Recommended Practices for DSRC Licensing and Spectrum Management

A Guide for Management, Regulation, Deployment, and Administration for a Connected Vehicle Environment

www.its.dot.gov/index.htm
Final Report — December 2015
FHWA-JPO-16-267

U.S. Department of Transportation

Produced by the Intelligent Transportation Society of America
U.S. Department of Transportation
Federal Highway Administration

Notice

Technical Report Documentation Page

1. Report No. **FHWA-JPO-16-267**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Recommended Practices for DSRC Licensing and Spectrum Management: A Guide for Management, Regulation, Deployment, and Administration for a Connected Vehicle Environment		**5. Report Date** December 2015 **6. Performing Organization Code**
7. Author(s) Steven Bayless, Adrian Guan, and Anthony Shaw, (ITS America); Mark Johnson, (Squire Sanders Patton Boggs); and Gary Pruitt and Bruce Abernathy (Rockwell Collins/ARINC)		**8. Performing Organization Report No.**
9. Performing Organization Name And Address Intelligent Transportation Society of America (ITS America) 1100 New Jersey Ave. SE, Suite 850 Washington, DC 20003		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH61-13-D-00017
12. Sponsoring Agency Name and Address United States Department of Transportation Federal Highway Administration 1200 New Jersey Ave. SE Washington, DC 20590		**13. Type of Report and Period Covered** **14. Sponsoring Agency Code**
15. Supplementary Notes Volker Fessmann, FHWA Government Task Manager		

16. Abstract

The goal of this document is to make licensing requirements transparent and best practices accessible to any organization, public or private, seeking to deploy "Connected Vehicle" Dedicated Short Range Communications (DSRC) Roadside Units (RSU) and services that support vehicle-to-infrastructure (V2I) applications.

17. Key Words	18. Distribution Statement
DSRC, Connected Vehicle, Spectrum, Licensing, Management, Regulation, 5.9 GHz, Communications, Wireless, Vehicle, Highway, intelligent transportation systems	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

Acknowledgements

ITS America would like to thank Virginia Department of Transportation, Maricopa County (Arizona) Department of Transportation, Virginia Tech Transportation Institute, and the University of Michigan Transportation Institute for providing feedback to the authors on some of the issues addressed in this document.

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Introduction

The goal of this document is to make licensing requirements transparent and best practices accessible, to any organization, public or private, seeking to deploy Connected Vehicle Dedicated Short Range Communications (DSRC) Roadside Units (RSU) services that support vehicle-to-infrastructure (V2I) communications.

The U.S. Department of Transportation's Connected Vehicle program seeks to ensure that vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications are available to support crash avoidance, mobility, and other intelligent transportation applications. Crash avoidance applications which utilize Dedicated Short Range Communications are currently being designed to exchange critical safety and other data among neighboring vehicles, pedestrians carrying mobile devices, and roadside traffic control systems, with the goal of reducing the risk of collisions or other disruptions to traffic flow. Under the U.S. DOT's Connected Vehicle program, the Federal government hopes to facilitate the deployment of DSRC in light-duty vehicles sometime beyond 2015.

Spectrum is a finite resource, and poor management of spectrum assets may reduce the performance of safety or other "mission critical" intelligent transportation applications. Challenging spectrum environments are likely to include local areas where different DSRC applications operate in close quarters with each other or with other non-DSRC based communications such as licensed fixed satellite service communications, licensed government radio-location (radar) services, and secondary and unlicensed services.

For DSRC-based Connected Vehicle applications, the mobile service allocation is limited to Dedicated Short Range Communications Service (DSRCS) systems operating in the Intelligent Transportation System (ITS) radio service communications frequency band as defined by the Federal Communications Commission (FCC) in CFR 47 Part 2.[1] In the United States, the DSRC service operates in the 5850 – 5925 MHz band (henceforth the 5.9 GHz band), and coexists as a primary use along with other Federal users authorized by the National Telecommunications and Information Administration (NTIA), as well as with a number of commercial satellite operators. These federal users and commercial satellite users have transmitters deployed in relatively distant and isolated areas with respect to the most trafficked roadway networks. In some cases, however, deployments may be near outer suburban and rural corridors. This document recommends a process for coordinating with these users to reduce interference.

Coordinating with other DSRC roadside service providers will also be an important ongoing management task. In field deployments, adapting the design, siting, placement, location, power, antenna, and other elements that maximize performance of DSRC roadside units will be important for organizations deploying DSRC-based applications. This document addresses these spectrum management practices to reduce the risk of various unintended effects, such as the so-called "hidden terminal," multi-path, or channel overload effects.

[1] See: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title47/47tab_02.tpl. (last accessed November 2015)

This guide begins by introducing the institutional capacities a public agency or private entity wishing to deploy DSRC RSUs may find it necessary to acquire. Next, this guide offers guidance on complying with FCC service rules, followed by a discussion of field deployment planning and spectrum management considerations. Finally, this guide offers guidance on the process for licensing and registering DSRC equipment, guidance which includes practical considerations for filing with the FCC and process flows for RSU deployment.

Audience for Recommended Practices

The audience for this guide includes all public sector institutions, be they local, tribal, county, state, or federal entities seeking to plan, deploy, and operate DSRC-related services. However, most requirements for obtaining an ITS Radio Service/DSRC RSU license are the same for private entities as public entities.

The guide describes establishing and maintaining ITS Radio Services/DSRC services from planning, deployment, commissioning, monitoring, and optimization, to the decommissioning of RSUs. The end of this document includes a flowchart that describes the decisions and steps needed to meet all licensing and spectrum management requirements.

Changing Regulations and Provisional Recommendations

Where requirements for road operators may be unique to all other DSRC users, such as in the provisioning of traffic control devices, this document highlights implications and impacts and makes non-binding recommendations and best practices. Recommendations addressed are institutional and management practices for planning organizations, State road operators, or similar entities.

Road operators may need to coordinate their RSU deployment and operations with different entities, be they public or private organizations, in order to manage spectrum resources. Responsibilities include reviewing FCC service rules, regulations, and technical requirements; field deployment and planning; licensing administration; and ongoing management activities.

The technical and service rules governing DSRC are evolving and will continue to evolve in conjunction with changes in Connected Vehicle architecture and application services. Even when the FCC released its DSRC rules Report and Order in 2004, the commission declined to resolve a number of issues, suggesting that the commission could revisit issues later, if necessary, should DSRC deployment show such issues to represent unique challenges.

To address key gaps or ambiguities, this document includes a number of “Special Notes,” sections which describe limitations where the regulation, administrative practices, deployment planning, and operations may evolve and impact an RSU equipment operator or application service provider in the future.

Of particular interest is the FCC's current proposal to change the technical and service rules to allow unlicensed use of the 5.9 GHz band. Under 47 CFR Part 15[2], any future unlicensed devices must not cause any interference with primary devices operating within the assigned spectrum, and must accommodate any interference caused to them by primary and secondary services. As of publication of this guidance, the FCC is currently considering establishing rules to mitigate the risks to DSRC from future unlicensed devices (e.g., next generation of Wi-Fi).

[2] See: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title47/47cfr15_main_02.tpl. (last accessed November 2015)

Institutional Capacities for Spectrum Management

Organizations seeking to deploy vehicle-to-infrastructure applications must install RSU equipment and obtain an FCC license and registration for each RSU site. These organizations also need the institutional knowledge and resources to address the following:

Compliance with FCC Service Rules and other Regulations, including regulations implementing the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA):[3] These rules and regulations describe the roles and responsibilities of a licensee with regard to FCC regulations, and identify limitations or places where the regulation might evolve and impact a licensee in the future.

Planning and Field Deployment: FHWA is preparing Guidance to identify the significant parameters and guidance on design, siting, placement, ensuring optimal performance of the radio, and testing and certification of equipment.

Manage Spectrum: Expertise will be needed to identify necessary services to detect and mitigate radio frequency interference and manage service capacity.

Administration of Licensing and Registration: As summarized in this Guide, the FCC provides knowledge about how to obtain and maintain a license from the FCC, how to address interference, how to coordinate between adjacent jurisdictions, and other topics deemed necessary to administer a site.

The following competencies and resources are essential before deployment:

A. Access to or direct knowledge and capability to perform frequency coordination, deployment, and interference analysis, including access/use of any FCC-specified propagation model to determine interference and all deployment planning elements:
    a. Site selection, deployment design, and service planning;
    b. DSRC site installation (physical considerations, installation, integration, power, and backhaul);
    c. Radio frequency analysis and requirements (power level, multipath, and hidden terminal effects analyses); and
    d. Service planning (overlapping service areas, service arbitration, and channel allocation).
B. Access to or direct knowledge of the geographic elements of the road network needed to properly deploy RSU application services in a way that minimizes potential service channel conflicts, especially for safety-of-life and public safety services.
C. Access to or direct capacity to maintain a database that integrates DSRC RSU licensing and site registration data from the FCC with other configuration data, such as data

[3] See: https://www.fcc.gov/encyclopedia/tower-and-antenna-siting.

required for the WAVE Management Entity or a future designated Security Credential Management System. (WAVE stands for Wireless Access for Vehicular Environments, and is described in the IEEE 1609 family of standards.)

D. General access to or direct knowledge of other practices relevant to the deployment, commissioning, monitoring, remediation, optimization, and decommissioning of intelligent traffic control systems.

In general, all configuration and management data should be maintained, including data related to FCC licensing, site requirements and all technical and service rules governing the 5.9 GHz band. The 5.9 GHz band should be maintained to ensure that any organization can troubleshoot difficulties, such as errors in configuration and operation, or malicious attempts to manipulate DSRC services.

There will be a number of authorities that may possess the relevant institutional capacities needed to manage spectrum, comply with FCC rules, deploy components, and administer sites. Such organizations may include, but are not limited to:

- Transportation infrastructure operators, including operators of public and private roads, or parking/depot/dock or multi-modal facilities (such as transit or rail terminals, freight or passenger rail terminals, rail/road crossings, airports or other aerospace facilities, or maritime ports).
- Special types of road users, including public safety entities, transit and other passenger carrier fleets, freight carrier fleets, and other non-public and private vehicle fleets with associated transportation infrastructure connected to road networks.

