ATIS-0700040

ATIS Standard on -

North American Spectrum Bands (United States and Canada)

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Alliance for Telecommunications Industry Solutions

Approved June 2018

Abstract

This document summarizes the commercial and commercial/unlicensed wireless bands currently used in North America.

Foreword

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The Wireless Technologies and Systems Committee (WTSC) develops and recommends standards and technical reports related to wireless and/or mobile services and systems, including service descriptions and wireless technologies. WTSC develops and recommends positions on related subjects under consideration in other North American, regional, and international standards bodies.

The mandatory requirements are designated by the word shall and recommendations by the word should. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages. The word may denotes an optional capability that could augment the standard. The standard is fully functional without the incorporation of this optional capability.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, WTSC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, WTSC, which was responsible for its development, had the following leadership:

D. Zelmer, WTSC Chair (AT&T)
M. Younge, WTSC Vice-Chair (T-Mobile)
F. Khatibi, WTSC RAN Chair (Qualcomm)
E. Ehrlich, WTSC RAN Vice Chair (InterDigital)

The RAN subcommittee was responsible for the development of this document.

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North American Spectrum Bands

1 Introduction

Mobile system operators are deploying wireless systems across North America with a choice of standardized technologies in different frequency bands. The objective of this document is to summarize and indicate the commercial and unlicensed wireless bands currently used in North America.

2 Background

The basic US Wireless Bands (as designated by 3GPP TSG RAN WG4) are listed in Table 2.1. Over the years, the various bands have been modified and expanded to allow additional bandwidth/capacity. The various bands are illustrated and further identified in the remainder of the document. Specific band numbers with issues have been identified in the notes of Table 2.1. No Carrier Aggregation documentation will be included in this document.

Table 2.1 – United States Band Numbers with Frequencies

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}			
2	1850 MHz	–	1910 MHz	1930 MHz	–	1990 MHz	FDD
4	1710 MHz	–	1755 MHz	2110 MHz	–	2155 MHz	FDD
5	824 MHz	–	849 MHz	869 MHz	–	894MHz	FDD
7	2500 MHz	–		2620 MHz	–	2690 MHz	FDD
12	699 MHz	–	716 MHz	729 MHz	–	746 MHz	FDD
13	777 MHz	–	787 MHz	746 MHz	–	756 MHz	FDD
14	788 MHz	–	798 MHz	758 MHz	–	768 MHz	FDD
17	704 MHz	–	716 MHz	734 MHz	–	746 MHz	FDD
23[1]	2000 MHz	–	2020 MHz	2180 MHz	–	2200 MHz	FDD
24	1626.5 MHz	–	1660.5 MHz	1525 MHz	–	1559 MHz	FDD
25	1850 MHz	–	1915 MHz	1930 MHz	–	1995 MHz	FDD
26	814 MHz	–	849 MHz	859 MHz	–	894 MHz	FDD
29	NA			717 MHz	–	728 MHz	FDD[2]
30	2305 MHz	–	2315 MHz	2350 MHz	–	2360 MHz	FDD
41	2496 MHz		2690 MHz	2496 MHz		2690 MHz	TDD
46	5150 MHz	–	5925 MHz	5150 MHz	–	5925 MHz	TDD[8]
47	5855 MHz	–	5925 MHz	5855 MHz	–	5925 MHz	TDD[11]
48	3550 MHz	–	3700 MHz	3550 MHz	–	3700 MHz	TDD
49	3550 MHz	–	3700 MHz	3550 MHz	–	3700 MHz	TDD[16]
66	1710 MHz	–	1780 MHz	2110 MHz	–	2200 MHz	FDD[4]
70	1695 MHz	–	1710 MHz	1995 MHz	–	2020 MHz	FDD[10]
71	663 MHz	–	698 MHz	617 MHz	–	652 MHz	FDD

n259	27.5 – 28.35 GHz	27.5 – 28.35 GHz	TDD
n260	37-40 GHz	37-40 GHz	TDD

NOTE 1: Band 23 is not applicable.

NOTE 2: Restricted to E-UTRA operation when carrier aggregation is configured. The downlink operating band is paired with the uplink operating band (external) of the carrier aggregation configuration that is supporting the configured Pcell.

NOTE 4: The range 2180-2200 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured.

NOTE 5: A UE that supports E-UTRA Band 66 shall receive in the entire(DLting band

NOTE 7: A UE that complies with the E-UTRA Band 66 minimum requirements in this specification shall also comply with the E-UTRA Band 4 minimum requirements.

NOTE 8: This band is an unlicensed band restricted to licensed-assisted operation using Frame Structure Type 3.

NOTE 10: The range 2010-2020 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured and TX-RX separation is 300 MHz. The range 2005-2020 MHz of the DL operating band is restricted to E-UTRA operation when carrier aggregation is configured and TX-RX separation is 295 MHz.

NOTE 11: This band is unlicensed band used for V2X communication. There is no expected network deployment in this band so both Frame Structure Type 1 and Frame Structure Type 2 can be used.

NOTE 16: This band is restricted to licensed-assisted operation using Frame Structure Type 3.

NOTE: Table 2.1 taken from 3GPP 36.101-f00.zip (Table 5.5-1 E-UTRA operating bands)

3 Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < http://www.atis.org/glossary >.

3.1 Definitions

3.1.1 ITU Terms

The International Telecommunication Union (ITU) – which is the United Nations' specialized agency for Information and Communication Technologies (ICT) – bears, as one of its principal responsibilities, the "allocation" of global radio spectrum.

As defined in the Radio Regulations, the term "allocation" (Article 1.16) is an:

Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radiocommunication services or the radio astronomy service under specified conditions. This term shall also be applied to the frequency band concerned.

An allocation is typically made to a radiocommunication service – of which the mobile service is an example (the fixed service, fixed satellite service, and mobile satellite service are other examples; the full list can be found in the Radio Regulations, Articles 1.19 through 1.60).

Within an allocation, it is possible to identify the frequency band for a specific application. For example, within the mobile service, identifications can be made for IMT (International Mobile Telecommunications), PPDR (Public Protection and Disaster Relief – also known as Public Safety), RLANs (Radio Local Area Networks) and so on. Sometimes, the word "designation" is used instead of "identification" - though the two terms are not equivalent. Even more unfortunately, neither of these terms is defined in the Radio Regulations, though Articles 1.17 and 1.18 do define "allotment" and "assignment" respectively.

Generally, only allocations are made in the Radio Regulations; however, it is possible to make identifications (for a specific application) as well. It is important not only to keep these two terms in mind when it comes to spectrum, but also to understand the distinction between them (no identification without an allocation – at least in the Radio Regulations).

NOTE: The Radio Regulations, edition of 2016[1], contains the complete texts of the Radio Regulations as adopted by the World Radiocommunication Conference (Geneva, 1995) (WRC-95), subsequently revised and approved by the World Radiocommunication Conference (Geneva, 1997) (WRC-97), the World Radiocommunication Conference (Istanbul, 2000) (WRC-2000), the World Radiocommunication Conference (Geneva, 2003) (WRC-03), the World Radiocommunication Conference (Geneva, 2007) (WRC-07), the World Radiocommunication Conference (Geneva, 2012) (WRC-12) and the World Radiocommunication Conference (Geneva, 2015) (WRC-15), including all Appendices, Resolutions, Recommendations and ITU-R Recommendations incorporated by reference.

3.2 Acronyms & Abbreviations

5G	Fifth Generation
ATC	Ancillary Terrestrial Component
ATIS	Alliance for Telecommunications Industry Solutions
ATG	Air to Ground
AWS	Advanced Wireless Service
B/ILT	Business/Industrial/Land Transportation
BRS	Broadband Radio Service
CBRS	Citizens Broadband Radio Service
CBSD	Citizens Broadband Radio Service Device
CMA	Cellular Market Area
DL	Downlink
DTV	Digital Television
EA	Economic Area
EBS	Educational Broadband Service
ESMR	Enhanced Specialized Mobile Radio
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FSS	Fixed Satellite Service
FWA	Fixed Wireless Access
GAA	General Authorized Access
HAAT	Height Above Average Terrain
ISED	Innovation, Science and Economic Development Canada
ITFS	Instructional Television Fixed Service
IMT	International Mobile Telecommunications
LMDS	Local Multipoint Distribution Service
MCS	Multipoint Communication Systems
MDS	Multipoint Distribution Service
MMDS	Multichannel Multipoint Distribution Service
MSS	Mobile Satellite Service
MTA	Major Trading Area
NPSPAC	National Public Safety Planning Advisory Committee
NTIA	National Telecommunications and Information Administration

[1] This document is available from International Telecommunication Union (ITU) < http://www.itu.int/pub/R-REG-RR/e >

PAL	Priority Access License
PCS	Personal Communications Services
PLMR	Private Land Mobile Radio
PPDR	Public Protection and Disaster Relief
PS	Public Safety
RAS	Radio Astronomy Service
REAG	Regional Economic Area Grouping
RLAN	Radio Local Area Network
RSS	Radio Standards Specification
SAS	Spectrum Access System
SDARS	Satellite Digital Audio Radio Service
SMR	Specialized Mobile Radio
SRSP	Standard Radio Systems Plan
TVWS	Television White Space
UHF	Ultra-High Frequency
UL	Uplink
UMFUS	Upper Microwave Flexible Use Service
VHF	Very High Frequency
WBS	Wireless Broadband Service
WCS	Wireless Communications Service
WMTS	Wireless Medical Telemetry Service

4 600 MHz Frequency Band

4.1 United States 600 MHz Allocation

The US broadcast television bands occupy 294 megahertz of spectrum in five frequency bands that are allocated for broadcasting use. All five bands are allocated principally to broadcast television under Part 73 of the Federal Communications Commission's (FCCs) rules. In addition, the 470-512 MHz band segment [Ultra-High Frequency (UHF) channels 14-20] is allocated for fixed and land mobile services on a co-primary basis with broadcasting. Broadcast television stations operate on six-megahertz channels designated 2 to 51. The bands consist of 54-72 MHz [low Very High Frequency (VHF) channels 2-4], 76-88 MHz (low VHF channels 5-6), 174-216 MHz (high VHF channels 7-13), 470-608 MHz (UHF channels 14-36), and 614-698 MHz (UHF channels 38-51).

