility for evolving standards and innovations.
iii. License-exempt use of On-Board Units (OBUs) may be permitted under defined technical conditions, while authorization may be required for Roadside Units (RSUs) to ensure coordinated deployment and effective interference management.

2. In this context, it is pertinent to refer to IND29 footnote of NFAP-2025, which states that "*the frequency band 5875 to 5925 MHz may be used for V2X/ITS under Mobile service. This does not preclude the use of this frequency bands for other allocated services*".

2.1 Further, it is mentioned that First Schedule of the Telecommunication Act, 2023 lists entries eligible for administrative frequency assignment, including the safety and operation of transport systems. Additionally, the DoT charging order dated 11.12.2023

contains provisions for calculating spectrum charges.

3. However, considering the large-scale impact of ITS on the transport sector of the country, TRAI is requested to provide recommendations on the following, under the terms of clause 11(1)(a) of the TRAI Act, 1997 as amended:

i. Regulatory mechanism (spectrum assignment, authorization and pricing) for Roadside Units (RSUs);
ii. Any other recommendations relevant to the issue.

4. This is issued with the approval of competent authority.

Enclosure: Report of the Task Force.

(M K Pattanaik)
Joint Wireless Adviser
to the Government of India

Report of the Task Force on Intelligent Transportation System for the use of 5.9 GHz

Part 1: Recommendations on Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) in the 5.875-5.925 GHz and corresponding radio aspects

1. Introduction

1.1 The Ministry of Road Transport & Highways established a Task Force for the development and Implementation of Intelligent Transportation Systems (ITS) in country, with specific focus on Vehicle to Everything (V2X) communications vide OM dt. 09th September, 2024. The mandate of the Task Force is as follows:

i. Recommendations of Automotive Industry Standards and regulations related to Intelligent Transportation Systems, and rollout of communication between vehicle to anything (V2X).
ii. Recommendations/suggestions on vehicle-to-vehicle & vehicle-to-infrastructure communication, use of 5.875 – 5.925 GHz frequency in the Intelligent Transportation System.
iii. Recommendations/suggestions on various radio frequency levels and delicensing frequency bands to the Department of Telecommunications (DOT).

1.2 From telecommunications and road transportation perspectives, ITS have been developed to evaluate and implement innovative solutions aimed at enhancing the safety, efficiency and sustainability of our transportation networks.

1.3 Further, the task force also considered NFAP-2022 (IND 29), the report of DoT titled 'Report by the Committee on V2X/ITS Policy formulation' dated 20.01.2023 and MoRTH Letter No. RT-11036/80/2023-MVL dated 07.10.2024.

1.4 The Task Force determined that finalizing the mandate for allocation of spectrum in the band of 5.875 – 5.925 GHz for Intelligent Transport system is time critical. In view of this, part 1 of the report outlines the key findings and recommendations identified by the Task Force. Further, final report which will be released subsequently would include recommendation on Automotive Industry Standards and regulations related to ITS stack, security framework and rollout of communication between vehicle to anything (V2X).

2. Elements of V2X communication system for ITS

2.1 ITS is composed of several components, including V2X communication, which covers interactions such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-network (V2N). These interactions, collectively referred to as V2X, are essential for developing a connected transportation network that can respond dynamically to changing conditions and improve road safety.

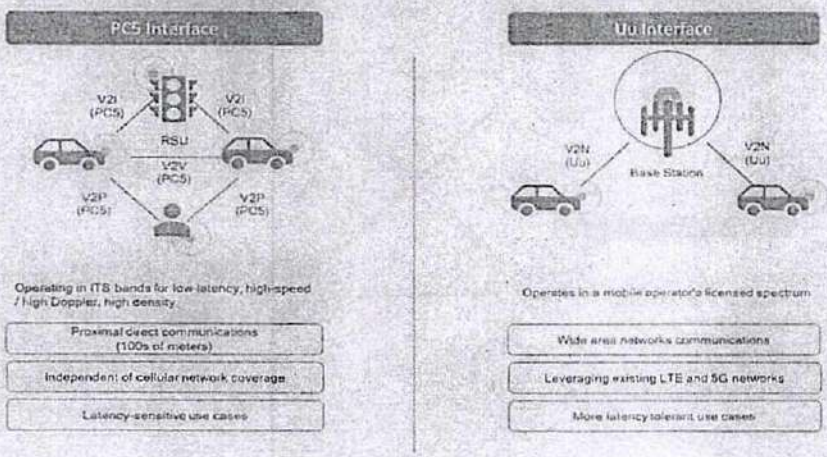
2.2 V2X use cases can leverage "cooperative awareness" to deliver intelligent benefits for end-users. This involves entities like vehicles, roadside infrastructure and pedestrians, etc. for gathering environmental data (e.g., from nearby vehicles or sensor-equipped entities) and sharing it through short-range communication. This exchange of information

supports safety-critical use cases, such as collision warnings, prioritizing the passage of emergency vehicles.

2.3 ITS and the message sets related to V2X use cases have been defined by relevant standards development organizations (SDOs) and can generally be supported by any wireless communication technology that meets the requirements to efficiently transmit messages for specific V2X use cases.

2.4 In 3GPP Specifications, V2V and V2I are facilitated using the PC5 interface, while V2N operates over the Uu interface. The V2V and V2I communication links use the globally harmonized frequency band at 5.9 GHz, while V2N communication links utilizes existing cellular networks, as further illustrated in the figure below.

Communication Modes for V2X



2.5 From a system implementation perspective, the key elements of a V2X communication system for ITS include:

1. On-Board Units (OBUs): These devices are installed in vehicles to enable communication with other vehicles and infrastructure.
2. Roadside Units (RSUs): These are installed along the roads to facilitate communication between vehicles and the transportation infrastructure.

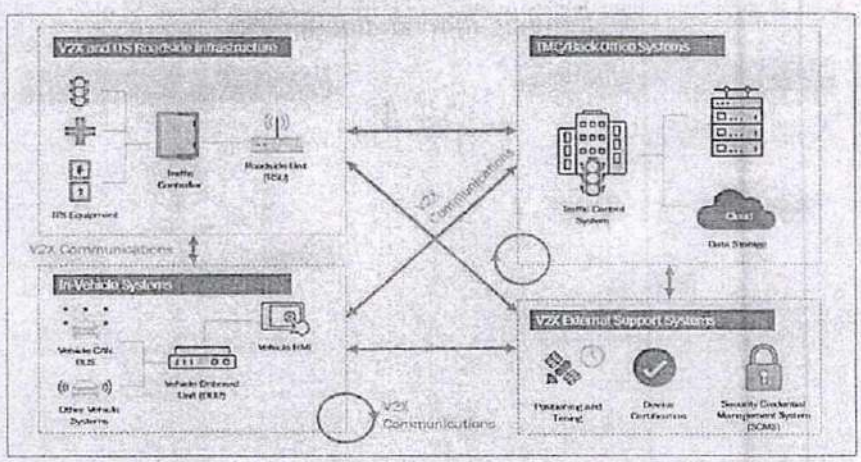
2.6 The integration of these elements forms the backbone of an effective ITS, providing the necessary infrastructure for enhanced safety, real-time traffic management, and improved mobility solutions.

2.7 The Direct V2X communications are designed to operate in 5.9 GHz spectrum dedicated to surface transportation allow for reliable, low latency message exchange for safety use cases.

2.8 V2N operates in a mobile operator's existing licensed cellular spectrum. This mode of communication could be used for traffic management, situational awareness and deployment flexibility, while maximizing operational efficiency.

2.9 C-V2X, is an umbrella term that encompasses all 3GPP V2X technologies, including both direct (PC5) and mobile network communications (Uu)[1].

2.10 A typical implementation architecture of V2X system is depicted below (based on US DOT[2]):



3. Importance of V2X for Road Safety

3.1 Globally, there are approximately 1.19 million traffic fatalities each year, with India reporting the highest number. In 2022, States and Union Territories (UTs) in India recorded a total of 461,312 road accidents, resulting in 168,491 fatalities and 443,366 injuries[3]. This alarming figure underscores the urgent need to enhance road and vehicle safety. Vehicular communication technologies, such as C-V2X, have the potential to significantly improve road safety and help reduce these figures.

3.2 C-V2X has the potential to significantly enhance safety and efficiency on the roads in various ways, improving both transportation and road safety. Some key benefits are as under:

i. Enhanced Road Safety
ii. Smoother Traffic Flow
iii. Better Emergency Response

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[1] https://5gaa.org/c-v2x-explained/, 5GAA Cellular Vehicle-to-Everything

[2] https://www.itskrs.its.dot.gov/briefings/executive-briefing/vehicle-everything-v2x-technology US Department of Transportation, ITS Joint Program Office published an executive briefing on V2X System depicting the different elements in an end-to-end V2X system.

[3] MoRTH Road Accident Statistics 2022 morth.gov.in/sites/default/files/RA_2022_30_Oct.pdf

iv. Pedestrian, Cyclist, and Powered Two-Wheeler Safety
v. Improved Public Transportation

3.3 The Task Force highlighted that intersections are a major contributor to road fatalities worldwide, with many countries now focusing on technology to improve safety at these critical points. C-V2X technology has the potential to address these issues by improving road safety, reducing congestion, and enhancing the overall efficiency of transportation networks[4].

3.4 The committee agrees that C-V2X technology, direct mode (PC5) operating in the 5.9 GHz band plays a pivotal role in reducing road fatalities and improving overall road safety. The committee also agrees that indirect mode (Uu) using existing cellular infrastructure plays an important role in ITS.

4. Discussions and Background on V2X/ITS Technology

4.1 The Task Force acknowledged the ongoing discussions in India regarding V2X/ITS, particularly highlighted in the report submitted by the committee on V2X/ITS policy formulation chaired by the Wireless Advisor, WPC, DoT in January 2023. Additionally, the Telecommunications Engineering Centre (TEC) published a Technical Report, "Technologies and Standards for Intelligent Transport Systems," TEC 31218:2023, in October 2023.

4.2 After extensive deliberations over the past few years across multiple committees, C-V2X has been thoroughly documented in the existing reports from DoT and TEC. These reports are in alignment with global technology trends, and the committee believes that 3GPP-based C-V2X is ideally suited for utilizing the 5.9 GHz spectrum in India.

5. Technical details on V2X emissions

5.1 TEC adopted national standards as per the Standards Adoption Policy[5]. The following specification are relevant to the discussion on near-term basic safety messages via V2X.

- 3GPP (Rel 14 - Rev 4) Specifications
- 3GPP (Rel 14 – Rev 5) Specifications
- 3GPP (Rel 15 – Rev 4) Specifications
- 3GPP (Rel 15 – Rev 5) Specifications

5.2 3GPP Rel 14 and 15, documents 36.101, has the following clauses that are relevant to C-V2X. Referring to 3GPP TS 36.101, the following sections provide the

[4] https://5gaa.org/road-traffic-operation-in-a-digital-age-a-holistic-cross-stakeholder-approach/ 5GAA white paper on Road Traffic Operation in a Digital Age: A Holistic Cross-Stakeholder Approach
[5] https://www.tec.gov.in/standards-adoption-policy

relevant information for emission limits. The details of 3GPP TS 36.101 are provided in Annex 1.

5.3 The committee recommends the following transmission limits from 36.101 for OBU and RSU that are based on 3GPP Rel. 14 and 15.

Technical Characteristics

Frequency band	Device type	Maximum conducted Output Power	Maximum Effective Radiated Power Limits
5875-5925 MHz	OBU		4W (36 dBm)
	RSU	200mW (23 dBm) in spread of 20 MHz or higher	4W (36 dBm)

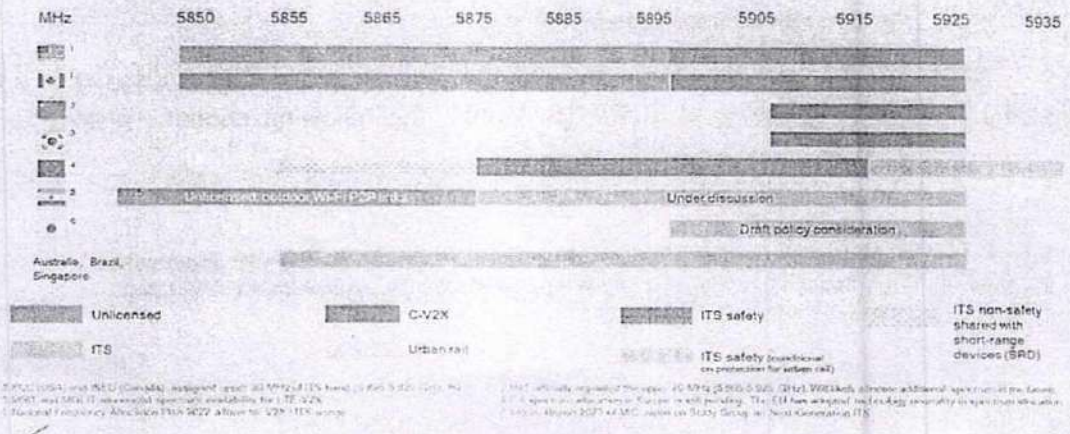
5.4 For transmitters (OBU and RSU) operating in the 5.875-5.925 GHz frequency bands, all emissions outside of the bands are specified in the Table below:

Out-of-band Emission (applicable for both OBU and RSU)

Offset frequency from the end of the occupied frequency bandwidth	Reference value (average power)	Resolution bandwidth
± 0-1 MHz	-16 dBm	100 kHz
± 1-5 MHz	-13 dBm	1 MHz
± 5-30 MHz	-16 dBm	1 MHz
± 30 MHz and beyond	-28 dBm	1 MHz

6. Global regulatory outlook

6.1 Globally, V2X development and implementation has been active in a host of countries. The information summarizes each country's involvement, notable projects, government initiatives, and industry partnerships.



6.2 Further, within ITU-R and APT, several reports focused on the usage of the 5.9 GHz band for V2X/ITS have been published in the recent past highlighting the importance of harmonized ITS frequency band. The relevant ITU-R Recommendations and reports includes:

- ITU-R Recommendation M.2121 "Harmonization of frequency bands for Intelligent Transport Systems in the mobile service"
- ITU-R Report M.2444 "Examples of arrangements for Intelligent Transport Systems deployments under the mobile service"
- ITU-R Report M.2445 "Intelligent transport systems (ITS) usage"
- ITU-R Report M.2520 "The use of the terrestrial component of International Mobile Telecommunications for the Cellular-Vehicle-to-Everything"
- ITU-R Report M.2534 "Connected automated vehicles"
- APT Report APT/AWG/REP-121 "APT Report on cellular based V2X for ITS applications in APT countries"

6.3 Further, from a spectrum licensing perspective, the following table summarizes the licensing rule applicability to the 5.9 GHz band globally.

	Country	OBU	OBU Licensing condition	RSU	RSU Licensing condition
Region 1	Europe [6]	License-exempt	No individual licensing	License-exempt	Only checked for compliance to ETSI EN 302 571
	Saudi Arabia[7]	License-exempt	No individual licensing	License-exempt	Licensing to be further coordinated with national stakeholders.
Region 2	USA[8]	Licensed-by-Rule	No individual licensing (FCC Part 95[9])	Licensed	2nd FCC R&O dt. 21 Nov 2024 § 90.388 Eligibility: entities are eligible to hold an authorization to operate C-V2X RSUs (a) Any territory, possession, state, city, county, town or similar governmental entity

[6] https://docdb.cept.org/document/412 ECC Decision (08)01 The harmonised use of Safety-Related Intelligent Transport Systems (ITS) in the 5875-5935 MHz frequency band

[7] https://www.cst.gov.sa/en/mediacenter/pressreleases/Pages/2023091601.aspx Roadmap for Using the 5.9 GHz Band for Vehicle-to-Everything (V2X) Systems by CST

[8] https://www.fcc.gov/document/use-5850-5925-ghz-band Use of the 5.850-5.925 GHz Band

[9] https://docs.fcc.gov/public/attachments/DOC-344617A1.pdf Part 95 Personal Radio Service Reform Report and Order - WT Docket No. 10-119 Background: The Commission's Part 95 Personal Radio Services (PRS) rules address a wide variety of wireless devices that are used by the general public to satisfy personal communications needs. These devices generally use low-power transmitters.

	Country	OBU	OBU Licensing condition	RSU	RSU Licensing condition
					(b) Any entity meeting the eligibility requirements of §§ 90.20, 90.33 or 90.35 for non-exclusive/small-fee
	Canada [10]	License-exempt	No individual licensing	Licensed	Pending public consultation. Expected to be similar to USA
Region 3	Australia [11]	Class License [12]	No individual licensing	Class License	No individual licensing
	China [13]	License-exempt	No individual licensing	Licensed	Administratively assigned to RSU operator (typically govt. road / transport)
	Korea	License-exempt	No individual licensing	Licensed	Administratively assigned to RSU operator (typically govt road / transport)
	Indonesia [14]	Class License	No individual licensing	Class License	Only checked for compliance to ITS Standards. No license.
	Singapore [15]	License exempt	No individual licensing	Licensed	Non-Exclusive and Exclusive licensing [16]

communicate over shared radio frequencies, and (with a few exceptions) do not require an individual FCC license for each user.

[10] https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/learn-more/key-documents/decision-technical-and-policy-framework-radio-local-area-networks-devices-5850-5895-mhz-band-and Decision on the Technical and Policy Framework for Radio Local Area Network Devices in the 5850-5895 MHz Band and for Intelligent Transportation Systems in the 5895-5925 MHz Band

[11] https://www.acma.gov.au/book/five-year-spectrum-outlook-2022-27-and-2022-23-work-programpart-2-2022-23-annual-work-programoptimising-established-planning-frameworks/intelligent-transport-systems

[12] https://www.acma.gov.au/class-licences Class licences in ACMA. A class licence lets you operate common radio equipment on shared frequencies. You don't need to apply for a class licence or pay any fees

[13] https://www.gov.cn/zhengce/zhengceku/2018-12/31/content_5442658.htm (Chinese) Translated: https://www-gov-cn.translate.goog/zhengce/zhengceku/2018-12/31/content_5442658.htm?_x_tr_sl=zh-CN&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp

[14] https://jdih.komdigi.go.id/produk_hukum/view/id/949/t/peraturan+menteri+komunikasi+dan+digital+nomor+2+tahun+2025 (Indonesian)

[15] https://www.imda.gov.sg/-/media/imda/files/regulation-licensing-and-consultations/ict-standards/telecommunication-standards/radio-comms/imda-ts-dsrc.pdf

[16] https://www.imda.gov.sg/-/media/imda/files/regulation-licensing-and-consultations/consultations/pending-consultations/proposed-regulatory-framework-and-standards-for-its/decision---its-regulatory-framework-and-standards.pdf

6.4 A brief on global activity on C-V2X technology is placed at Annex 2.

6.5 The Task Force noted the summary of applicable regulatory conditions for spectrum in various countries as below:

- **For OBU:** Globally, there is no individual licensing for OBUs. The OBUs are license exempt globally (or licensed-by-rule / Class Licensed without any requirement of individual license).
- **For RSU:** In Europe the RSU is license-exempt, and in few other countries the devices are Class Licensed with no requirement of individual license (e.g., Australia, Indonesia) in consideration of spectrum for safety. In other countries RSUs are licensed by a competent authority, like road operators and traffic agencies as the main entities.

7. Recommendations

7.1 The Task Force recommends adopting the V2X/ITS frequency range of 5.9 GHz (5.875-5.925 GHz), which has already been considered for V2X technologies/ Intelligent Transport System in the NFAP-2022, recognizing it as the spectrum band for enhancing road safety and reducing road fatalities.

7.2 The Task Force acknowledges the recommendation of para 13.2(i) of the DoT report titled 'Report by the Committee on V2X/ITS Policy formulation' dated 20.01.2023 to identify harmonized technology. To ensure that vehicles and infrastructure can seamlessly interoperate to achieve the goal of road safety, this Task Force recommends the frequency range of 5.875-5.925 GHz for the use of C-V2X technology.

7.3 The Task Force recommends setting transmission power limits with a maximum e.i.r.p of 4W for both On-Board Units (OBUs) and Roadside Units (RSUs), with a conducted power output of 200mW (23 dBm) over a bandwidth of 20 MHz or higher for RSUs. Additionally, the Task Force advises adhering to the out-of-band emission limits outlined in the table below for both OBUs and RSUs.

Offset frequency from the end of the occupied frequency bandwidth	Reference value (average power)	Resolution bandwidth
± 0-1 MHz	-16 dBm	100 kHz
± 1-5 MHz	-13 dBm	1 MHz
± 5-30 MHz	-16 dBm	1 MHz
± 30 MHz and beyond	-28 dBm	1 MHz

7.4 The Task Force recommends that within the frequency range of 5.875-5.925 GHz, OBUs of vehicles using C-V2X technology should not require individual licenses or authorizations. This would allow OBUs to be easily installed in all types of vehicles, promoting widespread adoption and accessibility for individual users.

7.5 The Task Force recommends a licensing framework to be applied for RSUs with appropriate spectrum charges to ensure proper deployment, maintenance, and operation in the low-power, short-range spectrum. The State Government or any authority authorized in this behalf by the State Government or National Highways Authority of India (NHAI) or any other road owning agencies will be better suited to handle oversight and authorization for RSU installation to ensure that RSUs are correctly located, functional, and meet all necessary safety and operational standards.

Signed via email
(Manoj Desai)
Member
ARAI

4/3/2025
(P.K. Banerjee)
Member
SIAM

Signed via email
(Madhusudan Joshi)
Member
ICAT

Signed via email
(Amit Ranjan Chitranshi)
Member
NHAI

(Vikram Tiwathia)
Member
COAI

Not in agreement
Dissent note annexed via email Note-©
(Santosh Sam Koshy)
Member
C-DAC

Signed via email
(Pranav Singh)
Member
IDEMIA

(Divya Sachdeva)
Member
5GAA

3/3/2025
(Shiv Kumar)
Member
ITS India Forum

signed via email
(Punit Rathod)
Member
Qualcomm

Signed with suppression Note-(A)
7/3/25
(Ankit Dugar)
Director, MVL & Member
MoRTH

Mayank Tyagi 7/3/25
(Mayank Tyagi)
Deputy Secretary, Highways & Member
MoRTH

Not in agreement with Report
Dissent Note annexed
Note-(B)
(Sharad Kumar Chauhan)
Member
WPC, DoT
28/02

28/02/2025
(Namrata Singh)
Director (IoT) & Member Secretary
TEC, DoT

12/3/25
(R. S. Singh)
DDG (IoT) & Chairman
TEC, DoT

(X) 5GAA's request for deadline extension for signing of report (vide email dated 03rd March, 2025, attached) could not be considered, as their internal process of approval require consensus among 100+ members which would delay the release of report.

(A) COAI – As the allocation of V2X spectrum to the V2X providers constitutes a commercial activity, TRAI's recommendations should be sought on the assignment methodology & pricing.

Annex 1: 3GPP TS 36.101 – Emission Limits

This annexure provides the references to technical conditions from TEC National Standards (from TSDSI / 3GPP). The following sections are reproduced from TS 36.101.

A1.1 Operating Bands and Channel Bandwidths for C-V2X

5.5 Operating bands

E-UTRA is designed to operate in the operating bands defined in Table 5.5-1.

Table 5.5-1 E-UTRA operating bands

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive	Duplex Mode
	F_{UL_low} – F_{UL_high}	F_{DL_low} – F_{DL_high}	
47	5855 MHz – 5925 MHz	5855 MHz – 5925 MHz	TDD[11]
NOTE 11: This band is unlicensed band used for V2X communication. There is no expected network deployment in this band so Frame Structure Type 1 is used.			

5.5G Operating bands for V2X Communication

E-UTRA V2X Communication is designed to operate in the the operating bands defined in Table 5.5G-1.

Table 5.5G-1 V2X operating band

E-UTRA Operating Band	E-UTRA V2X Operating Band	V2X UE transmit		V2X UE receive		Duplex Mode	Interface
		F_{UL_low} – F_{UL_high}		F_{DL_low} – F_{DL_high}			
47	47	5855 MHz	5925 MHz	5855 MHz	5925 MHz	HD	PC5

5.6G Channel bandwidth for V2X Communication

5.6G.1 Channel bandwidths per operating band for V2X Communication

E-UTRA V2X Communication channel bandwidths and operating band is shown in Table 5.6G.1-1. The same (symmetrical) channel bandwidth is specified for both the TX and RX path.

Table 5.6G.1-1: V2X Communciation channel bandwidth

E-UTRA V2X band / V2X channel bandwidth						
E-UTRA V2X Operating Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
47				Yes		Yes

Table 5.5G-1 V2X operating band

E-UTRA Operating Band	E-UTRA V2X Operating Band	V2X UE transmit			V2X UE receive			Duplex Mode	Interface
		F_{UL_low}	–	F_{UL_high}	F_{DL_low}	–	F_{DL_high}		
47	47	5855 MHz		5925 MHz	5855 MHz		5925 MHz	HD	PC5

A1.2 Maximum output power for C-V2X

6.2.2 UE maximum output power

The following UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth for non CA configuration unless otherwise stated. The period of measurement shall be at least as defined in Table 6.2.2-0.

Table 6.2.2-1: UE Power Class

EUTRA band	Class 1 (dBm)	Tolerance (dB)	Class 2 (dBm)	Tolerance (dB)	Class 3 (dBm)	Tolerance (dB)	Class 4 (dBm)	Tolerance (dB)
47			26	±2	23	±2		

6.2.2G UE maximum output power for V2X Communication

When UE is configured for E-UTRA V2X sidelink transmissions non-concurrent with E-UTRA uplink transmissions for E-UTRA V2X operating bands specified in Table 5.5G-1, the allowed V2X UE maximum output power for shall be as applied in Table 6.2.2-1 in subclause 6.2.2.

A1.3 Out of Band emissions for C-V2X

6.6 Output RF spectrum emissions

The output UE transmitter spectrum consists of the three components; the emission within the occupied bandwidth (channel bandwidth), the Out Of Band (OOB) emissions and the far out spurious emission domain.