For the purposes of this document, *road users* are any entity – pedestrian, vehicle driver, vehicle passenger, or organization – that seeks to use road networks, road rights-of-way, or other road-networked facilities to convey passengers or freight from an origin to a destination.

A *transportation infrastructure operator* is any entity that may be responsible for the operations of road networks or road-networked facilities open to public travel, including single and multi-modal terminals and other transportation-related facilities. Transportation infrastructure operators include any local, tribal, State, or federal government entities involved in the planning, construction, or operation of road networks. Transportation infrastructure operators may also include other types of operating agencies such as transportation regulators, planning organizations, or special operating authorities (e.g. departments of motor vehicles, metropolitan planning organizations, port authorities, maintenance organizations, etc.).

Special Note:
Centralized Management and Services Organization

Although not required, it is strongly recommended – especially for organizations supporting public safety missions – to identify a single organization in their State or in a Federal Highway Administration (FHWA) region to collect and store data for reference regarding FCC licensing and registration, along with other higher level service data (e.g. management information like configuration information, "service" channel advertisements or security credentials, and other data not directly related to acquiring and maintaining an FCC license). Any road operator can contact their regional FHWA office if they need information on options in their region.

Public safety entities include organizations that support road users (and may also be road users themselves) or transportation infrastructure operators. Public safety entities include police, fire,

emergency medical services, and other traffic "incident management" entities at all levels of government, as well as non-governmental, private entities in public-private partnerships. Public safety entities have the responsibility to manage and control public safety on the infrastructure associated with their license area, and in accordance with normally accepted practices, or in accordance with jurisdictional agreements that impose requirements for public safety.

Road operators and other public agencies with planning and operations branches (or other in-house capacity with which to manage telecommunication and information services) are often the best types of organizations to take on spectrum management, site planning/deployment, and licensing/ registration tasks. A number of third parties (either public or private) may also be supportive, such as:

- State, regional, or metropolitan transportation planning organizations;
- Public safety entities (e.g. police, fire, emergency medical services, and other traffic incident management entities and their support organizations, at any level of government);
- Frequency coordinators or other public- or private-sector management services organizations;
- Public or private third-party site registration or other service management organizations under contract with a public agency or private organization;
- The FHWA and its regional offices;
- The V2I Deployment Coalition administered[4]; and
- U.S. DOT Affiliated Testbeds and/or universities and academic research centers that have deployed RSU sites in the past.

Each organization deploying an RSU needs to identify organizations and points of contact in adjacent jurisdictions, regularly interact with these organizations, and establish a spectrum/channel coordination process locally. (See Administration of Licensing and Registration section) An organization possessing the knowledge and resources to act as a management services organization to support interactions across multiple jurisdictions could be a State authority or office, such as an organization within a State road operator, or a designated State-level

Special Note: Security Management and Licensing

One major management issue is security. It is likely that a future Security Management Credential System (SCMS) will issue credentials to RSU application service providers. These credentials, or certificates, assure all road users that the RSU application service providers are legitimate and the services they are providing are functioning as intended. A future SCMS will likely consult the FCC's licensing database to ensure that a given RSU application service provider is complying with FCC requirements, and that RSUs are operating in accordance to their license and registration profile. For more information, please refer to U.S. DOT's Connected Vehicle Certification page at:

http://www.its.dot.gov/connected_vehicle/connected_vehicle_cert.htm.

[4] This coalition is administered by the American Association of State Highway Transportation Officials (AASHTO), ITS America, and the Institute of Transportation Engineers (ITE). For additional details on the coalition, see: http://www.transportationops.org/blog/headline-news/vehicle-infrastructure-deployment-coalition-host-workshop-following-its-americas. (Last accessed, October 2015)

organization such as an office of public safety communications. Another option could be a national or regionally chartered credential or management authority such as a frequency coordinator.

The chart shown in Figure 1 illustrates the highest-level process for ensuring that FCC and other spectrum management requirements are met over the lifecycle of an RSU deployment. Specifically, the figure addresses deployment, commissioning, monitoring, remediation/optimization, and at the end of the lifecycle, decommissioning or replacement.

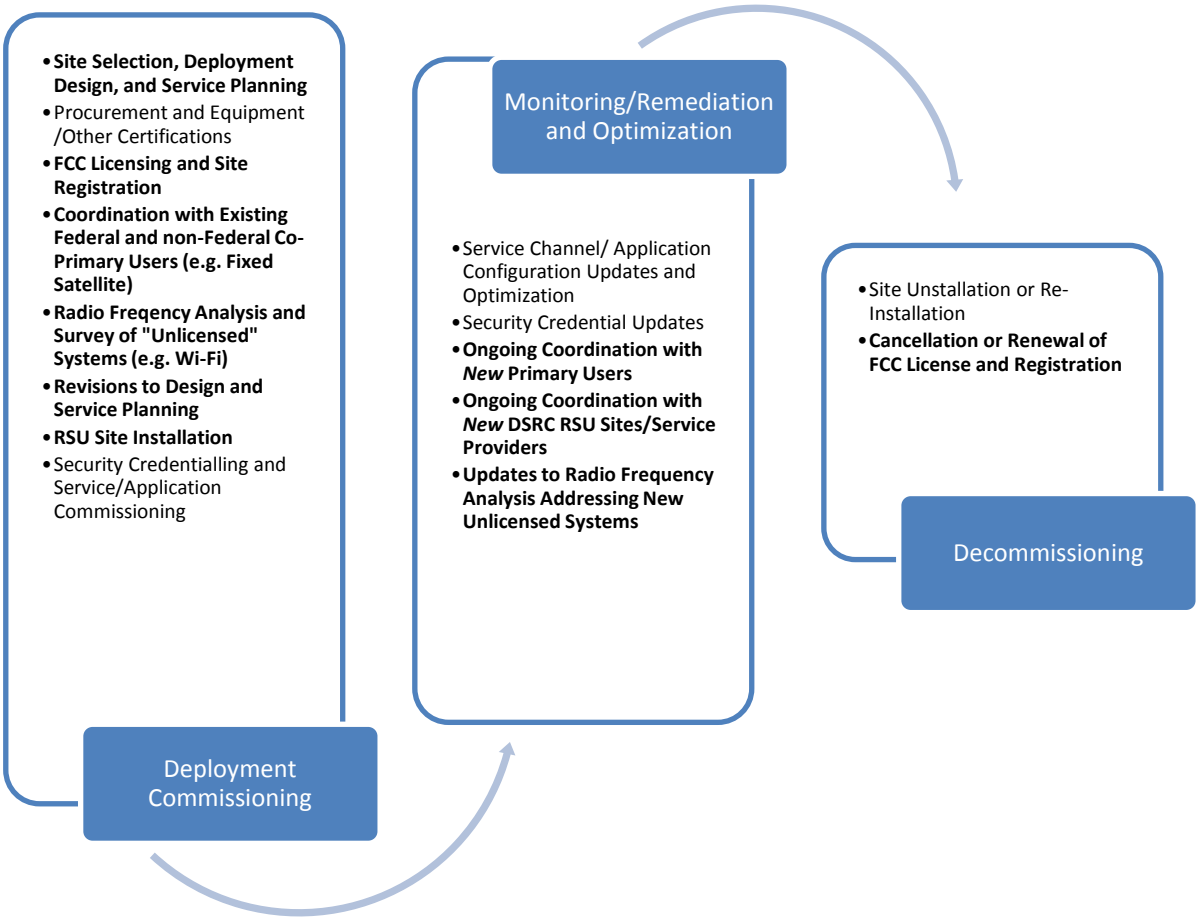

Figure 1: High Level Management Responsibilities for DSRC Service Lifecycle (words in bold relate to deployment, regulation, field deployment, and administration). Source: ITS America. Used by permission.

Compliance with FCC DSRC Service Rules and Other Regulations

This section presents the licensing and service rules for the DSRC service in the ITS Radio Service 5.9 GHz band. On February 10, 2004, the FCC released its Report and Order (FCC R&O) setting forth licensing and service rules for DSRC services in the 5.9 GHz Band.[5] This FCC R&O states that DSRC RSUs will be licensed in accordance with 47 CFR Part 90 Subpart M[6] of the FCC's rules, while vehicle onboard equipment (OBE) DSRC devices will be licensed in accordance with 47 CFR Part 95 Subpart L[7] of the FCC's rules. FCC Public Notice DA 04-3165[8] provides the details of the DSRC RSU licensing process. In their R&O, the FCC focused the technical and service rules on interoperability, priority framework for control, safety-of-life and public safety services, application scope, eligibility for service providers, and spectrum management and coordination.

DSRC Service Interoperability

To ensure interoperability and robust deployment, the FCC adopted a single communications standard known as the "ASTM-DSRC Standard." All licensees must conform their operations and equipment to this standard as a rule. Licensees should be aware that the industry accepted standard has been subject to change over time and that FCC may change its rules to reflect these changes. (See "Special Note on Interoperability" below.)

[5] *In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, WT Docket No. 01-90, ET Docket No. 98-95, Report and Order, FCC 03-324 (rel. Feb. 10, 2004).
[6] See: http://www.ecfr.gov/cgi-bin/text-idx?SID=4dad5dcee4ae8428ee55ade036ec86d9&node=sp47.5.90.m&rgn=div6. (Last accessed October 2015)
[7] See: http://www.ecfr.gov/cgi-bin/text-idx?SID=933fbc0d373cc947e6a650052afbabb3&mc=true&node=sp47.5.95.l&rgn=div6. (Last accessed October 2015)
[8] See: https://apps.fcc.gov/edocs_public/attachmatch/DA-04-3165A1.pdf. (Last accessed October 2015)

Special Note on Interoperability: Update of ASTM-DSRC Standard

Since publication in September 2003, there have been updates and a formal transfer of the standard from ASTM to IEEE. At the request of DSRC stakeholders, the FCC kept open the DSRC proceeding for a potential update in the FCC's rules to the adopted version of the ASTM-DSRC Standard. There is now an IEEE 802.11-2012 and IEEE 1609 protocol for DSRC that replaces the ASTM-DSRC standard. It may be necessary to update the FCC's rules to reference the new, evolving IEEE 802.11-2012 and IEEE 1609 standards. (The auto industry considers the Physical and Media Access Control portions of ASTM-DSRC to be deprecated in favor of the IEEE 802.11p standard, which was incorporated into the IEEE 802.11-2012 standard.)