A key part of the FCC's efforts to meet the demand for spectrum is the first-of-its-kind Broadcast Incentive Auction, a means of repurposing spectrum by encouraging licensees to voluntarily relinquish spectrum usage rights in exchange for a share of the proceeds from an auction of new licenses to use the repurposed spectrum.

The repurposing of the broadcast television spectrum was initially described in the 2010 National Broadband Plan and authorized by Congress in 2012. The auction used market forces to align the use of broadcast spectrum with 21st century consumer demands for video and broadband services. It preserved a robust broadcast TV industry while enabling stations to generate additional revenues that they can invest into programming and services to the communities they serve. By making valuable "low-band" airwaves available for wireless broadband, the broadcast incentive auction benefitted consumers by easing congestion on wireless networks, laying the groundwork for "fifth generation" (5G) wireless services and applications, and spurring job creation and economic growth.

In the May 2014 Incentive Auction Report and Order, the FCC adopted rules to implement the broadcast television spectrum incentive auction, which will involve reorganizing the existing television band and repurposing a portion of the UHF television band for new wireless broadband services.

This repurposing of the 600 MHz spectrum involved the FCC conducting a reverse auction and a forward auction collectively termed the *Broadcast Television Incentive Auction*.

The Incentive auction was a voluntary, market-based means of repurposing spectrum by encouraging full power and Class A television licensees to voluntarily relinquish some or all of their spectrum usage rights in exchange for a share of the proceeds from an auction of new licenses to use the repurposed spectrum. A broadcaster bids to relinquish some or all of its spectrum usage rights. A mobile broadband provider bids to purchase spectrum licenses. The bids in the forward auction must exceed the broadcaster's bids in the reverse auction to meet the "clearing costs" in order to be successful.

The reverse and forward auctions were integrated into a series of stages. Each stage consisted of a reverse and forward auction bidding process for clearing a given amount of spectrum. The FCC repacked full-power and Class A TV stations that remain on the air so that they occupy a smaller portion of the UHF band and enable the reallocation of contiguous nationwide spectrum for the forward auction.

Repacked stations and winning "band change" bidders had up to 39 months from the effective date of the repacking to vacate their old channel. Unlicensed devices and wireless microphones were permitted in guard bands.

The reverse auction began March 29, 2016. The forward auction of Stages 1 to 3 failed to meet the clearing cost. On December 13, 2016, the Stage 4 bidding in the reverse auction started. The Clearing Cost of Stage 4 was set at $10,054,676,822, which was below the forward auction results of stages 1 to 3, meaning the auction would be successful in Stage 4. A successful forward auction was completed in February 2017.

The 600 MHz band plan converted 6 MHz television channels into 5 MHz "building blocks." The Frequency Division Duplex (FDD) Band plan consisting of specific paired uplink and downlink bands comprised of those building blocks as shown in Table 4.1.

The Band Plan for Stage 4 of the auction consisted of seven sets of paired blocks (10 MHz) and had 84 megahertz of repurposed spectrum as shown in Figure 4.1. There was an 11 megahertz duplex gap to ensure there was no overlap of third order intermodulation products between transmit and receive channels, and a transition bandwidth that can be supported by mobile filter technologies. The 600 MHz band plan had a 35 megahertz pass band in both the uplink and downlink bands and required 81 megahertz of antenna bandwidth.

There was an additional three megahertz guard band between the mobile downlink and the Wireless Medical Telemetry Service (WMTS) in channel 37. TV channel 37 is allocated for Radio Astronomy Service (RAS) and the WMTS service and is not used for TV broadcasting. There are exclusion zones around protected radio astronomy observatories.

RAS is allocated on a primary basis to WMTS. Channel 37 was originally allocated to RAS to provide appropriate spectral sampling of the spectral energy distribution of astronomical sources.

The TV bands are also used by wireless microphones. Wireless microphones are secondary to the broadcast television service and must comply with minimum separation distances from co-channel TV stations. TV white space (TVWS) devices both fixed and portable are also allowed.

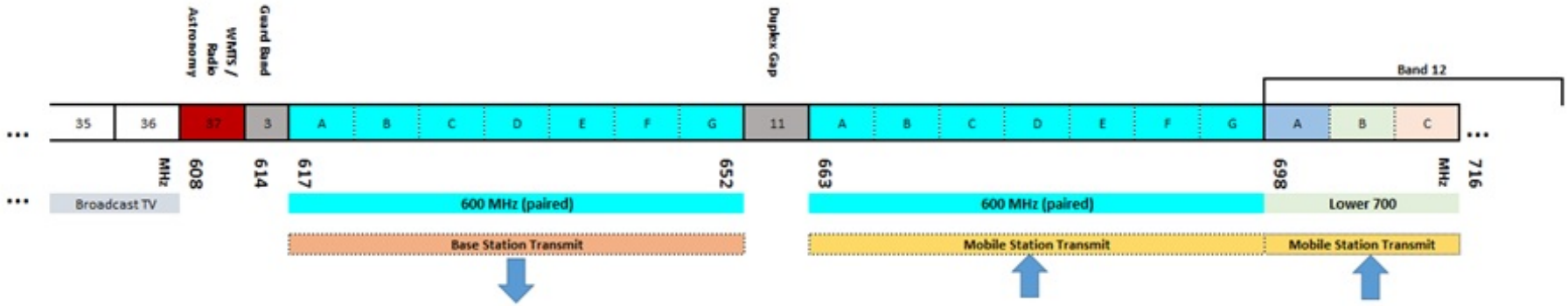


Figure 4.1 – United States 600 MHz Band Plan

Table 4.1 – United States 600 MHz Channel Blocks (Paired)

Block	Uplink/ Downlink	Low Frequency (MHz)	High Frequency (MHz)
A	D	617	622
B	D	622	627
C	D	627	632
D	D	632	637
E	D	637	642
F	D	642	647
G	D	647	652
A	U	663	668
B	U	668	673
C	U	673	678
D	U	678	683
E	U	683	688
F	U	688	693
G	U	693	698

4.2 Canada 600 MHz Allocation

The 600 MHz band (614-698 MHz) is designated for flexible use for commercial mobile, fixed, and broadcasting services. The 2015 Canadian decision to repurpose the 600 MHz band noted the benefits of adopting the U.S. band plan for the repurposed spectrum. This spectrum is planned to be auctioned in March 2019 (Auction of spectrum licenses in the 600 MHz band).

The Canadian 600 MHz band plan shown in Figure 4.2 includes seven paired blocks of 5+5 MHz totaling 70 MHz, a duplex gap from 652 MHz to 663 MHz, and a guard band from 614 MHz to 617 MHz.

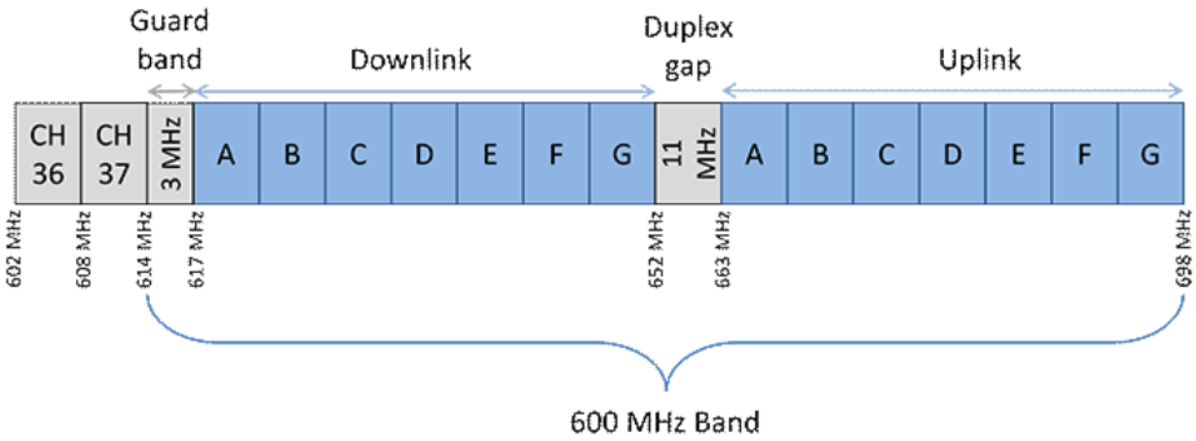


Figure 4.2 – Canada 600 MHz Band Plan (614-698 MHz)

The paired downlink band starts at 617 MHz extending to 652 MHz, consisting of 7 blocks labeled from A to G. The paired downlink band is separated from the uplink by a duplex gap of 11 MHz from 652 MHz to 663 MHz. The paired uplink band starts at 663 MHz to 698 MHz, consisting of 7 blocks similarly labeled from A to G.