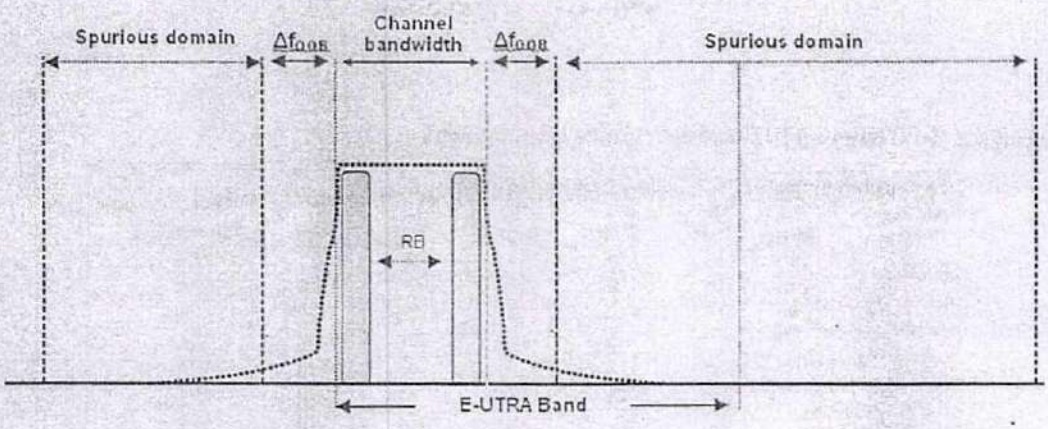


Figure 6.6-1: Transmitter RF spectrum

6.6.1G Occupied bandwidth for V2X Communication

When UE is configured for E-UTRA V2X sidelink transmissions non-concurrent with E-UTRA uplink transmissions for E-UTRA V2X operating bands specified in Table 5.5G-1, the requirements in subclause 6.6.1 apply for E-UTRA V2X sidelink transmission.

6.6.2 Out of Band Emission

The out of band emissions are unwanted emissions immediately outside the assigned channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. This out of band emission limit is specified in terms of a spectrum emission mask and an Adjacent Channel Leakage power Ratio.

6.6.2.1 Spectrum Emission Mask

The spectrum emission mask of the UE applies to frequencies (Δf_{OOB}) starting from the ± edge of the assigned E-UTRA channel bandwidth. For frequencies offset greater than Δf_{OOB} as specified in Table 6.6.2.1.1-1 the spurious requirements in subclause 6.6.3 are applicable.

6.6.2.1.1 Minimum Requirement

The power of any UE emission shall not exceed the levels specified in Table 6.6.2.1.1-1 for the specified channel bandwidth.

Table 6.6.2.1.1-1: General E-UTRA spectrum emission mask

Spectrum emission limit (dBm)/ Channel bandwidth							
Δf_{OOB} (MHz)	1.4 MHz	3.0 MHz	5 MHz	10 MHz	15 MHz	20 MHz	Measurement bandwidth
± 0-1	-10	-13	-15	-18	-20	-21	30 kHz
± 1-2.5	-10	-10	-10	-10	-10	-10	1 MHz
± 2.5-2.8	-25	-10	-10	-10	-10	-10	1 MHz
± 2.8-5		-10	-10	-10	-10	-10	1 MHz
± 5-6		-25	-13	-13	-13	-13	1 MHz
± 6-10			-25	-13	-13	-13	1 MHz
± 10-15				-25	-13	-13	1 MHz
± 15-20					-25	-13	1 MHz
± 20-25						-25	1 MHz

NOTE: As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. However, to improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

Annex 2: Global Activity on C-V2X

A2.1 ITU-R Region 1: Europe

There is a trend of public-private partnerships driving C-V2X development across Europe, with a focus on real-world testing and practical applications. The involvement of major automotive manufacturers and tech companies suggests strong industry support for this technology.

In 2017, Orange in partnership with PSA Group announced the completion of C-V2X field trials in France.[17] France has also participated in the European DRIVE C2X project, which created a consistent Europe-wide testing environment for cooperative systems. The project, which ran from 2011 to 2014, was comprised of six test sites in Germany, Italy, the Netherlands, Sweden, France and Finland.

Germany is at the forefront of Cellular Vehicle-to-Everything (C-V2X) technology development and deployment in Europe, driven by its robust automotive industry and strong government support. Germany's leadership is exemplified by initiatives like the ConVeX (Connected Vehicle to Everything of Tomorrow) project, which has successfully integrated C-V2X direct communications into a 5G test network covering highways, roads, and urban areas. This collaborative effort, involving major players such as Audi, Ericsson, Qualcomm, and others, demonstrates Germany's commitment to advancing real-world applications of C-V2X technology.[18]

Germany has also hosted significant C-V2X demonstrations, including a notable event in Berlin organized by the 5G Automotive Association (5GAA) in October 2024. These showcases have highlighted cutting-edge use cases like "cooperative parking" and vulnerable road user protection, utilizing V2X technologies in vehicles from manufacturers like Audi and BMW.[19] These demonstrations not only emphasize the practical applications of C-V2X in improving road safety and traffic efficiency but also underscore the technology's readiness for mass deployment, with a target set for 2026.[20]

In addition, there aredeployments in Norway, Sweden, UK, and other Member States.

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[17] GSMA, "Cellular Vehicle-to-Everything (C-V2X) enabling intelligent transport," 21 December 2017. https://www.gsma.com/solutions-and-impact/technologies/internet-of-things/wp-content/uploads/2017/12/C-2VX-Enabling-Intelligent-Transport_2.pdf

[18] Qualcomm, "ConVeX Consortium Hosts Europe's First Live C-V2X Direct Communication Interoperability Demonstration Between Motorcycles, Vehicles, and Infrastructure," 3 July 2018. https://www.qualcomm.com/news/releases/2018/07/convex-consortium-hosts-europes-first-live-c-v2x-direct-communication.

[19] 5GAA, "5GAA Members to Demonstrate Latest C-V2X Tech in Berlin," 11 October 2024. https://5gaa.org/5gaa-tech-demonstrations-berlin-2024/.

[20] 5GAA, "Berlin real-world use cases demonstrate game-changing C-V2X technology," 9 December 2024, https://5gaa.org/berlin/.

A2.2 ITU-R Region 2: Americas

In the Americas, the United States leads with C-V2X rules issued at the end of 2024. Canada is in the exploratory stage with established spectrum regulatory and technical standards. In Latin America, the V2X market is growing..

A2.2.1 Canada

ISED Canada has initiated efforts to deploy C-V2X technology, concentrating on spectrum allocation and technical standards. These steps include:

1. Spectrum Allocation

In December 2022, ISED designated the 5895-5925 MHz range exclusively for Intelligent Transportation Systems using C-V2X technology.[21]

Particularly,

> ***Decision (D8):*** *ISED will allow ITS OBUs to operate under a licence-exempt (no-protection, no-interference) basis in the 5895-5925 MHz band.*
>
> ***Decision (D9):*** *ISED will implement a spectrum licence approach for ITS RSUs in the 5895-5925 MHz band.*
>
> ***Decision (D10):*** *A licensing framework for RSU deployments in the 5895-5925 MHz band will be determined through a future consultation.*

2. Establishment of Technical Standards

ISED's RSS-252 standard, Issue 2 (May 2023), certifies license-exempt C-V2X devices in the 5895-5925 MHz band. It sets technical parameters for C-V2X on-board units to ensure compliance and interoperability in Canada's ITS framework.

3. Public Consultations

ISED held public consultations on C-V2X device standards until August 11, 2023, seeking feedback from industry and stakeholders on certification requirements and technical specifications.

A2.2.2 United States

In Nov 2024, Federal Communications Commission (FCC) adopted final rules on cellular-vehicle-to-everything (C-V2X) technology through the **Second Report and Order**[22] on

[21] Decision on the Technical and Policy Framework for Radio Local Area Network Devices in the 5850-5895 MHz Band and for Intelligent Transportation Systems in the 5895-5925 MHz Band, https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/learn-more/key-documents/decision-technical-and-policy-framework-radio-local-area-networks-devices-5850-5895-mhz-band-and

[22] https://www.fcc.gov/document/fcc-adopts-c-v2x-auto-safety-spectrum-rules

the "Use of the 5.850-5.925 GHz Band." The Second Report and Order was published in the published in the Federal Register on December 13, 2024 and the final rules will go into effect on January 11, 2025.[23] Through this decision, the FCC further address the transition of 5.9 GHz Intelligent Transportation System (ITS) operations from Dedicated Short Range Communications (DSRC)-based technology to C-V2X-based technology.

Under the FCC's rules, the upper 30 MHz of the 5.9 GHz band (5.895-5.925 GHz) is preserved for Intelligent Transportation Systems (ITS), particularly Cellular Vehicle-to-Everything (C-V2X) technology, partitioning the band into three 10 MHz bandwidths: (i) 5.895-5.905 GHz, (ii) 5.905-5.915 GHz, and (iii) 5.915-5.925 GHz bands, for individual or combined use.

The Second Report and Order establishes a two-year sunsetting window for DSRC operations. During this period, the FCC will refrain from issuing new licenses and will only renew existing licenses for a period not to exceed December 14, 2026.

In particular, the FCC 2nd R&O Appendix A Final Rules highlight the following:

§ 90.7 Definitions

Cellular Vehicle to Everything (C-V2X). The use of cellular radio techniques to transfer data between roadside and on-board units or between on-board units to perform operations related to the improvement of traffic flow, traffic safety, and other Intelligent Transportation System applications in a variety of environments. C-V2X systems may also transmit status and instructional messages related to the units involved.

On-Board Unit (OBU). An On-Board Unit is an Intelligent Transportation System transceiver, operating in the 5895-5925 MHz band, that is normally mounted in or on a vehicle, or which in some instances may be a portable unit. An OBU can be operational while a vehicle or person is either mobile or stationary. The OBUs receive and transmit on one or more radio frequency (RF) channels. Except where specifically excluded, OBU operation is permitted wherever vehicle operation or human passage is permitted. The OBUs mounted in vehicles are licensed by rule under part 95 of this chapter and communicate with Roadside Units (RSUs) and other OBUs. Portable OBUs also are licensed by rule under part 95 of this chapter.

Roadside Unit (RSU). A Roadside Unit is an Intelligent Transportation System transceiver, operating in the 5895-5925 MHz band, that is mounted along a road or pedestrian passageway. An RSU may also be mounted on a vehicle or is hand carried, but it may only operate when the vehicle or hand-carried

[23] https://www.federalregister.gov/documents/2024/12/13/2024-28980/use-of-the-5850-5925-ghz-band

unit is stationary. Furthermore, an RSU operating under this part is restricted to the location where it is licensed to operate. However, portable or hand-held RSUs are permitted to operate where they do not interfere with a site-licensed operation. An RSU broadcasts data to or exchanges data with OBUs. For DSRC-based RSUs operating in the Intelligent Transportation System until [INSERT DATE 2 YEARS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER], an RSU also provides channel assignments and operating instructions to OBUs in its communications zone, when required.

Further, for eligibility to hold an RSU license,

> **§ 90.388 Eligibility.** The following entities are eligible to hold an authorization to operate C-V2X RSUs: (a) Any territory, possession, state, city, county, town or similar governmental entity. (b) Any entity meeting the eligibility requirements of §§ 90.20, 90.33 or 90.35.

And the license term

> **§ 90.149 License term.**
>
> * * * * * (b) Non-exclusive geographic area licenses for Intelligent Transportation Systems radio service Roadside Units (RSUs) in the 5895-5925 MHz band under subpart M of this part will be issued for a **term not to exceed ten years** from the date of original issuance or renewal. The registration dates of individual RSUs (see §§ 90.375, 90.389 of this part) will not change the overall renewal period of the single license.

A2.3 ITU-R Region 3: Asia-Pacific

Many countries in Asia-Pacific strongly support C-V2X with rigorous testing and development, aligning national strategies with its growth.

A2.3.1 China

According to the 5G Automotive Association (5GAA), China was the first country to have a comprehensive national strategy for the Internet of Vehicles (IoV). China has over 5000 km of roads covering intelligent V2X pilot demonstrations[24]. In early 2024, China's Ministry of Industry and Technology (MIIT) officially launched a pilot program for 'vehicle-road-cloud integration' of intelligent connected vehicles, scheduled from 2024 to 2026.

[24] 5GAA, "C-V2X in action," https://5gaa.org/c-v2x-in-action/

Twenty cities, including Beijing and Shanghai, were selected to participate in the pilot.[25] All pilot vehicles must have C-V2X technology and digital identity certificates. The program aims for 50% of new vehicles, including city buses, government vehicles, and taxis, to have C-V2X by the end of the pilot.[26]

In July 2024, C-V2X was added to the China New Car Assessment Program's evaluation of vehicle safety. The China Society of Automotive Engineers (C-SAE) hosts an annual event to enhance interoperability among OEMs, chipset vendors, module vendors, and app developers. These initiatives, along with government efforts to define a national C-V2X strategy and allocate spectrum in the 5.9 GHz band for C-V2X services, aim to encourage industry adoption.[27]

A2.3.2 Hong Kong

In August 2024, ASTRI and Citybus signed an MoU to test C-V2X technology on routes from Hong Kong Science Park to University MTR station and within Kai Tak. The goal is to evaluate connected autonomous buses in complex public road environments.[28] Previous trials led by ASTRI have included a major public road test.[29]

The Hong Kong government backs C-V2X technology via the Smart City Blueprint, aiming to develop C-V2X and autonomous vehicles. Funding from the Smart Traffic Fund supports advanced C-V2X applications to improve mobility and road safety.[30]

A2.3.3 Japan

Japan conducted its first C-V2X trials in 2018, involving a collaboration of major automotive, telecom, and ITS companies including Continental, Ericsson, Nissan, NTT DOCOMO, OKI, and Qualcomm Technologies. These trials focused on various

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[25] Auto World Journal, "China Launches Pilot Program for Vehicle-Road-Cloud Integration in ICVs," 3 July 2024, https://www.autoworldjournal.com/china-launches-pilot-program-for-vehicle-road-cloud-integration-in-icvs/.

[26] GlobalNewswire, "Global and China C-V2X and CVIS Industry Research Report 2024: By 2034, C-V2X will Cover 100% of National Highways and 75% of Urban Intersections," 8 August 2024, https://www.globenewswire.com/news-release/2024/08/08/2926669/28124/en/Global-and-China-C-V2X-and-CVIS-Industry-Research-Report-2024-By-2034-C-V2X-will-Cover-100-of-National-Highways-and-75-of-Urban-Intersections.html.

[27] ITS International, "China paves way to enhanced safety with C-V2X," 30 September 2021, https://www.itsinternational.com/its5/its7/feature/china-paves-way-enhanced-safety-c-v2x.

[28] ASTRI, "Citybus and ASTRI sign key MoU Launching groundbreaking autonomous driving and C-V2X projects," 20 August 2024, https://www.citybus.com.hk/en/uploadedPressRelease/21050_20240820_ENG.pdf.

[29] ASTRI, "ASTRI launches one of the world's largest C-V2X public road tests, promoting Smart Mobility to improve the city's mobility competence while enhancing road safety and efficiency," 30 March 2021, https://www.astri.org/news-detail/astri-launches-one-of-the-worlds-largest-c-v2x-public-road-tests-promoting-smart-mobility-to-improve-the-citys-mobility-competence-while-enhancing-road-safety-and-efficiency/.

[30] ASTRI, C-V2X Technology, May 2022, https://www.astri.org/tdprojects/connected-vehicle-v2x-technology/.

communication scenarios including Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P), and Vehicle-to-Network (V2N), yielding promising results with low latency and high reliability.[31]

The Japan government has shown strong support for C-V2X technology through initiatives like the Automated Driving for Universal Services for the Cross-ministerial Strategic Innovation Promotion Program (SIP-adus) program, which has identified 25 use cases for cooperative automated driving. This program was established to promote studies toward the implementation of C-V2X in society.[32] Companies in Japan are also actively participating in C-V2X development, with Nissan involved in selecting V2X use cases, NTT DOCOMO promoting studies on C-V2X using LTE/5G communications technology, and OKI contributing its roadside unit infrastructure for V2I demonstrations.[33]

A2.3.4 South Korea

In December 2023, South Korea adopted LTE-V2X as its primary vehicle communication technology, moving away from Dedicated Short-Range Communications (DSRC). This aligns with trends in the U.S. and China. South Korea has dedicated significant bandwidth in the 5.9 GHz frequency band for C-V2X, showing strong support for this technology. The decision is expected to boost infrastructure spending and product development in the country.[34]

Ministry of Science and ICT (MSIT) and the Ministry of Land, Infrastructure and Transport (MOLIT), plan to implement Cooperative-Intelligent Transport Systems (C-ITS) using C-V2X technology across the country. This system aims to facilitate communication between vehicles and roadside infrastructure, improve road safety, and support the development of automated driving vehicles.[35]

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[31] Nissan Motor Corporation, Leading automotive, telecom and ITS companies unveil first announced cellular V2X trials in Japan, 11 January 2018, https://usa.nissannews.com/en-US/releases/leading-automotive-telecom-and-its-companies-unveil-first-announced-cellular-v2x-trials-in-japan.

[32] Cabinet Office, "Cross-Ministerial Strategic Innovation Promotion Program Innovation of Automated Driving for Universal Services (SIP-adus)," https://www8.cao.go.jp/cstp/english/sipadus_news.html.

[33] iTS International, "Automotive, Telecom and ITS companies launch C-V2X trials in Japan," 16 January 2018, https://www.itsinternational.com/its7/news/automotive-telecom-and-its-companies-launch-c-v2x-trials-japan.

[34] 5GAA, "The Republic of Korea Picks C-V2X as its Technology of Choice," 12 December 2023, https://5gaa.org/the-republic-of-korea-picks-c-v2x-as-its-technology-of-choice/.

[35] C-ITS, "About C-ITS," https://www.c-its.kr/english/introduction.do.

(A)

Government of India
Ministry of Road Transport & Highways
*****

Note on the Report of Task Force.

The Part-I of the Report of the Task Force has been signed but your attention is again drawn to the following points:

a. The first and the foremost reason for adoption of V2X Technology/Intelligent Transport System is to improve road safety and reduce road fatalities. As per the Road Accidents in India report (2022), the number of fatalities is 1.68 lakh across 4.61 lakh accidents. We as a nation are committed to reduce road fatalities and injuries by 50% by 2030 as a signatory to the Stockholm declaration (Feb 2020). The adoption of V2X/ITS is one of the key technological measures which can play an important role in enhancing road safety.
b. Para 13.1 of the DoT report titled 'Report by the Committee on V2X/ITS Policy formulation' dated 20.01.2023 has compared the two major competing technologies for the implementation of V2X and recommended that C-V2X standards may be given preference over DSRC standards. Para 13.2(i) has also recommended for C-V2X technology as a harmonized standard in the frequency band of 5875-5925 MHz (50 MHz).
c. The task force has acknowledged the recommendation of the above report vide para 7.2 and has accordingly recommended the frequency range of 5875-5925 MHz (50 MHz) for the use of C-V2X Technology. During multiple deliberation between members of the task force, it was agreed that CV2X is the best technology presently available which will help in achieving the stated objective of improving road safety while also balancing the requirements of automotive industry.
d. It is clarified that the MoRTH is open to examining newer and better technologies for adoption in future. In such scenario, interoperability across technologies should be ensured to achieve the overarching goal of improving road safety.
e. It is also informed that the transmission power limits as well as out-of-band emission limits as recommended in Para 7.3 has been decided based on technical inputs of stakeholders/members of the task force. The same can be reviewed in the future based on ground realities and implementation feedback, if necessary.
f. The recommendation of the task force vide para 7.4 and 7.5 has been formulated based on the global regulatory outlook vide para 6 of the Report.
g. The role of MoRTH in this task force is to identify a technological solution through automotive engineering to improve road safety and prevent road fatalities. In reference to the value of the spectrum associated with V2X /ITS, it is submitted that the subject is not under the purview of MoRTH.

07/03/25
Ankit Dugar
Director (MVL), MoRTH

Mayank Tyagi
Mayank Tyagi
Deputy Secretary (Highways), MoRTH

Note (B)

Dissent Note for "Part 1: Recommendations on Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) in the 5.875-5.925 GHz and Corresponding Radio Frequency Levels" of the Report of the Task Force on Intelligent Transportation System for the use of 5.9 GHz, by the Task Force

I hereby formally express my dissent regarding certain aspects of "Part 1: Recommendations on Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) in the 5.875-5.925 GHz and Corresponding Radio Frequency Levels" as recommended in the said Report. My concerns are as follows:

1. Concerns on Task Force Recommendations

(a) Differing Regulatory Approaches

The Task Force's recommendation for the use of C-V2X technology within the 5.875-5.925 GHz frequency range, which is in conflict with the provisions of the **Indian Telecommunication Act 2023.** The Act emphasizes that spectrum should be utilized in a "flexible, liberalized, and technologically neutral manner." This recommendation, which restricts the use of the spectrum to C-V2X technology, contradicts the principles of technological neutrality and fails to account for other viable Intelligent Transportation System (ITS) technologies. Limiting the spectrum to only one technology undermines the core objectives of the Act.

(b) Regulatory Framework for On-Board Units (OBUs) and Roadside Units (RSUs)

The Task Force recommends that OBUs should not require individual licenses or authorizations within the frequency range of 5.875-5.925 GHz, while for RSUs a licensing framework to be applied for RSUs with appropriate spectrum charges. This creates a regulatory inconsistency, given that both OBUs and RSUs are part of the same network and utilize the same spectrum for similar services then how two distinct regulatory approaches can be applied for identical services. Further, Task force recommend the non-requirement of individual licenses or authorizations for OBUs, only for vehicles using C-V2X technology. Thus, dual approach in the regulatory framework, may lead to complicated enforcement and operational challenges. A uniform regulatory framework should be applied to both OBUs and RSUs to ensure clarity and coherence.

(c) Commercial Aspect of Vehicle Manufacturing

Vehicle manufacturing and selling is a commercial activity, and it is anticipated that customers will be additionally charged for vehicles equipped with OBUs under V2X technology, marketed as a premium feature. Further, the Task Force has not provided a clear roadmap by when and how for the installation, maintenance and charges for providing services of RSUs by the Ministry of Road Transport and Highways (MoRTH) or National Highways Authority of India (NHAI) or any other entity. This current uncertainty on when and how RSUs will be installed or maintained is concerning. It is likely that private entities or public-private partnerships (PPP) will handle the installation, making the service similar to mobile cellular services, potentially involving user fees.

(d) Spectrum Allocation for Commercial Services: As manufacturing and selling of vehicle equipped with OBUs for V2X is a commercial activity, it would not be appropriate to allocate high valuable spectrum for free to support a commercial service. Spectrum is a finite resource, and allocating it without proper pricing may result in inefficient use of this resource.

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2. Spectrum Valuation

The recent **2024 spectrum auction reserve price** for the 3300 MHz band was set at Rs. 355.04 crores per MHz for a 20-year period. If this were applied to the 5.875-5.925 GHz band, then the cost for 50 MHz of spectrum would be approximately **Rs. 900 crores per annum**. Given the high value of this spectrum, a more substantial fee structure should be considered.

3. Recommended Approach

(a) Regulatory Framework

I recommend adopting a regulatory framework similar to that applied to aero-mobile or maritime mobile licensing, which is also designed for safety purposes in air and sea. This framework could involve a payment of one-time fixed charge paid by each vehicle using the spectrum, without the regular licensing renewals model.

(b) One-Time Fee for Vehicle Manufacturers

A one-time fee should be paid by vehicle manufacturers based on the Vehicle Identification Number (VIN) (which is chassis number) of the vehicle. This fee would cover the lifetime usage of the spectrum for each vehicle, eliminating the need for annual renewals. The introduction of a one-time fee would streamline the process and reduce administrative burdens for both vehicle manufacturers and the regulatory bodies.

(c) Fee Formulation

I propose that the Department of Telecommunications (DoT) by itself or in collaboration with Telecom Regulatory Authority of India (TRAI) may determine a suitable one-time fee structure. The fee should reflect the value of the spectrum, the commercial nature of the V2X services, and the long-term sustainability of the spectrum allocation.

(d) Registration Process

The registration process could be facilitated through the SARAL SANCHAR portal (DoT), where vehicle manufacturers would register the vehicle using its VIN (Chassis number) and make the required one-time payment through the integrated Bharat-Kosh platform. Upon successful payment, a certificate should be issued, confirming that the vehicle which VIN is authorized to operate within the 5.875-5.925 GHz frequency range for ITS services during the vehicle's lifetime.

28/02/2025

Date:28/02/2025

Sharad Kumar Chauhan,
Member,
WPC Wing, DoT

(2)

Note ©

Dissent Note

Subject: Dissent on the recommendations of the Report of the Task Force on Intelligent Transportation System for the use of 5.9GHz - Part 1: Recommendations on Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) in the 5.875-5.925 GHz and corresponding radio aspects

I, Santosh Sam Koshy, member of the Task Force on the above-mentioned subject would like to express my dissent on some of the recommendations as stated in the Finalized Report of the task force. I would like to explain the reasons and nature of my dissent herewith, and request that the same be recorded in the final report, and/or considered for revision, if found applicable.

Summary of Acceptance/Dissent

S.No	Recommendation	Acceptance / Dissent	Reasons Thereof
7.1	The Task Force recommends adopting the V2X/ITS frequency range of 5.9 GHz (5.875-5.925 GHz), which has already been considered for V2X technologies/ Intelligent Transport System in the NFAP-2022, recognizing it as the spectrum band for enhancing road safety and reducing road fatalities.	Accepted	NA
7.2	The Task Force acknowledges the recommendation of para 13.2(i) of the DoT report titled 'Report by the Committee on V2X/ITS Policy formulation' dated 20.01.2023 to identify harmonized technology. To ensure that vehicles and infrastructure can seamlessly interoperate to achieve the goal of	Dissent	1. The recommendation cites para 13.2(i) of the DoT report, whose reference has not been provided in the document. Further, the same is not available during a general search on the Internet. 2. Further, allocation of the entire 50MHz for a specific technology like C-V2X is not justifiable. Even in countries where the specification is towards C-V2X technology specifically, a maximum of 30 MHz has been allocated (reference is taken from this report, page 6, graphic below para 6.1). 3. Moreover, it may be noted that even in USA which adopted a technology centric approach, it continues to retain a

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road safety, this Task Force recommends the frequency range of 5.875-5.925 GHz for the use of C-V2X technology.

75MHz band in the spectrum range of 5.850 to 5.925 GHz for ITS applications, with the upper 30MHz being allocated to C-V2X and the lower 45 MHz remaining unlicensed for other ITS applications.