Since 2004, this standard has evolved along with other elements of the Connected Vehicle architecture and application services. Various organizations have used the ASTM-DSRC Standard and revised it to develop a number of vehicle-to-vehicle and vehicle-to-infrastructure applications and to support test infrastructure. As of this report, most automakers, automotive suppliers, and road operators use IEEE 802.11-2012 and IEEE 1609 standards in their test configurations.

DSRC systems are designed to have seamless operations across all jurisdictional boundaries based on the incorporation of IEEE 802.11p as defined in IEEE 802.11-2012 and IEEE 1609. This configuration in general has met the FCC's requirements, and is recognized as the *de facto* standard by automotive, aftermarket, and roadside equipment manufacturers and application developers. Other standards beyond the physical and media access layers, such as for internetworking, security, and applications, are also standardized in the IEEE 1609 and SAE J2735 standards, among others. SAE J2735 defines the message structure and thus is the standard for messages associated with DSRC applications. Certification testing for standards compliance and interoperability by a designated DSRC certification body is covered in other chapters of this guide.

DSRC Channel Plan and Service Priority Framework

The FCC adopted the proposed band plan consisting of seven channels of 10 MHz each (70 MHz total), including a control channel as the center channel and a reserve of 5 MHz just below channel 172.

5.850 GHz				5.885-5.895 GHz			5.925 GHz
		Channel 175			Channel 181		
5850-5855 reserve 5 MHz	CH 172 service 10 MHz	CH 174 service 10 MHz	CH 176 service 10 MHz	CH 178 control 10 MHz	CH 180 service 10 MHz	CH 182 service 10 MHz	CH 184 Service 10 MHz

Figure 2: DSRC Service Channel Plan. Source: FCC Report and Order, 2004.

The 5.9 GHz band is divided into seven ten-megahertz channels consisting of one control channel (CH 178), six service channels, and one five megahertz channel, which would be held in reserve. The FCC will issue an unlimited number of non-exclusive licenses to State, local, and

other non-federal government public safety and non-public safety entities authorizing operation on seventy megahertz of the 5.9 GHz band, excluding the reserve channel.

The control channel (CH 178, at 5.890 GHz) is defined for use by RSU service providers to transmit high priority safety messages and to announce or "advertise" services. Two channels (CH 180 and CH 182) are designated for low-power, short-range communications. Two channels (CH 174 and CH 176) are designated for medium-power, medium-range communications. Channel 184 is specifically designated for high-power, longer-range safety-of-life applications such as intersection collision avoidance.

The band plan supports the Control Channel Protocol. According to the adopted band plan, Channel 178 (5.885-5.895 GHz) is designated as the control channel, which must be accessed periodically by every OBU for instructions or to complete short, public safety priority transmissions. OBUs are required to listen to the control channel typically every 50 milliseconds to check for public safety messages or instructions to switch to a service channel to acquire information of interest and complete a transmission. Services provided on a channel are advertised on CH 178, and these advertisements are managed by the RSU operator.

Before transmitting, an RSU or OBU must first monitor the channel, and if another message is being transmitted, it must wait before initiating its transmission. This is a channel access process defined by IEEE 802.11-2012 called "Carrier Sense Multiple Access/Collision Avoidance" (CSMA/CA). If an RSU or OBU leaves the control channel to transmit on a service channel, they must return to the control channel to check for public safety messages or other instructions.

The band plan also reflects a "priority framework." The control channel priority scheme, according to the FCC, is also capable of giving priority access to safety-of-life and public safety communications.[9] In other words, a higher priority communication will precede channel access of lower- or non-priority communications, when necessary. The priority access process is also defined in the IEEE 802.11-2012 standard. The lower- or non-priority communication will be sent after the higher priority communication is completed. While acknowledging that work is continuing on the upper protocol layers of the ASTM-DSRC standard to establish the priority message protocols, the FCC adopted a three-level priority framework for DSRC as follows:

1. *Safety-of-Life.* DSRC communications involving an imminent threat to safety of life must have access priority over all other DSRC communications. This highest priority level applies to safety-of-life communications regardless if associated with traditional public safety entities (such as State and local governments) or with non-governmental entities (such as for vehicle-to-vehicle collision avoidance messages exchanged among road users and between road users and road operators).

[9] The FCC, however, rejected proposals to reserve certain service channels for specific applications, such as Channel 172 for vehicle-to-vehicle communications. Rather, all users, public safety and non-public safety, are to be licensed to operate on all channels. Nonetheless, the FCC designated channel 172 for vehicle safety communications and other high priority applications, and Channel 184 for high power public safety and intersection collision avoidance applications.

2. Public Safety vs. Non-Public Safety. Public safety communications, whether by traditional public safety entities or other qualifying entities, must have priority access over all DSRC communications except safety of life. (Communications by the following entities are presumed to be public safety: State and local governments, possessions, territories, districts, and authorities including mass transit and toll authorities, among others – see next section on "eligibility.")

3. One Safety/Public Safety vs. Another Safety/Public Safety. Determining priority of communications among entities within the safety and/or public safety priority levels is to be determined by Federal, State, or local transportation agencies working in coordination. (See previous section on "Institutional Capabilities.")

Open Eligibility for DSRC Service Providers/Users

The FCC concludes that public safety and non-public safety (i.e. private) services can utilize the 5.9 GHz band. The FCC also adopts a priority message scheme to ensure that safety and public safety communication services receive priority status which is implemented through the Enhanced Distributed Channel Access (EDCA) and CSMA/CA channel access processes.

Entities providing public safety and non-public safety services can be granted non-exclusive geographic area licenses to operate fixed RSUs. Government entities will be licensed for a geographic area consistent with their legal jurisdictional area of operations. Private entities will be licensed for an area based on its area of operations, such as State, county, or nationwide. Licensees must restrict the license area to that in which they will install RSUs.

Special Note: Public Safety Services vs. Public Safety Entities

The FCC uses "public safety" to refer to both services and entities. However, it is not altogether inconceivable that a private sector entity may provide a safety-of-life or public safety service. This confusion between services and entities may present problems when organizations apply for a license. (See the "Administration" section regarding license type.) For example, if a private sector entity provides a safety-of-life or public safety service on channels 172 or 184 from an RSU, it must be a bona-fide service and should be at least indirectly or informally endorsed by a road operator or regulator responsible for traffic safety.

All licensees can seek authority to operate in all DSRC channels across the 70 MHz of the 5.9 GHz band. However, safety-of-life and public safety communications have priority over all other communications, which means that channels designated for public safety communications cannot be used for commercial and private communications. In addition, the FCC has designated Channel 172 exclusively for vehicle-to-vehicle safety communications for accident avoidance and mitigation, and safety-of-life and property applications. Similarly, Channel 184 is designated exclusively for high-power, longer-distance public safety applications involving safety-of-life and property.

The FCC has declared the following entities eligible to hold an authorization to operate RSUs in the 5.9 GHz band: any territory, possession, State, city, county, town, or similar governmental entity, and any public safety or industrial/business entity meeting the eligibility requirements of

FCC Rule 47 CFR 90.33 or 90.35. In addition, the FCC will issue an unlimited number of non-exclusive licenses to non-federal government public safety and non-public safety entities.

FHWA foresees State and local public safety and private safety entities operating RSUs for the benefit of road users, public safety entities, and transportation infrastructure operators. It is envisioned that jurisdictions will have oversight over commercial and private entities using DSRC safety-of-life/public safety channels to communicate safety messages to vehicles. These private organizations may have contracts or agreements with road agencies to provide services related to traffic safety, construction, maintenance on public roads, or other rights-of-way (such as construction firms making road repairs and establishing work zones).

Scope and Application of DSRC Services

The ITS Radio Service was established by the FCC "for the purpose of integrating radio-based technologies into the nation's transportation infrastructure," and is comprised of the Location and Monitoring Service, grandfathered automatic vehicle monitoring systems, and DSRC.

The FCC definition of DSRC is as follows: "The use of radio techniques to transfer data over short distances between roadside and mobile radio units, between mobile units, and between portable and mobile units to perform operations related to the improvement of traffic flow, traffic safety and other intelligent transportation service applications in a variety of environments. DSRC systems may also transmit status and instructional messages related to the units involved."[10]

Special Note: Other Intelligent Transportation Services Applications

The FCC has not defined "other intelligent transportation service applications." However, road operators may interpret this term to mean any application that benefits road users, public safety entities, or transportation infrastructure operators beyond improvements in transportation mobility and safety.

An RSU is a DSRC transceiver that is mounted along a road or pedestrian passageway and typically linked to a wide area communications infrastructure for backhaul to a service, maintenance, or management center. An RSU may also be mounted on a vehicle or be hand-carried, but under the FCC's rules, such RSUs may only operate when the vehicle or hand-carried 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.

On-board units, such as those installed in vehicles, are "licensed by rule" and will not require individual licenses for each deployed OBU. An OBU is a DSRC transceiver that is "normally" mounted in or on a vehicle, or in some instances may be a portable unit. An OBU may also be considered as a pedestrian-carried portable device such as a smartphone with a DSRC radio chip set that allows it to communicate with RSUs and other OBUs.

[10] *In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, WT Docket No. 01-90, ET Docket No. 98-95, Report and Order, FCC 03-324 (rel. Feb. 10, 2004).

An OBU can be operational while a vehicle or person is either mobile or stationary. Except where specifically excluded, OBU operation is permitted wherever vehicle operation or human passage is permitted. So called “portable” OBUs are also authorized by 47 CFR Part 95 rules and may be, for example, aftermarket devices brought into the vehicle or carried by pedestrians, as long as the device is tested to comply with FCC rules and nationally recognized standards supporting OBU and RSU communications.