It should be noted that channel 37 will continue to be used for Radio Astronomy Systems and wireless medical telemetry services. Additionally, no Canadian broadcaster is being moved to channel 36 or 37, which will reduce the potential for interference to broadcast services from the mobile services and vice versa.

The guard band 614-617 MHz will be held in reserve until further notice.

A Standard Radio Systems Plan (SRSP) confirming the technical rules for systems operating in the commercial mobile spectrum in the 600 MHz band has yet to be released. Similarly, there is no Radio Standards Specification (RSS) available for device certification at this point.

5 700 MHz Frequency Band

5.1 United States 700 MHz Allocation

This spectrum is part of the 698-806 MHz band (700 MHz Band), which has been occupied by television broadcasters and is being made available for new commercial and public safety services as a result of the digital television (DTV) transition. The FCC considered the 700 MHz Band in two parts, 698-746 MHz (the Lower 700 MHz Band) as shown in Figure 5.1 and the 746-806 MHz (the Upper 700 MHz Band) as shown in Figure 5.2.

5.1.1 Lower 700 MHz Band Plan

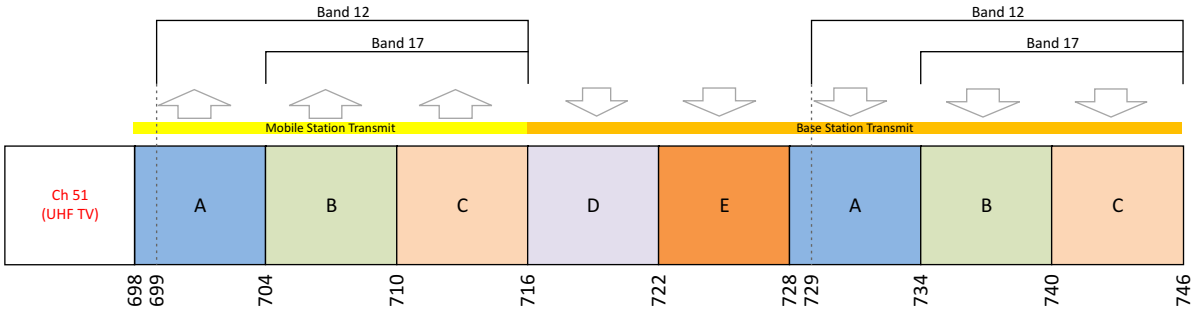


Figure 5.1 – United States Lower 700 MHz Band Plan (698-746 MHz)

Table 5.1 – Lower 700 MHz Paired (FDD) & Unpaired Channel Blocks

Block Identifier	Frequency Range
Block A	698-704/728-734 MHz (2x6 MHz)
Block B	704-710/734-740 MHz (2x6 MHz)
Block C	710-716/740-746 MHz (2x6 MHz)
Block D	716-722 MHz (6 MHz)
Block E	722-728 MHz (6 MHz)

5.1.2 Upper 700 MHz Band Plan

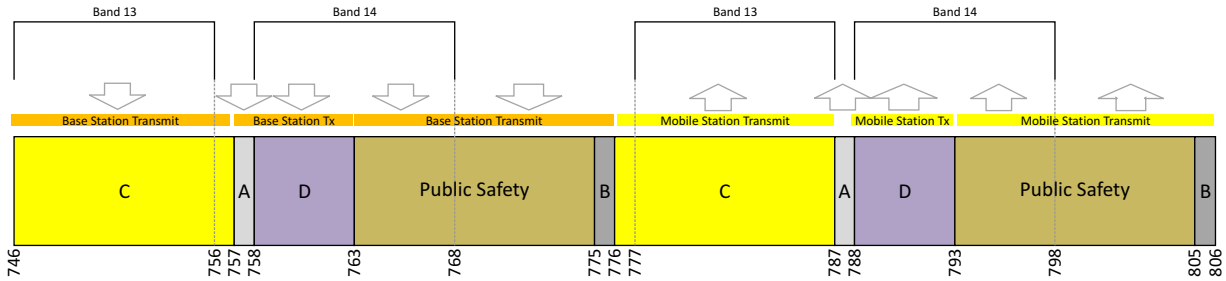


Figure 5.2 – United States Upper 700 MHz Band Plan (746-806 MHz)[2]

Table 5.2 – Upper 700 MHz Paired Channel Blocks (FDD)

Block Identifier	Frequency Range
Block C	746-757/776-787 MHz (2x11 MHz)
Block A	757-758/787-788 MHz (2x1 MHz)
Block D	758-763/788-793 MHz (2x5 MHz)
Block B	775-776/805-806 MHz (2x1 MHz)

5.2 Canada 700 MHz Allocation

In Canada, the 698-806 MHz band [700 MHz band, referred to as Mobile Broadband Service (MBS)] has also been made available for new commercial and public safety services as a result of the DTV transition. The Canadian regulator for radio frequency use, Innovation, Science and Economic Development Canada (ISED), has decided to harmonize its band plan for the 700 MHz band with the U.S. band plan. Nevertheless, one difference exists between these two band plans.

Figure 5.3 shows the band plan architecture for commercial mobile spectrum use, which was adopted for the 700 MHz band by ISED. The difference from the U.S. allocation is for the Upper C block which is subdivided into two separate blocks, namely C1 and C2.

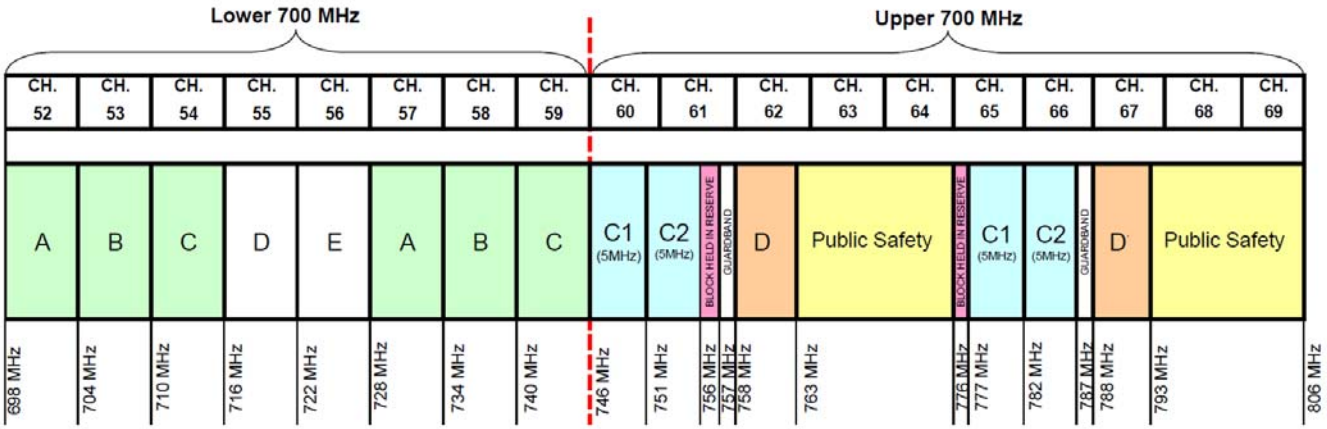


Figure 5.3 – Canadian band plan for the bands 698-756 MHz & 777-787 MHz

Table 5.3 – Frequency Blocks Available for the 700 MHz Auction

Block	Frequency	Pairing	MHz
A	698-704 MHz/728-734 MHz	paired	2x6 MHz
B	704-710 MHz/734-740 MHz	paired	2x6 MHz
C	710-716 MHz/740-746 MHz	paired	2x6 MHz
D	716-722 MHz	unpaired	6 MHz
E	722-728 MHz	unpaired	6 MHz
C1	777-782 MHz/746-751 MHz	paired	2x5 MHz
C2	782-787 MHz/751-756 MHz	paired	2x5 MHz

The two 1 MHz blocks (the frequency bands 756-757 MHz and 776-777 MHz, resulting from subdividing the Upper C block into blocks C1 and C2) has been held in reserve, and were thus not be part of the auction.

No new applications for broadcasting certificates were accepted for TV stations operating on channel 51 (692-698 MHz) following the ISED decision. Block A licensees, in areas where mobile deployments are affected by TV broadcasting on channel 51, are encouraged to enter into mutually acceptable arrangements with the relevant broadcasters.