4. Further, even in the upper 30MHz band that is allocated, in para 25 of the FCC Second Report and Order (FCC 24-123), para 25, it has clearly been specified that the definition of the 30MHz band shall continue to be treated as 3 sub bands of 10-MHz channel bandwidth, respectively. The decision to retain these as they are (three 10 MHz channels) or to combine these bands into one 20MHz and one 10-MHz channels or a single and contiguous 30 MHz channel shall be user driven. This clearly demonstrates that even 10 MHz bands are sufficient for multiple ITS applications.
5. Further, it may be noted that a claim of insufficiency of the allocated bandwidth of 30MHz for C-V2X by the automotive industry in USA was questioned by the Dynamic Spectrum Association (DSA) in para 18 of the FCC report, thereby emphasizing that the allocated band of 30MHz is adequately sufficient for C-V2X based ITS applications.
6. I therefore do not see the need to allocate the entire 50MHz to a specific technology like C-V2X, especially if the spectrum is proposed to be non-chargeable license.
7. Further, the recommendation of the task force clearly removes any possibility for newer technologies to be adopted in the future in the proposed band and remains very silent about the non-interoperable aspects of the 3GPP releases which specify two different technologies for C-V2X as in LTE C-V2X and NR C-V2X (Releases 14, 15 and 16). It may be noted that both these technologies are not interoperable or

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			backward compatible (para 12 of FCC report). While the FCC has acknowledged this, they have refrained from specifying any 3GPP release centred allocation but expect all equipment to be interoperable and both forwards and backwards compatible. 8. However, in my opinion, such expectations do not augur very well with technology limitations and may result in ambiguity. While there is specificity in the definition of the technology (C-V2X) in the FCC's report, there is clear vagueness in the specific standards (3GPP releases) or the allocation of channel frequencies, which is left to the industry to decide. 9. I humbly submit that such vagueness would create more confusion in the Indian Industry and therefore requires more consultation and/or pilot applications to provide data upon which final decisions can be made. While I am ok with trying out C-V2X as a technology standard for V2X/ITS communication, such specification may be disconnected from entire spectrum allocation and/or restricted to 20/30 MHz, which allows for futuristic technology introductions.
7.3	The Task Force recommends setting transmission power limits with a maximum e.i.r.p of 4W for both On-Board Units (OBUs) and Roadside Units (RSUs), with a conducted power output of 200mW (23 dBm) over a bandwidth of 20 MHz or higher for RSUs. Additionally, the Task Force advises adhering to the out-of-band emission limits outlined in the	Accepted with suggestions	1. I accept the recommendation to limit the EIRP of OBUs to 23 dBm (200mw at the transmitter) but suggest increasing the RSU power upto EIRP of 36dBm (4W at transmitter). RSUs may require higher power and range for different ITS applications. Since RSUs may be typically deployed at greater heights for better coverage, increasing the transmit power may support a wider range of ITS applications. 2. Clarity is also sought on why the recommendation specifies a bandwidth of 20MHz or more for RSUs. It is not clear whether the minimum bandwidth of a channel is restructured to 20 MHz disallowing channels of 10 MHz or whether such is applicable only to RSUs

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	table below for both OBUs and RSUs.		and therefore OBUs may communicate in channels of 10 MHz. 3. It is also important to clarify whether the compliance to the maximum EIRP specified in the recommendation pertains to detection via RMS or peak values. 4. It is also suggested to adopt the specification of radiated power in terms of the power spectral density (PSD) which applies over the entire band and therefore caters to channel combinations, while allowing manufacturers to implement the technology without worrying about the transmitter power. It is suggested to discuss the same with experts from the subject area before accepting such recommendations. 5. I suggest that clarity is brought to the recommendation.
7.4	The Task Force recommends that within the frequency range of 5.875-5.925 GHz, OBUs of vehicles using C-V2X technology should not require individual licenses or authorizations. This would allow OBUs to be easily installed in all types of vehicles, promoting widespread adoption and accessibility for individual users.	Neutral	1. I believe this is a policy decision of the Ministry of Telecommunication. 2. I would like to draw attention to a similar debate on whether or not to charge spectrum allocation, from FCC's report (para 19). The Internet and Television Association (NCTA) mooted auctioning the spectrum and contended with it being offered freely. However, the FCC overruled the suggestion by drawing attention to the Transportation Equity Act for the 21st Century in which the Congress directed the FCC to consider the spectrum needs of ITS. Having already implemented DSRC without licensing, the FCC adopted the same strategy. 3. The decision to charge or not is therefore purely executive and arguments can be made both ways. I have no say in this matter, but to comply by the policies of the Ministry of Telecommunications, GoI which is better poised to make such decisions.
7.5	The Task Force recommends a	Dissent	1. I believe this recommendation is arbitrary and without justification as to

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	licensing framework to be applied for RSUs with appropriate spectrum charges to ensure proper deployment, maintenance, and operation in the low-power, short-range spectrum. The State Government or any authority authorized in this behalf by the State Government or National Highways Authority of India (NHAI) or any other road owning agencies will be better suited to handle oversight and authorization for RSU installation to ensure that RSUs are correctly located, functional, and meet all necessary safety and operational standards.	why spectrum charges are to be allocated to RSUs alone, when these are critical elements in Road Safety Applications. For example, Ambulances require the RSU for a green corridor, which is intended to save lives. Similarly, at intersections, RSUs may have roles to play in providing safety information to vehicles which are hidden from each other due to non-line of sight conditions. Further, very important safety critical applications like stranded vehicle information also require RSU interventions. 2. In charging RSUs for spectrum usage, it may increase the cost to the end user of the service and may also limit the role and use of RSU for ITS applications pertaining to road safety. 3. It is also important to highlight here that relevant stakeholders like Highway Operators, Traffic Signals, etc., should be cognizant of the repercussions of this recommendation. Therefore, a concerted effort to engage them is essential if this recommendation is to be formulated. 4. In my personal view, there is no distinction between the spectrum requirements of both the OBU and the RSU. Therefore, it is important to have a uniform policy for both types of devices, as according to the norms of MoT, GoI.

Suggestions and Way Forward

1. Concerning recommendation 7.2, I believe that reference to the spectrum need not be made. Further, it may be emphasized that the spectrum allocation is for V2X/ITS applications and in the current context, since C-V2X is the most viable technology, the same may be used until further notice. This will allow for incorporation of newer technologies for vehicular communication and will be flexible as a policy decision, without becoming entirely technology specific.
2. The decision to auction/charge the spectrum is more a matter of policy, rather than recommendation. The task force is only liable to present the global position in this matter.

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3. The recommendation to consider the RSU as a chargeable license is arbitrary and without justification. In our endeavour to promote road safety and traffic management, the role of the RU is equally important and cannot be distinguished, therefore. I suggest dropping this recommendation.
4. Concerning recommendation 7.3, more details are required and should be clear for usage.

Sincerely,

02/03/2015

Santosh Sam Koshy

Member of Task Force,

Scientist E,

C-DAC Hyderabad

Annexure-II

Report by the Committee on V2X/ITS policy formulation

1) Introduction

Sustainable transport, with its objectives of universal access, enhanced safety, reduced environmental and climate impact, improved resilience, and greater efficiency is one of the central objectives in creating sustainable cities and communities as part of the United Nations' Sustainable Development Goals.

Scientific advances and the rapid deployment of new technologies are essential for the transition to sustainable transport. Built-in safety features, environmentally friendly fuels and engines, widespread digitalization, apps that process real time information, autonomous vehicles and intelligent transport systems have become central features of the transport innovation landscape.

Intelligent Transport Systems (ITS) are a suite of public transport planning, operations management and customer service applications that are enabled by advanced information and communications technologies. They act to enhance the effectiveness, efficiency, and usability of the public transport service to the benefit of public transport authorities, operators and passengers.

ITS involve customized, situation-specific applications to address specific functions. They utilize a mixture of proprietary and generic technologies for that purpose. They utilize multiple data sources, mostly in real time, and enable a direct effect on outcomes which are usually not possible without the ITS application.

To enable the networking as well as the communication between the various components of an ITS system radiocommunication technology play a crucial part. Such technology broadly termed as Intelligent Transport System (ITS) or V2X (Vehicle to Anything) radiocommunication is a set of radiocommunication technologies used for traffic safety and traffic efficiency related applications as well as electronic tolling systems, Automotive RADARS used for safety applications such as driver warning systems for collision avoidance etc. It also helps to a great extent in reducing the Carbon footprint due to increased traffic efficiency, reducing environmental pollution and reduces the operating cost of manual road toll collection and road accidents.

ITS/V2X have enhanced vehicular networking functionality to provide communication between the vehicles, and also between the vehicle and infrastructure/pedestrians. It also transports the vehicular information over a network for centralised management as well as supports in-vehicle communications. Enhanced vehicular networking functionality of ITS/V2X also includes accurate location information and data encryption in the vehicle terminal. Apart from inter vehicle communication and vehicle to network communications, ITS/V2X consists of a host of allied components which enable collision avoidance, GNSS based tracking and blind spot detection thereby enhancing efficiency and safety of transportation.

Further, continuing application of Intelligent Transport Systems (ITS) under a national framework to establish a safe and efficient transport system is also a guiding principle for the National Road Safety Policy in India.

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2) Components in a V2X system

i) Vehicle-to-infrastructure (V2I); Directly connects vehicles to roadside infrastructure which in turn can be connected to the wider mobile network. V2I is used for Traffic management such as traffic light, intersection management, road safety information, streetlights to share traffic signal change notice, automatic parking speed limit warning, bad road condition warning and pedestrian crossing information etc.

ii) Vehicle-to-vehicle (V2V); Directly connects vehicles for early warnings (e.g. an upcoming emergency) including beyond line of sight vehicles to augment the shorter-range on-board sensors. The amount of data exchanged in this mode will not be high but very low latency is required.

iii) Vehicle-to-pedestrian (V2P); Directly connects vehicles to pedestrians equipped with compatible mobile devices to issue alerts about potential dangers nearby.

iv) Vehicle-to-network (V2N); Connects vehicles to the mobile network to support services like streaming media for entertainment and connectivity for dynamic route management, etc. V2N also facilitates communication between the vehicles which are not within the communication range of each other.

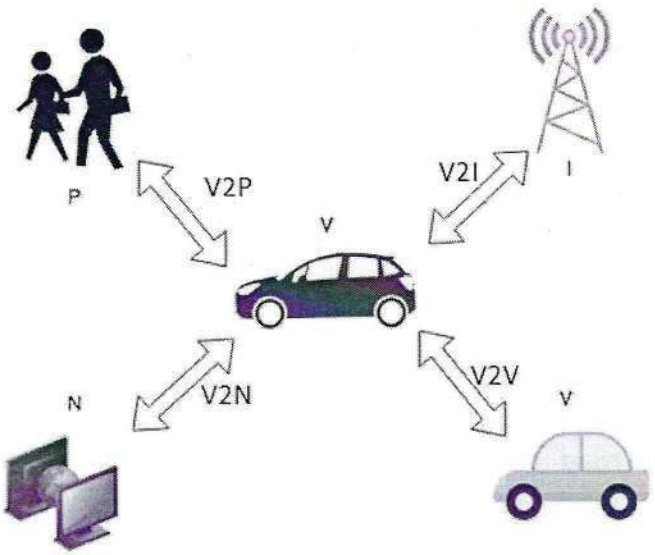
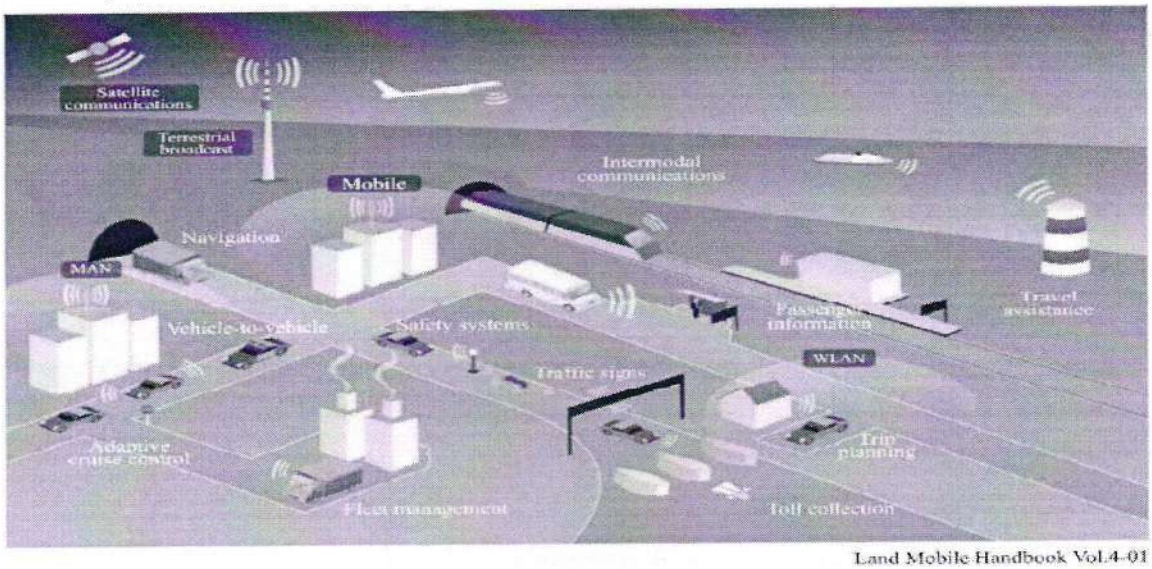


Figure 1

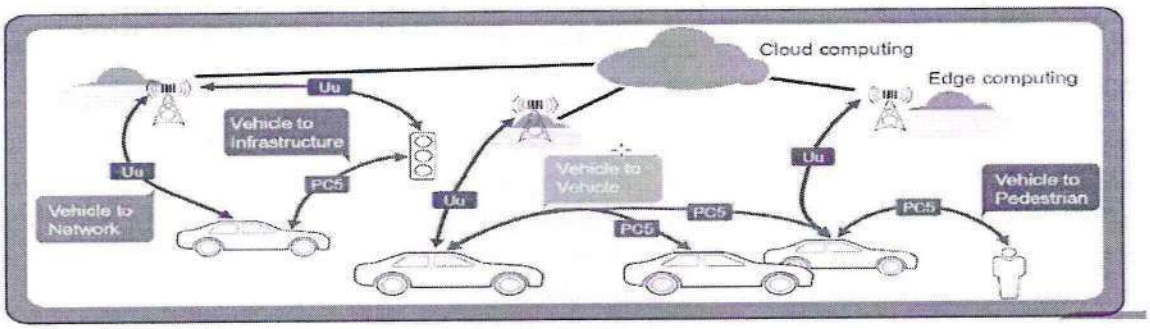
These four components of V2X applications can use "co-operative awareness" to provide more intelligent services for end-users. This means that entities, such as vehicles, roadside infrastructure, application server and pedestrians, can collect knowledge of their local environment (e.g., information received from other vehicles or sensor equipment in proximity) to process and share that knowledge in order to provide more intelligent services, such as cooperative collision warning or autonomous driving. Therefore, the function of ITS system can be categorized as data acquisition, data processing and distribution of information to the users.

Few Representative diagrams of the operations of V2X/ITS systems are depicted below.



Land Mobile Handbook Vol.4-01

Figure 2



Source: 3GPP

Figure 3

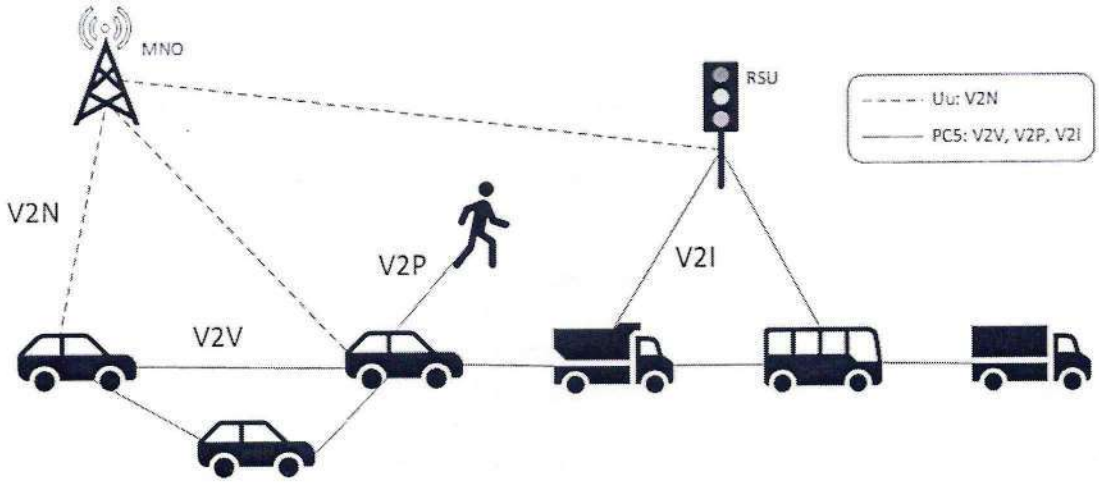


Figure 4

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3) ITS/V2X – the technological landscape

ITS/V2X technologies have been standardized and studied in various standards development organizations. At the international level, ITU-R, ISO TC 204, 3GPP and IEEE are working on developing the standards, recommendations and reports. In Asia-Pacific region, AWG is working at the regional level and ARIB, TTA, IMDA TSAC and other standard organizations in their country/region. In Europe, ETSI TC ITS and CEN TC278 are working at the regional level. SAE International and SAE India are also working on V2X standards.

3.1 Standardisation in various ITS/V2X technologies.

Wireless communication technologies for connected and automated vehicles are at an advanced stage of standardization and commercial operation. The overall set of standards can be classified into two groups:-

i. access layer technologies

ii. the higher layer technologies and standards.

3.1.1 Access layer standards:

As mentioned in the section 3 above, the ad hoc access layer V2X communication technologies are:

IEEE based: IEEE technology is based on the amendment to IEEE 802.11 called IEEE 802.11p (2010), part of IEEE 802.11-2016, to include Wireless Access in Vehicular Environments (WAVE). It is the IEEE standard used by Vehicle-to-Everything (V2X) applications in the 5.9 GHz (5.85-5.925 GHz) band. This access technology is deployed in Europe under the name of ITS-G5 and dedicated short range communication (DSRC) in the US, as well as ITS Connect in Japan. IEEE 802.11p uses Orthogonal Frequency Division Multiplex (OFDM)with a channel bandwidth of 10 MHz. The 802.11p support:

i. relative velocities up to 200 km/hr,
ii. response times of around 100 msec, and
iii. communication range of up to 1000 m.

A successor to IEEE 802.11p is currently being developed in IEEE under the working name IEEE 802.11bd to make it comparable to DSRC & 5G NR C-V2X. IEEE 802.11bd standard is based on the IEEE 802.11ac (i.e. Wi-Fi 5). The IEEE 802.11bd standard woks in 5.9 GHz band with 10/20 MHz bandwidth. It supports relative velocities up to 500 km/hr, and twice the communication range of 802.11p.

3GPP based: 3GPP based access layer technology is an enhancement on the initial work on D2D communications defined as part of ProSe services (in Release 12 and Release 13 specifications) for supporting ad hoc communication are LTE V2X (from Release 14 to Release 15) and NR V2X (from Release 16 to the current Release 18) leveraging the existing cellular infrastructure. C-V2X can operate in in-coverage scenarios using LTE air interface as well as out-of-coverage scenarios using sidelink air interface.

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Further, 3GPP Release 18 is currently working on standardizing aspects related to sidelink based positioning, improved co-channel co-existence between LTE & NR V2X, etc. The 3GPP based access layer technologies are in advanced stages of commercialization in several countries across the world.

3.1.2 Network Connectivity

Additionally, the cellular connectivity for V2N is based on 3GPP 4G and/or 5G standards, requiring coverage by base stations and subscriptions to mobile network operators. Both the access layer technologies, IEEE based and 3GPP based may be able to leverage the V2N capabilities using 3GPP 4G and/or 5G. The V2N link (4G / 5G) serves as a good means to enable many connected car features. It may also help in enhancing the functionality and efficiency of the transport system. This may be useful in exchanging information about traffic, maps, and other information between the vehicle and the network.

3.1.3 Higher Layer standards

In addition to the ad-hoc access layer and the cellular connectivity, there is an additional set of higher layer standards required to support all the Higher layer technologies for V2X above the access layer available at:

i. ETSI ITS set of standards
ii. IEEE 1609 set of standards
iii. SAE set of standards

3.1.4 End-to-end communication

The complete use-case definition for V2X includes all the protocol layers involving an end-to-end communication between the multiple entities involved. This includes both the access layer and the higher layer communication. The relationship between the two layers is important to understand the technical performance and capabilities required to satisfy the V2X use-case.

At a conceptual level, the vehicles may desire to exchange certain information (that includes some amount of message size, reliably within a certain timeframe). The use-case itself imposes the desired performance metrics to be achieved to support the safety / utility function. The higher layer standards provide the information to be exchanged and the common language. And finally, the access layers enable the actual transfer of messages between the entities.

3.2 A region-wise comparison of the V2X technologies, are tabulated in ITU-R report M.2445 (2018). Further details about current technologies and spectrum in use or under consideration is captured in Section 5 below

4) Related technologies (radiodetermination etc.) assisting ITS/V2X

4.1 Automotive radar

Automotive radar facilitates various functions that increase the driver's safety and convenience. Automotive radar systems are of two categories according to the applications and frequency band

– Adaptive Cruise Control (ACC) 'long-range radar (LRR) (usually operating at 76 GHz band, 76-77 GHz) with a maximum continuous bandwidth of 1 GHz and EIRP of 55 dBm. This enables a vehicle to maintain a cruising distance from a vehicle in front. It controls the accelerator, vehicle breaks and engine powertrain to maintain a desired time gap (speed and distance) to the vehicle ahead of it. It is called as type 'A' radar and fitted at front end of the vehicle. The typical range is about 200 m with narrow antenna beam.

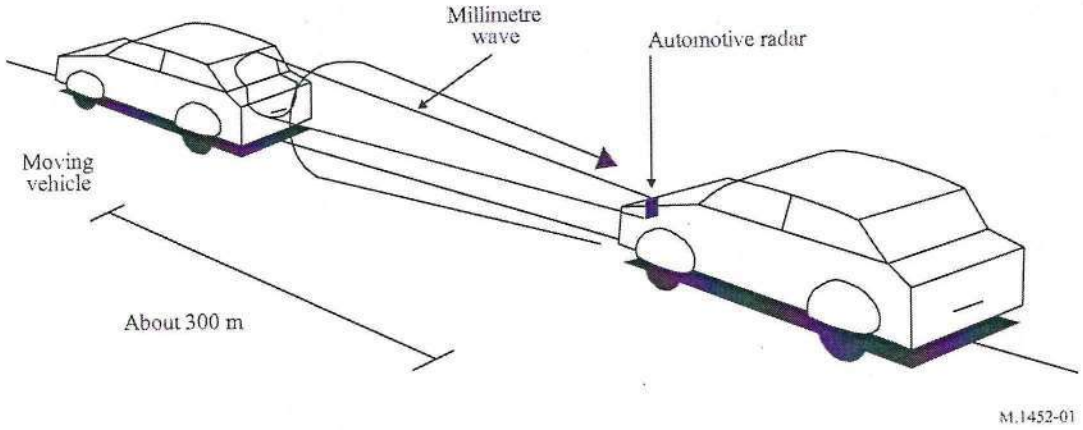

Figure 5

Also, The Federal Communications Commission (FCC) and the Ministry of Internal Affairs and Communications (MIC) in Japan have designated 76-77 GHz band for automotive radar. MIC, Japan has also recommended introduction of high-resolution radar in 77-81 GHz band for safety related applications. The European Conference of Postal & Telecommunications (CEPT) has designated the band 77-81 GHz for automotive radars. The European Telecommunications Standards Institute (ETSI) has adopted the harmonized standard in the frequency band 77-81 GHz for the applications of short range radars. FCC has also allowed 77-81 GHz band for vehicular radar operations aligning with rest of the world. Countries in Asia Pacific Region have also designated 76-77 GHz and 77-81 GHz bands for short range automotive radar application for ITS. Therefore, the frequency bands 76-77 GHz and 77-81 GHz are globally harmonised bands for short range automotive radar applications.

– Anti-collision 'short-range radar (SRR) (usually operating at 24 GHz and 79 GHz bands, 77-81 GHz). This is being developed as part of a system to warn the driver of a pending collision, enabling avoiding action to be taken. In the event where collision is inevitable, the vehicle may prepare itself (for example by applying brakes, pre-tensioning seat belts) to minimize injury to passengers and others. Typical range is about 30 m with wide beam antenna and required bandwidth is 4GHz. The wide bandwidth facilitates to identify objects that are closely spaced. Such radars are fitted at front and back ends of the vehicle.

4.2 Global Navigation Satellite Systems in ITS

From the simple yet essential legacy ITS applications to the advanced ITS services integrating sophisticated features brought by modernization, this ability to identify position is and will continue to be fundamental to any ITS system.

Various entities have developed several GNSS already; Europe has Galileo, USA has Global Positioning System (GPS), Russia had GLONASS and China has BeiDo Navigation Satellite System.

India has also developed an indigenous satellite-based navigation system known as NavIC.

5) Frequency bands for ITS – Global Scenario:

5.1 ITU-R in its recommendation ITU-R M2121-0 (01/2019) recommended to designate 75 MHz band in 5850-5925 MHz for ITS in all regions worldwide. Most of the countries have already designated the same or a similar amount of spectrum in the 5.9 GHz band for V2X communications. Currently, this recommendation is being revised by ITU-R WP5A.

5.2 ITU-R in its report ITU-R M.2444-0 (11/2018) provides examples of arrangements of ITS deployments under the mobile service in different countries. This report is being revised by ITU-R WP5A.

5.3 In Region 1, European Union designated parts of the 5 855-5 925 MHz band in 2008 for the use of ITS applications for road safety and traffic efficiency.

i. ITS-5GA: 5.875 GHz to 5.905 GHz (30 MHz) for safety related applications.
ii. ITS-5GB: 5.855 GHz to 5.875 GHz (20 MHz) for non- safety applications.
iii. ITS-5GD: 5 905 MHz to 5 925 MHz (20 MHz) for future ITS applications.

CEPT in its report 71, stated that the frequency band 5875-5925 MHz is designated for all safety related ITS applications (Road ITS and Urban Rail ITS) and the frequency band 5925-5935 MHz is designated for safety-related Urban Rail ITS applications and proposed 5875-5915 MHz (40 MHz) for road ITS applications in place of earlier designated 5875-5905 MHz (30 MHz), and also proposed sharing possibilities between 5915-5925 MHz (10 MHz) with Urban Rail ITS application subject to Road ITS application being limited to V2I. Further, 5915-5925 MHz will be extended for V2V applications when solutions ensuring protection of Urban Rail ITS become available. Study as per CEPT is being carried out by ETSI.

5.4 Some countries in Region 2 has designated the frequency band 5850-5925 MHz (75 MHz) for ITS application. Out of 75 MHz spectrum, first 5 MHz (5850-5855) has been kept reserved as guard band and the remaining 70 MHz spectrum has been divided into 7 blocks of 10 MHz each with three types of channels: control channel, shared channels and aggregated channels of 20 MHz bandwidth. The two aggregated channels are used to support multi-channel operations.

5.5 Recently, Federal Communications Commission (FCC), USA, in November 2020[1], updated its ITS rules to permit C-V2X at 5895-5925 MHz, and unlicensed indoor use of 5850-5895 MHz for Wi-Fi applications and clarified that C-V2X as the sole ITS connected vehicle technology in the U.S. is the best decision for promoting more robust ITS deployment in the 5.9 GHz band in the coming years. Waivers by multiple state and

[1] 35 FCC Rcd 13440 (16), FCC Modernizes 5.9 GHz Band to Improve Wi-Fi and Automotive Safety, https://www.fcc.gov/document/fcc-modernizes-59-ghz-band-improve-wi-fi-and-automotive-safety-0

local Department of Traffic (DOTs), automakers, and equipment makers have requested waivers to deploy C-V2X in the 5905-5925 MHz portion. Final C-V2X rules will be adopted in an upcoming FCC Order. Auto stakeholders have requested 40 MHz additional mid-band spectrum for advanced C-V2X use cases.