DSRC Service Spectrum Management and Sharing

Coordination between DSRC service providers ensures that spectrum resources are properly managed and available to support transportation safety, as specified in the FCC’s current technical and service rules addressing DSRC, and guidance or regulation issued by modal administrations of U.S. DOT.

In addition to DSRC, other specific non-federal radio services authorized in the 5.9 GHz band include Fixed Satellite Service (FSS), fixed microwave service, and amateur radio service radios. Federal government high-power radars operating in the radiolocation service also operate in the 5.9 GHz band. The locations of the federal government radars are listed in FCC rule 47 CFR 90.371. The FCC’s rules specify that any RSU deployed within 75 km of one of these high-powered radar sites listed in FCC Rule 47 CFR 90.371 must be coordinated via NTIA. (Note that NTIA may update and change the sites listed in FCC Rule 47 CFR 90.371.)

Special Note: Potential Interference from Unlicensed Devices

Spectrum management responsibilities may be made more complicated if unlicensed or other secondary users are in the band. Unlicensed services must be monitored to ensure they comply with FCC rules, and do not reduce the availability or utility of DSRC applications. It may not be possible to locate the owner/operator of an offending unlicensed transmitter to coordinate activity, since they are not required to register with the FCC. However, interference issues, if persistent, may be addressed directly with the FCC’s Office of Engineering and Technology or the Enforcement Bureau.

Primary Spectrum Management Responsibilities

DSRC, FSS, and U.S. military radars are each “co-primary” with one another in the 5.9 GHz band. A “primary” user has the highest rights to use the spectrum, free from interference from all other services. Co-primary users share “primary” rights and must coordinate with other users. A number of unlicensed services are in the band, and unlicensed users cannot cause, and must accept, interference from primary and secondary users. There may also be operations in adjacent bands that may cause interference into DSRC services from so-called “out-of-band” emissions.

Generally, the FCC encourages the receiver of interference to contact the owner/operator of the transmitter causing the interference to resolve the interference issue. Where there are secondary users causing interference, the secondary user must resolve the interference issue to the satisfaction of the primary user, including stopping its operations. If the interferer is in an adjacent band and the emissions do not comply with the FCC emission mask or other requirements, then FCC can enforce compliance with its rules.

The following constitute the main responsibilities of RSU site operators or owners in reference to other service providers that are "primary" in the 5.9 GHz band.

Coordination with U.S. Military Radars: The FCC's DSRC rules require RSUs to be coordinated with U.S. military sites identified in FCC Rule 47 CFR 90.371 if the proposed RSU site is within 75 km of the site, whether or not radars are installed or operational. DSRC frequency assignments will need to be coordinated with local radar assignments to avoid co-channel operations or adjacent interference at short separation distances.

Coordination with Fixed Satellite Service Providers: In the 5.9 GHz band, there are FSS uplink facilities generally located along the east and west coasts of the continental United States. These uplink services also operate on a co-primary basis with DSRC services, but the maximum effective radiated power (ERP) values from such earth station antennas are directed toward the sky, and not toward the terrestrial surface, where new DSRC systems are expected to be deployed. DSRC operations may encounter antenna side-lobe radiation near an FSS earth station. The FCC's rules for FSS, 47 CFR Part 25, require frequency coordination for locating new FSS earth stations in bands in which these systems are authorized to operate, including in the 5.9 GHz band; however, the current rules do not require coordination between DSRC and FSS in the band.

Special Note: Coordination with Satellite Service Providers

The FCC has not yet formally addressed potential sharing and coordination issues between primary DSRC operations and FSS in the 5.9 GHz band. However, a FSS-DSRC spectrum sharing administrative and technical protocol (FSS-DSRC Spectrum Sharing Protocol) developed by the Satellite Industry Association (SIA), AASHTO, and ITS America is available and can provide guidance to RSU service providers. If you are a State road operator, it is recommended you contact AASHTO (www.transportation.org) for more information. Others may contact SIA (http://www.sia.org/) or ITS America (www.itsa.org) for further information.

The coordination processes for both military radar sites and FSS providers are discussed later in the "Administration of Licensing and Registration" section. However, the FCC's DSRC rules do not require formal coordination between two or more RSU application service providers when siting an RSU station. The FCC concluded that formal frequency coordination between RSU DSRC licenses is not necessary for several reasons: (1) the channelization framework established in the adopted ASTM-DSRC standard uses a control channel protocol; (2) the priority framework for DSRC messages as implemented by the IEEE 1609 standards; and (3) use of a "listen-before-talk" feature by DSRC radio equipment (i.e., the media access control features in the ASTM Standard by reference). All of these factors, according to the FCC, reduce the risk of interference and, accordingly, warrant against requiring formal frequency coordination.

Nonetheless, the FCC specified in its technical and service rules that safety-of-life and public safety communications must "…be protected from interference given the consequences to the traveling public should any one of the safety applications fail due to unacceptable error rates or

delay."[11] The FCC confirmed that non-public safety use of the 5.9 GHz band would be inappropriate if such use would degrade safety-of-life and/or public safety applications.

In its technical and service rules for DSRC services, the FCC implicitly encourages adjacent DSRC RSU service providers to consider selecting different service channels in order to reduce the risk of interference and service degradation. It is recommended that all DSRC RSU application service providers coordinate with any other licensed DSRC users with registered sites providing safety-of-life, public safety, or other mission critical services. For details on how this might be accomplished, please see the deployment and spectrum management section of this document.

Other Spectrum Management Considerations

In addition to radars and satellite uplinks, there exist "highly localized" emitters such as devices covered by Part 15 or Part 18 of the FCC Rules (these are typically low power indoor consumer electronics such a microwave ovens, cordless phones, etc.). Most (but not all) of these emissions are spurious emissions, rather than co-channel emissions tuned to center frequencies in this band.

DSRC RSU application service providers will need to conduct RF surveys to ensure that neighboring primary services do not represent interference risk to DSRC services.

Systems operating in the 5.9 GHz band include:

Satellite Service Providers in Adjacent Bands: The FCC's rules do not require frequency coordination between FSS earth stations operating in the adjacent 5.925–6.425 GHz band and RSUs operating in the 5.9 GHz band. However, there will be an area around a limited number of FSS earth stations operating in the 5.925–6.425 GHz band in which RSUs may receive interference from the FSS uplink transmissions, particularly in DSRC Channel 184 (5.915—5.925 GHz).

Amateur Radio: FCC Rule 47 CFR Part 97 does not mention coordination but does state that an amateur radio station must not interfere with primary services in bands in which amateur radio operates.

Industrial, Scientific, and Medical (ISM): ISM devices may escape survey detection under some circumstances. The 5.8 GHz ISM band is 150 MHz wide and spans from 5.725 GHz to 5.875 GHz. As with the other ISM bands, the 5.8 GHz ISM band was originally intended for devices that neither transmit or receive data, but whose operation relies upon radio frequency energy to perform their function (e.g., microwave ovens). Today, the 5.8 GHz ISM band is used by many types of common consumer and industry products, including cordless telephones. The 5.725 – 5.875 GHz portion of the ISM band overlaps with the lower 25 MHz of the 5.9 GHz band. Part 18 of the FCC's rules does not require licensing nor site registration for ISM devices. The ISM owner is responsible for accepting any interference

[11], Report and Order, FCC 03-324, p.12.

from licensed and registered radio sites within the DSRC frequency band and for resolving any interference issues caused by the ISM equipment.

Unlicensed National Information Infrastructure (U-NII): U-NII, authorized under Part 15, Subpart E of the FCC's rules, is a classification for radio devices that employ wideband digital modulation techniques and provide high data rate mobile and fixed communications for individuals, businesses, and institutions. The IEEE 802.11a amendment defines the use of the 5 GHz U-NII bands. Due to the different FCC power requirements, the 5.8 GHz band is a preferred spectrum for long distance fixed point-to-point broadband access and wireless bridging. Please consult the FCC 5 GHz U-NII Notice of Proposed Rulemaking[12] for the latest information before beginning RSU site operations.

[12] Located at: https://www.fcc.gov/document/5-ghz-unlicensed-spectrum-unii. (Last accessed October 2015)

DSRC Field Deployment Planning

It is important for road operators to develop a comprehensive field deployment plan for a system as complicated and distributed as a DSRC system. Road operators must balance application requirements against constraints such as spectrum management considerations and the availability of supporting infrastructure and resources.

Individual RSU applications may have different area coverage requirements, while associated terrain and building structures, in turn, may dictate different installation designs and antenna selection. In addition, each RSU site must meet the collective requirements of all applications deployed at that site (e.g., tolling, intersection collision avoidance, etc.). There are also practical considerations that reduce cost and complexity such as placing RSUs to leverage available resources such as power and backhaul telecommunications conduit, right-of-way accessibility, and other roadside infrastructure (signage, poles, gantries, traffic control devices, etc.).

Service planning must also ensure that FCC regulatory requirements can be met, especially that RSU operations do not interfere with other primary users (e.g., radar and satellite). Furthermore, not only should road operators plan deployments in their own jurisdictions in a systematic way, they should also carefully coordinate their activities with neighboring or overlapping jurisdictions and other DSRC system licensees operating in the area.

Radio frequency analysis is a critical task in RSU deployment. This analysis should address, for example, transmission power levels and risks such as multipath and “hidden terminal” effects. Situations where RSU service areas may overlap is a special case that road operators and other RSU providers must consider.

Site Selection, Deployment Design, and Service Planning

The ease or difficulty of a site location may affect the decision of which DSRC site locations are deployed first. For example, if the area is relatively flat with few buildings or obstructions to RF signals, the layout and location decisions may be straightforward. Conversely, a complex, multi-highway interchange featuring urban canyons with bridges, tunnels, and sunken roadways will require extensive design, analysis and testing to ensure effective RF signal coverage. If a road operator seeks to deploy RSUs in more complicated environments, it is strongly suggested that the agency seek outside expertise in deployment design and service planning relevant to spectrum management.

In most cases, the DSRC services planned for an area deployment need to be identified and developed before installation and implementation begins. Applications, protocols, channel allocation, and data capacity need to be determined. Initially, the applications will be a basic set of safety messages and applications. This will grow as additional public and private applications are developed and deployed.