The two guard bands between adjacent services in the Upper 700 MHz band (i.e., the frequency bands 757-758 MHz and 787-788 MHz) will be held in reserve until further notice.

The bands 763-768 MHz and 793-798 MHz (PSBB block) are designated for public safety broadband use. Consequently, these bands were not part of the 700 MHz auction.

A decision on the use of the bands 758-763 MHz and 788-793 MHz (the D block in the Upper 700 MHz band) has not yet been made by ISED and will be addressed following a separate consultation.

SRSP-518 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the 700 MHz band. Equipment must be certified in accordance with RSS-130.

6 800 MHz Frequency Band

6.1 United States 800 MHz SMR Allocations

The Specialized Mobile Radio (SMR) service was first established by the FCC in 1979 to provide land mobile communications on a commercial (i.e., for profit) basis. Enhanced Specialized Mobile Radio (ESMR) is the term used to designate 800 MHz systems that use cellular system architecture.

Prior to Band Reconfiguration, there were a total of 430 channel pairs allocated in the 800 MHz SMR services in non-border areas. The post rebanding band plan is shown in Figure 6.1.

The Industrial/Business Radio Pool covers the licensing of the radio communications of entities engaged in commercial activities; engaged in clergy activities; operating educational, philanthropic, or ecclesiastical institutions; or operating hospitals, clinics, or medical associations.

In 1987, the FCC set aside six megahertz of spectrum in the 800 MHz band for exclusive use by local, regional, and state public safety agencies under guidelines developed by the National Public Safety Planning Advisory Committee (NPSPAC). The 800 MHz NPSPAC spectrum is administered on a regional basis by 55 regional public safety planning committees.

Figure 6.1 – United States 800 MHz SMR band plan

6.2 850 MHz Cellular Allocations

6.2.1 United States 850 MHz Cellular Allocation

Cellular licenses are issued by FCC market areas and channel blocks. FCC market areas consist of one or more counties. The market area for Cellular licenses is Cellular Market Areas (CMAs).

Channel blocks are groups of frequencies. The channel blocks for US cellular licenses are:

- *A Block*: 824-835, 845-846.5, 869-880, and 890-891.5 (25 MHz) – issued by CMAs.
- *B Block*: 835-845, 846.5-849, 880-890, and 891.5-894 (25 MHz) – issued by CMAs.

The current cellular band plan is shown in Figure 6.2 and the original cellular band plan is shown in 6.3.

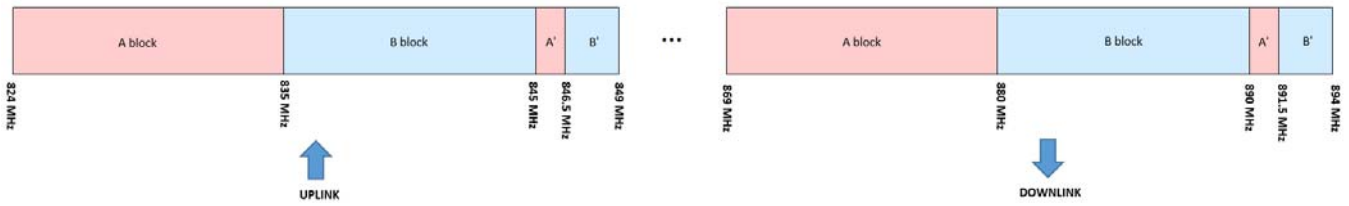


Figure 6.2 – United States 850 MHz Band Plan

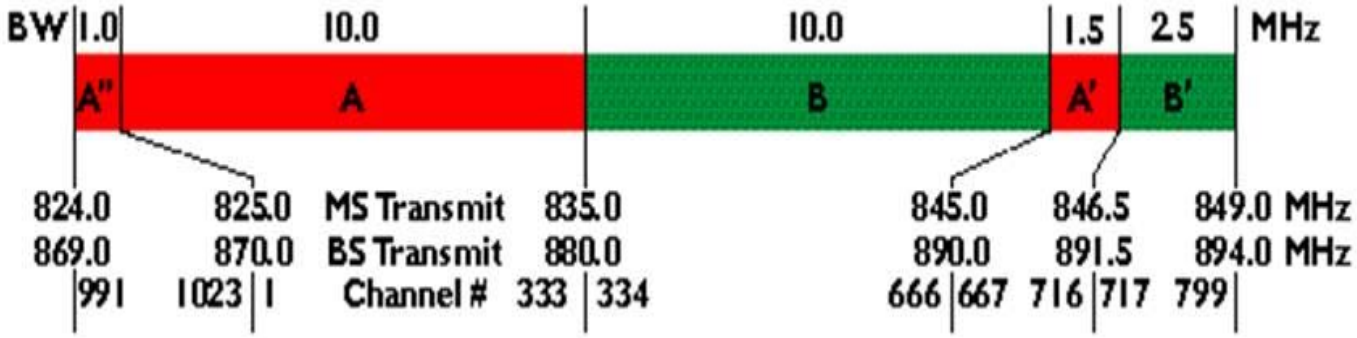


Figure 6.3 – Original United States 850 MHz Cellular Band Plan

6.3 Canada 800 MHz

The 800 MHz band was opened for land mobile in the mid-1990s, which is sometimes referred to as the SMR band. The Figure 6.4 shows the band plan for 800 MHz for Land Mobile service consisting of two separate blocks, namely 806 to 824 MHz and 851 to 869 MHz. Commercial land mobile (SMR and ESMR) base transmit from 851-866 MHz is paired with mobile transmit from 806 to 821 MHz. The remaining two blocks of spectrum, 821-824 MHz and 866-869 MHz, are designated for public safety.

Figure 6.4 – Canada 800 MHz Band Plan

SRSP-502 has been released establishing the technical rules for systems operating in the land mobile spectrum in the 800 MHz band. Equipment must be certified in accordance with RSS-119.

6.3.1 Canadian 850 MHz Cellular Allocation

The frequency bands allocated to the cellular and advanced services are 824-849 MHz paired at 45 MHz separation with 869-894 MHz is shown in Figure 6.5 consisting of four paired blocks labeled A, B. The band 824-849 MHz is used for mobile transmit, and the band 869-894 MHz is used for base transmit.

Figure 6.5 – Canada 850 MHz Cellular Allocation Band Plan

The sub-bands 835-845 MHz and 846.5-849 MHz paired with 880-890 MHz and 891.5-894 MHz, identified as Sub-band B, have been designated for systems operated by the local telephone-cellular service provider. For this duplex operation, the base station transmit RF channels are in the bands 880-890 MHz and 891.5-894 MHz; the corresponding mobile transmit RF channels are in the bands 835-845 MHz and 846.5-849 MHz.

The sub-bands 824-835 MHz and 845-846.5 MHz paired with 869-880 MHz and 890-891.5 MHz, identified as Sub-band A, have been designated for systems operated by the other cellular service provider. For this duplex operation, the base station transmit RF channels are in the bands 869-880 MHz and 890-891.5 MHz; the corresponding mobile station transmit RF channels are in the bands 824-835 MHz and 845-846.5 MHz.

The use of the bands 824-849 MHz and 869-894 MHz near the Canada/United States border is subject to an Interim Arrangement, Cellular Radio Systems Operating in the 800 MHz Band.

SRSP-503 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the 850 MHz band. Equipment must be certified in accordance with RSS-132.

6.3.2 United States Air to Ground

In an FCC Report and Order (04-287), the FCC revised rules governing the four MHz of dedicated spectrum in the 800 MHz commercial Air to Ground (ATG) Radiotelephone Service band.

ATG spectrum auction in 2006 created two blocks within ATG band: C block and D block. Figure 6.6 shows the ATG band in relation to neighboring frequency bands. ATG C block is adjacent to cellular B' band. ATG D block is adjacent to Public Safety (PS) and Specialized Mobile Radio (SMR) bands. ATG lower frequency band is used for base station to aircraft transmission, and the upper band is used for aircraft to base station transmission. The ATG duplexing scheme is reverse of the duplexing scheme used in Cellular band. The ATG base station transmit frequency is adjacent to Cellular B' band base station receive frequency, while Cellular B' band base station transmit is adjacent to ATG base station receive. The ATG band can be thought of as a guard band between Cellular band and PS/SMR bands. As there are only a few hundred ATG base stations nationwide, frequency coordination and interference mitigation between hundreds of base stations is easier than between tens of thousands of cellular and PS/SMR base stations.

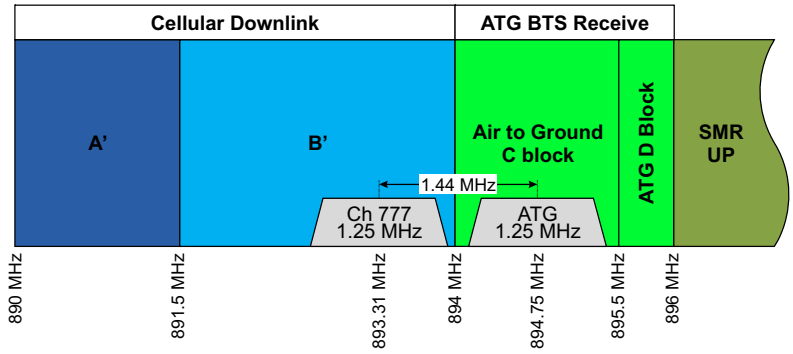


Figure 6.6 – Air to Ground Spectrum

Cellular and ATG operators have good success mitigating macrocell adjacent band interference through use of RF filters, antenna placement, and site collocation.