5.6 Recently, Canada also revised its ITS rules, in December 2022[2], and decided to "mandate the use of C-V2X technology in the 5895-5925 MHz band for ITS services". The recent decision also quoted that "ISED is of the view that delaying the selection of a single ITS technology would leave the implementation of ITS services in jeopardy with the risk of having non-interoperable ITS deployments" while making its decision to permit the use of C-V2X in the band.

5.7 Region 3 countries identified the bands 755.5-764.5 MHz, 5 770-5 850 MHz and/or 5 855-5 925 MHz for the use by ITS applications. Most of Region 3 countries designated approximately 70 MHz spectrum in 5.9 GHz band including Australia (70 MHz), Korea (70 MHz), Singapore (50 MHz), India (50 MHz). Further, it may be noted that this band is not delicensed in most countries.

5.8 Japan: 80 MHz spectrum in 5.8 GHz band (5770-5850 MHz) for other functionalities such as electronic toll collection was enacted in 2001 and further revised in 2008. 9 MHz spectrum in 700 MHz Band (755.5-764.5 MHz) for V2V/V2I using ITS connect deployed in 2015 and the policy is still technology neutral.

5.9 Korea: 70 MHz spectrum in 5.8 MHz band (5855-5925 MHz) for V2V/V2I (C-ITS of Europe) enacted in 2016 on technology neutral basis i.e. open to both DSRC and C-V2X. The spectrum is divided into seven different channels of 10 MHz each, where the fifth channel, 5895–5905 MHz, is meant for CCH and the others for SCH.

5.10 China: 20 MHz spectrum in the frequency band 5905-5925 MHz for V2V/ V2I/ V2P (V2X communication)- enacted in 2018 and opted only for C-V2X technology and additional spectrum is likely to be allocated in future.

5.11 Singapore: 70 MHz spectrum in the frequency band 5855-5925 MHz for V2V/ V2I enacted in 2017.

5.12 Australia: 70 MHz spectrum in the frequency band 5855-5925 MHz for V2V/V2I- enacted in 2017.

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[2] SMSE-012-22, Decision on the Technical and Policy Framework for Radio Local Area Network Devices in the 5850-5895 MHz Band and for Intelligent Transportation Systems in the 5895-5925 MHz Band, https://ised-isde.canada.ca/site/spectrum-management-telecommunications/en/learn-more/key-documents/decision-technical-and-policy-framework-radio-local-area-networks-devices-5850-5895-mhz-band-and

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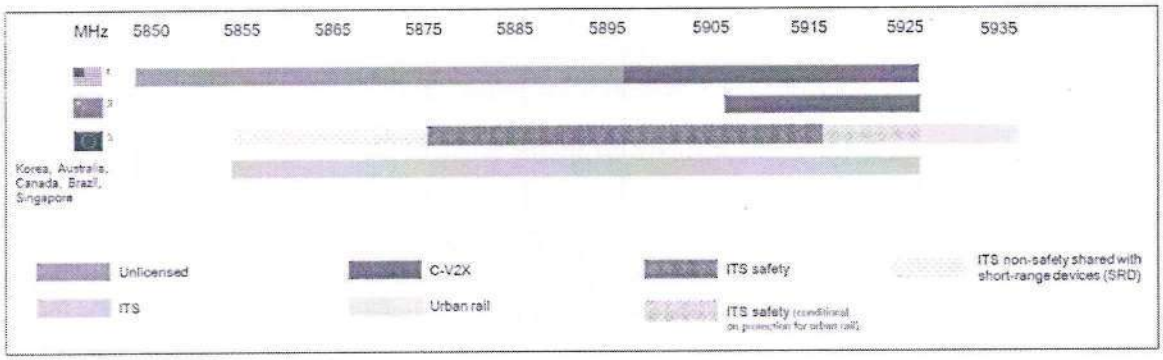

Figure 6

Note:

1. FCC assigned upper 30 MHz of ITS band to C-V2X (5.895-5.925 GHz, B47).
2. MIIT officially regulated the upper 20 MHz (5.905-5.925 GHz) to C-V2X, China will likely allocate additional spectrum in the future.
3. ITS spectrum allocation in Europe is still pending. The EU has adopted technology neutrality in spectrum allocation.

6) Studies and developments of ITS/V2X in ITU-R/APT Region:

The following agenda items and documents related to ITS/V2X are deliberated upon in ITU-R.

6.1 Agenda item 1.12 of WRC-19: to consider possible global or regional harmonized frequency bands, to the maximum extent possible, for the implementation of evolving Intelligent Transport Systems (ITS) under existing mobile-service allocations, in accordance with Resolution 237 (WRC-15)

6.2 Decision on agenda 1.12 of WRC-19: Recommendation 208 (WRC-19) that administrations consider using globally or regionally harmonized frequency bands, or parts thereof, as described in the most recent version of Recommendations (for e.g. ITU-R M.2121) while planning and deploying evolving ITS applications.

6.3 Besides, ITU-R has released a number of recommendations (ITU-R M.1452, M.1453, M.2084, M.1890, M.2121, M.2057), reports (M.2228, M.2394) and handbook (Handbook on land mobile-volume 4) in regard to ITS applications in mobile service including automotive radar applications.

6.4 ITU-R Working Party 5A (WP 5A) has started developing a new Report ITU-R M.[CAV] "Connected Automated Vehicles" in response to ITU-R Question 261/5 "Radiocommunication requirements for connected automated vehicles (CAV)" since 2020.

6.5 ITU-R Working Party 5D (WP 5D) has completed its work on a new Report ITU-R M.[C-V2X] and has been approved by ITU-R SG5 on "The use of the terrestrial component of IMT systems for Cellular-Vehicle-to-Everything" in response to ITU-R Question 262/5 "Usage of the terrestrial component of IMT systems for specific applications".

6.6 APT's group AWG has published its report APT/AWG/REP-121 (09-2022) on "Cellular based V2X for its applications in APT countries" that addresses the usages of Intelligent Transport System (ITS) radiocommunication applications.

7) Current regulatory provisions in India w.r.t. ITS:

7.1. As per NFAP – 2022, the frequency band 5850-5925 MHz is allocated for FIXED, FIXED-SATELLITE (Earth-to-space) and MOBILE as primary service and Radiolocation as secondary service. The frequency band 5875-5925 MHz (50 MHz) is allowed for V2X technologies/Intelligent Transport Systems through India Footnote IND 29 of NFAP-2022.

7.2. Experimental Licenses were granted to M/s Zero Sum ITS Solutions India Pvt Ltd for ITS applications (ITS-Connect technology) in Ahmedabad in the sub-1 GHz band, as below:

i. Phase-I: (February, 2018) The approval was for a period of 3 months for detection of a certain class of vehicles (VIP) in 755-765 MHz

ii. Phase-II :(July 2018) Approval was given extending Phase-I by another 3 months for detection of emergency vehicles and facilitate their passage by changing the signal. Through another extension, this experiment was allowed up to September, 2019. They applied again in September, 2020 a fresh but the approval was not given due to probability of auctions for IMT services.

iii. Phase-III: They requested for 626-646 MHz (20 MHz)-alternatively anywhere 20 MHz in the 590-865 MHz range. They were granted experimental license in November 2021 for 6 months in 598.5-607.5 MHz (9 MHz bandwidth) for experiment in a wider area on 10 ambulances. As per report, Zero-Sum ITS solutions India with the approval of Ahmedabad Janmarg Ltd, a SPV of the Ahmedabad Municipal Corporation, conducted a demonstration experiment in January, 2022 showcasing a public transportation vehicle priority system.

7.3. A proposal for DSRC/ ITS in 5875-5925 MHz band and autonomous braking/ radar application in frequency range 77-81 GHz has been received from M/s C-DAC in collaboration with IIT-Madras around 15th April, 2022.

7.4. C-V2X technology for improving road-safety and reducing traffic congestion has been trialled and tested in the 5875-5925 MHz band for a range of safety-of-life use-cases by M/s Suzuki in collaboration with IIT Hyderabad in May 2022. . The demonstrations were also attended by senior officials from TRAI and DoT[3].

7.5. 24.05-24.5 GHz and 76-77 GHz bands have already been allowed for license-exempt use for transport & traffic telematics/ automotive radar applications (relevant notifications).

[3] https://pcr.iith.ac.in/files/pressrelease/V2X.pdf

8) Challenges in deciding the technology and regulations:

8.1 DSRC and C-V2X are not compatible to each other. If some vehicle are equipped with DSRC and others vehicles using C-V2X, these vehicles will be unable to communicate with each other. Therefore, allowing both the technologies would not give the true potential of Intelligent Transport System.

8.2 DSRC/C-ITS/ ITS-G5 of Europe and WAVE of USA are both working in 5.9 GHz band.

8.3 ITS-Connect of Japan, which was experimented in Ahmedabad is a sensor-based technology and is an important future technology for Autonomous (Driverless) driving. They have successfully conducted experiment in 700 MHz band (sub 1 GHz frequencies), which is not earmarked for ITS separately in India. The experiment showcased V2I, wherein Road infrastructure such as Digital Variable Messaging Sign Boards and Traffic Signals shared real time information with Emergency Vehicles and buses upto a distance of 800 metres, resulting in a reduction of 15% travel time per trip for ambulances and an 80% reduction of waiting time for buses at traffic signals.

8.4. C-V2X supported by 3GPP in LTE/ 5G upgradations has all the features facilitating safe and autonomous driving. For direct communications (V2V, V2I, V2P) it supports the 5.9 GHz frequency band. It offers good features such as Device to Device (vehicle to vehicle) direct communication along with the Device to Base Station (V2N) link. There have been strong testing for interoperability in plug-tests by ETSI[4] and 5GAA[5] showing an overwhelming success rate of more than 93%. In the future, when fully connected vehicles run on the road, DSRC communication will not be able to support such vehicles, and there will be a need for 5G C-V2X technology.

9) The latest developments of C-V2X:

9.1 China started the trials of LTE based V2X communication technology (LTE-V2X) to verify road safety and non-road safety applications from 2015. In 2016 China approved LTE based V2X trial projects in 5905-5925 MHz range (total 20 MHz). In 2017, radiofrequency testing, communication link performance of LTE based V2X devices and co-existence testing with incumbent services was carried out by them in Lab and Field trial in 5.9 GHz band. The results show that LTE based V2X devices can fulfil RF requirements and communication criterion according to 3 GPP specifications. Multiple city- based trials were planned in China in 2018. In 2018, they formally released the frequency planning for Internet of Vehicles network based on LTE-V2X.

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[4] https://www.etsi.org/newsroom/news/2058-2022-04-etsi-c-v2x-plugtests-event-achieves-a-93-interoperability-success-rate

[5] https://5gaa.org/wp-content/uploads/2022/04/5GAA-Workshop-31-March-2022-ETSI-C-V2X-PlugtestsPart-1_.pdf

9.2. Ford started it plans to start deploying C-V2X (LTE/ 5G) in China in 2021 and United States in 2022.

9.3 Audi published their experiences from pilot projects and the plans for rollout of C-V2X technology[6]. They also highlighted the strong momentum towards C-V2X in USA, Germany, and the world.

9.4 Strong ecosystem availability for C-V2X chipsets, modules, devices, road side units, outdoor units from the industry is documented by 5GAA .

9.5 The global momentum on C-V2X is also documented in the figure shared by COAI:

Figure 7

9.6 DSRC and DSRC based ITS-G5 has also over 2300 road side units deployed in Europe covering a distance of over 20,000 km and over 500,000 vehicles are fitted with ITS G-5 devices. Volkswagen is a very strong supporter of ITS G-5 and has launched several cars supporting this technology.

10) Issue of interoperability/ important features

10.1 The ITS/ V2X is critical to road-safety (saving of lives) and reducing the carbon footprint. As different standards are either planned or under operation in different geographies of the world, the issue of compatibility/ interoperability of all the vehicles on the road and the road-side infrastructure is crucial (like mobile phones which connect to the network seamlessly). It is important to keep a harmonized ecosystem avoiding a major challenge in opting for multiple technologies.

[6] https://www.audi.com/en/innovation/autonomous-driving/car-to-x.html

10.2 Availability of harmonized standards to vehicle manufacturer should be published to ensure interoperability across different vendors.

10.3 To be effective, Vehicle to Infrastructure capability would be important in enabling a wide variety of features that are beneficial for society. There should be incentives for the city and state road and traffic departments to utilize the new technologies to enhance safety and efficiency.

10.4 Ministry of Road Transport & Highways, State Governments, Department of telecommunications and ITS service providers etc. are considered as stakeholders. Due to the involvement of different stakeholders, there is a need to define the roles and responsibilities of each stakeholder. The lack of cooperation and communication may jeopardise the implementation.

10.5 It may not be necessary that a model successfully implemented in any country work the same way in our local environment. It is quite possible that tested ITS system may not achieve the required accuracy due to the local climatic conditions and the abnormal traffic conditions in our country.

11) Constitution of a committee to address the issues and the Terms of Reference

A committee has been constituted to recommend the overall policy requirement including spectrum requirement for the introduction of roll out of V2X in the country.

11.1 The present members of the committee are as tabulated below.

No	Name	Designation	Position in Committee
1.	Sh. V. J. Christopher	Wireless Adviser, WPC Wing	Chairman
2.	Sh. Shivendu Gupta	DDG (WPF), DoT	Member
3.	Sh. S. K. Singhal	DDG (AS), DoT	Member
4.	Sh. Jerry Daniel J	Scientist-G, C-DAC, Thiruvananthapuram	Member
5.	Sh. R. Prakash	Technical Expert, C-DOT	Member
6.	Sh. Bharat Bhatia	President, IAFI	Member
7.	Sh. Prashant K. Banerjee	Executive Director, SIAM	Member
8.	Sh. Vikram Tiwathia	DDG, COAI	Member
9.	Sh. Ashish Tayal	Director (R-1), TEC	Member
10.	Dr. P. S. M. Tripathi	DWA, WPC Wing	Member
11.	Sh. Vineeth Mathew	AWA, WPC Wing	Member Convener
12.	Sh. Jitendra Singh	Qualcomm	Co-opted member
13.	Dr. Punit Rathod	Qualcomm	Co-opted member
14.	Mallesh B	Zero-Sum ITS Solutions India Pvt Ltd	Co-opted member
15.	Nagesh AS	SMEV	Co-opted member

11.2 The Terms of Reference of the committee is as mentioned below.

i. To study the international developments towards adoption of ITS/ V2X;

ii. To study the overall requirements including policy interventions, to start deployment of the ITS/ V2X in the country;

iii. To study the spectrum requirement for introduction/ roll-out of ITS/ V2X in the country;

12) Deliberations/Findings of the committee

12.1 First Meeting of the V2X Committee

The V2X committee held its first meeting on 04.07.2022 through the online platform of C-DoT meetings. During the first meeting the inputs from the various stakeholders including C-DAC, SIAM and ITU-APT foundation was shared with all the members. COAI and SIAM also gave a presentation on the various aspects of the C-V2X technologies and its impact in reducing road accidents and improving road safety including the global momentum documented by 5GAA (5G Automotive Association). CDAC also highlighted the various technical aspects of V2X and highlighted the popularity of V2X over the legacy DSRC system.

12.2 Second Meeting of the V2X Committee

During the second meeting of the V2X Committee held on 27.07.2022, the matter related to the interoperability of the V2X technologies (that DSRC and C-V2X are two independent technologies) and the possible interference with the WiFi services in the adjacent 5GHz band was also deliberated upon. On the topic of spectrum coexistence, Qualcomm volunteered to make a presentation in the next meeting. Qualcomm made a presentation on the aspect on various aspects related to C-V2X technology, its global status (including global trials and spectrum allocations). The presentation by Qualcomm also highlighted the need to avoid technology islands by fragmentation of spectrum in multiple incompatible technologies. It also highlighted a strong opportunity for India to lead with the implementation of forward-looking technology because it is not constrained by installed base of legacy systems. It was also decided to further explore and understand the other implementations of the V2X in the country, In this regard, it was decided to further seek a presentation from Zero-Sum ITS Solutions India Pvt Ltd who had carried out experiments in ITS/V2X in Ahmedabad city in the sub-1 GHz band.

12.3 Third Meeting of the V2X Committee

The third meeting of the V2X Committee was held on 06.09.2022. During the meeting Zero-Sum ITS Solutions India, Pvt. Ltd gave a presentation on the demonstration trials carried out in India. Further, they also highlighted the requirement of frequency allocation in the sub- 1 GHz band, which carries less data but has more wrap around and travels over a significantly larger range that is critical for traffic safety applications and is suitable for dense and urban cities in Asia.

Qualcomm made a presentation on the co-existence feasibility of C-V2X with adjacent Wi-Fi implementations in India (as per GSR 1048-E) and other incumbents in the band

(e.g., Earth-to-Space FSS). The presentation also highlighted the recent update from USA DC Court of Appeals (Aug 2022) upholding the FCC order to allocate 5.9 GHz spectrum to C-V2X from the earlier allocation of DSRC.

Further, it was decided in the meeting to also obtain the views of Ministry of Road Transport and Highways as MoRTH is the nodal ministry in laying the basic road and other allied infrastructure. Further, the requirement of additional frequency bandwidth from 77 GHz – 81 GHz for vehicular RADARs was also discussed and the requirement of further delicensing this band was also deliberated by the committee.

12.4 Fourth Meeting of the V2X Committee

The fourth meeting of the V2X Committee was held on 06.10.2022. During the meeting all the comments and edits received from the members were discussed. SIAM requested additional time to provide comments from its members. It was pointed out by members that the draft has become stable after all the reviews and edits brought to the fourth meeting. SIAM was requested to provide its inputs positively by 10.10.2022 to assist in finalizing the report at the earliest. While reviewing the text, it was also agreed to delete some duplicated text to improve readability of the report. Qualcomm was requested to provide an updated figure for the global momentum around C-V2X (for updates after Feb 2020).

The meeting agreed to finalize the document with globally harmonized technology and frequency bands incorporating all the edits and the requested inputs.

12.5 Fifth Meeting of the V2X Committee

Consequent to the submission of the report on V2X on 31.10.2022, it was desired by the Competent authority to reconvene the committee after including at least two automobile associations and also to seek presentation from them on their view on the technology that we may adopt in V2X. Accordingly, SOCIETY OF MANUFACTURERS OF ELECTRIC VEHICLES (SMEV) , a registered association representing Indian manufacturers of electric vehicles (EV) and electric vehicle components, was also made part of the committee as the second automobile association, SIAM being the first. Further, a member from Zero-Sum ITS Solutions India Private Limited, a promoter of the competing technology of DSRC was also included in the committee to bring a balanced view to the discussions on the proposed technology that we may adopt in V2X.

The expanded committee met on 14-12-2022 under the chairmanship of Wireless Advisor and deliberated further on the relevant issues. A presentation was also given by SIAM and SMEV highlighting their views on the technology that needs to be adopted for V2X in India.

SIAM in their presentation explored the various possible scenarios where V2X technology can benefit the country and also recommended C-V2X as a candidate technology for V2X in India considering the developments in other countries as well as the technical improvements C-V2X has over DSRC.

SMEV also agreed for the requirement of a harmonized technology in the country to ensure compatibility and also to reap the benefits of economies of scale.

The other members of the committee also agreed to this view of SIAM and SMEV. Additionally Zero-Sum ITS Solutions India Private Limited requested for making provisions in sub – 1 GHz for the roll out of V2X. In this regard, it was clarified that as per NFAP 2022, there is no existing provision to allocate spectrum in sub – 1 GHz band, however, the matter may be decided later.

13) Recommendations of the Committee

The ITS/ V2X is critical to road-safety and reducing the carbon footprint. As different standards are either planned or under operation in different geographies of the world, the issue of compatibility/ interoperability of all the vehicles on the road and the road-side infrastructure is an important consideration in choice of the technology for V2X in Indian scenario. Adoption of a harmonized technology option would have advantages of an evolved ecosystem avoiding major challenge in implementation.

In view of the above facts and the deliberations carried out by the committee, the following could be important considerations in the choice of a V2X/ITS system in our country -

13.1. **Technological options for V2X in India:** The two major competing technologies for the implementation of V2X are C-V2X (Cellular based V2X technology, which is a globally harmonized technology) and DSRC (where there are multiple country specific modification of the IEEE 802.11p standard). In India there are no legacy V2X implementations and hence the requirement for the backward compatibility for the newly adopted system does not arise. Further, any proposed V2X technology must be universally adopted so that the benefits of "economies of scale" can be reaped.

C-V2X has gained momentum both domestically and internationally through its ability to achieve greater network effects and can leverage cellular networks to reduce infrastructure costs. It also promises a more efficient and effective use of the spectrum. While the NFAP designated Dedicated Short-Range Communications (DSRC) services for ITS services more than a decade ago (NFAP 2011, IND 71), DSRC has not been meaningfully adopted or deployed, and this critical spectrum has largely been unused.

Moreover, In India, demonstration trials were carried out for both cellular based and non-cellular based technologies as mentioned in para 7 above.

However taking into consideration the requirements from the Automobile associations and in view of the evolving V2X/ITS standards worldwide the committee foresee that C-V2X deployment of ITS services will dominate in future. Therefore, the Committee recommends that C-V2X standards may be given preference over DSRC standards.

13.2. **Frequency bands for V2X in India:**

i. Spectrum in Mid-Band (1 - 6 GHz):

The frequency band 5 875-5 925 MHz (50 MHz) has already been identified for V2X Technologies/Intelligent Transport Systems in NFAP 2022. The same may be recommended for C-V2X technology as a harmonized standard. The higher part of ITS band i.e. 5905 – 5 925 MHz (20.0 MHz) may be reserved for basic-safety related use-cases and lower part of the band i.e. 5 875 – 5 905 MHz (30.0 MHz) may be reserved for advanced use-cases using V2X/ITS.

ii. Spectrum in sub 1 GHz Band:

Further, to cater to any requirement in the sub-1 GHz band, 10 MHz may be suitably considered in the sub 1-GHz IMT bands at a later stage based on any future requirements. Sub 1 GHz is vital for V2V and V2I communication in dense urban landscapes where the range and penetration of sub 1 GHz band is higher with low latency, especially in the area of V2I communication with Traffic Signal infrastructure.

13.3. **Other allied frequency requirements for V2X in India:**

Besides the 5.9 GHz band, the two other frequency bands i.e., 24.05-24.25 GHz and 76-81 GHz, are also important for ITS applications.

The 24.05-24.25 GHz band is already delicensed as per GSR 1047(E) dated 18.10.2018 for Transport and traffic telematics devices.

The frequency band 76-77 GHz has already been delicensed vide GSR No.699(E) dated 16.09.2015. The Committee recommends that frequency band 77-81 GHz band may also be delicensed for automotive radar applications in line with international practice.

13.4. **Other recommendations**

i. Constitution of a Committee comprising of various stakeholders for coordination and implementation of ITS in India.
ii. Companies working in ITS technology may be encouraged to conduct experiment in our local condition for confidence building. It would help in its early implementation.

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Wireless Advisor and Chairman

(a) IMT identified spectrum within Sub 1 GHz band should not be considered for V2X.

Final Report of the Task Force on Intelligent Transportation System

Recommendations for Automotive Industry Standards and regulations related to Intelligent Transportation Systems, and rollout of communication between vehicle to anything (V2X)

Table of Contents

1. Background

1.1 The Ministry of Road Transport & Highways (MoRTH) established a Task Force for the development and Implementation of Intelligent Transportation Systems (ITS) in country, with specific focus on Vehicle to Everything (V2X) communications vide OM dated 09th September, 2024. The mandate of the Task Force is as follows:

i. Recommendations of Automotive Industry Standards and regulations related to Intelligent Transportation Systems, and rollout of communication between vehicle to everything (V2X).

ii. Recommendations/suggestions on vehicle-to-vehicle & vehicle-to-infrastructure communication, use of 5.875 – 5.925 GHz frequency in the Intelligent Transportation System.

iii. Recommendations/suggestions on various radio frequency levels and delicensing frequency bands to the Department of Telecommunications (DOT).

1.2 The Task Force submitted Part 1 of the report to MoRTH in March 2025 (attached as Annexure – 1), having recommendations on V2X communications in the 5.875-5.925 GHz band and corresponding radio aspects. The key findings of Part 1 of the report are summarized as below:

i. Adoption of C-V2X as a harmonized technology for deployment of Intelligent Transport System in the country.

ii. Adoption of V2X/ ITS frequency range of 5.9 GHz (5.875-5.925 GHz), which has already been considered for V2X/ ITS in the NFAP-2022, recognizing it as the spectrum band for enhancing road safety and reducing road fatalities.

iii. On-Board Units (OBUs) of vehicles using C-V2X technology should not require individual licenses or authorizations, while Road Side Units (RSUs) may be deployed with appropriate authorization to ensure proper deployment, maintenance and operation in this low-power, short-range spectrum.

iv. Recommended transmission power limits, conducted power output and out-of-band emission limits for both OBUs and RSUs.

1.3 This final report of the Task Force is focused on suitable ITS Stack for Indian ecosystem, defining cybersecurity framework for V2X communication, implementation strategies to roll out ITS and regulatory measures. This final report includes recommendations on Automotive Industry Standards and regulations related to ITS stack, cybersecurity framework and rollout of V2X communication in India and is in addition to part-1 of the report mentioned in para 1.2 above.

2. Introduction

According to the MoRTH report on Road Accidents[1] in India 2023, over 4.80 lakh road accidents took place in the country in 2023 that resulted in over 1.72 lakh people fatalities. When compared with the 2022 data on road accidents, the crashes have increased by 4.2% and there is an increase of 2.6% in fatalities.

[1] https://morth.nic.in/sites/default/files/Road-Accident-in-India-2023-Publications.pdf

Key contributing factors include poor traffic management, inadequate infrastructure, driver error and adverse weather conditions. C-V2X technology has the potential to revolutionize road safety and traffic management in India. By enabling real-time communication between vehicles, infrastructure and vulnerable road users, C-V2X can reduce accidents caused by intersection conflicts, adverse weather conditions and driver error. Furthermore, its ability to complement Advanced Driver Assistance Systems (ADAS) systems and provide dynamic traffic management solutions makes it a critical tool in addressing India's road safety challenges. A phased implementation strategy, starting with urban centres and national highways and later expanding to rural areas and State Highways, along with supportive regulatory frameworks, could pave the way for safer and more efficient roadways across the country.