DSRC system capacity will need to be defined to allow for growth. (System capacity is defined by the selected channel data rate, the length of messages, the frequency of transmission of a

specific message type, and the maximum number of vehicles to be serviced within the communications range.) System capacity may fall when multiple RSU applications overlap geographically and contend for the same service channel. This may create situations where channels are overloaded and application performance is degraded.

Channel use must be managed by RSU application service providers. Those RSU application service providers that are providing safety-of-life or public safety services must manage services in a way that keeps packet error rates (PER) below the designated thresholds for those services, or otherwise as required to maintain the utility and availability of services. If licensees are unable to resolve conflicts, the FCC may impose restrictions, including specifying the transmitter power, antenna height and direction, additional filtering, or the area and/or hours of operation of the stations concerned.

Selecting sites for deployments also requires compliance with FHWA and Federal Communications Commission (FCC) regulations implementing the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA). More information on the FCC's NEPA and NHPA requirements can be found at https://www.fcc.gov/encyclopedia/tower-and-antenna-siting.

RSU Site Analysis for Fixed and Nomadic Locations

Site analysis addresses a variety of issues, such as physical requirements, environmental conditions, application needs, component location, and range, and coverage. Physical requirements include basic elements common to many roadside communications systems or traffic control devices. Siting includes antenna connection and positioning. The RSU antenna is typically mounted about five meters above the roadway. The height of the installation can have a significant impact on the overall RF performance. Where two RSUs are used, antennas must be separated to eliminate mutual interference.

Important environmental factors a governing the selection of a site and the details of the physical installation include:

Local landscape and built-up environment: The environment around the site, especially in relation to the roadways served. For example, terrain, buildings, signs, and the roadway geometry all contribute to the overall RF performance. A poorly-designed installation can introduce multipath effects.

Local weather and seasonal variations in the local environment: For example, exposure to high snow or ice accumulations may have a very negative impact on RF performance. Heavy vegetation that blocks the line-of-sight in a particular direction may have a substantial impact on the range of the system in the affected direction

Application needs and local application conditions must be addressed as well. If applications require an RSU (or RSUs) to communicate with all vehicles entering or leaving a given roadway space (i.e., a highway segment, intersection, road-rail grade crossing, etc.), proper placement inside the right of way is a key consideration. Good RF coverage of a freeway is critical for a number of applications, and agencies should fully understand application-level requirements (e.g. lower packet error rates required for safety or mobility applications).

In many cases, not all applications may be known in advance—an RSU may initially be deployed to support a single DSRC application. However, the initial site design and configuration might not support the RF coverage requirements of future DRSC applications deployed at the same site. In general, the best approach in this case is to locate the RSU so that it maximizes RF coverage. Occasionally, an agency may need to compromise and choose siting that may not be ideal from an RF coverage perspective, but may possess other critical qualities and assets, such leveraging the use of existing infrastructure (i.e.,, poles and other mountings, power sources, and communications backhaul to support proper installation, remote monitoring, and maintenance).

Managing coverage can be addressed by adjusting power output of the RSU; a lower power output can reduce the effective range of the DSRC signal. Reduced power works by shortening the distance at which minimum packet error rate is encountered by a typical OBU. Please note, however, that this approach may not be entirely accurate since different OBUs may possess different radio sensitivity and antenna gain characteristics.

An RSU may also be mounted on a vehicle or is hand-carried, but it may only operate when the vehicle or hand-carried unit is stationary. Portable or hand-held RSUs are permitted to operate where they do not interfere with site-licensed operation."[13] A road operator deploying a portable RSU, for example, would need to search in the FCC's licensing database to identify any local licensed site operators before deploying a portable unit.

Radio Frequency Analysis at Site

Radio frequency analysis includes the consideration of proper RSU power levels, as well as an assessment of the risk and impact of multipath or "hidden terminal" effects. The primary factor governing RSU site analysis is the ability to assure clear line-of-sight access from all lanes of the roadway that the RSU is expected to serve. Once a clear line of sight has been achieved, then the secondary factors of power level need to be addressed, such as the possibility of RSU signal/zone of communications overlap.

Power level margins are necessary to accommodate an acceptable maximum error rate, with the objective being 10% PER. A minimum margin of 10 dB is recommended. Weather conditions, foliage growth, and other factors may impact attenuation of an RF signal. An RF interference test should be made at each candidate site to determine the noise floor.

A search of the FCC International Bureau (IB) via its IBFS database will determine if there are any existing or proposed FSS earth stations that might pose interference risks.[14] If there are no FSS earth station sites in the vicinity, the DSRC applicant would then submit the site for registration in the FCC licensing database before construction. If, however, an FSS earth station

[13] FCC Rule 90.7. See http://wireless.fcc.gov/services/index.htm?job=about&id=smrs for more information. (Last accessed October 2015)
[14] See: http://licensing.fcc.gov/myibfs/. (Last accessed October 2015)

is identified that presents a risk of interference, it is recommended that the FSS-DSRC Spectrum Sharing Protocol[15] be followed for siting the RSU.

For high-powered U.S. military radar sites that are co-primary with DSRC, the FCC licensing database will automatically flag any proposed RSU site location that is within 75 km of a U.S. military radar site. The FCC will coordinate a transmitter location with NTIA/IRAC if required. Licensees need not provide any special information or take any special action other than using the FCC Form 601 Main Form and Schedule M.

An RSU may both cause and suffer interference, and the purpose of RF testing is to determine potential risk. If testing or analyses indicate a potential for significant interference from other nearby primary (e.g., secondary and unlicensed) emitters, there are several options. The first is that RSU can be and antenna patterns adjusted to minimize potential interference risk, assuming no significant impact to RSU applications and service. Another option is to take steps at the original site to mitigate potential interference. Ultimately, the interference can be documented and presented to the FCC for resolution; however, the FCC resolution process can be lengthy.

Overlapping RSU Service Areas and Channel Allocation

Instances of geographically overlapping jurisdictions may result when a State DOT has responsibility for highways while a city has responsibility for arterials in the same geographical area. If these entities do not coordinate their RSU deployments, RSU services may overlap and overload channels, or create situations where hidden terminal effects degrade performance.

Overlapping RSUs may not be an issue in terms of technical performance in every case. The CSMA/CA schemes used in IEEE 802.11 Standard [4] assure that the RSUs will not interfere with each other, as long as they are within range of each other, can detect the channel use by the other, comply with IEEE 802.11 standards, and are using the same channel bandwidths.

Special Note: Radio Frequency Interference vs. Service Channel Overloading

The FCC technical and service rules are often focused on minimizing radio frequency interference between different communications services. Generally, multiple RSUs or OBUs overloading a service channel is not considered interference from the perspective of the FCC's service rules. DSRC licensees using the same channels do not cause RF interference to each other. They do, however, compete for channel use and can cause channel overload. FCC technical and service rules address this problem by giving public safety communications priority of channel use. The IEEE 802.11-2012 standard defines the CSMA/CA process that allows multiple users of channels with access fairness for messages of the same priority.

[15] See the following references:
http://apps.fcc.gov/ecfs/document/view;jsessionid=5p6LR1hcRWMXlhHk05SXYDvB0PjkkZyDnzpHxQ6nV1qgRp5DbfRG!638063854!NONE?id=6520037697 and
http://apps.fcc.gov/ecfs/document/view;NEWECFSSESSION=ns0ZW3LKhhfsrCydJThjGDpDr8VB7hLhHSr0SLm0Bp5p2YTVTGxq!-1135238304!-1678543329?id=6519841843 (Last accessed November 2015)

However, overlapping RSUs should operate on different service channels where possible. Using separate service channels will provide substantially more system capacity, and may also avoid marginal hidden terminal effects. Even though CSMA/CA will allow RSU channel sharing, it means that one channel will be handling messaging for multiple application services provided by two or more overlapping RSUs. With more RSUs using the same channel, there is a risk of overloading the channel. Frequency re-use, which means assigning different service channels to adjacent RSUs, is a more practical approach to spectrum management in urban areas.

Administration of Licensing and Registration

All DSRC license applicants seeking to operate DSRC RSUs, whether road operators, road users, or private service providers, must meet certain requirements to obtain and maintain a license from the FCC. DSRC licenses authorize the applicant to operate in a specified, non-exclusive geographical area and from identified RSU sites within that geographic area. A license applicant must also ensure that equipment at sites is certified to conform to the FCC rules.

The FCC adopted a three-step licensing approach: Applicant Registration, Non-Exclusive Geographical Licensing, and Site Registration.

Step #1: Apply for a FCC Registration Number. Any FCC license applicant must first obtain an FCC Registration Number (FRN) through the FCC's COmmission REgistration System (CORES). This online process requires organization and contact information such as the applicant's name, address, and individual point-of- contact.

Step #2: Apply for Non-exclusive Geographic Area Licensing. An entity must obtain an FCC license before it can register individual RSUs (Step 3). Licensees, both public and private, are to be granted authorization for identified geographic areas, but other licensees may also acquire a license for the same area. Government entities will be licensed to operate in a geographic area consistent with that entity's legal jurisdictional area of operations. Non-governmental entities will be licensed for an area based on each applicant's area of operations, such as by county, State, multi-State, or nationwide. All licensees will be authorized to operate in all channels in the 5.9 GHz band. Licenses will be granted for a term of 10 years and may be renewed. After receiving their FRM (Step 1), in Step 2, geographical license applicants fill out FCC Form 601 using their FRN on-line through the FCC licensing database. An eligible jurisdiction or entity must complete and submit FCC Form 601 and Schedule D[16].