6.3.3 Canada Air to Ground

In 2009, Canada issued a nationwide license allowing operation of a terrestrial Frequency Division Duplex (FDD) network for air-to-ground application. ISED decided to harmonize its band plan with U.S. band plan. The band plan, described below in Figure 6.7, is based on two block pairs: 849-850.5/894-895.5 MHz and 850.5-851/895.5-896 MHz. The band 849-851 MHz is limited to transmissions from ground stations, and the use of the band 894-896 MHz is limited to transmissions from airborne stations.

SRSP-515 has been released establishing the technical rules for systems operating in the commercial mobile. The use of a regionally harmonized band plan in Canada and the United States has historically proven to be advantageous for airline travelers, permitting them to place aircraft telephone calls over the North American continent.

The band plan includes a wider 1.5 + 1.5 MHz block pair and a narrower 0.5 + 0.5 MHz block pair as shown in Figure 6.7.

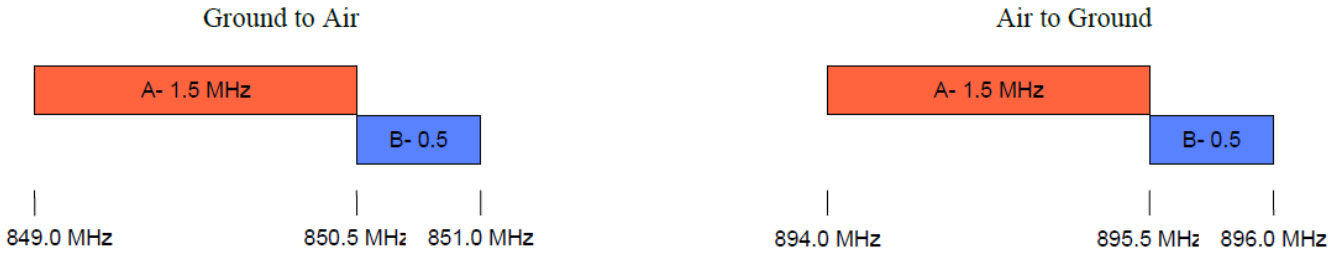


Figure 6.7 – Canada Air to Ground Band Plan

The band plan provides for two block pairs as shown in Table 6.1.

Table 6.1 – Canada Air to Ground spectrum in the air-to-ground band. Equipment must be certified in accordance with RSS-127 blocks

Spectrum Block	Block Size	Spectrum License
849-850.5 + 894-895.5	3 MHz	A
850.5-851 + 895.5-896	1 MHz	B

7 900 MHz Frequency Band

7.1 United States 900 MHz

The 900 MHz band (896-901/935-940 MHz) was designated in 1986 by the FCC for narrowband private land mobile radio (PLMR) communications by Business/Industrial/Land Transportation (B/ILT) licensees and SMR providers, with systems in place today. The 900 MHz band consists of 399 narrowband (12.5 kilohertz) frequency pairs grouped into 10-channel blocks that alternate between SMR blocks that are geographically licensed by Major Trading Area (MTA) and B/ILT blocks in which channels are assigned on a site-by-site basis.

SMR service was established by the FCC to provide land mobile communications on a commercial (i.e., for profit) basis, while B/ILT radio systems serve a great variety of communications needs to support licensees' day-to-day business operations, safety, and emergency needs, including activities such as dispatching and diverting personnel or work vehicles, coordinating the activities of workers and machines on location, or remotely monitoring and controlling equipment.

The Narrowband PCS dates back to 1990 when the FCC released a Notice of Inquiry. In 1993, the FCC announced service rules for the Narrowband PCS Service. The Narrowband PCS is in the 901 – 902, 930 – 931, and 940 – 941 MHz spectrum range. The most common use of Narrowband PCS spectrum is two-way paging and telemetry. Telemetry includes services such as monitoring utility meters from an off-site location.

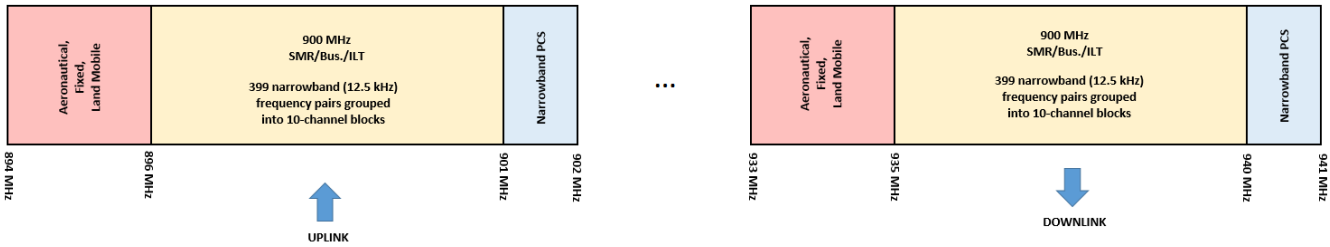


Figure 7.1 – United States 900 MHz Band Plan

7.2 Canada 900 MHz

- The 900 MHz band in Canada covers the frequency range 896 to 902 MHz similar to the United States. Following ISED's SP 1.7 GHz decision in June 2009, the band was subdivided as indicated below and illustrated in figure 8.2:896-902 and 935-941 MHz for trunked mobile service.
- 901-902 and 940-941 MHz authorized as extension to the trunked mobile service.
- 930-931 MHz for Narrowband PCS.

SRSP-506 has been released establishing the technical rules for systems operating in the land mobile spectrum in the 896-901 and 935-940 MHz bands. Equipment must be certified in accordance with RSS-119. SRSP-509 has been released establishing the technical rules for systems operating in narrowband personal communications services in 901-902 MHz, 930-931 MHz and 940-941 MHz bands. Equipment must be certified in accordance with RSS-134. Note that SRSP-506 and SRSP-509 have not been updated since ISED's 2009 decision.