3. Role of C-V2X in Reducing Road Accidents and Managing Traffic in India

3.1 Intersection Accidents

Intersections in India are highly accident-prone areas due to the lack of adherence to traffic rules, unpredictable vehicle behaviour and congestion. In 2023, 15.9% of the total accidents occurred at intersections (para 3.16 of MoRTH report on Road Accidents in India 2023)[2].

Implementing C-V2X technology in the safety features mentioned below will significantly minimize the risk of accidents considering the heterogeneous traffic and inadequate infrastructure.

i. Intersection Collision Avoidance

a. Real-Time Alerts: Implementing C-V2X technology in vehicles and infrastructure can enable real time communication between traffic signals (V2I) and other vehicles (V2V) to provide drivers with real-time alerts about vehicles approaching an intersection from blind spots or at high speeds.
b. Priority Management: Emergency vehicles like ambulances, fire tenders and other emergency response vehicles can signal priority passage through intersections, reducing delays and improving safety.
c. Dynamic Traffic Signal Control: Using C-V2X technology in traffic engineering shall assist in optimizing traffic signal timing based on real-time traffic density, reducing congestion and mitigating the likelihood of accidents caused by sudden stops or lane indiscipline.

ii. Blind Spot Detection

a. Extended Awareness: By communicating with nearby vehicles, C-V2X enabled systems can provide drivers with extended situational awareness, detecting vehicles in blind spots that ADAS sensors may miss, especially in crowded intersections in India.

3.2 Adverse Weather Conditions

India experiences diverse weather conditions, including monsoons, fog and dust storms, which impair visibility and reduce the effectiveness of ADAS systems that rely on optical sensors. In

[2] https://morth.nic.in/sites/default/files/Road-Accident-in-India-2023-Publications.pdf

2023, 15.6% of road accidents were attributed to poor weather conditions (para 3.17 of MoRTH report on Road Accidents in India 2023)[3]. Implementing C-V2X technology as a fusion to ADAS systems can mitigate these risks through:

i. Enhanced Visibility
   a. Vehicle-to-Vehicle Communication (V2V): Implementation of C-V2X technology enables vehicles to exchange information about their location, speed and trajectory, providing drivers with critical situational awareness even in low-visibility conditions like fog or heavy rain.
   b. Weather Alerts: Vehicles equipped with C-V2X can receive weather-related warnings from infrastructure (V2I), allowing drivers to adjust their speed and driving behaviour proactively.

ii. Adaptive Traffic Management
   a. Dynamic Routing: In cases where roads become unsafe due to flooding or landslides, C-V2X systems can provide alternative routes to drivers based on real-time data from RSUs and other vehicles.
   b. Hazard Notification: C-V2X equipped infrastructure devices can alert drivers about slippery roads, waterlogging or debris ahead, minimizing the risk of losing control or colliding in adverse weather.

3.3 Complementing ADAS

ADAS systems rely heavily on onboard sensors like cameras, radar and LiDAR. These sensors have limitations in certain scenarios:

i. Camera Obstruction: Cameras may be obstructed by dust, rain or mud.
ii. Limited Range: Radar and LiDAR have a restricted detection range, which may fail to detect fast-moving vehicles or objects beyond the range.

C-V2X technology implementation extends situational awareness beyond the range of onboard sensors by leveraging communication between vehicles, infrastructure and pedestrians:

i. Predictive Awareness: Unlike the sensors used in ADAS, C-V2X doesn't rely on line-of-sight detection. It predicts potential collisions based on shared vehicle data and infrastructure data, even in obstructed scenarios.
ii. Cross-Layer Communication: C-V2X bridges the gap between in - vehicle systems like ADAS and external entities like RSUs and connected devices, creating a holistic safety net.

3.4 Traffic Management

C-V2X technology implementation can play a transformative role in optimizing traffic flow, reducing congestion and improving road safety:

i. Dynamic Traffic Flow Optimization
   a. Real-Time Traffic Analysis: C-V2X systems can communicate with infrastructure to dynamically assess traffic density and suggest alternate routes to drivers, reducing bottlenecks.
   b. Intelligent Lane Management: In high-density areas, C-V2X can enable dynamic lane usage (e.g., reversible lanes during rush hours), reducing congestion-induced accidents.

[3] https://morth.nic.in/sites/default/files/Road-Accident-in-India-2023-Publications.pdf

ii. Emergency Response Coordination

a. Incident Detection: C-V2X systems can detect accidents and immediately relay the location and severity of the incident to emergency services, ensuring faster response times.
b. Traffic Clearance: Emergency vehicles can signal their approach to C-V2X enabled traffic signals and nearby connected vehicles, enabling smoother passage through congested areas.

3.5 Safety of Vulnerable Road User (VRU)

VRUs such as pedestrians and cyclists account for a significant proportion of road accident fatalities in India. Implementing C-V2X in vehicles and Infrastructure can protect vulnerable road users through:

i. VRU Communication

a. Proactive Alerts: Pedestrians equipped with connected devices can receive alerts about approaching connected vehicles, while connected vehicles can detect pedestrians (equipped with connected devices) crossing unexpectedly.
b. Cyclists can use connected devices to share their location with nearby vehicles, reducing the risk of collisions, especially in urban areas with mixed traffic.

3.6 India-Specific Challenges and C-V2X Solutions

India's road conditions pose unique challenges that C-V2X can address:

i. Unregulated Traffic Behavior

Implementing C-V2X can enable predictive modelling of vehicle behavior in chaotic traffic scenarios, alerting drivers about sudden lane changes or vehicles driving in the wrong direction.

ii. Infrastructure Gaps

C-V2X systems can compensate for inadequate signage and poorly designed intersections by providing real-time alerts and navigation assistance.

iii. Traffic load

Data analysis from the C-V2X ecosystem can help study India-specific traffic patterns and predict congestion zones, enabling proactive traffic management and improved urban mobility.

4. Regulatory measures for implementation and rollout of ITS/ C-V2X in India

Implementing ITS/ C-V2X technology in India requires a comprehensive framework of regulatory measures that address road safety, traffic management, infrastructure and policy considerations. These measures are detailed below:

4.1 Standardization of Technology

i. Adoption of Global Standards: India must align with global standards for ITS/ C-V2X technologies, such as those established by organizations like ETSI (European Telecommunications Standards Institute), to ensure interoperability, ecosystem clarity and ease of integration between RSUs and vehicles.

ii. The technology roadmap shall ensure backward compatibility across Day 0, Day 1, and Day 2 use cases in order to enable phased adoption, ensure interoperability and preserve the associated value proposition.

iii. Localized Adaptations: Regulatory bodies should work to adapt these global standards to suit India's road, infrastructure and environmental conditions, ensuring compatibility with existing infrastructure, communication networks and deployment models while maintaining interoperability with global ecosystems.

4.2 Legal and Regulatory Framework

i. Data Privacy and Security: The policy should safeguard the data collected through ITS/ C-V2X systems and should be in compliance with Digital Personal Data Protection (DPDP) Rules 2025 under DPDP Act[4], 2023.

ii. Liability Framework: The accountability in cases of accidents or malfunctions involving ITS/ C-V2X systems should be clearly delineated between manufacturers, operators and users.

iii. Root of Trust: A robust Root of Trust shall be established for ITS/C-V2X systems using legally recognized digital trust mechanisms in India. The national root certifying framework for ITS certificate shall act as the trust anchor for issuing and validating digital certificates through licensed certifying authorities. All certificates shall conform to the IEEE 1609.2 standard to ensure secure, trusted, and verifiable communications across the ITS/C-V2X ecosystem.

iv. Driver and Vehicle Compliance: The vehicles equipped with C-V2X systems should meet the technical specifications and drivers of public service vehicles should be adequately trained to use such technology.

4.3 Infrastructure Development

i. Road-Side Units (RSUs): Dedicated infrastructure like RSUs to facilitate communication between vehicles and external systems (e.g., traffic lights, sensors) should be initially planned in urban centres and national highways and then expand it to rural areas and state highways.

ii. The infrastructure management should also be planned for real-time monitoring and controlling traffic flows, especially in congested urban areas.

iii. The deployment, operation and maintenance of RSUs should be under the overall administrative control of Central or State Governments or any other agencies authorized by them.

4.4 Spectrum Allocation

A harmonized Frequency Band (5.875 – 5.925 GHz) may be notified for C-V2X communication to avoid interference with other wireless communications, as already detailed in the Part – 1 of the ITS Task Force Report.

4.5 Road Safety Enhancements

C-V2X-enabled vehicles should incorporate advanced safety features such as collision avoidance alerts, Intersection Movement Assist (IMA) and emergency braking systems to reduce accident risks.

[4] https://static.pib.gov.in/WriteReadData/specificdocs/documents/2025/nov/doc20251117695301.pdf

Additionally, these systems must be capable of detecting pedestrians and cyclists, providing timely alerts to drivers and integrating ITS-based solutions to enable faster response times for ambulances, fire services and police vehicles, ensuring improved emergency management and overall road safety.

4.6 Pilot Projects and Testing

i. Pilot projects shall initially be undertaken in controlled environments and subsequently in real-world operating conditions prior to any large-scale rollout of ITS/C-V2X systems in India. The existing ITS Task Force shall be entrusted with end-to-end monitoring of these pilot projects, including, evaluation and post-deployment review. The Task Force shall continue to guide and supervise the pilots throughout their lifecycle and the outcomes shall be reported to MoRTH for making informed policy decisions and determine the implementation strategies for phased large-scale deployment.

ii. Deployment should begin in high-priority zones such as metropolitan cities, highways and accident-prone intersections/ areas; and then scale up based on the results.

4.7 Public Awareness and Training

i. Awareness about benefits and usage of ITS/ C-V2X among drivers, pedestrians and other stakeholders should be done.

ii. Training of traffic management personnel, law enforcement personnel and vehicle operators to handle ITS/ C-V2X systems should be undertaken.

4.8 Collaboration between Stakeholders

i. Government and Industry Partnerships: Foster collaboration between policymakers, automotive manufacturers, telecom service providers and technology developers (OBU/RSU manufacturers etc.).

ii. International Best Practices: Leverage learnings from countries that have successfully implemented ITS/ C-V2X technologies.

4.9 Continuous Monitoring and Updates

i. Real-Time Insights: Establish mechanisms to monitor the impact of ITS/ C-V2X systems on road safety and traffic management.

ii. Policy Updates: Periodically update regulations to keep pace with advancements in technology (adoption of ADAS, evolution of network, acceptance by global markets etc.) and changes in road conditions.

iii. A centralized authority may be established for inter-state operations of ITS/ C-V2X, along with a centralized platform to implement ITS/ C-V2X services, ensuring inter-state harmonization and interoperability.

4.10 Certification

i. OBU and RSU being radio equipment will require testing and certification under Mandatory Testing and Certification of Telecommunication Equipment (MTCTE) regime of Government of India for EMI/EMC, Safety, Security, Communication technologies etc.

5. Prioritization of C-V2X use-cases from India's implementation environment for road safety (as Day-0, Day-1, Day-2)

Prioritizing C-V2X use cases for India requires careful consideration of the country's unique road safety challenges, implementation environment and infrastructure readiness. The categorization into Day-0, Day-1 and Day-2 use cases provides a structured roadmap for phased adoption, starting with immediate solutions and progressing to advanced capabilities.

A comprehensive framework for defining and analysing C-V2X use cases and their associated Service Level Requirements (SLRs) should be built upon by considering factors such as road environments and other involved actors.

Use Cases that do not demand highly precise location data or instantaneous response from the host vehicle may be prioritized for initial deployment using V2V and V2N-N2V based C-V2X solutions. This phased approach aims to leverage existing cellular infrastructure (4G/5G) to enable Day-0 use cases with minimal additional ecosystem requirements.

5.1 Implementation Strategy

i. Day-0 Focus: Start with use cases that pertain to vehicle-to-vehicle and existing vehicle-to-network communication.
ii. Day-1 Expansion: Gradually implement Safety Critical use cases with minimal to moderate infrastructure requirements, focusing on urban areas and highways.
iii. Day-2 Vision: Invest in long-term infrastructure development and advanced communication systems to enable applications requiring increased vehicle automation for pan India implementation.

5.2 Day-0 Use Cases (Immediate Implementation)

These use cases focus on applications that require minimal infrastructure and can be deployed quickly to address India's urgent road safety needs. They rely primarily on the basic functionality of V2X systems in vehicles.

i. Emergency Electronic Brake Light (EEBL)

a. Description: Alerts vehicles behind when a leading vehicle (in LOS / non. LOS) applies emergency braking, reducing rear-end collisions.
b. Relevance for India: India faces frequent rear-end collisions, especially on highways and congested urban roads.
c. Dependencies: V2V communication; minimal infrastructure required.
d. Implementation Priority: Immediate; as this use case can be deployed immediately in vehicles equipped with C-V2X technology.

ii. Forward Collision Warning (FCW)

a. Description: Warns a driver of an imminent collision with a vehicle ahead.
b. Relevance for India: Addresses high-speed crash scenarios on highways and roads with poor lane discipline.
c. Dependencies: V2V communication; no roadside infrastructure needed.
d. Implementation Priority: Immediate; to reduce accidents caused by tailgating and sudden braking.

iii. Hit from Behind Warning

a. Description: Provides an alert in case of an approaching vehicle at high speed in the same lane from rear side. Also, to provide an alert when a non -platooning vehicle is

running very close to other vehicle at higher speed, particularly approaching from behind.

b. Relevance for India: Hit From Back category of road accidents amount to 21% in 2023, 21.4% in 2022 and 21.2 % in 2021. This is the largest portion of road accident collision type as per the MoRTH report on "Road Accidents in India 2023".
c. Dependencies: V2V communication; no roadside infrastructure needed
d. Implementation Priority: Immediate; to reduce accidents caused by slow down or sudden braking.

iv. Intersection Movement Assist (IMA)

a. Description: Warns drivers when it is unsafe to enter an intersection due to potential collisions with crossing traffic. Also applicable in case of vehicle stationary at turn (LOS/ non-LOS) due to internal malfunction / temporary halt or parking.
b. Relevance for India: Critical for urban intersections where traffic signals are often ignored or poorly managed.
c. Dependencies: Basic V2I communication at key intersections.
d. Implementation Priority: Immediate; especially in urban areas with high accident rates.

v. Queue Warning - (V2V)

a. Description: Alerts drivers about congestion or queues ahead to prevent sudden braking and collisions.
b. Relevance for India: Particularly useful on highways and urban roads with frequent bottlenecks.
c. Dependencies: Integration with traffic data from map providers and V2V data.
d. Implementation Priority: Immediate; requiring existing map infrastructure and V2V functionality.

5.3 Day-1 Use Cases (Medium-Term Implementation)

These use cases require moderate infrastructure investments and more advanced communication capabilities. They aim to improve traffic management and safety in a broader scope.

i. Queue Warning - (Integration with Traffic Monitoring system)

a. Description: Alerts drivers about congestion or queues based on data of Traffic Management systems to prevent sudden braking and collisions.
b. Relevance for India: Particularly useful on highways and urban roads with frequent bottlenecks.
c. Dependencies: Integration with traffic monitoring system's data (I2N and V2N) along with traffic data from map providers.
d. Implementation Priority: Medium-term; requiring roadside infrastructure integration.

ii. Traffic Signal Priority for Emergency Vehicles

a. Description: Provides priority to emergency vehicles (ambulances, fire trucks) by optimizing traffic signals.
b. Relevance for India: Can save lives by reducing response times in emergencies.
c. Dependencies: I2N-V2N/ V2I communication integrated with traffic management systems.
d. Implementation Priority: Medium-term; focusing on metropolitan cities first.

iii. Cooperative Collision Avoidance

a. Description: Vehicles work together to avoid collisions by exchanging detailed data about their movements.
b. Relevance for India: Useful for high-speed highways and accident-prone zones.
c. Dependencies: Advanced V2V communication and real-time data sharing.
d. Implementation Priority: Medium-term; requiring widespread adoption of C-V2X systems.

iv. Do Not Pass Warning (DNPW)

a. Description: Alerts drivers when overtaking is unsafe due to oncoming traffic or limited visibility.
b. Relevance for India: Useful on narrow highways and roads with frequent overtaking-related accidents.
c. Dependencies: V2V communication; no external infrastructure required.
d. Implementation Priority: Medium-term; particularly for rural highways.

5.4 Day-2 Use Cases (Long-Term Implementation)

These use cases involve sophisticated C-V2X functionalities and require significant infrastructure development and advanced communication networks (e.g., 5G). They focus on proactive traffic management and autonomous driving support.

i. Dynamic Traffic Flow Optimization

a. Description: Uses vehicle and infrastructure communication to optimize traffic flow in real-time.
b. Relevance for India: Reduces congestion and travel times in densely populated areas.
c. Dependencies: Real-time data integration with traffic management systems.
d. Implementation Priority: Long-Term; requiring roadside infrastructure integration.

ii. Hazardous Location Notifications

a. Description: Warns drivers about hazardous road conditions such as potholes, flooding, road works, silent zone or sharp turns ahead.
b. Relevance for India: Addresses challenges posed by poor road infrastructure and unpredictable weather.
c. Dependencies: I2N -V2N communication integrated with environmental sensors and road condition monitors.
d. Implementation Priority: Long-term; requiring sensor deployment.

iii. Parking, Toll & Challan Payments

a. Description: Using C-V2X based infrastructure for payment of parking bills in addition to existing RFID based mechanism. This may further aid the planned GNSS based tolling mechanism. Also, the setup will help in assessing the traffic rule violation and auto challan payment.
b. Relevance for India: Addresses challenges of unsettled challan payment in India, create an additional seamless Toll payment mechanism & strengthening the implementation & adherence to the traffic rule.
c. Dependencies: V2I communication integrated with environmental sensors and road condition monitors.
d. Implementation Priority: Long-term; requiring extensive sensor deployment, partnering with payment gateway, banking entity and Regulatory bodies.

iv. Vulnerable Road User (VRU) Protection

a. Description: Alerts drivers about pedestrians, cyclists or other non-motorized road users in their vicinity.
b. Relevance for India: India has a high number of accidents involving pedestrians and cyclists, especially in urban areas.
c. Dependencies: C-V2X-enabled devices for VRUs; integration with roadside sensors.
d. Implementation Priority: Long-term; with an initial focus on high-risk zones.

v. Cooperative Adaptive Cruise Control (CACC)

a. Description: Enables vehicles to coordinate their speeds and movements to maintain smooth traffic flow.
b. Relevance for India: Reduces congestion and enhances safety on congested highways and arterial roads.
c. Dependencies: V2V communication and basic roadside infrastructure.
d. Implementation Priority: Long-term; requiring more advanced vehicle systems.

vi. Autonomous Driving Support

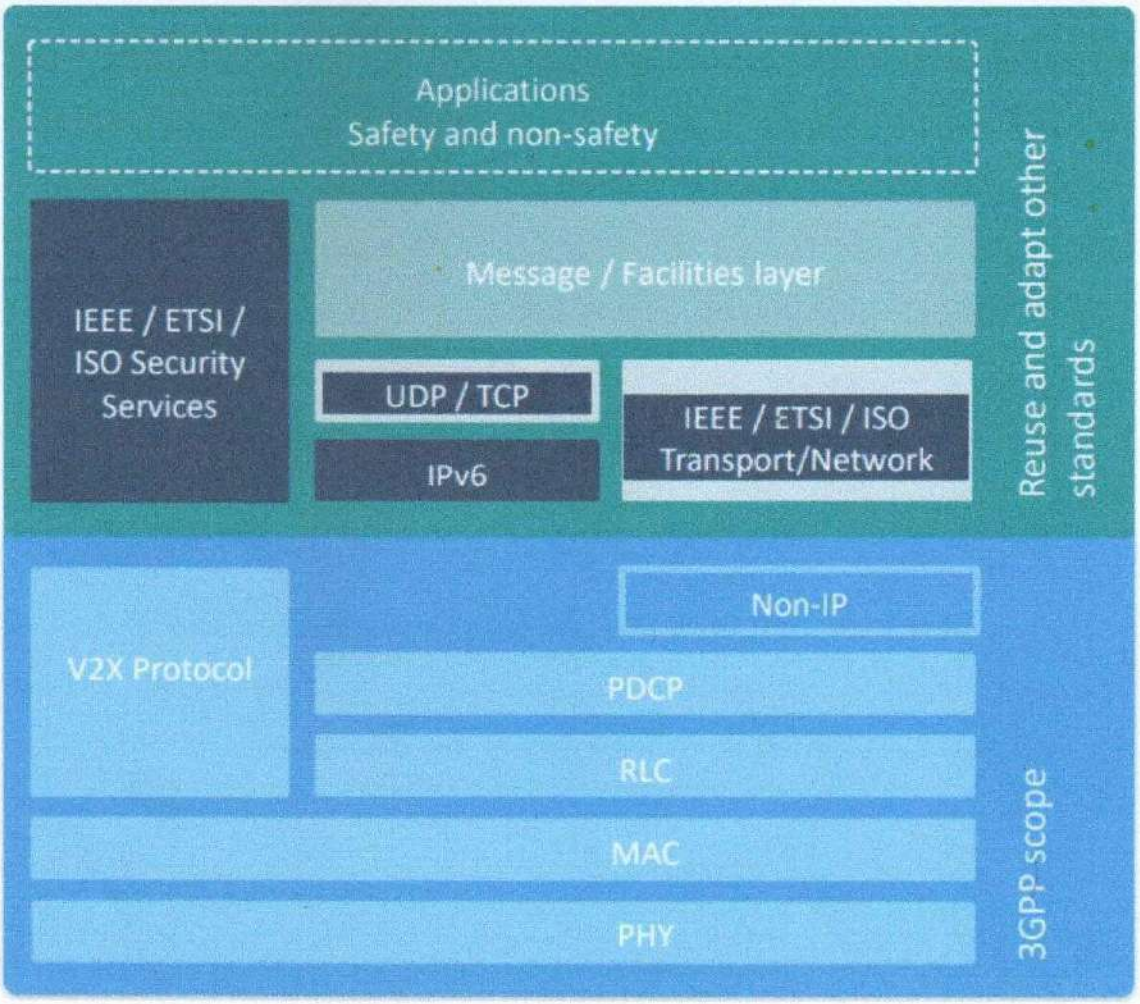
a. Description: Enables vehicles to communicate with other vehicles and roadside infrastructure for fully autonomous driving.
b. Relevance for India: Can revolutionize mobility but requires extensive infrastructure overhaul.
c. Dependencies: High-speed 5G networks, advanced RSUs and fully connected vehicles.
d. Implementation Priority: Long-term; after extensive testing and regulatory readiness.

By following this phased approach, India can ensure a smooth and impactful rollout of C-V2X technology tailored to its road safety needs and traffic management priorities.

6. Harmonized ITS Stack for C-V2X

When deciding on a harmonized ITS stack for C-V2X in India, it is essential to evaluate global standards, interoperability, local requirements and technological readiness. The selection of an ITS stack determines how C-V2X facilitates communication between vehicles (V2V), infrastructure (V2I), pedestrians (V2P) and networks (V2N). Below is a detailed analysis to help make an informed decision about which harmonized ITS stack to use in India.

Several ITS stacks are available globally for C-V2X communication, each developed to support specific technologies, standards and use cases. Below is a comprehensive overview of the major ITS stacks available worldwide, which can be considered for C-V2X implementations for the Radio Layer and Higher Layer. Part-1 of Task Force Recommendations dealt with Radio Layer, so this section will focus only on Higher Layers.



6.1 Advantages of the 3GPP C-V2X Radio Layer

i. Dual Communication Modes
   a. PC5 Mode (Direct Communication): Supports short-range communication between vehicles, infrastructure and other road users without relying on cellular networks. Ideal for safety-critical applications like collision warnings and intersection management.
   b. Uu Mode (Network-Based Communication): Uses cellular networks (4G/5G) for long-range communication, enabling cloud-based traffic management, navigation and infotainment services.

ii. Alignment with India's Telecom Infrastructure
   a. India has a well-established and expanding 4G network, with active deployment of 5G infrastructure. C-V2X leverages this existing infrastructure, reducing the need for new investments in RSUs.

iii. Global Industry Support
   a. Backed by major automotive and telecom stakeholders, including Qualcomm, Huawei and automotive OEMs like BMW, Audi and Ford.
   b. Adopted widely in China, the U.S. and parts of Europe, ensuring global interoperability and economies of scale for hardware.

iv. Future-Proof for 5G

C-V2X is part of the 3GPP ecosystem, making it future-ready for advanced applications like autonomous driving and ultra-reliable low-latency communication (URLLC).

v. Cost-Effectiveness

a. Reduces the reliance on dedicated roadside infrastructure by using cellular networks for long-range communication.
b. Affordable for manufacturers and users, aligning with India's cost-sensitive market.

6.2 Key Global ITS Stacks

For Higher layer, largely two options are under discussion globally.

i. ETSI (Europe) – ETSI has standardised different radio access options: ITS-G5 (based on IEEE 802.11), LTE-V2X PC5 and 5G-V2X PC5 with ETSI ITS stack. European manufacturers have announced that they will shift towards 5G-V2X for advanced driving use cases.
ii. IEEE WAVE/SAE (United States) - Wireless Access in Vehicular Environments (WAVE) standard, based on IEEE 802.11p. - Initially adopted in the U.S. for V2X applications but has seen reduced momentum in favour of C-V2X. The IEEE/WAVE and SAE stack has also been adopted to work with LTE-V2X (C-V2X). The same is under consideration in Korea and Japan. The Chinese deployment is based on LTE-V2X with a C-SAE stack, very similar to the US SAE stack.

6.3 India's Context and Requirements

India has unique challenges and requirements that must be considered when selecting a harmonized ITS stack for C-V2X:

i. Road Safety and Traffic Challenges - High accident rates, poor lane discipline, and a mix of motorized and non-motorized traffic - Need for safety-critical applications like collision avoidance, pedestrian protection and emergency vehicle prioritization.
ii. Infrastructure Readiness - Limited deployment of ITS infrastructure, such as RSUs - Rapid expansion of 4G and 5G networks, with high mobile penetration.
iii. Cost Sensitivity - India is a price-sensitive market, so the ITS stack should minimize costs for consumers and manufacturers.
iv. Interoperability - Harmonization with global standards to ensure interoperability with imported vehicles and systems.
v. Scalability and Future-Proofing - The chosen stack should support current applications and scale to advanced use cases like autonomous driving and dynamic traffic flow optimization.

6.4 Conclusion

For V2X deployments, the 3GPP C-V2X radio along with ETSI ITS stack is emerging as the most suitable choice for India due to its scalability, communication modes and alignment with future 5G networks. India, with its expanding 4G/5G infrastructure and cost-sensitive market, is well-positioned to adopt the 3GPP C-V2X radio stack as the primary choice of radio layer along with ETSI ITS stack, ensuring both short-term road safety improvements and long-term scalability for advanced ITS applications.