Step #3: Register Site(s) under Geographic License. DRSC licensees are to identify and register their RSU sites, channels, and other relevant data in the FCC's licensing database. Each licensee must register each RSU site in the licensing database under its geographic license. The authority to operate an RSU begins after the FCC screens the filing and posts the registration in the licensing database. Registrations that do not require additional analysis will be processed automatically within one business day (for electronically filed registrations). The licensing database will identify those proposed RSU sites that are subject to coordination with NTIA as they are to be located within 75 km of a U.S. military radar site, which will delay processing. (Note that prior coordination is not required between FSS and DSRC, and the licensing database does not include site location and information regarding FSS earth station sites.) RSUs must be fully constructed and operational one year after site registration is

[16] All of the listed forms can be located at: https://transition.fcc.gov/Forms/Form601/601MainForm_ScheduleA.pdf. (Last accessed October 2015)

completed. An eligible jurisdiction or entity must complete and submit FCC Form 601 and Schedule M to register the RSU and file the FCC Form 601 and Schedule K to certify construction of the RSU.

Equipment Certification

The FCC requires all transponders, transmitters, and transceivers, whether associated with RSUs or OBUs used in the 5.9 GHz band, to be certified in accordance with subpart M of Part 90, subpart L of Part 95, and subpart J of Part 2 of its Rules.[17] (See Special Note on RSU Equipment and Service Certification for more information.) Organizations seeking to deploy RSUs should work with RSU device manufacturers to ensure that devices are certified.

Special Note: RSU Equipment and Service Certification

U.S. DOT intends to certify RSU up to and beyond the requirements specified by the FCC for equipment. To date, however, U.S. DOT has not provided guidance on certification, but will likely do so in a short time frame. U.S. DOT, however, has identified four layers of device and applications certification, one of which includes the FCC requirements in Parts 90, 95 and 2:

1. Environmental performance (e.g., temperature, vibration, weather);
2. Communications protocol conformance (e.g. DSRC radio service interoperability, which includes FCC requirements);
3. Interface conformance (i.e. both the message syntax and contents are formatted properly); and
4. Applications functionality and performance.

U.S. DOT has also identified organizations that will conduct qualification and certification testing of DSRC devices. For the latest information on U.S. DOT's certification program, please refer to U.S. DOT's Connected Vehicle Certification Website located at http://www.its.dot.gov/connected_vehicle/connected_vehicle_cert.htm. In the interim, a prospective RSU application service provider should also consult with the RSU equipment manufacturer regarding whether equipment meets FCC certification requirements before proceeding.

Data Elements in Licensing and Registration

License and site registration information is kept in the FCC's licensing database. The licensing database allows electronic filing of applications to be processed by the commission. It also enables applicants to indicate the application purpose and radio service code, and guides them through the filing process until the application is submitted. The licensing database provides the ability to search for applications by providing information such as a file number, applicant name, or application purpose and to search for licenses by providing information such as a call sign, licensee name, or radio service. Other features of the licensing database include the ability to download application and license data as well as the ability to use mapping software to visually display the specific location or overall geographic area of wireless licenses. This data may be imported into a road agency's asset management database (see "Management" section).

FCC Form 601 requires individuals to identify their geographic area of operations (can be based on geographic jurisdiction, such as State, county, etc.) or at a distance around a geographic point (such as operating within a 40 km radius around a geographic point). FCC Form 601 also

[17] *In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, WT Docket No. 01-90, ET Docket No. 98-95, Report and Order, FCC 03-324 (rel. Feb. 10, 2004).

specifies that applicants identify the relevant frequency band (for DSRC, the fully available band from 5855-5925 MHz). Geographical license applicants who provide safety-of-life and/or public safety services apply for an "IQ" DSRC service license; non-public safety service providers apply for a "QQ" DSRC service license.

The purpose of Main Form 601 is to obtain information sufficient to identify the filer, establish the filer's basic eligibility and qualifications, classify the filing, and determine the nature of the proposed service. In addition to licensing and site registration, FCC Form 601 is used to make subsequent license modifications, amendments, renewals, cancellations, administrative updates, withdraws, requests for extensions, and registration of location, among other elements.

Most data requirements for licensing and registration are straightforward. Key decisions for licensing include whether to designate the proposed DSRC service for the requested license as either "Public Safety" or "Non-Public Safety," who to designate as the "real party in interest," determination of regulatory status, and other key elements. DSRCS licensing and registration applicants must fill out FCC Form 601 Schedules D, M, and in some cases H.

Schedule D: The *Schedule for Station Locations and Antenna Structures* is used to supply technical information for all transmit station locations (including Fixed, Mobile, Temporary Fixed, and 6.1 Meter Control Stations), and antenna structures for all services except microwave.

Schedule H: *Technical Data Schedule for the Private Land Mobile and Land Mobile Broadcast Auxiliary Radio Services* is used for site-specific applications and amendments in the private land mobile and broadcast auxiliary radio services.

Schedule M: *Schedule for Registration* is used to register a transmitter location. Radio service is also designated in this schedule.

FCC Radio Service Codes for DSRCS are:

IQ - Intelligent Transportation Service (Public Safety)

QQ - Intelligent Transportation Service (Non-Public Safety)

State and local governments, possessions, territories, districts, and authorities (including mass transit and toll authorities) should apply for an "IQ" DSRC service license. A public safety system operated by a non-governmental entity under the control of a government entity that holds the license should use the radio service code for a "Public Safety" service (IQ).

Special Note:
Registering Temporary RSUs in the FCC Licensing Database[18]

Although not stated, a reasonable presumption is that entities deploying temporary RSUs must hold a valid DSRC license and deploy the temporary RSUs within their authorized geographic area. However, the FCC's licensing and registration procedures do not provide for registration of temporary RSUs. Specifically, there is no category identified on the license application form and Schedule M (Schedule for Registration) for a temporary RSU. It is advisable to contact FCC about filing for a temporary RSU registration as a Special Temporary Authority (STA).

[18] If using a temporary or portable RSU, agencies may need to update the license regularly during use and/or look to gain a license for a larger geographic area for some period of time, for instance 10-20 days. FHWA is working with the FCC to provide more specific guidance.

Other entities, particularly non-governmental entities that provide services that are not safety-of-life or public safety related should select the "Non-Public Safety" service (QQ), even if they provide safety/public safety DSRC services. "Non-Public Safety" functions may also include non-critical public RSU services that support operation or maintenance of large public transportation facilities such as transit, airport, ports, and other intermodal facilities.

FCC Form 601 requires that the entity name a "real party of interest." Applicants must identify a real party (or parties) of interest if different from the applicant. The real party of interest is defined as a person who "has an ownership interest, or will be in a position to actually or potentially control the operation of the station." In cases where road users, public safety entities, transportation infrastructure operators, or other organizations are contracting RSU deployment and/or operation to another party, FHWA recommends the organizations be registered with the FCC as the real party of interest.

Applicants for a DSRC license must also declare their regulatory status among the following designations: as a *common carrier, non-common carrier*, *private, internal communications*, *broadcast services,* or *band manager*. Based on the instructions for FCC Form 601, it is recommended that applicants, including governmental, non-governmental, and private, select the "Private" regulatory status: "Private internal users are those users that use telecommunications services purely for internal business purposes or public safety communications and not on a for-hire or for profit basis."

Special Note: "Private" Intelligent Transportation Services that Serve "Public Safety"

In possibly rare exceptions, some critical public safety or traffic safety services may be provided by a private RSU operator either on their own, or on behalf of a public safety organization (i.e. real party of interest). For licensing purposes, private RSU operators should identify the service as "QQ – Non-Public Safety," even if providing safety-of-life or public safety services. Only if a government entity holds the license should it identify the service as "IQ – Public Safety." The choice of radio service code does not affect the priority afforded to safety/public safety DSRC communications.

For type of radio service, it is recommended that "fixed" be selected, as RSUs are required to be stationary when transmitting. The FCC Schedule M requires the following information for RSU registrations:

1. Call sign: Assigned by FCC.
2. Licensee name: Designated by registrant. Use name on charter or articles of incorporation or similar documentation.
3. RSU identification number: Assigned by FCC.
4. RSU site coordinates: Surveyed or otherwise determined by registrant.
5. Channel number(s): Provided by registrant. Registrants should refer to IEEE 1609 Standard for identification of service channels.
6. Equipment class: Provided by registrant. Based on relevant "communications zone" of RSU transmissions at proposed site.
7. Power: Provided by registrant.
8. Antenna height: Provided by registrant.
9. Antenna manufacturer and model: Provided by registrant.
10. Antenna gain: Provided by registrant.
11. Antenna azimuth: Provided by registrant.
12. Antenna elevation angle: Provided by registrant.
13. Registration data: Provided by registrant.

Special Guidance for U.S. Federal Operators of RSU Sites

The 5.9 GHz band for DSRC services is currently designated as a non-federal band. U.S. federal government agencies cannot use FCC Form 601 to register their sites, but must seek authority from NTIA for efforts related to wireless site deployment, licensing, and site registration. Federal authorizations to operate in this band will be coordinated with the FCC through the NTIA Interdepartmental Radio Advisory Committee (IRAC) Frequency Assignment Subcommittee.

Special Note: DSRC Canada and Mexico Frequency Coordination

Given DSRC's short range, rarely would there be issues regarding interference at great distances across international borders. However, agencies establishing RSU application services, in particular at U.S./Canada or U.S./Mexico border crossings, may need to consult with the FCC. There is no formal agreement between the United States and Canada or the United States and Mexico governing border-area use of the 5850-5925 MHz band for DSRC.

Absent a formal agreement, authorizations to operate RSUs are granted subject to the following conditions: (a) RSUs must not cause harmful interference to stations in Canada or Mexico that are licensed in accordance with the international table of frequency allocations for Region 2 and must accept any interference that may be caused by such stations; (b) the authority to operate DSRC RSUs is subject to modifications and future agreements between the United States and Canada or the United States and Mexico, as applicable.

Use of the FCC Licensing Database and "Attached Priority"

The administrative burden for road users and infrastructure operators seeking an RSU license is relatively low. Given the low power of RSUs, the interference-mitigation provisions of the ASTM-DSRC standard, and the fact that the potential number of sites could be in the tens of thousands, the FCC concluded that the burden and expense that site licensing and formal coordination would impose on applicants, other licensees, and the FCC would be unwarranted. Moreover, the FCC also concluded that licensing RSUs for less than all of the service channels would impede DSRC service flexibility in using the band with the other primary allocations.