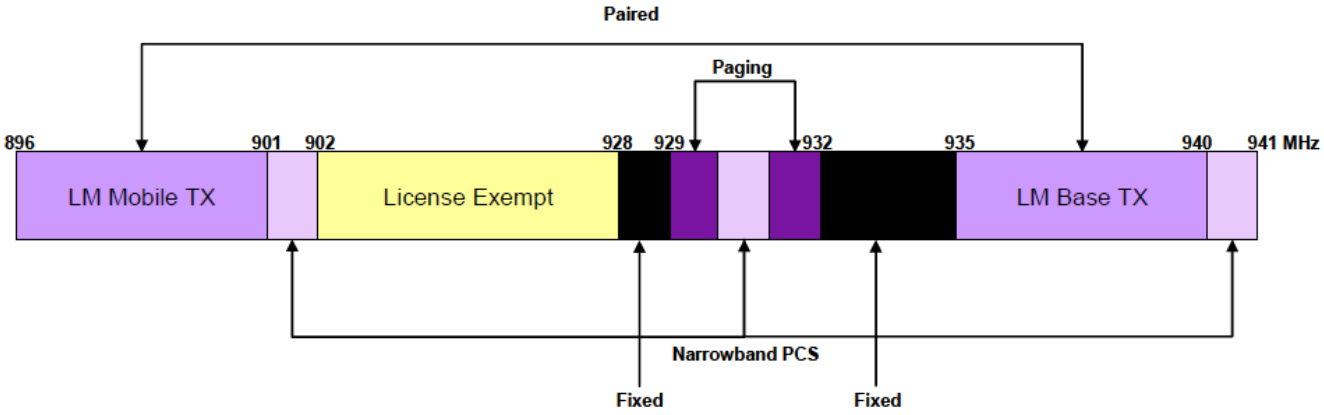


Figure 7.2 – Canada 900 MHz Band Plan

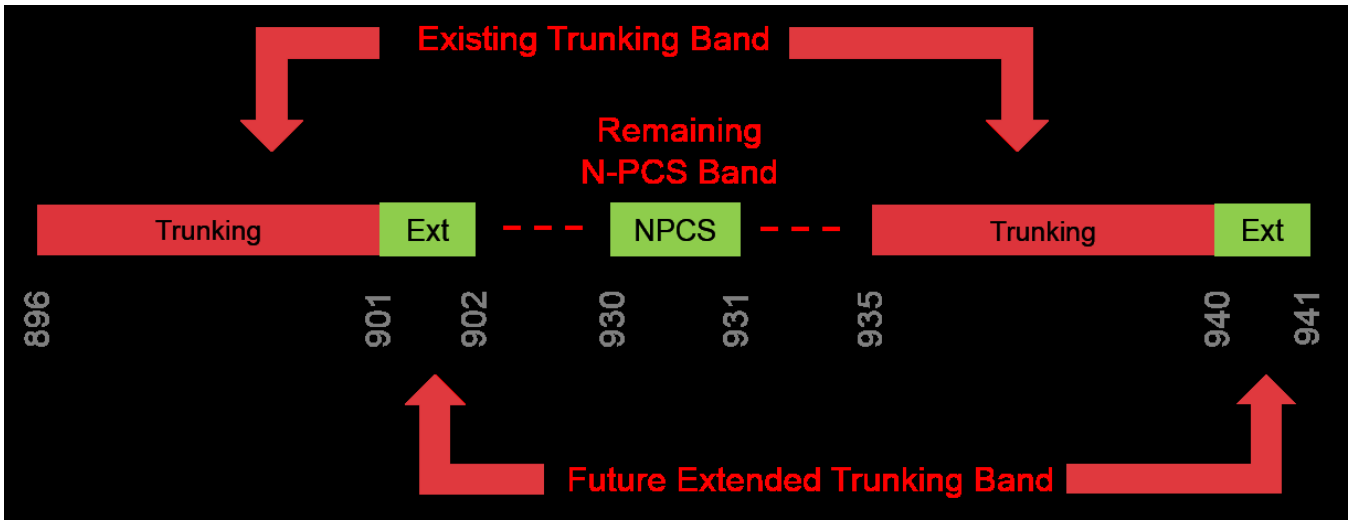


Figure 7.3 – Expanded 896-941 MHz Band in Canada

8 Advanced Wireless Services (AWS)

Advanced Wireless Service (AWS) is the collective term the FCC uses for innovative fixed and mobile terrestrial wireless services using bandwidth that is sufficient for the provision of a variety of applications, including those using voice and data (such as internet browsing, message services, and full-motion video) content. The services provided by AWS licensees are limited only by the Fixed and Mobile designation of the spectrum we allocate for AWS and the services rules we ultimately adopt for the bands.

8.1 United States AWS Allocation

8.1.1 AWS Background

The Commission has designated several different AWS spectrum bands over the years. The following contains a general description of the individual AWS bands that primarily focuses on recent actions the Commission has taken to establish rules to license these bands. The descriptions contain links to pages with more detailed information about each band, including historical information.

AWS-1: In 2002, the FCC released an Order that allocated 90 MHz of spectrum for AWS in the 1710-1755 and 2110-2155 MHz spectrum range. These spectrum bands are known as AWS-1. In 2002, the FCC released a

Notice of Proposed Rulemaking that sought comment on service rules for AWS. In 2003, the FCC released an Order that established rules to license AWS in the 1710-1755 and 2110-2155 MHz spectrum range.

AWS at 1915-1920 MHz/1995-2000 MHz ("H Block"): In 2012, the FCC released a Notice of Proposed Rulemaking to develop rules for the H Block, as part of an effort to implement the Middle Class Tax Relief and Job Creation Act of 2012 (Spectrum Act). In June 2013, the FCC released a Report and Order containing licensing, operating, technical, and competitive bidding rules for the H Block.

AWS-3: Following a Notice of Proposed Rulemaking in July 2013, the Commission adopted a Report and Order in March 2014 with allocation, technical, and licensing rules for commercial use of the 1695-1710 MHz, 1755-1780 MHz and 2155-2180 MHz bands. These spectrum bands are collectively known as AWS-3. The AWS-3 Report and Order required that commercial operators successfully coordinate with Federal incumbents before operating in certain Protection Zones. In July 2014, the FCC and National Telecommunications and Information Administration (NTIA) put out a Joint Public Notice Announcing AWS-3 Coordination Details, which refined the default nationwide coordination zones and provided additional information regarding coordination between Federal and non-Federal commercial shared use of the 1695-1710 MHz and 1755-1780 MHz bands.

AWS-4: In 2012, the FCC released a Notice of Proposed Rulemaking that proposed to apply AWS service rules for spectrum in the 2000-2020 and 2180-2200 MHz spectrum range. These spectrum bands, which are also allocated and authorized for Mobile Satellite Service (MSS), are known as AWS-4. Later the same year, the FCC released a Report and Order and Order of Proposed Modification adopting flexible use service rules in those bands. In February 2013, the Commission issued an Order of Modification to modify the licenses of the incumbent MSS licensees in that spectrum to grant them AWS-4 terrestrial operating authority. In December 2013, the Wireless Telecommunications Bureau issued a Memorandum Opinion and Order granting a petition for waiver of certain rules in the 2000-2020 MHz band, subject to certain conditions, in order to provide the licensees of that band with flexibility to use it for uplink or downlink operations, and providing a concomitant extension of the AWS-4 buildout milestone.

8.1.2 AWS Licensing

The FCC typically uses an auctions process, absent a need to do otherwise, to assign initial licenses for AWS from among mutually exclusive applications. Access to AWS spectrum may also be attained through the secondary market, which generally allows AWS licensees to transfer, sell, or lease spectrum, in whole or in part.

You can find information about AWS licenses in the Universal Licensing System (ULS) and the Spectrum Dashboard. The ULS radio service code and description for AWS-1 is AW, 1710-1755/2110-2155 MHz bands; for H Block is CY, 1915-1920 MHz / 1995-2000 MHz; and for AWS-4 is AD, 2000-2020 / 2180-2200 MHz bands.

The FCC service rules for AWS are in 47 C.F.R. Part 27.

8.1.3 AWS Market Areas & Channel Blocks

AWS licenses are issued by FCC market areas and channel blocks.

FCC market areas consist of one or more counties. The market areas for AWS licenses are:

- Cellular Market Area (CMA) – There are 734 CMAs.
- Economic Area (EA) – There are 176 EAs.
- Regional Economic Area Grouping (REAG) – There are 12 REAGs.

Channel blocks are groups of frequencies. For the specific channel blocks associated with a particular AWS band, please see 47 C.F.R. § 27.5(h),(j),(k) (Frequencies) and § 27.6(h),(i),(j),(k) (service areas).

8.2 United States 1710/2155 MHz Allocation (AWS-1)

AWS is the collective term used by the FCC for new and innovative fixed and mobile terrestrial wireless applications using bandwidth in this pair of bands that is sufficient for the provision of a variety of applications including those using voice and data (such as internet browsing, message services, and full-motion video) content. AWS is commonly associated with so-called third generation (3G) applications and service rules that were established in

2006. The 90 MHz of spectrum in the 1710-1755 and 2110-2155 MHz bands is termed the AWS-1 band and is shown in Figure 8.1.

Figure 8.1 – United States AWS-1 Band Plan (1710-2155 MHz)

Table 8.1 – United States AWS-1 Paired Channel Blocks (FDD)

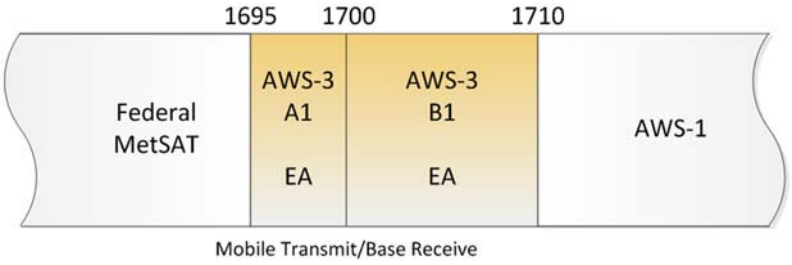
Block Identifier	Frequency Range
Block A	1710-1720/2110-2120 MHz (2x10 MHz)
Block B	1720-1730/2120-2130 MHz (2x10 MHz)
Block C	1730-1735/2130-2135 MHz (2x5 MHz)
Block D	1735-1740/2135-2140 MHz (2x5 MHz)
Block E	1740-1745/2140-2145 MHz (2x5 MHz)
Block F	1745-1755/2145-2155 MHz (2x10 MHz)

8.3 United States 1755/2180 MHz Allocation (AWS-3)

Following a Notice of Proposed Rulemaking in July 2013, the FCC adopted a Report and Order in March 2014 with allocation, technical, and licensing rules for commercial use of the 1695-1710 MHz, 1755-1780 MHz and 2155-2180 MHz bands. These spectrum bands are collectively known as AWS-3 as shown in Figure 8.2.

The AWS-1, AWS-3 and AWS-4 spectrum bands are shown in Figure 8.3. The AWS-1, AWS-3, and AWS-4 Blocks with associated pairing are shown in Table 8.3.