7. Security requirements for C-V2X

Security is an essential and critical requirement of C-V2X communication as it involves real-time data exchange between vehicles, infrastructure, pedestrians and networks. To ensure secure and trustable communication in the V2X ecosystem, several security features as listed here, are important:

i. Secure Communication, ensuring confidentiality, integrity and authenticity of messages and entities,
ii. Trustable Communication that is anchored on Public Key Infrastructure (PKI) based Digital Certificates,
iii. Privacy Protection Techniques to protect user information from malicious snooping attackers,
iv. Secure Certificate Trust List Management ensuring authorized trust anchors for vehicular environments that are dynamic and often involving dissimilar entities and stakes – devices, users, infrastructure,
v. Certificate Revocation List (CRL) Management to root out compromised entities, and
vi. A preferable/desirable anchoring of security artefacts through Hardware Root of Trust implementations.

7.1 Certificates for Authentication

Certificates are essential for ensuring that entities (vehicles, infrastructure, VRUs, etc.) involved in C-V2X communication are legitimate and authorized to participate.

i. Types of Certificates
   a. Device Certificates: Issued to vehicles and RSUs to authenticate their identity.
   b. Message-Signing Certificates: Used to sign V2X messages to ensure their origin and integrity.
   c. Root Certificates: Issued by the CA and used to validate the chain of trust.

ii. Purpose of Certificates
   a. Authentication: Verify the identity of communicating entities.
   b. Message Integrity: Ensure that messages have not been tampered with during transmission.
   c. Non-Repudiation: Prevent entities from denying their involvement in communication.

iii. Implementation in C-V2X
   a. Vehicles and RSUs must be equipped with digital certificates issued by a trusted CA.
   b. Certificates must comply with global standard ETSI TS 103 097.

7.2 Root of Trust (RoT)

The concept of Root of Trust (RoT) provides a foundational layer of security in C-V2X systems. RoT ensures that all cryptographic operations (e.g., encryption, signing and verification) are performed in a secure and tamper-resistant environment.

i. Components of RoT
   a. Hardware Security Modules (HSMs): Embedded hardware in vehicles and RSUs that securely store private keys and perform cryptographic operations.
   b. Secure Boot: Ensures that the system boots into a trusted state by verifying the integrity of the firmware.
   c. Trusted Execution Environment (TEE): Isolated environment within the vehicle's Electronic Control Unit (ECU) for secure processing of sensitive operations.

ii. Purpose of RoT
   a. Protect cryptographic keys from unauthorized access.
   b. Ensure that certificates and security credentials are stored securely.
   c. Enable secure communication and message signing.

iii. Implementation in C-V2X
   a. Vehicle manufacturers must integrate HSMs and TEEs into OBUs.
   b. RSUs and other infrastructure components should incorporate RoT to safeguard their cryptographic operations.

7.3 A survey of security provisions in global V2X standards

To ensure interoperability and compliance, C-V2X devices must adhere to security frameworks supported by global standards. There are 2 popular security frameworks that have been specified by IEEE and ETSI.

7.3.1 Security Framework in the IEEE 1609.2 Standard:

The standard was initiated in 2006 to define secure message formats and the processing of secure messages for WAVE devices. Subsequently, the standard underwent significant revisions in 2013, 2016 and the latest revision was released in 2022. In addition to strengthening security services, the latest IEEE 1609.2 revisions include trust and privacy protection techniques as essential elements of V2X systems. The security services that are specified in the standard list out requirements and specifications for security datagrams (SPDUs), security operations like encryption/decryption, signing/verification, cryptographic requirements and potential cryptographic algorithms that are essential for enabling security and trust in the vehicular environment.

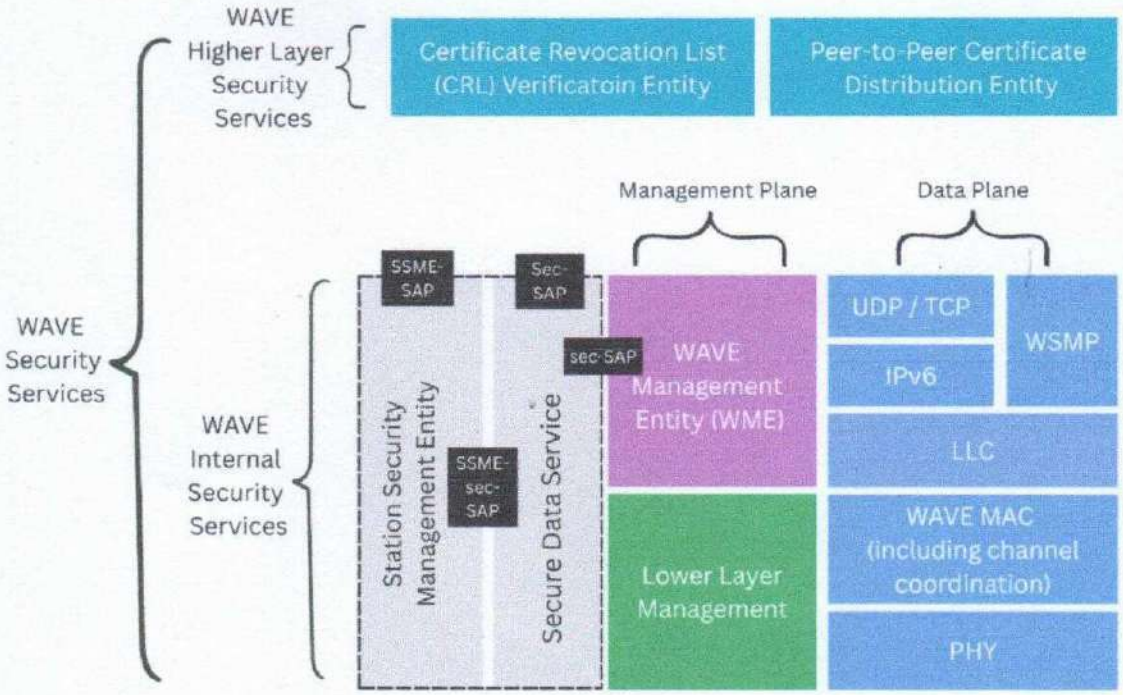


Figure: *The Security Stack specified in IEEE 1609.2*

As depicted in the figure, the 1609.2 security standard specifies 2 components: the WAVE Internal Security Services and the WAVE Higher Layer Security Services. The WAVE Internal Security Services defines 2 entities namely the Secure Data Service (SDS) entity and Security Services Management Entity (SSME). Several Service Access Points (SAPs) are specified in the security stack which enables interactions with other entities in the V2X stack. Similarly, the WAVE Higher Layer Security Services introduces higher layer entities (akin to application services) for Certificate Management on the end device namely, Certificate Revocation List Verification Entity and the Peer-to-Peer Certificate Distribution Entity.

The SDS is responsible for creating and processing Secure Protocol Data Units (SPDUs). It implements cryptographic protection for datagrams it receives from Higher Layer entities. SSME on the other hand provides mechanisms to manage and store certificates, securely. Typically, handoff between various higher layer entities and the security layer happens only through the SAPs provided by the SDS layer (SEC-SAP). In the IEEE V2X stack, only applications/higher layer entities interact with the security services layer. No other layer of the stack has any interactions with the security services layer.

Trust in vehicular environments is enabled through PKI based digital certificates. A special revision of the standard IEEE 1609.2.1-2020 called Security Credential Management System (SCMS) introduces and specifies implementation details related to the security architecture of the trust framework, various entities (Certifying Authorities) involved in the chain of trust and the management processes for incorporating trustworthy certificates. The SCMS architecture introduces a certificate format for V2X communication called the IEEE 1609.2 (or ITS) certificate which differs from traditional ITU-T X.509 certificates. These certificates are utilized for device enrolment and authorization, making the architecture unique and non-interoperable with traditional X.509 based PKI systems. The IEEE standard also introduces privacy protection techniques by incorporating pseudonymity and un-linkability through butterfly key expansion techniques. This prevents malicious actors from snooping and following a particular vehicle, thereby protecting identity and privacy in such environments.

7.3.2 Security Framework in the ETSI standards:

The security framework of V2X for the EU region is specified through a series of standards in the Cooperative-ITS (C-ITS) stack. These standards refer IEEE 1609.2 and their amendments as the base standard for the security framework. Upon this base standard, profiles of usage are defined (as customizations/subsets of the base standard) which shall be implemented as applicable or as relevant to the EU region.

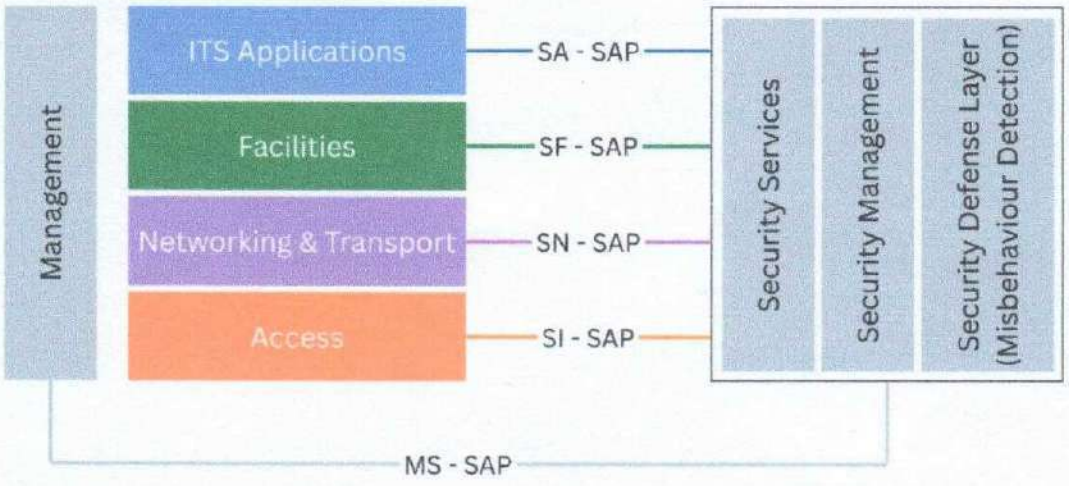


Figure: *Security Framework in ETSI Stack*

The communications security architecture for ETSI is specified in the ETSI TS 102 940 standard. As depicted in the figure, security services are factored at every layer of the ITS stack and is represented through 3 components: security services, security management and security defense layer. The ETSI TS 102 731 standard introduces all the security services that are

applicable to the ETSI stack and its various facilities. Further, the ETSI TS 102 941 standard introduces the C-ITS Certificate Management System (EU CCMS) which deals with trust for the ITS environment. It describes and elaborates on the architecture, entities, processes and operations specified in TS 102 940 standard. Similarly, ETSI TS 103 097 specifies the secure data structures that include header and certificate formats for secure V2X communication. Since ETSI refers to IEEE, the certificate format and cryptographic functions have been adopted with subtle and minor variations.

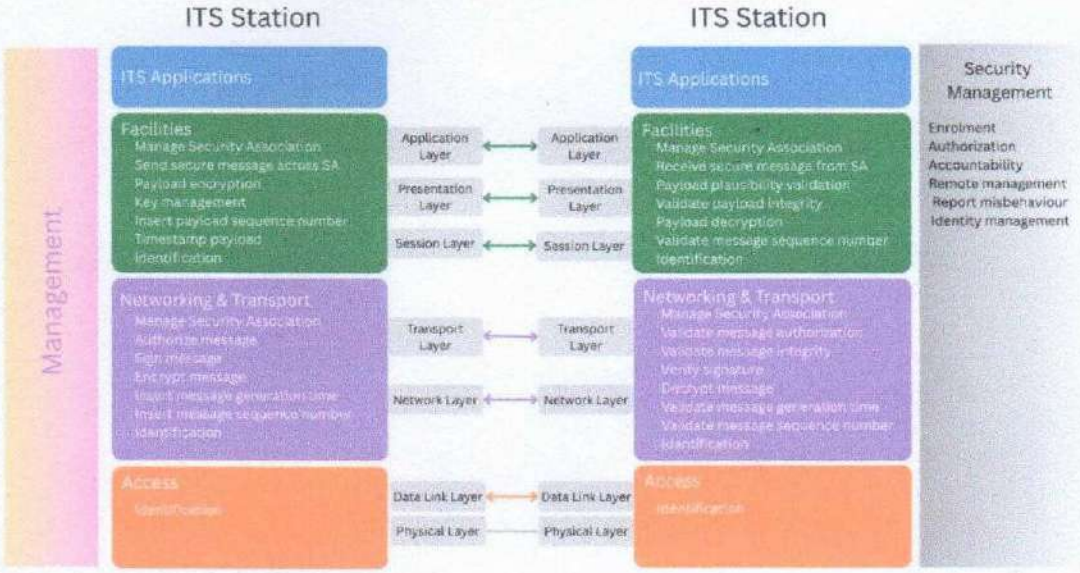


Figure: *Security Services offered at different layers of the C-ITS Stack*

Unlike the IEEE stack, the handoff between the V2X stack and the security layer happens at 2 points. Payload security is enabled by interactions between the facilities and security layer, while message security is enabled by interactions between the Networking and security layer. In addition to these services, the ETSI provides scope for security defence mechanisms like IDPS or Firewall integrations but does not explicitly specify how these could be integrated within the stack.

7.3.3 A comparison of Security Framework between IEEE and ETSI Standards:

The ETSI standards refer to IEEE as the base standard for its specification. There are many similarities between the two standards. Some of these are listed here:

i. Both standards use the same certificate format, introduced by the IEEE 1609.2 standard. There are a few subtle deviations in the certificate content, however.
ii. Trust is anchored in a Root CA that follows the native IEEE 1609.2 certificate model and a Certificate Trust List of authorized Root CAs is maintained by respective models.
iii. The cryptographic algorithms are similar.
iv. Both utilize short-lived pseudonym certificates to enhance privacy and frequent certificate rotation ensures un-linkability.

While both standards align at many points, there are subtle differences in their PKI architecture and security processes, owing to regional preferences and requirements. The following table summarizes these differences:

Criteria	IEEE 1609.2 Standard	ETSI Security Standards
Interaction between V2X stack and Security Layer	Lateral Interaction – The application (Higher Layer Entity) invokes the security layer. The security layer performs requested operations and returns the SPDU to the application for further processing.	Hierarchical and Multi-Point Interaction – The application invokes the facilities layer by requesting for payload security services. The facilities layer invokes the security layer and requests for required services. The SPDU is handed back to the facilities layer, to be sent down the stack to the transport layer. Similarly, the networking layer invokes the security layer for message level security incorporations, if required.
PKI Architecture	Deeper Hierarchy: The SCMS architecture specifies a Root CA (RCA), Intermediate CAs (ICA), Enrolment CAs (ECA), Authorization CAs (ACA), and Registration Authority (RA). End entities communicate with the ECA and the RA. There is no direct interaction between the End Entity and the ACA	Shorter Hierarchy: The EU CCMS architecture specifies a Root CA (RCA), Enrolment Authorities (EA) and Authorization Authorities (AA). End Entities interact directly with the corresponding CAs. There is no ICA or RA in architecture.
Certificate Trust List – (Chain of Trust)	The SCMS Manager designates a set of electors that are chosen from relevant stake-holders like Industry to form the trust anchor	The European Commission: The EC designates a Trust List Manager which becomes the Trust Anchor
	Elector consensus with a quorum policy is used in SCMS to manage the corporate certificate trust list.	A single Trust List Manager (TLM) issues a European Certificate Trust List (ECTL) containing the set of trusted Root Certificates
	The Trust Chain may be longer, owing to multiple CAs along the hierarchy	Shorter Trust chain and quicker verification.
Certificate Revocation Mechanism	Managed by a Misbehavior Authority (MA) who signs and manages CRLs. OCSP is also supported in IEEE.	Managed by a Misbehavior Authority (MA) who signs and manages CRLs. OCSP is not supported currently.
	Active Revocation – A misbehaving vehicle certificate is published on the CRL, deeming all its certificates untrustworthy.	Passive Revocation – Misbehaving vehicles are denied new certificates. However, existing certificates are valid until they expire.

Hardware Root of Trust	Encourages Hardware Security Requirement in Annexure – F of the 2022 standard. FIPS 140-2 compliance is suggested	As a practice, the C-ITS policy 6.1.5.1 of EU specifies the use of Cryptographic Modules with an EAL level >=4.
Device Permission Management	The enrolment certificate specifies the maximum number of application permissions that can be held by it	CCMS does not include any specification for maximum number application permissions in its enrolment certificate.
Privacy Protection – Butterfly Key Expansion	Full feature list of keys and SPDU support	Stripped down version in ETSI

7.3.4 Conclusions from the Survey of Global Security Standards for ITS/ V2X

i. Both standards provide mechanisms for secure communication, trust via PKI based digital certificates and privacy protection through key expansion.
ii. ETSI standard refers the IEEE standard and customizes it according to its regional preferences. Such customizations are subsets of the IEEE specifications.
iii. Interactions between the security services layer and other V2X layers are largely different between the standards.
iv. The PKI architecture proposed by both standards are functionally similar with subtle variations in the hierarchies, entities and the regulatory requirements.
v. Interoperability between the security layers of the two stacks are not possible.
vi. ETSI species a centralized trust model, anchored in a Trust List Manager. In practice, the Trust List Manager is designated by the European Commission to sign and issue European Certificate Trust Lists, which contain the certificates of authorized Root CAs in the hierarchy. In contrast, IEEE specifies a group of electors that authorize the certificate trust list through a quorum of signers.
vii. The PKI architecture of ETSI is a shorter hierarchy and could result in reduced certificate verification time. Further, ETSI performs security operations at both payload and network layer, increasing the robustness of the communication.
viii. Neither standard mandate the use of Hardware Root of Trust in the end entities. These are desirable aspects that improve the security posture of the hardware. As a practice, the standards encourage hardware security modules, both at CA infrastructure levels and at the end entities

In view of the above points, it may seem like ETSI stack provides tighter security with simpler architecture, while adhering to a centralized hierarchy, similar to the Indian Root of Trust, maintained by the Controller of Certifying Authorities (CCA), Government of India.

7.3.5 PKI Trust Model for India – Challenges, Opportunities and Possible Directions

The Information Technology Act, 2000 in India recognizes the legal sanctity of digital signatures that are based on asymmetric cryptosystems. Digital signatures are hence treated on-par with handwritten signatures. Within the confines of the IT Act, the CCA is authorized to license and regulate the working of Certifying Authorities in the Country. The CCA is therefore

a statutory organization, appointed by the Central Government for promoting the growth of e-commerce and e-governance through the use of digital signatures.

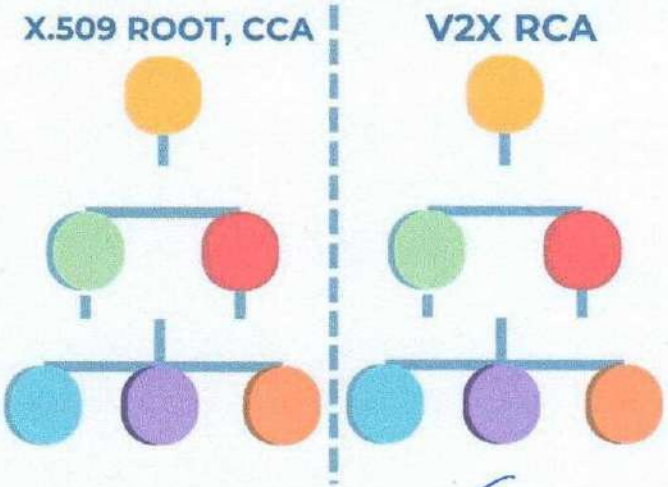
The CCA has established the Root Certifying Authority of India (RCAI) under section 18(b) of the IT Act to digitally sign the public keys of Certifying Authorities (CA) in the country. The CCA certifies the public keys of CAs using its own private key, which enables users in the cyberspace to verify that a given certificate is issued by a licensed CA. The CCA also maintains the Repository of Digital Certificates, which contains all the certificates issued to the CAs in the country. At present, CCA recognizes the ITU-T X.509 format of digital certificates as an accepted standard in the country and issues CA certificates, adhering to this standard.

The PKI framework specified by both ETSI and IEEE standards are inherently based on the IEEE 1609.2 definition of the certificate format. Pilot implementations in US and Europe have established IEEE 1609.2 certificate-based Root CAs, capable of issuing Enrolment, Authorization and End Device certificates in its native IEEE 1609.2 form. However, in India, since CCA recognizes ITU-T X.509 certificate as the standard, incorporating the IEEE 1609.2 certificate format cannot be directly achieved due to incompatibility between the standards. Further, there are no global standards that seek to resolve and develop a coexistence framework for certificates belonging to different trust models. Such a facility would require system level customization, rendering the solutions globally non-compatible.

With the intention of promoting and expanding the use of PKI based digital certificates, CCA is executing an R&D project to develop a PoC and demonstrate the efficacy of PKI based Digital Certificates for specific use cases in the IoT ecosystem like Automotive applications. C-DAC Hyderabad is the implementing agency tasked with the responsibility of demonstrating a PKI based trust framework for V2X communication between vehicles. In addition to demonstrating the PKI based trust framework in automotive devices, an important aspect for consideration is to evaluate the IEEE certificate format and evolve methodologies and strategies for the co-existence of these certificates under a X.509 trust hierarchy. Some considerations in developing such a bridged framework are to ensure global interoperability and standards alignment, while maintaining National sovereignty and ease of implementation.

The following 3 PKI based trust architectures are proposed for consideration, discussing their implementation aspects and listing out a few of their pros and challenges:

A. Separate and Independent V2X Root CA



Description:

A single national Root CA could act as the Trust Anchor for the entire V2X ecosystem, similar to the X.509 based RCAI implementation. This would be established as a dedicated V2X trust anchor, rather than bringing it under the existing X.509 hierarchy. This architecture mimics global implementations of an independent V2X Root CA.

Pros:

i. **Simplified Architecture:** Certificate validation is easier since no trust list of RCAs needs to be maintained.

ii. **Reduced Complexity:** Easier Trust List Management & Revocation Processes. The RCA can maintain a trust list of authorized EAs and AAs, making it very simple to verify.

iii. **Accountability:** Single Authority Ensures Compliance.

iv. **Global Compliance and Interoperable:** Easy to integrate with multiple global service providers.

Challenges:

i. **Policy Enforcement** - May require formalization via policy or regulation.

ii. **Multiple Independent Trust Hierarchies:** From the nation's perspective, such an architecture may result in de-centralizing every usage domain's PKI needs. For every instantiation thereafter, a separate and independent Root CA would be required, increasing the infrastructure requirements, bringing in multiple owners and requiring greater auditing and accountability.

iii. **Scalability Concerns:** As the ecosystem grows (Enrolment, Authorization CAs), heavy reliance on one RCA could cause bottlenecks. Intermediate CAs may have to be inset between the Root CA and corresponding Enrolment and Authorization CAs, similar to the IEEE stack. This may increase the trust chain length, requiring intermediaries being trusted.

iv. **Ownership:** Since V2X relies on multiple stakeholders for different application use cases, ownership and maintenance of application specific authorizations has to be resolved.

B. Subordinate Certificate Framework

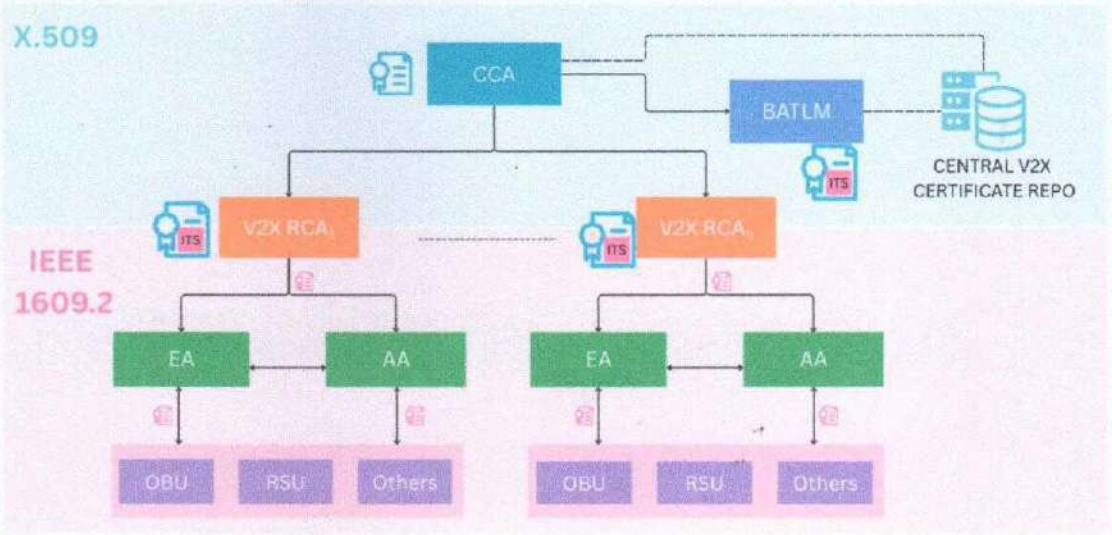
Description:

This method introduces an integration framework to incorporate the IEEE 1609.2 Certificate within an X.509 Certificate. A prospective V2X-RCA generates its self-signed IEEE 1609.2 certificate. This certificate is embedded into a X.509 Certificate Request to the CCA/RCAI. A special extension field of the X.509 certificate could be used with a custom Object Identifier (OID) to represent and include the subordinate IEEE 1609.2 certificate. The resulting X.509 certificate, issued by the RCAI, recognizes and authorizes the subordinate IEEE certificate as the V2X-RCA. This X.509 certificate shall also be maintained by the CCA as evidence. Beyond this point, there are 2 possible implementation strategies:

i. The X.509 certificate embedding the IEEE 1609.2 certificate becomes the V2X certificate standard for India.

ii. The IEEE certificate could be dislodged from the X.509 certificate and be independently used in the downstream PKI architecture, to create and issue multiple IEEE certificates for associated entities – Enrolment CA, Authorization CA and End Entities.

The following figure depicts the block level details of the subordinate architecture.



Pros:

i. **Reuse of Existing CCA Infrastructure:** Leverages current X.509 PKI model without requiring a separate V2X certificate policy and associated infrastructure.

ii. **Interoperability:** PKI entities with X.509 capability can understand and validate the certificate. Validation can chain up to the CCA without need for additional intelligence.

iii. **Deployment Efficiency:** Faster adoption since no overhaul of existing PKI is required.

iv. **Scalability:** The PKI architecture could be potentially scaled up ensuring multiple V2X Root CAs in the hierarchy.

v. **Indigenous:** Indian V2X Security Standard with Make in India Specification.