There is no potential conflict in obtaining licenses between public and private applicants. As set forth in the FCC's rules, DSRC licenses are non-exclusive, so one party obtaining a geographic license, or registering a site or sites under that license in that geographic area, does not preclude another party from obtaining a license for the same geographic area identified in the FCC licensing database.

However, there are circumstances where conflicts between RSU DSRC service providers may exist. Non-reserve DSRC channels (Channels 174, 175, 176, 180, 181, and 182) are available on a shared basis only for use in accordance with the FCC's rules. All licensees should use the FCC licensing database in deciding selection and use of channels in order to reduce potential RSU service conflicts. (Note that interference includes overloading a DSRC channel such that safety messages have a high probability of packet collisions.)

According to the FCC, "Given the low power of RSUs and the interference-mitigation provisions of the ASTM-DSRC Standard, "interference" disputes among DSRC operations should be rare. Nonetheless, we clarify that in the event a dispute arises, it is to be resolved using the priority framework set forth in paragraph 31, supra. If a dispute arises between non-public safety RSU

licensees, the licensee of the later-registered RSU must accommodate the operation of the early registered RSU, i.e., interference protection rights would be date-sensitive, based on the date that the RSU is first registered and the later registered RSU would have to modify its operations."[19]

Site Construction and Notice

The FCC's rules generally provide that a license that is not in operation for a year or more is considered to be permanently discontinued and the licensee shall cancel automatically. Similarly, any RSU station that has not operated for one year or more is considered to have been permanently discontinued. It is the DSRC licensee's responsibility to delete from the registration database any RSUs that have been discontinued.

In many cases, the FCC requires registration prior to construction. As part of that process, FCC has implemented environmental and historic preservation rules implementing NEPA and the NHPA.[20]

DSRC licensees have 12 months to construct and place into operation a registered RSU. In addition, licensees are required to file a notice of construction with the FCC for each registered site. RSU site priority attaches to prior registered sites that have been fully constructed within the requisite 12-month construction period. If a licensee fails to provide notice of construction to the FCC for a registered site within the 12-month construction period, the site registration will be placed in "Termination Pending" status and will be terminated automatically if the licensee does not file a timely petition for reconsideration.

Moreover, only DSRC equipment that has an FCC equipment certification pursuant to the FCC's rules can be deployed and the license applicant must provide the DSRC manufacturer's details as required for licensing and registration.

Process Flow of an RSU Deployment

Three interconnected flow charts in Figures 3, 4, and 5 show the lifecycle process from commissioning a site, to monitoring and remediation in RSU operations. These figures integrate data elements, guidance, use of the FCC licensing database, and processes for identifying and resolving interference.

Figure 2 shows the commissioning process from geographical licensing, to FSS coordination and on to site registration. Figure 3 continues from Figure 2 and shows the commissioning process from site registration, to attachment of date priority and through to NTIA coordination. Figure 4 continues from Figure 3 and shows the monitoring/remediation process, which includes site construction, interference mitigation, and continuing operations.

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[19] *In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band)*, WT Docket No. 01-90, ET Docket No. 98-95, Report and Order, FCC 03-324 (rel. Feb. 10, 2004).

[20] More information on those rules is available at https://www.fcc.gov/encyclopedia/tower-and-antenna-siting. (Last accessed October 2105)

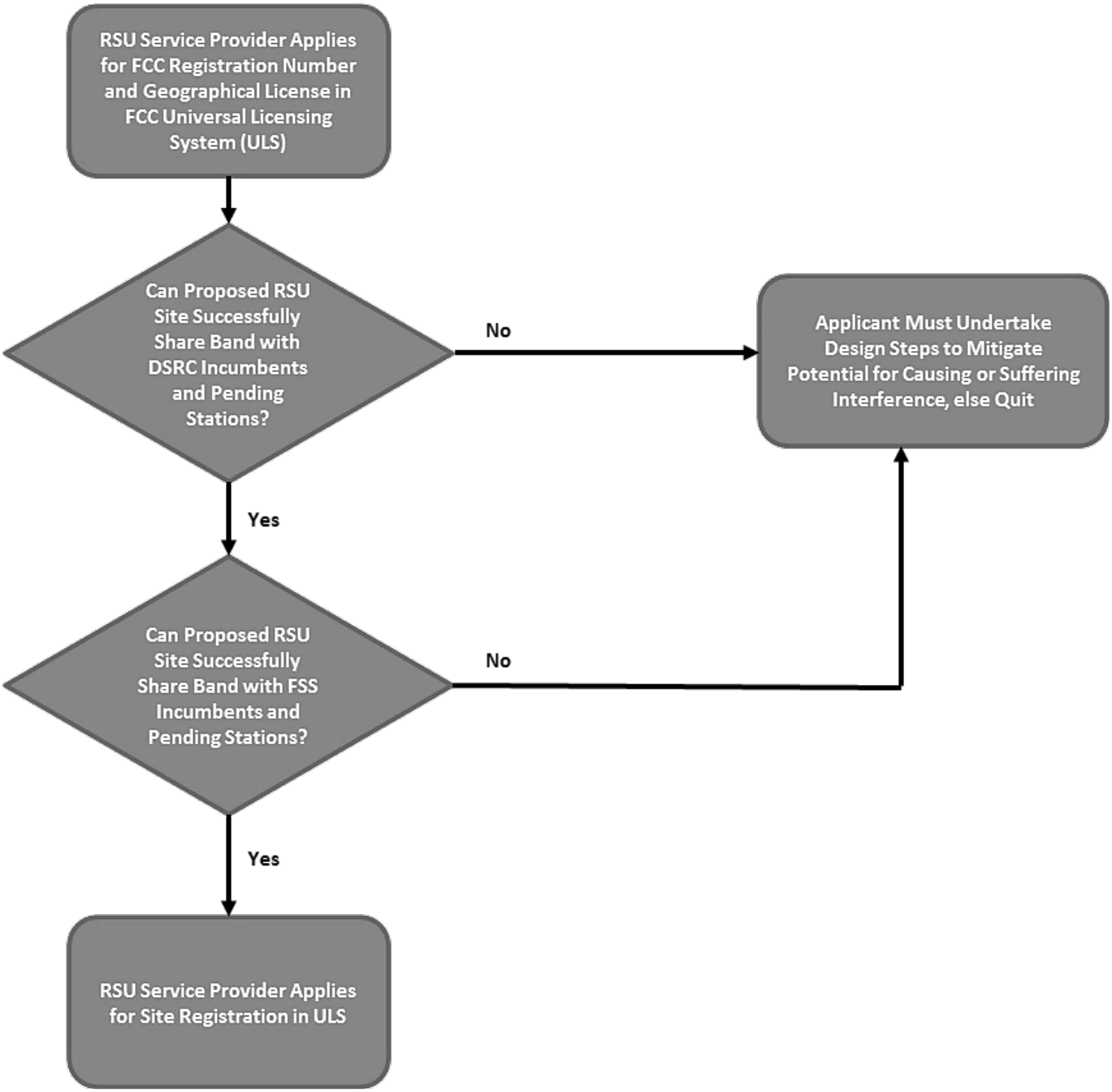

Figure 3: Commissioning Process from Geographical Licensing, to FSS Coordination, and through to Site Registration. Source: ARINC. Used with Permission.

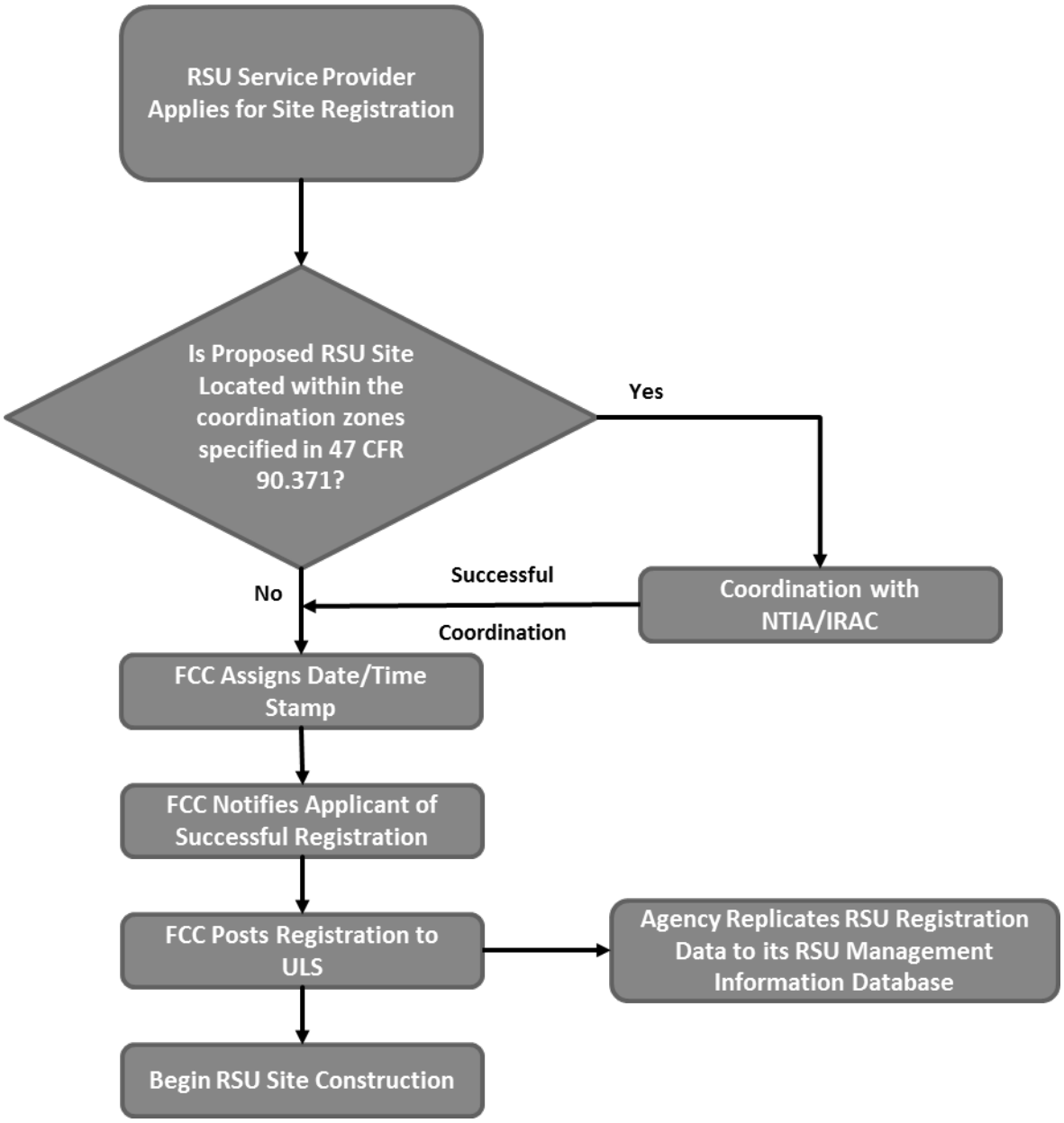

Figure 4: Commissioning Process from Site Registration, to Attachment of Date Priority, and through to NTIA Coordination. Source: ARINC and ITS America. Used with Permission.[21]