1695-1710 MHz



1755-1780 and 2155-2180 MHz

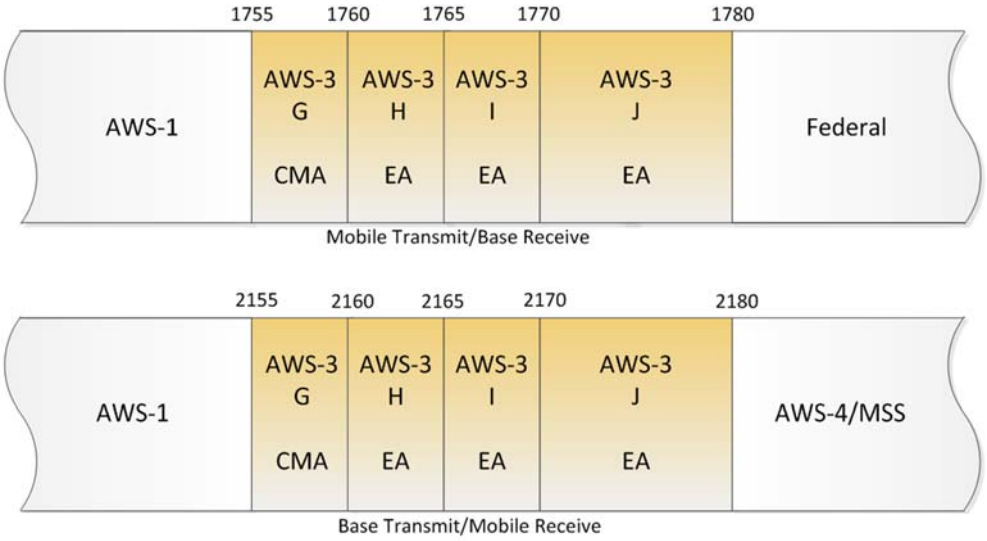


Figure 8.2 – United States AWS-3 Frequency Block / License Summary

Table 8.2 – United States AWS-3 Blocks

Block	Frequencies	Bandwidth	Pairing	Geographic Area Type	Number of Licenses
A1	1695-1700 MHz	5 MHz	unpaired	EA	176
B1	1700-1710 MHz	10 MHz	unpaired	EA	176
G	1755-1760/2155-2160 MHz	10 MHz	2 x 5 MHz	CMA	734
H	1760-1765/2160-2165 MHz	10 MHz	2 x 5 MHz	EA	176
I	1765-1770/2165-2170 MHz	10 MHz	2 x 5 MHz	EA	176
J	1770-1780/2170-2180 MHz	20 MHz	2 x 10 MHz	EA	176

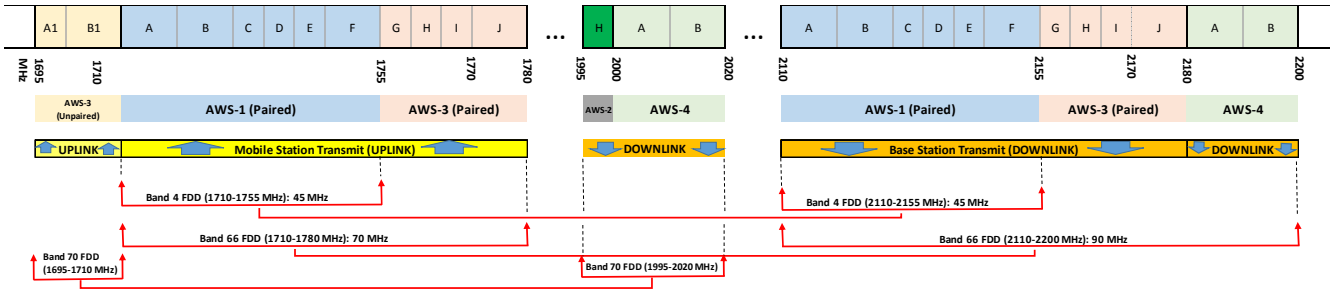


Figure 8.3 – United States AWS-1 & AWS-3 Band Plan

Table 8.3 – United States AWS-1, AWS-3, AWS-4 Blocks

Spectrum	Block	Frequencies	Pairing
AWS-1	A	1710-1720 and 2110-2120 MHz	Paired
	B	1720-1730 and 2120-2130 MHz	Paired
	C	1730-1735 and 2130-2135 MHz	Paired
	D	1735-1740 and 2135-2140 MHz	Paired
	E	1740-1745 and 2140-2145 MHz	Paired
	F	1745-1755 and 2145-2155 MHz	Paired
AWS-3	A1	1695-1700 MHz	Un-paired
	B1	1700-1710 MHz	Un-paired
	G	1755-1760/2155-2160 MHz	Paired
	H	1760-1765/2160-2165 MHz	Paired
	I	1765-1770/2165-2170 MHz	Paired
	J	1770-1780/2170-2180 MHz	Paired
AWS-4	A	2000-2010 MHz and 2180-2190 MHz	Paired*
	B	2010-2020 MHz and 2190-2200 MHz	Paired*

* NOTE: Licensee using DL portion of AWS-4 with AWS-3/1 DL blocks

8.4 Canada 1710/2155 AWS-1 Allocation

AWS are first and foremost subscriber-based services to provide Canadians with access to the public telephone network and the Internet. Canada identified prime mobile spectrum in the 1710-1755 MHz and 2110-2155 MHz to keep Canada in step with developments in North America and Europe which support a modern telecommunications infrastructure.

Flexibility is provided to the licensees within the context of wireless access applications within the mobile and fixed service allocations.

Canada proposed that this spectrum be designated for AWS with a service capability of high mobility and fixed operations. This supported the terminology in order to align service within North America.

In developing a band plan for the purposes of consultation, ISED used the 5 MHz block as a basic unit. The 5 MHz block is harmonized with the U.S. and other countries to provide for technical neutrality, which facilitates roaming and bilateral coordination. The band plan and block sizes shown in Figure 8.4 and Table 8.4 below are based on the 5 MHz block grid, with band edges that align with the U.S. for both base and mobile stations, and internationally for base stations.

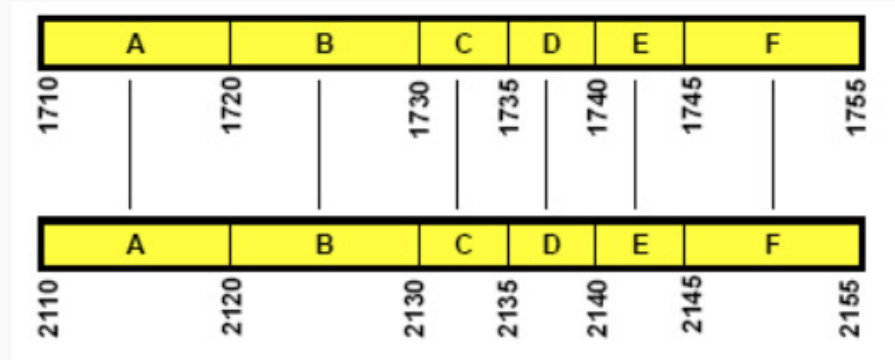


Figure 8.4 – Canada AWS-1 Band Plan (1710-2155 MHz)

Table 8.4 – Canada AWS-1 blocks

Spectrum Block	Bandwidth (MHz)	Tier	Lower Frequency (MHz)	Upper Frequency (MHz)
A	20	3	1710 – 1720	2110 -2120
B	20	2	1720 – 1730	2120 – 2130
C	10	2	1730 – 1735	2130 – 2135
D	10	3	1735 – 1740	2135 – 2140
E	10	3	1740 – 1745	2140 -2145
F	20	3	1745 – 1755	2145 -2155

ISED divides Canada into geographic service areas called "tiers" based on the geographic areas of Statistics Canada 1996 census subdivisions as follows:

- Tier 1 is a single national service area;
- Tier 2 consists of 8 provincial and 6 large regional service areas;
- Tier 3 consists of 59 regional service areas; and
- Tier 4 comprises 172 localized service areas.

For the AWS spectrum, Canada adopted the use of Tier 2 and 3 service areas.

SRSP-513 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the AWS-1 band. Equipment must be certified in accordance with RSS-139.

8.5 Canada 1755/2180 MHz AWS-3 Allocation

In Canada, the Band 1755-1780 MHz and 2155-2180 MHz is identified as AWS-3.

Figure 8.5 shows the Canadian band plan for AWS-1 and the Canadian band plan for AWS-3. AWS-1 is comprised of the bands 1710 to 1755 MHz and 2110 to 2155 MHz and was previously auctioned. AWS-3 is comprised of the bands 1755 to 1780 MHz and 2155 to 2180 MHz. The band plan for AWS-3 includes three blocks: block GHI from 1755 to 1770 MHz and from 2155 to 2170 MHz, block J1 from 1770 to 1775 MHz and 2170 to 2175 MHz, and block J2 from 1775 to 1780 MHz and 2175 to 2180 MHz.

ISED proposed to use the same band plan (uplink at 1755-1780 MHz and downlink at 2155-2180 MHz) as currently used in the United States. However, ISED proposed that the three 5 MHz blocks, (G, H and I) be combined into one 15 + 15 MHz block, in addition to the 10 + 10 MHz block J. The Department proposed large blocks because they would allow licensees to benefit from increased throughput, capacity and network efficiencies. In addition, large blocks would allow service providers to aggregate more efficiently the AWS-3 blocks with their other spectrum holdings across the AWS-1 and other bands. Furthermore, combining the G, H and I blocks into one GHI block would still align sufficiently with the U.S. band plan to simplify coordination and minimize the risk of an incompatible equipment ecosystem.