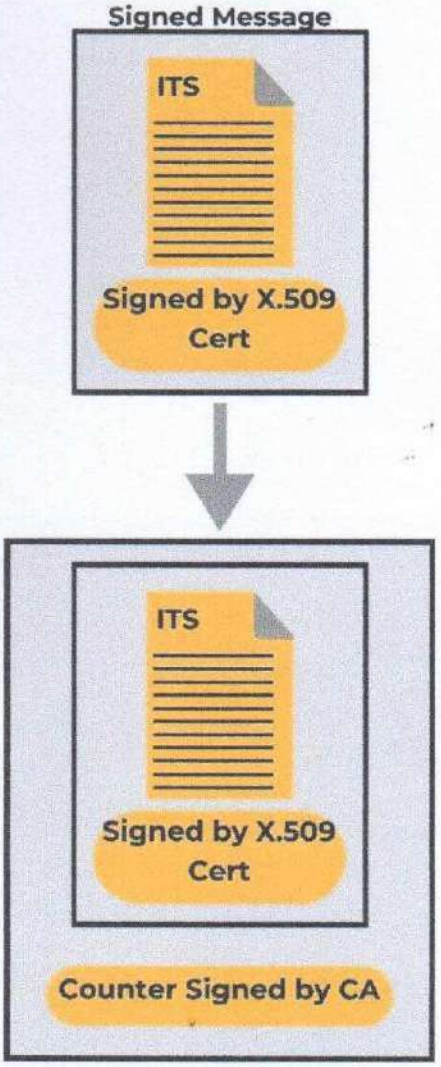
Challenges:

i. **Increased Complexity in Certificates:** Embedding will make the certificates larger and more complex to parse. Such embeddings on the end device may render the certificate globally incompatible and complex to validate, affecting latency and functional performance. Strategy 2, described earlier, could be a potential approach, but this would require additional and independent trust anchors to manage the Trust List.

ii. **Custom OID Dependency:** Requires careful management of custom OIDs, which may affect standardization and compatibility.

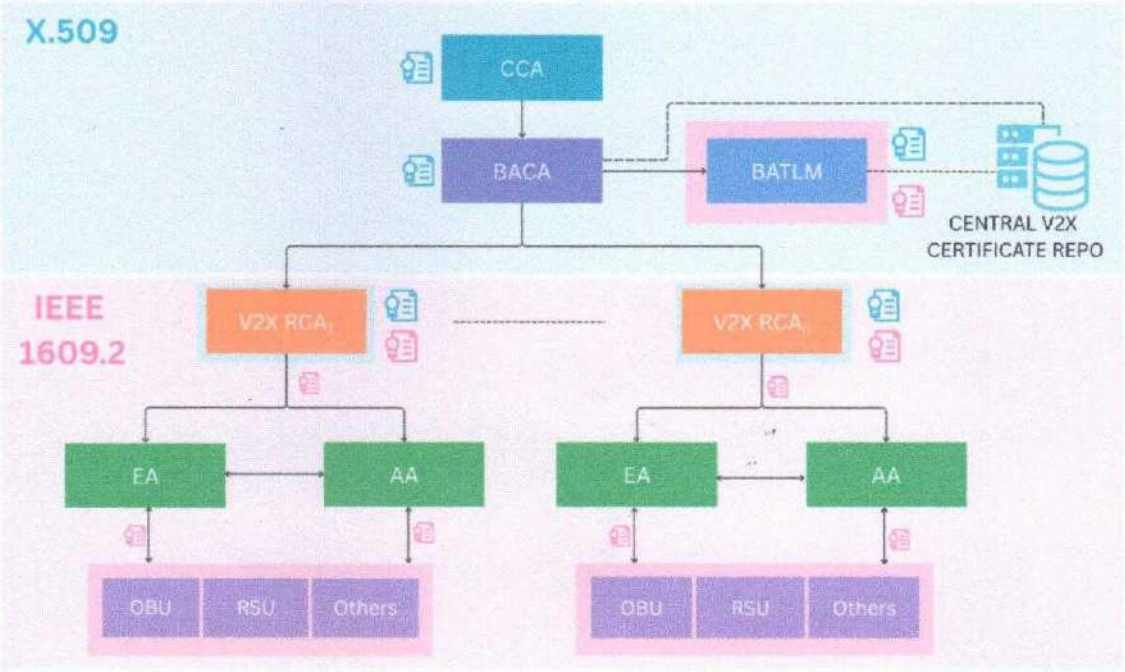
iii. **Standards Non-Compliance:** Becomes exclusive to India and requires additional software to be developed on the intermediate CAs and end devices, if chaining up to the CCA Root is required.

C. **Counter-Signing Certificate Framework**



Description:

The prospective V2X Root CA (V2X-RCA) could obtain its X.509 certificate from the CCA or its designated and trusted CA to establish the initial trust. This designated CA could be exclusively utilized for V2X requirements, becoming the policy manager for V2X in India. Thereafter, the V2X-RCA generates a self-signed IEEE 1609.2 Certificate which becomes its IEEE Root Certificate for the V2X ecosystem. This certificate is signed using the issued X.509 Certificate, according to the IETF RFC 5652 Cryptographic Message Syntax (CMS) standard. Thereafter, the CCA or its designated CA countersigns the V2X-RCA signature and generates a valid and trusted certificate for the V2X-RCA. The CCA/designated CA authorizes the certificate's insertion into the Certificate Trust List. After this bootstrapping procedure, the V2X-RCA issues ITS certificates directly, reducing complexity and overhead for end devices. Countersigning is mainly used in the bootstrap phase to link X.509 and IEEE 1609.2 certificate credentials. The architecture is described in Figure



Pros:

i. **Secure Bootstrapping & Co-existence:** Provides a process for validating IEEE certificates of V2X-RCAs through a standardized cryptographic process. Both certificate models can co-exist within the CCA's trust hierarchy.

ii. **Controlled Enrolment:** Ensures that only trusted and verified V2X-RCAs are allowed to exist and issue certificates in the V2X ecosystem.

iii. **Alignment with CCA Trust Framework:** Aligns with existing X.509 infrastructure, without the overheads of a custom OID in the certificate format.

iv. **Standards Compliant:** The Counter-signing process is an IETF standard and is utilized globally. This technique is used in e-passports where International and Regional preferences exist.

v. **Scalable:** The architecture is scalable and could balance load from the automotive requirements by integrating multiple V2X-RCAs through a streamlined process.

Challenges:

i. **Additional Overhead:** Requires an extra validation step during bootstrap of RCAs. This may however be restricted to the V2X-RCA levels, maintaining the countersigned certificate of the V2X-RCA.

ii. **Multi-Party Dependency:** Relies on coordination between different trust entities that exist in the hierarchy.

7.3.6 Conclusions

Establishing a PKI based trust framework becomes an essential aspect for enhancing security in V2X ecosystem. While global standards like IEEE and ETSI have proposed and implemented a PKI based trust architecture for V2X systems using exclusive V2X certificates, India has to carefully assess and adopt its implementation strategy, considering aspects like global conformity, performance, ease of implementation and maintainability, policy and regulatory requirements and national sovereignty.

From the approaches discussed above, A and C PKI based trust architectures may be suitable for India. Alternate strategies could include starting with trust architecture C and based on its performance and regulatory requirements, trust architecture A could be eventually adopted. However, the Task force recommends to choose between above mentioned PKI based trust architecture and pilot projects may be undertaken in real world operating conditions and based on the learnings draw a implementation roadmap prior to any large-scale rollout.

7.4 Conclusion

A robust security framework for C-V2X communication requires the integration of certificates, RoT, PKI frameworks and dynamic CRL updates. By implementing these mechanisms and adhering to global standards, India can ensure a secure and scalable C-V2X ecosystem that addresses both immediate safety requirements and future technological advancements.

8. Recommendations

Regulatory measures and implementation:

8.1 It is recommended that adequate regulatory measures including certification and testing are initiated by MoRTH, towards adoption of C-V2X, ITS stack and security services framework for India.

8.2 Industry, specially OEMs must be encouraged to implement Day-0 use cases on priority and ensure that the learnings are properly documented for development of the guidelines by the competent authority for uniform C-V2X implementation at Pan-India level.

8.3 It is recommended to expedite the allocation of the frequency spectrum so that Day-0 use cases i.e. V2V use cases for V2X implementation and scalable pilot projects may be undertaken immediately in urban centres and selected national highways and later expanded to state highways and rural areas. This will help identify and address technical and regulatory challenges prior to large-scale pan India deployment.

8.4 It is recommended to establish a centralized authority for inter-state operations of ITS/ C-V2X, along with a centralized platform to implement ITS/ C-V2X services, ensuring inter-state harmonization and interoperability.

ITS Radio and Stack Standardization:

8.5 For ITS Stack, based on wider ecosystem consultation and consensus, ETSI TC ITS stack may be adopted for V2X/ITS implementation in the country. Adoption of corresponding ETSI standard as National Standard may be taken up by the appropriate standardisation body in India (e.g. TSDSI, TEC).

ITS Security Services Standardization:

8.6 For Security services, a harmonized approach based on ETSI TS 102 941, which is derived from IEEE 1609.2, should be adopted to ensure PKI Root of Trust and scalability. This includes the possibility of either having a separate and dedicated national ITS root CA [para 7.3.5 (A)] or alternatively, consideration for a coexistence framework wherein the national root CA (X.509) countersigns the ITS certificates [para 7.3.5 (C)].

8.7 The standardization of the national security framework may be implemented by the concerned competent authority i.e. CCA, for harmonized security services architecture for V2X/ITS in India.

V2X Implementation Standards

8.8 The certification of radio equipment (OBU and RSU) may be undertaken by competent authority i.e. TEC, DoT to ensure the C-V2X radios comply with emission limits and essential requirements established by the DoT for wireless emissions, EMI/EMC, communication security, etc. in the harmonized band (5.9 GHz).

8.9 The standardization of automotive related implementation may be undertaken by agencies designated by MoRTH, to ensure that the C-V2X system reliably provides the functionality related to safety in a vehicle and roadside infrastructure.

8.10 Consideration of C-V2X test cases in future revisions of Bharat NCAP with robust BNCAP evaluation protocol at appropriate stage when ecosystem is developed.

Pilot Projects

8.11 Pilot tests should be conducted in controlled environments before large-scale rollout and deployment should begin in high-priority zones such as metropolitan cities, highways and accident-prone areas and scale up based on results.

Task Force continuity

8.12 This ITS Task Force, being an inter-disciplinary group of experts involving several diverse stakeholders in single platform, is recommended to continue its function as an expert group to ensure evaluation of pilot projects on ITS and to provide time to time recommendations throughout the journey of implementation of ITS in India. The Task Force shall continue to guide and supervise the pilots throughout their lifecycle and the outcomes shall be reported to MoRTH for making informed policy decisions and determine the implementation strategies for phased large-scale deployment.

Jointly Signed by e-mail by Ravindra G. Shah and Ujjwala Karle.
Sh. Manoj Desai
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ARAI

Signed by e-mail
Dr. Madhusudan Joshi
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Sh. Santosh Sam Koshy
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C-DAC

Signed by e-mail
Dr. Punit Rathod
Member
Qualcomm

Annexure-2
* Please take in to account the COAI Note attached pertaining to spectrum aspects.
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Member
COAI

Ms. Seema Babal
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ACMA

Dr. Shiv Kumar
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(SESEI)

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Sh. Sharad Kumar Chauhan
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31/12/2025
Ms. Namrata Singh
Director (IoT) & Member Secretary
TEC, DoT

19/1/2026
Sh. R. S. Singh
DDG (IoT) & Chairman
TEC, DoT

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2. TEC reports TR_Technologies and Standards for Intelligent Transport System.pdf
3. ETSI TS 102 941: Defines a security architecture for ITS communications in Europe.
4. IEEE 1609.2: Specifies security services for DSRC-based V2X communication in the U.S.
5. SAE J3061: Provides cybersecurity guidelines for vehicular systems.
6. 3GPP Specifications: Defines security mechanisms for LTE/5G-based C-V2X communication.
7. ETSI TC ITS Release 2 specifications provide a comprehensive suite of protocols and message formats that can be utilised for V2X communications and should be adopted in India, particularly for direct V2X communication[5].

[5] 5GAA Report, "Vehicle-to-Network-to-Everything (V2N2X) Communications: Architecture, Solution Blueprint, and Use Case Implementation Examples", June 2025. https://5gaa.org/vehicle-to-network-to-everything-v2n2x-communications-architecture-solution-blueprint-use-cases/

Annexure 1: Part-1 of the report

Attached as separate document.

No. RT-11036/80/2023-MVL

Government of India

Ministry of Road Transport and Highways

(MVL Division)

Transport Bhavan, 1, Parliament Street, New Delhi-110001

Dated the 20th November, 2025

OFFICE MEMORANDUM

The undersigned is directed to refer to D.O. letter No. R-11018/02/2022-PP dated 9th September 2025 from Secretary, Department of Telecommunications, Ministry of Communications, regarding the regulatory framework for Intelligent Transport Systems (ITS), and to convey appreciation for the efforts made by the Department of Telecommunications (DoT) in examining the recommendations of the Task Force and agreeing to adopt C-V2X as a harmonized technology for the country.

2. It is noted that the **National Frequency Allocation Plan (NFAP-2025)** has earmarked **5875-5925 MHz (50 MHz)** for Intelligent Transport System (V2X) use. In view of DoT's observation, it is proposed that V2V communication within the frequency range 5875-5905 (30 MHz) may be initiated, as this would improve braking, fuel efficiency and driving behaviour. Accordingly, **necessary steps for implementation of V2V communication in this frequency band may be initiated immediately.**

3. The **Vehicle-to-Infrastructure (V2I)** or **Road-Side Units (RSUs)** may be rolled out subsequently based on key learnings from pilot deployments. The authorization for RSUs will be restricted to **Central or State Governments or any other agencies authorized** by them.

4. It is further clarified that the report submitted by the Task Force is **not an interim report**, but **Part I of the Final Report** , which comprehensively covers all aspects related to spectrum allocation and policy framework for ITS. The final report, currently under preparation, will primarily focus on **technical and implementation frameworks** and will **not alter the spectrum-related requirements** already submitted.

5. MoRTH looks forward to continued coordination with DoT to ensure seamless implementation of the V2X ecosystem in India. The final report of the Task Force, containing detailed technical and rollout plans, will be shared with DoT shortly for further action and alignment.

(Brajesh Bhardwaj)
Under Secretary to the Govt. of India
Tel: 23719097/e-mail: brajesh.bhardwaj@nic.in

To,

The Secretary
Department of Telecommunications
Ministry of Communication
Sanchar Bhavan, New Delhi.

Copy to:

1. Secretary,MoRTH
2. Chairman,NHAI
3. Additional Secretary,(Transport),MoRTH
4. DDG/IOT and Chairman of the Task Force
5. Deputy Secretary(Highways), MoRTH

Government of India
Ministry of Communications
Department of Telecommunications
Wireless Planning and Coordination Wing
20, Ashoka Road, Sanchar Bhawan, New Delhi

No. P-11014/34/2009-PP Dated: 11.12.2023

ORDER

Subject: Spectrum Charges for Assignment of Frequencies to Captive Users (being charged on formula basis) for different types of Radiocommunication Services and applications.

In pursuance of the powers conferred under section 4 of the Indian Telegraph Act, 1885 (13 of 1885) and in supersession of this Ministry's Orders Nos. P-11014/34/2009-PP (I), (II), (III) & (IV) each dated 22.03.2012, the Central Government has decided that assignment of radio frequency spectrum to all users to whom radio frequency assignment is made through administrative process and spectrum charges are calculated based on a formulae, shall be made as per the methodology defined in this order.

2. Upon successful processing of application for assignment of radio frequency, a Letter of Intent (LoI) will be issued to the applicant which include, among others, information about the license fee and royalty charge (collectively called spectrum charges) required to be paid. Spectrum charges shall be informed for the full period of the assignment requested. If the request for assignment is for a period more than one year, the applicant can opt to pay the license fee and royalty annually, in advance for each year.

3. Immediately thereafter, but in any case not later than sixty (60) days from the date of issue of the LoI, the applicant shall pay the spectrum charges for issue of Decision Letter (DL), if otherwise permissible.

3.1 If the payment is not received within 60 days from the date of LoI, the application shall be treated as cancelled and the frequency shall be freed for assignment to other applicants. The applicant will have to submit a fresh application if they still want the frequency assignment.

4. A Construction Period of three months is permitted for the purpose of import of the equipment, site preparedness, deployment, etc. and spectrum charges be levied, after three months' period from the 1st day of the month of date of issue of LoI.

4.1 Three months' construction period shall not be applicable for temporary frequency assignment (assignment issued for the period less than one year). In such cases, spectrum charges shall be applicable from the 1st day of the month of date of issue of LoI.

5. Initially, DL shall be issued with a validity of 15 months (one year plus three months of construction period) from the 1st day of the month of date of issue of LoI that can be further extended for a period of another one year subject to payment of annual spectrum charges, in advance. For example: If date of issue of initial LoI is 20th August 2023, the spectrum charges will be levied from 1st November 2023 and the initial DL will be valid upto 31st October 2024. Further extension of one year will be expired on 31st October 2025.

5.1 In no case DL be renewed further, however, extension of another one year may be considered for Government users under certain circumstances subject to payment of annual spectrum charges, in advance.

6. The spectrum charges, comprises of Royalty and License fee, shall be calculated for following radiocommunication services as per the enclosed schedules:

6.1 All the above services have been defined in the National Frequency Allocation Plan of India (NFAP). The latest NFAP is available in DoT's website (www.dot.gov.in).

6.2 Spectrum charges, mentioned in all the schedules, are annual charges, unless otherwise specified.

6.3 Royalty charge has been made independent of numbers of equipment/set, unless otherwise specified. However, license fee will be applicable on them. Therefore, any increase/ decrease in the number of equipment (Fixed/ Mobile) in the existing frequency assignment shall require prior permission.

6.4 The spectrum charges due for different period shall be determined as follows:

License Period	**License Fee Payable**	**Royalty payable after three months period from the 1st day of the month of date of issue of LOI**	**Method of Payment**
One calendar month or less	At specified rate given in various schedules	Annual Royalty divided by 12	Full License fee and Royalty to be paid in advance at the time of issue of DL/frequency assignment.
More than one calendar month but less than 12 months	At specified rate given in various schedules	On pro-rata basis. However, part of a month shall be taken as one month.	--do--
More than one year	At specified rate given in various schedules	On pro-rata basis. However, part of a month shall be taken as one month.	Pay the License Fee plus Royalty for the entire duration in advance at the time of issue of DL/ frequency assignment or pay it in annual advance instalments.

7. Generally, there shall be no limit on number of frequency(ies) applied for any type of services. However, number of frequency(ies) shall be assigned subject to availability, technical justification, regulatory feasibility etc.

8. **Renewal of Frequency Assignment:**

8.1 The assignee shall be responsible for keeping the frequency assignment current and up to date until its surrender/ cancellation. To this effect, the assignee shall, at least 30 days before the end date of the validity of the frequency assignment, pay through Saral Sanchar Portal, the spectrum charges for the renewal of his/her existing frequency assignment.

9. **Frequency assignment/ authorization Modification Fee:**

9.1. Applicable fees for modification in the frequency authorization/ frequency assignment shall be charged at the rate of Rs. 1000/- per modification.

10. **Cancellation/ Surrender of Frequency Assignment:**

10.1 The assignee shall surrender the frequency assignment, if no longer required. To this effect the assignee shall apply for cancellation through Saral Sanchar Portal in accordance with OM No. L-14027/210/2020-WF dated 27.07.2023. Failure to surrender a frequency assignment within the stipulated time shall result in accrual of spectrum charges and late fee.

10.2 Non-purchase of equipment/ non-utilization of frequency assignment shall not be ground for exemption from payment of spectrum charges.

10.3 On surrender of frequency assignment, after adjustment of due spectrum charges, the balance amount will be either adjusted against other active frequency assignments or refunded to the applicant.

11. **Late fee for delayed payment of Spectrum Charges:**

11.1 Late fee shall be payable by the assignee on the frequency assignment for delay in payment of spectrum charges (Royalty and License fee) or any other dues payable against the frequency assignment. In this regard, any payment reflected in DoT's account after the midnight (2400 Hrs.) of the end date will be considered as a delay in payment irrespective of the date on which such transaction was initiated by the assignee of the frequency assignment.

11.2 The rate at which Late Fee is levied for a Financial Year shall be 2% added to one-year Marginal Cost of Lending Rate (MCLR) of State Bank of India, on the beginning of the Financial Year i.e. 1st April.

11.3 The Late Fee shall be compounded annually, subject to minimum annual Late Fee of Rs. 250/- per Frequency Assignment. A part of the month shall be considered as a full month for the purpose of calculation of Late Fee. A month shall be an English calendar month.

12. The applications for the frequency assignment shall continue to be processed through DoT's online portal (Saral Sanchar portal). Further, all renewals, cancellations, import permission, surrenders will also be issued through online portal (Saral Sanchar) as per prevailing instructions issued from time to time.

13. Any issue either arising due to interpretation of this Order or new uses/ applications not covered in the said Order shall be referred to the Standing Committee constituted vide WPC Wing OM of even No. dated 11.12.2023.

14. This Order issues with the approval of competent authority.

15. This Order shall come into force with effect from 01st April 2024. However, the revised spectrum charges on existing frequency assignments shall be applicable from the date of next renewal cycle.

Enclosure: As above.

11.12.2023

(P S M Tripathi)
Sr. Deputy Wireless Adviser to the Govt. of India

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To,

1. All concerned.
2. Wireless Finance Division
3. Wireless Monitoring Organisation
4. IT cell, DoT - for publication on DoT Website
5. ITPC, BSNL, Pune to send text messages to all licensee informing them about the new orders on frequency assignment.

Schedule-I: Terrestrial Broadcasting Services

General:

(i) FM Broadcast (Analog) frequency plan is based on a 200 kHz channel Plan.

(ii) The MF/ HF broadcast frequency plan is based on 20 and 10 kHz channel plan respectively.

(iii) V/UHF Terrestrial-TV Broadcast frequency plan is based on 7/8 MHz Channel plan.

(iv) The low power studio equipment shall not be used for outdoor events e.g. use in sports stadiums, outdoor social, cultural, religious events etc.

(v) Hot Standby is permitted by default and no separate license fee or royalty for Hot standby equipment will be applicable.

(vi) Permission for Community Radio Station standby station is included, and no separate permission will be required.

Part-I (Royalty Charges)

1. Annual Royalty Charges for Terrestrial Broadcasting Service:

Table-1

Type of Broadcasting	Power delivered to antenna	Royalty (in Rs) per radio station
Public Broadcasting (All India Radio and Doordarshan)	**Sound:**	
	Low Power FM (Up to 100 W)	30,000
	Medium Power FM (0.1 KW to 1KW)	60,000
	High Power FM (1KW-3KW)	1,25,000
	AM/MW Broadcasting	50,000
	Television:	
	Low Power TV (Up to 1KW)	VHF: 1,20,000 UHF: 3,60,000
	High Power TV (Above 1KW)	VHF: 1,20,000 UHF: 3,50,000
Private Commercial Broadcasting	FM stations	3,37,500
Community Radio Broadcasting (CRS)	Low power FM (Up to 50 W)	22,500

1.1 Royalty charges for Low Power indoor studio equipment will be Rs. 5000/- per set for lifetime use.

Part-II (License fee)

License Fee for stations under Broadcasting Service including standby sets:

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
i.	Broadcast transmitter station	500 per station
ii.	Low power studio equipment	250 per set (one time charge for lifetime)

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Schedule-II: Land Mobile Services in LF/MF/HF/VHF/UHF bands (Bandwidth up to 375 kHz)

General:

(i) Royalty Charges calculation for a frequency(s) will be based on the coverage area, the channel bandwidth of transmission, popularity of frequency band and the location-category; and will be independent of the number of stations using the same frequency(s) in a network.

(ii) The Coverage category of Fixed-Site users is as per Table -2

(iii) Highly Popular Bands, Medium poplar Bands, Less Popular bands, and others are as per Table- 3

(iv) The location category is as per Annex I.

(v) "Fixed-site" covers small area applications such as industrial units, factories, municipalities, etc. and can comprise of one or more base stations, mobile stations, or any combinations thereof.

(vi) Fixed-Site Charging methodology shall be applied where area of a district is small enough to be covered by four base/repeater stations.

(vii) In case of a network spread across two location population categories (different class of cities) the charging of higher population category shall be applicable.

(viii) Network having coverage beyond the Fixed-site category will be charged under District or State or Pan India category, as the case may be.

(ix) Area users are those which operate over larger area of operations such as: Pan-India users like India Railways, Defense, Central Paramilitary forces (CPMFs), oil marketing companies, airports authority, etc; State-wide users such as: state police organizations, Disaster Management authorities, State Forest departments, electricity boards, water resources departments etc; district-wide users such as: pubic transport, district

authorities; and generally consist of several base stations, mobile stations, and combinations thereof.

(x) It may be noted that area of operation of assigned frequency(ies) i.r.o. area users shall be restricted to their respective jurisdiction like Railways' operation will be limited along the railway track only, whereas security agencies will have their operational area over the entire area for which spectrum is assigned.

(xi) Under Area-based State-wide category charging, States has been categorized into two categories (Category-A and Category-B) based on the GDP of the States. Accordingly, separate rates is applicable for the same frequency band.

(xii) Royalty charges for frequency assignments that are in the sea (offshore), sub-surface use such as tunnel-radio will be charged at the minimum charging rate in the respective band/population category.

(xiii) If the antenna is used indoors or underground or is a down-fire, leaky feeder or radiating cable type, it will fall within category 1 of the respective band/population area.

(xiv) In order to promote efficient use of radio frequencies, number of Frequencies to be assigned to each user at a specific location in HF/VHF /UHF Land Mobile Service shall be as per the following criteria:

a. For Fixed-site operations, a maximum 10 simplex frequencies or 02 duplex frequencies will be assigned initially. Additional assignments will be based on justification.

b. The Royalty charges as in Table 1 will be applicable for the first 10 simplex channels or 2 duplex channels. Beyond these number of channels, an incremental additional charge of 30% higher for next 05 simplex channels or 02 duplex channels, and 50% higher charges on number of frequencies exceeding beyond 15 simplex or 04 duplex channels will be applicable.

(xv) Royalty for VHF bands and above (more than 30 MHz), will be levied for the channel bandwidth and not for the occupied bandwidth. Minimum unit of charging is 12.5 kHz.

(xvi) The Royalty charges for the systems using a 6.25 kHz channel size in VHF band and above (more than 30 MHz) will be half of that applicable for the basic 12.5 kHz channel size.

(xvii) Royalty for LF/MF/HF bands (less than 30 MHz) will be levied for the channel width and not for the occupied bandwidth. Minimum unit of charging is 3 kHz.