[21] Coordination zones are described in 47 CFR 90.371 located here: http://www.ecfr.gov/cgi-bin/text-idx?SID=4dad5dcee4ae8428ee55ade036ec86d9&node=sp47.5.90.m&rgn=div6#se47.5.90_1371. (Last accessed October 2015)

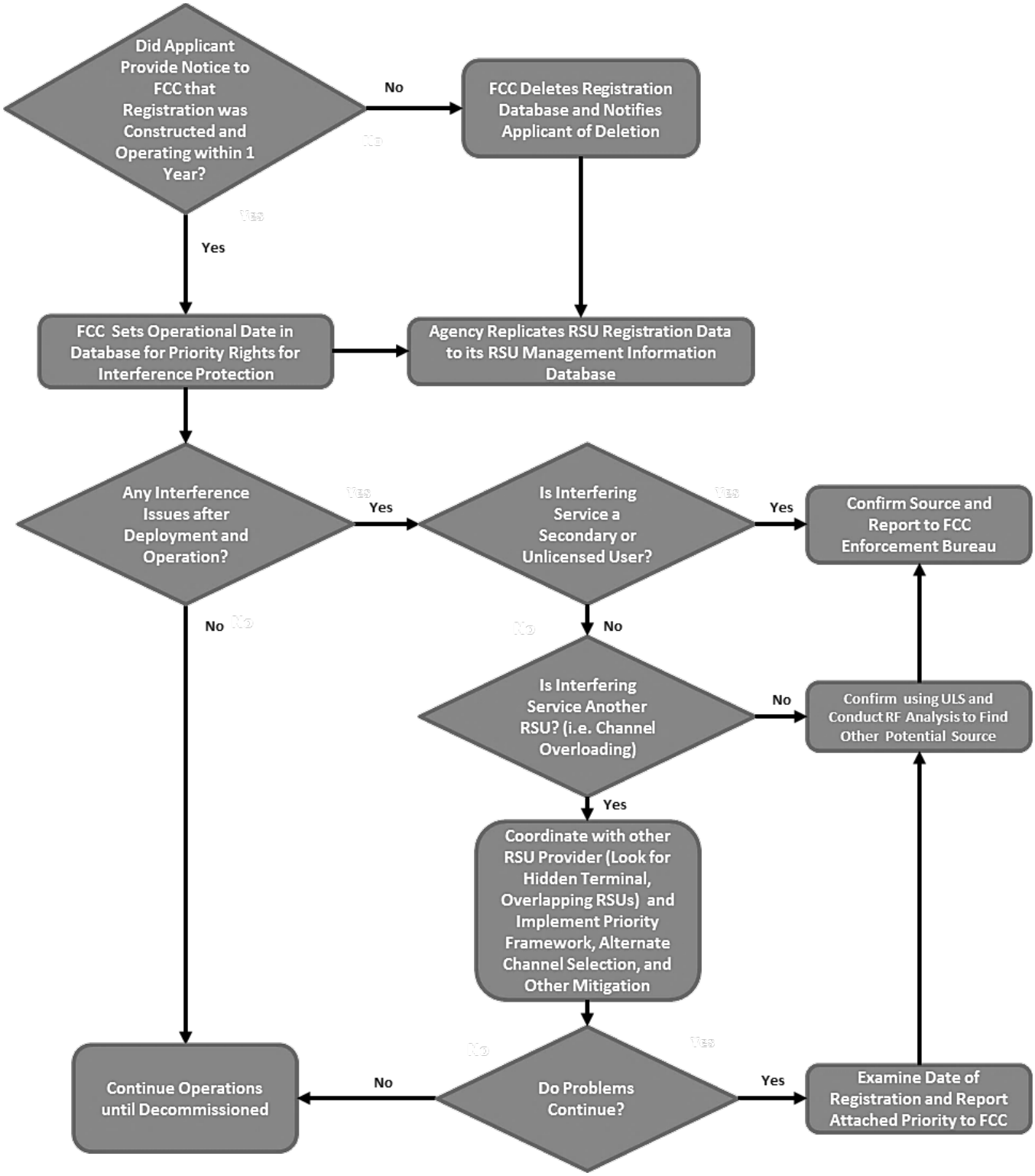

Figure 5: Monitoring/Remediation Process – Site Construction, Interference Mitigation, and Continuing Operations. Source: ARINC and ITS America. Used with Permission.

Conclusion

This FHWA guidance only applies to public agencies that are eligible for federal funding. Private road authorities, public safety organizations, or other entities that seek to deploy RSU application services in highway rights-of-way are strongly recommended to adhere to this guidance as much as possible. Compliance with FCC technical and service rules is mandatory for all DSRC RSU application service providers. All organizations are encouraged to follow best practices in deployment planning to ensure spectrum resources are used efficiently.

Road agencies that are about to deploy safety critical or mission critical systems need a degree of assurance that incumbent public or private sector RSU application service providers in the vicinity of a potential RSU site are not being operated in a configuration that may degrade performance of each other's applications. Road agencies should also conduct deployment planning, to include RF analysis.

The FHWA strongly encourages organizations frequently reference the FCC licensing database in their RSU planning and operations. Organizations desiring to register and operate an RSU site should initiate an informal coordination process with neighboring public or private organizations/jurisdictions operating DSRC services in geographical proximity.

Furthermore, road agencies will need to develop a process to ensure that they are good spectrum stewards and that they comply with requirements to coordinate with other primary spectrum users. Road agencies will also need to carefully diagnose and document interference issues that arise from secondary or unlicensed users, such as ISM and other U-NII users that are in-band; or out-of-band users such as satellite or other ISM/U-NII users; and report them to the FCC. Road agencies will also be encouraged to report potential issues to FHWA and the National Highway Traffic Safety Administration (NHTSA) if interference is significant enough to degrade DSRC safety-of-life services.

References

2015 FHWA Vehicle to Infrastructure Deployment Guidance and Products, Draft v9. 2014.

Abernathy, Bruce, Scott Andrews, and Gary Pruitt. *Signal Phase and Timing Applications, Communications Requirements, Communications Technology Potential Solutions, Issues and Recommendations.* FHWA-JPO-13-002. 2012.

Federal Communications Commission, "In the Matter of Amendment of the Commission's Rules Regarding Dedicated Short-Range Communication Services in the 5.850-5.925 GHz Band (5.9 GHz Band), 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," FCC *Report and Order*, WT Docket No. 01-90, ET Docket No. 98-95 RM-9096, February 10, 2004

Schaffnit Consulting, Inc. *White Paper: A Licensing and Site Registration Process for 5.9 GHz DSRC Roadside Units Incorporating "Active" Spectrum Management Functions*. 2005.

Stephens, D.R., T.J. Timcho, R.A. Klein, and J.L. Schroeder. *Vehicle-to-Infrastructure (V2I) Safety Applications: Concept of Operations.* FHWA-JPO-13-060. 2013.

Timcho, T.J., E.L. Young, R.A. Klein, J.L. Schroeder, and D.R. Stephens. *Vehicle-to-Infrastructure (V2I) Safety Applications: System Requirements.* FHWA-JPO-13-061. 2013.

Transportation Research Board. Committee to Review the USDOT Report on Connected Vehicle Initiative Communications Systems Deployment. Review of the *Status of the Dedicated Short-Range Communications Technology and Applications [Draft] Report to Congress.* 2015.

Wright, James, J. Kyle Garrett, Christopher J. Hill, and Rajat Rajbhandari. *National Connected Vehicle Field Infrastructure Footprint Analysis: Deployment Scenarios*. Final Report. 2013.

Appendix: List of Acronyms

AASHTO	American Association of State Highway Transportation Officials
ARINC	Aeronautical Radio, Incorporated
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
CORES	Commission Registration System
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
dB	decibels
DOD	Department of Defense
DSRC	Dedicated Short Range Communications
DSRCS	Dedicated Short Range Communications Service
EDCA	Enhanced Distributed Channel Access
ERP	Effective Radiated Power
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FRN	FCC Registration Number
FSS	Fixed Satellite Service
GHz	gigahertz
IBFS	International Bureau Filing System
IEEE	Institute of Electrical and Electronics Engineers
IQ	Intelligent Transportation Service (Public Safety)
ISM	Industrial, Scientific, and Medical
ITS	Intelligent Transportation Systems
ITS America	Intelligent Transportation Society of America
MHz	megahertz
MUTCD	Manual on Uniform Traffic Control Devices
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NTIA	National Telecommunications and Information Administration
OBE	On-board Equipment
PER	Packet Error Rate
QQ	Intelligent Transportation Service (Non-Public Safety)
R&O	Report and Order
RF	Radio Frequency
RSU	Roadside Unit
SAE	Society of Automotive Engineers
SCMS	Security Credential Management System
SIA	Satellite Industry Association

STP	Surface Transportation Program
U.S. DOT	United States Department of Transportation
U-NII	Unlicensed National Information Infrastructure
V2I	Vehicle-to-Infrastructure
WAVE	Wireless Access for Vehicular Environments

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