Part-I (Royalty Charges)

1. **Annual Royalty for Fixed-Site networks:**

Table 1: Annual Royalty (in Rs.) for Fixed-Site networks in VHF/ UHF band for 12.5 kHz bandwidth

Band category[1]	Highly Popular Bands (HPB)			Medium Popular Bands (MPB)			Less Popular Bands (LPB)
Coverage Category[2]	1	2	3	1	2	3	1,2 or 3
Population category A+	15,000	45,000	75,000	12,000	36,000	45,000	3,000
Population category A	10,000	25,000	40,000	8,000	24,000	36,000	
Population category B	7,500	15,000	25,000	5,000	12,000	20,000	
Population category C	5,000	10,000	15,000	3,750	7,000	15,000	
All others	3,000	5,000	8,000	2,000	4,000	5,000	

[1]Refer to Table-3

[2]Refer to Table-2

* Half of the charges will be applicable for 6.25 kHz channel bandwidth

Table 2: The Coverage Category

Coverage categories	Combinations of Effective Radiated Power (ERP) in Watts (P), and Antenna height above ground level (Ah)in meters – for base station(s)	Possible operational area - Radius (R) in km
Category 1	P ≤5W and Ah ≤10m	0 < R ≤3
Category 2	P ≤5W and 10m < Ah ≤30m	3 < R ≤15
	P> 5W and Ah ≤10m	
Category 3	P> 5W and Ah > 10m	15 < R ≤30
	P ≤5W and Ah > 30m	

Table 3: High/ Medium/Popular bands

Band categories	Bands	Frequency range (MHz)
Highly Popular bands (HPB)	VHF	137 – 174
	UHF-I	410 – 430
	UHF-II	430 –470
Medium Popular bands (MPB)	UHF-III	380 – 400 800 MHz for CMRTS (except for IMT band)
Less Popular bands (LPB)	Any other band other than above	

2. Annual Royalty for Area-based Operation in VHF/UHF band for Land Mobile stations:

Table-4: Annual Royalty (in Rs.)

Area	Royalty for Highly Popular bands	Royalty for Medium Popular bands	Royalty for Less Popular bands
All India	50,00,000	37,50,000	25,00,000
State-wide Category-A[1]	5,00,000	3,75,000	2,50,000
State-wide Category- B[2]	3,00,000	2,25,000	1,50,000
District-wide	5 x Fixed site Coverage Cat-3	5 x Fixed site Coverage Cat-3	5 x Fixed site Coverage Cat-3

[1]*State-wide Category-A: Delhi, Maharashtra, West Bengal, Gujarat, Karnataka, Tamil Nadu, Uttar Pradesh, Andhra Pradesh, Telangana, Haryana, Kerala, Madhya Pradesh, Punjab, Rajasthan, Assam, Bihar, Chhattisgarh, Jharkhand, Himachal Pradesh, and Orrisa.*

[2]*State-wide Category-B: Uttarakhand, Sikkim, Goa, Meghalaya, Tripura, Nagaland, Arunachal Pradesh, Manipur, Mizoram and Union Territories.*

3. **Royalty Charges for UHF Short Range Radio (USR)**

(i) USR will continue to be permitted in the 350-351 MHz frequency band. However, the frequency assignments for USR will be made on non-exclusive basis, where the user will be free to select the operating frequency from a pool of earmarked frequencies mentioned at Annexure-2 of NFAP 2022.

(ii) The USR system can be used anywhere in the country except restricted areas as notified by the Government. In restricted areas possession as well as operation of USR equipment are prohibited.

(iii) The royalty charges will be at the minimum rates under the Fixed site category and license will be granted for not less than 5 years (non-refundable, renewable after five years for 5-year terms).

4. **Royalty Charges for Land Mobile Service in LF/MF/HF band**:

Table-5: Annual Royalty Charges

Frequency bands	Royalty Charges per annum per spot (irrespective of the number of sets) (in Rs.)
HF (3-30 MHz)	1,00,000
MF (300 kHz – 3 MHz)	50,000
LF (9 kHz to 300 kHz)	50,000

Part-II (License fee)

License Fee for wireless stations operating under Land Mobile service including Standby sets will be as under:

S.No.	Type of Wireless station License	Annual License Fee (in Rs.)
i.	Base/ Fixed Station	500 per station
ii	Vehicle /Handheld Mobile station	250 per station

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Schedule-III: Maritime Mobile Service in LF/MF/HF/VHF/UHF bands

General:

(i) Maritime Mobile Services includes port operation service, ship movement service, which are also defined in NFAP.

(ii) Frequency assignments to general public will be made on a non-exclusive basis.

(iii) Ports and Search & Rescue (SAR) authorities shall be assigned the number of frequencies on an exclusive basis if requested by them.

(iv) Royalty for VHF/UHF bands and above (more than 30 MHz), will be levied for the channel bandwidth and not for the occupied bandwidth. Minimum unit of charging is 12.5 kHz.

(v) The Royalty charges for the systems using a 6.25 kHz channel size in VHF/UHF band and above (more than 30 MHz) will be half of that applicable for the basic 12.5 kHz channel size.

(vi) Royalty for LF/MF/HF bands (less than 30 MHz), will be levied for the channel bandwidth and not for the occupied bandwidth. The minimum unit of charging is 3 kHz.

(vii) No charges will be levied for the safety and calling frequencies mentioned at Para 2 of Part-I (Royalty Charges).

(viii) The transmitting frequencies in the VHF maritime mobile band will be in accordance with APPENDIX 18 of Radio Regulation of ITU-R.

Part-I (Royalty Charges)

1. Annual Royalty for radio stations in Maritime Mobile Service:

Table-1: Annual Royalty Charges

Frequency Band	Royalty Charges per annum (in Rs.) (irrespective of the number of sets)
VHF (Except AIS[1])	20,000
VHF (AIS/ ATON[2]) (For two frequencies)	20,000
HF (3-30 MHz)	1, 00,000
MF (300 kHz – 3 MHz)	50,000
LF (9 kHz to 300 kHz)	50,000

[1]*AIS: Automatic Identification System*

[2]*ATON: AIS to Aid to Navigation (Physical/Virtual/Synthetic)*

2. Frequency exempted from payment of spectrum charges Safety and calling frequencies:

Table -2: List of exempted frequency

Freq.	Mode	In VHF band (MHz)	In 2 MHz band (kHz)	In 4 MHz band (kHz)	In 6 MHz band (kHz)	In 8 MHz band (kHz)	In 12 MHz band (kHz)	In 16 MHz band (kHz)
Distress Alert Freq.	DSC	156.525 (Channel 70)	2187.5	4207.5	6312.0	8414.5	12577.0	16804.5
Distress traffic freq.	RTF	156.8 (Channel 16)	2182	4125	6215.0	8291.0	12290.0	16420.0
	*NBDP		2174.5	4177.5	6268.0	8376.5	12520.0	16695.0

* The latest ITU-R Recommendations will be followed.

2.1 Channel 06 (156.300 MHz: Safety and Inter-ship Communications), and Channel 13 (156.650 MHz: Inter-ship Navigation Safety), are also exempted from payment of spectrum charges.

Part-II (License fee)

License Fee for wireless stations operating under Maritime Mobile service including Standby sets:

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
1	Coast Station	500 per station
2	Vehicle /Handheld station	250 per station
3	Fishing trawlers	500 per trawler
4	Ship stations	5000 per ship

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Schedule – IV: Aeronautical Service in LF/MF/HF/VHF/UHF bands

General:

(i) Aeronautical Service includes aeronautical mobile (R) service and aeronautical mobile (OR) service, aeronautical radio navigation service, which are also defined in NFAP.

(ii) Frequency assignments for this service will be made on an exclusive basis.

(iii) Royalty for VHF bands and above (more than 30 MHz), will be levied for the channel bandwidth and not for the occupied bandwidth. The minimum unit of charging is 12.5 kHz.

(iv) The Royalty charges for the systems using a 6.25 kHz channel size in VHF/UHF band and above (more than 30 MHz) will be half of that applicable for the basic 12.5 kHz channel size.

(v) Royalty for LF/MF/HF bands (less than 30 MHz) will be levied for the channel bandwidth and not for the occupied bandwidth. Minimum unit of charging is 3 kHz.

Part-I (Royalty Charges)

1. Annual Royalty Charges for Aeronautical Mobile Service:

Table-1: Royalty Charges

Frequency Band	Royalty Charges (in Rs.) per annum per location (irrespective of the number of sets)
VHF/ UHF (ARNS/ AMS)	2,00,000 (For Tower and Approach) 75,000 (For Ground)
HF (3-30 MHz)	1,00,000
MF (300 kHz – 3 MHz)	50,000
LF (9 kHz to 300 kHz) (Radio Beacons, etc.)	50,000

ARNS: Aeronautical Radionavigation services: VOR (CVOR or DVOR), DME, NDB, TACAN, MARKER, GP, GS (ICAO definition may be referred).

AMS: Aeronautical Mobile Service (Route/off-Route)

Part-II (License fee)

License Fee for wireless stations operating under Aeronautical Mobile service including Standby sets:

Table-2: License Fee

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
1	Fixed Station	500 per station
2	Vehicle /Handheld Mobile station	250 per station
3	Aircraft stations	5000 per aircraft

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Schedule-V: Radars under Radionavigation Service/ Radiolocation Services

General:

(i) Radar is classified into low-power (less than 10-watt *EIRP*) and high-power radar systems (10-watt *EIRP* or higher).

(ii) The royalty charges will be calculated based on the Necessary bandwidth (20 dB bandwidth) as per the Annexure-II and will be independent of the coverage distance.

(iii) Royalty charges for low-power radars (payable at the beginning) shall be charged at 10% of one-year royalty charge of high-power radar of similar frequency ranges for use of the total life of the equipment or 10 years, whichever is earlier. It can be renewed for further periods in the multiple of 10 years under the extant rules.

(iv) The royalty charges for Wind profiler radars will be calculated using a social factor of 1/3 to the royalty charges of the high-power radar.

Part-I (Royalty Charges)

Annual Royalty Charges for high power radar station in Radio determination service /Radio Location Service:

Frequency Band	Rate (in Rs.) per 100 kHz
960- 2690 MHz	12,000
2690- 5000 MHz	12,000
5000-8500 MHz	3,000
8500- 14500 MHz	1,200
More than 14500 MHz	1,200

Part-II (License fee)

License Fee for wireless stations operating under Radio determination service / Radio Location including Standby sets:

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
1	Radar Station	1000 per station

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Schedule-VI: Fixed and Mobile Services having Multiplexed Multi-channels

General:

(i) Charging methodology is based on MxCxW formula (M= Basic Royalty, C=No. Freq. Carriers, W=Bandwidth Factor). It will be used for calculation of royalty charges for the Fixed services and Mobile services having multiplexed multi-channels.

(ii) The rate of M-Factor will be calculated based on the maximum Coverage distance as per Table-1

(iii) The bandwidth factor will be calculated as per Table-2. Any fraction would be rounded up to the next integer.

Part-I (Royalty Charges)

1. Annual royalty Charges for radio stations in Fixed Services and Mobile services having multiplexed multi-channels for Captive use will be multiplication of the M-factor (Basic Royalty), C-factor (No. of frequency carriers) and W-factor (Bandwidth).

Royalty (R) = MxCxW

Table-1: Rate of M-Factor

Distance Category	Maximum Distance (Km)	Value of M Factor
I	<= 2	750
II	> 2= 5	1500
III	> 5 <= 25	3000
IV	> 25 <=60	6000
V	> 60 <=120	11000
VI	> 120 <=500	18750
VII	> 500	25000

Table-2: Rate of bandwidth factor

Slabs of Adjacent Channel Separation (BW), in MHz	Value of W factor
More than 375 kHz and including 2 MHz	30
More than 2 but <= 3.5	40
More than 3.5 but <= 7	60
More than 7 but <= 14	90
More than 14 but <= 28	120
More than 28 but <= 56	150
More than 56 but <= 112	180
More than 112 but <= 256	210
More than 256 but <= 512	240
> 512	240+ 30 x (Excess bandwidth / 256) *

*That is, in steps of 256 MHz or part thereof

Part-II (License fee)

License Fee for wireless stations operating under Fixed and Mobile Services including Standby sets:

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
i.	Fixed station	1000 per station
ii.	Vehicle Mobile/ Handheld Mobile station	250 per station

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Schedule-VII: Satellite based Services.

General:

(i) Satellite based Service includes Fixed Satellite Services (FSS), Broadcasting Satellite Services (BSS), Mobile satellite Services (MSS) and Earth Exploration Satellite Services (EESS)

(ii) The standard annual royalty factor shall be Rs. 35,000/- per frequency. The same rates will be applied for all applications under FSS, BSS, MSS and EESS together with the relevant Bandwidth Factor (Bs) given in Table-1 below to arrive at the amount of Annual Royalty (R) per frequency payable for an Uplink or Downlink.

(iii) Royalty charges shall not be applicable on remote terminals of Data collection platforms. Only the license fee will be paid.

(iv) Bandwidth factor for the bandwidth will be calculated in the multiple of 500 kHz and the remainder will be calculated using increments of 100 kHz.

(v) The royalty will be charged on the total bandwidth assigned i.e., including any guard bands etc.

(vi) The royalty charges for Earth-Exploration Satellite Services / Meteorological Satellite Service, will be calculated only once for every frequency carrier used by the remote users under these services.

(vii) For Space Operation Services (TTC operation), the fixed royalty charges of Rs 1,50,000/- per Earth Station per annum will be levied.

(viii) Royalty charges will be levied in respect of frequencies transmitted from or into Indian territory.

(ix) For DSNG/SNG, the royalty charges will be levied for the frequencies used on both uplinks and downlinks. In case the same frequency carrier is used by the user from different OB vans belonging to licensee, additional royalty @ 25% of the basis royalty will be charged. However, if the additional OB vans are deployed within the same venue, e.g. a stadium, additional royalty @ 25% of the basis royalty will not be charged.

(x) For temporary Up linking, a minimum royalty equivalent to that for one month will be charged.

Part-I (Royalty Charges)

1. Annual Royalty Charges for Satellite Based Services:

Annual Royalty (R) = Rs. 35000xBs.

Table-1: Calculation of Bandwidth Factor (Bs)

S. No.	Total Assigned Bandwidth		Bandwidth Factor (B_s)			
			For uplink		For downlink	
			Broadcast*	Others	Broadcast	Others
(i)	Up to and including 500 kHz, B_s is either of these three	Up to and including 100 kHz [i.e., BW ≤ 100 kHz]	0.25	0.20	Nil	0.20
(ii)		More than 100 kHz to up to and including 250 kHz [i.e., 100 kHz < BW ≤ 250 kHz]	0.60	0.50	Nil	0.50
(iii)		More than 250 kHz to up to and including 500 kHz [i.e., 250 kHz < BW ≤ 500 kHz]	1.25	1.00	Nil	1.00
(iv)	More than 500 kHz [i.e., BW > 500 kHz]		Total B_s			

*Broadcast in this case means those uses that are related to transmission of television content through satellite, and include, teleports, DSNG vans, DTH, HITS etc.

Total B_s = [Appropriate B_s from row (iii) above × bandwidth in number of multiple of 500 kHz] + [Appropriate B_s from row (i) above × number of multiple of 100KHz or part thereof in balance bandwidth]

where,

Balance bandwidth = remainder of [bandwidth/ 500 kHz]

Part-II (License fee)

License Fee for wireless stations operating under Satellite Services (FSS, BSS, MSS) including Standby sets

S. No.	Type of Wireless station License	Annual License Fee (in Rs.)
1	Fixed Earth station DTH/ Teleport/ DSNG/NLD/ILD/DCP/IP-II	1000 per station
2	Captive VSAT/Inmarsat Earth Station	500 per station
3	Vehicle Mobile/Handheld Mobile station	250/- per station

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Annexure-I

Category-wise List of Cities

Name of the City	State	Category
Chennai	Tamil Nadu	A+
Delhi	Delhi	A+
Kolkata	West Bengal	A+
Mumbai	Maharashtra	A+
Ahmedabad	Gujarat	A
Bangalore	Karnataka	A
Hyderabad	Andhra Pradesh	A
Jaipur	Rajasthan	A
Kanpur	Uttar Pradesh	A
Lucknow	Uttar Pradesh	A
Nagpur	Maharashtra	A
Pune	Maharashtra	A
Surat	Gujarat	A
Amritsar	Punjab	B
Agra	Uttar Pradesh	B
Allahabad	Uttar Pradesh	B
Asansol	West Bengal	B
Bhopal	Madhya Pradesh	B
Cochin	Kerala	B
Coimbatore	Tamil Nadu	B
Dhanbad	Jharkhand	B

Indore	Madhya Pradesh	B
Jabalpur	Madhya Pradesh	B
Jamshedpur	Jharkhand	B
Ludhiana	Punjab	B
Madurai	Tamil Nadu	B
Moradabad	Uttar Pradesh	B
Patna	Bihar	B
Rajkot	Gujarat	B
Vadodara	Gujarat	B
Varanasi	Uttar Pradesh	B
Vijayawada	Andhra Pradesh	B
Visakhapatnam	Andhra Pradesh	B
Ahmednagar	Maharashtra	C
Ajmer	Rajasthan	C
Akola	Maharashtra	C
Alappuzha (Alleppey)	Kerala	C
Aligarh	Uttar Pradesh	C
Amravati	Maharashtra	C
Aurangabad	Maharashtra	C
Bareilly	Uttar Pradesh	C
Belgaum	Karnataka	C
Bellary	Karnataka	C
Bhagalpur	Bihar	C
Bhavnagar	Gujarat	C
Bhubaneshwar	Orissa	C

Bikaner	Rajasthan	C
Bilaspur	Chhattisgarh	C
Chandigarh	Chandigarh/UT	C
Dehradun	Uttarakhand	C
Devengeri	Karnataka	C
Dhule	Maharashtra	C
Erode	Tamil Nadu	C
Gaya	Bihar	C
Gorakhpur	Uttar Pradesh	C
Gulbarga	Karnataka	C
Guwahati	Assam	C
Gwalior	Madhya Pradesh	C
Hubli-Dharwad	Karnataka	C
Jalandhar	Punjab	C
Jalgaon	Maharashtra	C
Jammu	J&K	C
Jamnagar	Gujarat	C
Jhansi	Uttar Pradesh	C
Jodhpur	Rajasthan	C
Kakinada	Andhra Pradesh	C
Kannur	Kerala	C
Kolhapur	Maharashtra	C
Kota	Rajasthan	C
Kozhikode	Kerala	C
Kurnool	Andhra Pradesh	C

Malegaon	Maharashtra	C
Mangalore	Karnataka	C
Muzaffarnagar	Uttar Pradesh	C
Muzaffarpur	Bihar	C
Mysore	Karnataka	C
Nanded	Maharashtra	C
Nasik	Maharashtra	C
Nellore	Andhra Pradesh	C
Patiala	Punjab	C
Pondicherry	Pondicherry	C
Raipur	Chhattisgarh	C
Rajahmundry	Andhra Pradesh	C
Ranchi	Jharkhand	C
Rourkela	Orissa	C
Sagar	Madhya Pradesh	C
Saharanpur	Uttar Pradesh	C
Salem	Tamil Nadu	C
Sangli	Maharashtra	C
Shahjahanpur	Uttar Pradesh	C
Sholapur	Maharashtra	C
Siliguri	West Bengal	C
Srinagar	J&K	C
Tiruchy	Tamil Nadu	C
Tirunelveli	Tamil Nadu	C
Tirupati	Andhra Pradesh	C

Thiruvananthapuram	Kerala	C
Trissur	Kerala	C
Tuticorin	Tamil Nadu	C
Udaipur	Rajasthan	C
Ujjain	Madhya Pradesh	C
Vellore	Tamil Nadu	C
Warangal	Andhra Pradesh	C

** The above categorization of cities is based on the population as per MIB order dated 25th July 2011 [File No. 104/2/2008-FM(Vol-III)]*

Annexure-II

Necessary bandwidth Calculation Method for Radar Applications for calculation of Royalty charges:

The necessary bandwidth (20 dB Bandwidth) of the transmitted signal, as mentioned in the manufacturer's data sheet will be used to calculate spectrum charges. If the manufacturer's data sheet does not contain information on the bandwidth (20dB bandwidth), the following formulate will be used:

For a non-FM modulated radar:

$B_N = 1.79/\sqrt{t * tr}$ or $\frac{6.36}{t}$; whichever is less

For FM pulse radar:

$B_N = 1.79/\sqrt{t * tr} + 2B_c$

For FM pulse radar (with frequency hopping):

$B_N = 1.79/\sqrt{t * tr} + 2Bc;$

For frequency hopping radars using non-FM pulses (including spread spectrum or coded pulses:

$B_N = 1.79/\sqrt{t * tr} + B_{s;}$

for FM/CW radars B(necessary) = $2B_d$

$B_N = 2B_{d;}$

Where:

B_N = necessary bandwidth in MHz

Bc = bandwidth of the frequency deviation (the total frequency shift during the pulse duration) in MHz.

B_d = bandwidth of the frequency deviation (peak difference between instantaneous frequency of the modulated wave and the carrier frequency for FM/CW radar systems) in MHz.

Bs = maximum range in MHz over which the carrier frequency will be shifted for a frequency hopping radar.

t = emitted pulse duration in μ sec at 50% amplitude (voltage) points. For coded pulses, the pulse duration is the interval between 50% amplitude points of one chip (sub-pulse). The 100% amplitude is the nominal flat top level of the pulse.

t_r = emitted pulse rise time in μ sec from the 10% to the 90% amplitude points on the leading edge. For coded pulse, it is the rise time of a sub-pulse; if the sub-pulse rise time is not discernible, assume it is 40% of the time to switch from one phase or sub-pulse to the next.

Radars will deploy best practices to reduce Unwanted Emissions (Out of band and spurious emissions)

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List of Acronyms

3G	Third Generation
3GPP	3rd Generation Partnership Project
4G	Fourth Generation
5G	Fifth Generation
5GAA	5G Automotive Association
5GC	5G Core Network
5GS	5G System
AAI	Airport Authority of India
ABS	Anti-lock Braking System
ACMA	Australian Communications and Media Authority
ADAS	Advanced Driver Assistance Systems
AGR	Adjusted Gross Revenue
ApGR	Applicable Gross Revenue
AI	Artificial Intelligence
AIR	Authorised Indian Representative
ARAI	Automotive Research Association of India
BNCAP	Bharat New Car Assessment Program
BSNL	Bharat Sanchar Nigam Limited
C-DAC	Centre for Development of Advanced Computing
C-DoT	Centre for Development of Telematics
C-ITS	Cooperative Intelligent Transport Systems
C-V2X	Cellular Vehicle-to-Everything
CA	Carrier Aggregation
CAB	Conformity Assessment Bodies
CAICT	China Academy of Information and Communications Technology
CAV	Connected and Automated Vehicles
CB	Certification Body
CCA	Controller of Certifying Authorities
CCAM	Cooperative, Connected and Automated Mobility

CCMS	Cooperative Credential Management System
CCSA	China Communications Standards Association
CEPT	European Conference of Postal and Telecommunications Administrations
CFR	Code of Federal Regulations
CLW	Control Loss Warning
COAI	Cellular Operator Association of India
CSMA	Carrier Sense Multiple Access
CSW	Curve-speed warning
D2D	Device-to-Device
dBm	decibel-milliwatts
DoT	Department of Telecommunications
DSRC	Dedicated Short Range Communication
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPC	Evolved Packet Core
EPS	Evolved Packet System
ER	Essential Requirements
ETC	Electronic Toll Collection
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FNPRM	Further Notice of Proposed Rulemaking
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPS	Global Positioning System
GR	Gross Revenue
GSO	Geo-Stationary Orbit
GSR	General Statutory Rules
I2N	Infrastructure to Network

IAFI	ITU-APT Foundation of India
ICAT	International Centre for Automotive Technology in India
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFMC	In-Flight and Maritime Connectivity
ILAC	International Laboratory Accreditation Cooperation
IMT	International Mobile Telecommunications
IoT	Internet of Things
IoV	Internet of Vehicles
IP	Internet Protocol
ISED	Innovation, Science and Economic Development
ITE	Institute of Transportation Engineers
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
IVHS	Intelligent Vehicle-Highway Systems
LiDAR	Light Detection and Ranging
LTE	Long Term Evolution
M2M	Machine to Machine
MAC	Media Access Control
MeitY	Ministry of Electronics and Information Technology
MHz	Mega Hertz
MIC	Ministry of Internal Affairs and Communications
MIIT	Ministry of Industry and Information Technology
MIMO	Multiple Input Multiple Output
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MoD	Ministry of Defence
MOLIT	Ministry of Land, Infrastructure and Transport
MoRTH	Ministry of Road Transport and Highways
MSIT	Ministry of Science and ICT
MTCTE	Mandatory Testing and Certification of Telecommunication Equipment

MTNL	Mahanagar Telephone Nigam Limited
NCAP	New Car Assessment Programs
NCCS	National Centre for Communication Security
NCIIPC	National Critical Information Infrastructure Protection Centre
NFAP	National Frequency Allocation Plan
NHAI	National Highways Authority of India
NPA	National Police Agency
NPRM	Notice of Proposed Rulemaking
NR	New Radio
NTIA	National Telecommunications and Information Administration
OBU	On-Board Units
OEM	Original Equipment Manufacturer
OFCOM	Office of Communications
OOBE	Out of band emission
OVW	Oversize Vehicle Warning
P2N	Pedestrian to Network
PKI	Public Key Infrastructure
PMRTS	Public Mobile Radio Trunking Service
QoS	Quality of Service
R&O	Report and Order
RCAI	Root Certifying Authority of India
RCVW	Railroad Crossing Violation Warning
RF	Radio Frequency
RLVW	The Red-Light Violation Warning
RSU	Raodside Units
RSZW	Reduced Speed Zone Warning
SACFA	Standing Advisory Committee on Frequency Allocation
SAE	System Architecture Evolution
SCMS	Security Credential Management System
SDG	Sustainable Development Goals
SDO	Standard-Development Organizations

SIAM	Society of Indian Automobile Manufacturers
SL	Side Link
SMEV	Society of Manufacturers of Electric Vehicles
SRD	Short Range Devices
SSGA	Stop Sign Gap Assist
SSVW	Stop Sign Violation Warning
SWIW	Spot Weather Information Warning
TAC	Technical Acceptance Certificate
TEC	Telecommunication Engineering Centre
TRAI	Telecom Regulatory Authority of India
TSDSI	Telecommunications Standards Development Society, India
ULS	Universal Licensing System
UN	United Nations
UNECE	United Nations Economic Commission for Europe
USD	United States Dollar
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure
V2N	Vehicle to Network
V2P	Vehicle to Pedestrian
V2V	Vehicle to Vehicle
V2X	Vehicle-to-Everything
VER	Vehicle Emergency Response
VRU	Vulnerable Road User
VSAT	Very Small Aperture Terminal
WAVE	Wireless Access in Vehicular Environments
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WPC	Wireless Planning and Coordination
WTSA	World Telecommunication Standardization Assembly