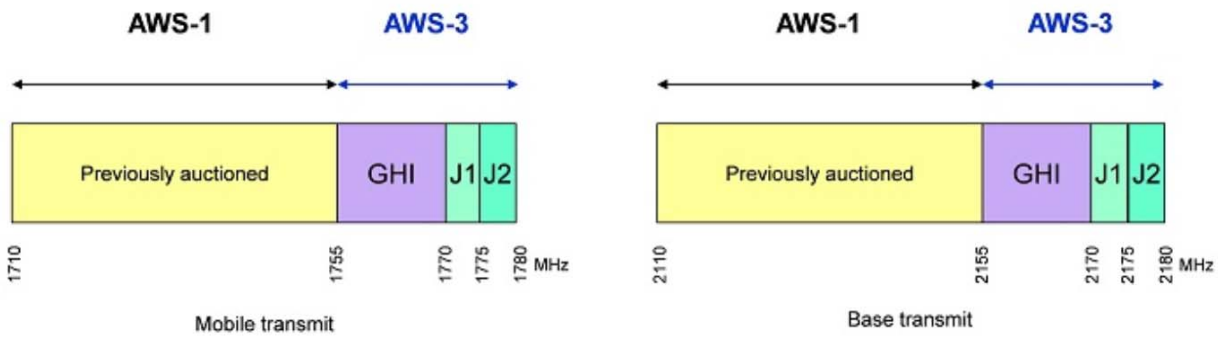


Figure 8.5 – Canada AWS-1 & AWS-3 Band Plans (1710-2180 MHz)

Table 8.5 – Canada AWS-3 blocks

Block	Frequency	MHz
GHI	1755-1770 MHz/2155-2170 MHz	15+15 MHz
J1	1770-1775 MHz/2170-2175 MHz	5+5 MHz
J2	1775-1780 MHz/2175-2180 MHz	5+5 MHz

SRSP-513 and RSS-139, mentioned in the previous clause for AWS-1, also respectively establish the technical rules for systems operating in the commercial mobile spectrum in the AWS-3 band and serve for equipment certification.

9 1900 MHz Allocations

9.1 United States 1900 MHz Allocation

In the United States, the FCC allocated 140 MHz of spectrum for licensed broadband PCS and designated two different types of geographic service areas for PCS licenses in the United States. Eight blocks of spectrum were allocated: from 1850 MHz to 1920 MHz and 1930 MHz to 2000 MHz. The spectrum allocation is divided into three 2x15 MHz blocks (blocks A, B, and C) and five 2x5 MHz blocks (blocks D, E, F, G, and H) as shown in Figure 9.1. A block of spectrum from 1920 MHz to 1930 MHz is allocated for unlicensed PCS applications. The FCC allows spectrum disaggregation, where PCS block licensees may resell portions of, or their entire spectrum, to other PCS providers.

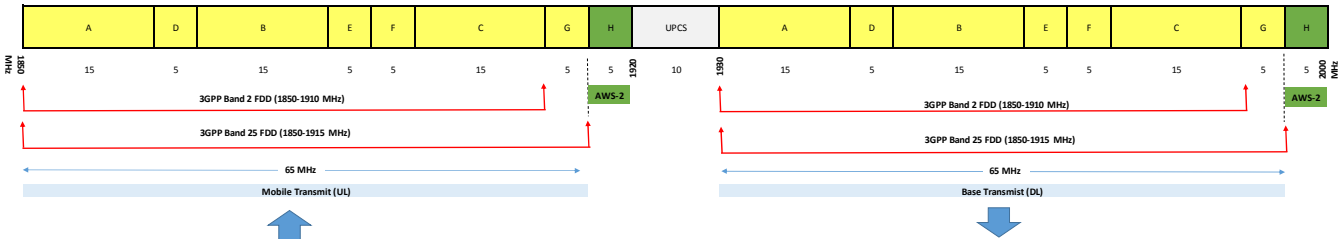


Figure 9.1 – United States PCS Band Plan (1850-1990 MHz)

Table 9.1 – United States PCS Paired Channel Blocks (FDD)

Block Identifier	Frequency Range
Block A	1850 - 1865/1930 - 1945 (2x15 MHz)
Block B	1870 - 1885/1950 - 1965 (2x15 MHz)
Block C	1895 - 1910/1975 - 1990 (2x15 MHz)
Block D	1865 - 1870/1945 - 1950 (2x5 MHz)
Block E	1885 - 1890/1965 - 1970 (2x5 MHz)
Block F	1890 - 1895/1970 - 1975 (2x5 MHz)
Block G	1910 - 1915/1990 - 1995 (2x5 MHz)
Block H	1915 - 1920/1995 - 2000 (2x5 MHz)

9.2 Canada 1900 MHz Allocation

In an effort to ensure North American harmonization of spectrum services, the Canadian spectrum regulator, ISED, usually follows the same spectrum allocation strategies as used by the FCC. In the 1900 MHz Band, IC has declared the use of the same band plan as in the United States, for licensed broadband PCS.

Although the Canadian and US band plans match, in addition to subdividing this frequency range into eight blocks (A-H), IC has further subdivided the B and C blocks into six smaller 2x5 MHz blocks (B1, B2, B3, C1, C2, and C3) as shown in Figure 9.2.

The A (2x15 MHz) and the B1-G (2x5 MHz) blocks have been licensed to Canadian wireless carriers in geographical blocks. IC is in the process of adding the H block, which extends from 1915-1920 MHz and 1995-2000 MHz (sometimes called the AWS-2 band), but this has not yet been finalized.

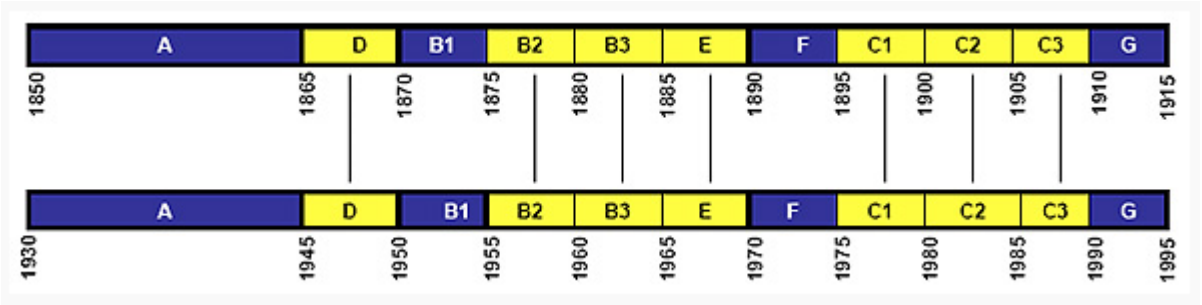


Figure 9.2 – Canada PCS Band Plan (1850-1995 MHz)

SRSP-510 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the PCS band. Equipment must be certified in accordance with RSS-133.

Table 9.2 – Canadian PCS Paired Channel Blocks (FDD)

Block Identifier	Frequency Range
Block A	1850 - 1865/1930 - 1945 (2x15 MHz)
Block B1	1870 - 1875/1950 - 1955 (2x5 MHz)
Block B2	1875 - 1880/1955 - 1960 (2x5 MHz)
Block B3	1880 - 1885/1960 - 1965 (2x5 MHz)
Block C1	1895 - 1900/1975 - 1980 (2x5 MHz)
Block C2	1900 - 1905/1980 - 1985 (2x5 MHz)
Block C3	1905 - 1910/1985 - 1990 (2x5 MHz)
Block D	1865 - 1870/1945 - 1950 (2x5 MHz)
Block E	1885 - 1890/1965 - 1970 (2x5 MHz)
Block F	1890 - 1895/1970 - 1975 (2x5 MHz)
Block G	1910 - 1915/1990 - 1995 (2x5 MHz)

10 2000-2180 MHz Frequency Band

10.1 United States 2000/2180 MHz (AWS-4) Allocation

On December 11, 2012, the FCC adopted flexible use rules for 40 megahertz of spectrum in the 2 GHz band (2000-2020 MHz and 2180-2200 MHz), which they termed the AWS-4 band [29]. The AWS-4 band plan is shown in Figure 10.1. It enables the implementation of standalone terrestrial services in the 2 GHz MSS spectrum band.

Figure 10.1 – United States AWS-4 Band Plan (2000-2020 MHz and 2180-2200 MHz)

10.2 Canada 2000/2180 MHz (AWS-4) Allocation

In Canada, the Band 2000-2020 MHz and 2180-2200 MHz is identified as AWS-4. ISED proposed to use the same band plan and block pairing as currently used in the U.S., as shown in Figure 10.2, including providing flexibility to use the band 2000-2020 MHz for either terrestrial uplink or downlink. It was noted that harmonizing the Canadian and U.S. band plans and block structures would allow the Canadian market to take advantage of the larger U.S. wireless ecosystem and would ensure that satellites licensed to provide services in Canada could continue to operate in Canada.

The bands 2000-2020 MHz and 2180-2200 MHz are hereinafter referred to as the 2 GHz band.

The requirement to provide Mobile Satellite Services in this band will continue to apply.

The requirement for dual-mode handsets is hereby removed for the 2 GHz band.

ISED is allowing will allow the Ancillary Terrestrial Component (ATC) licensee to decide if the terrestrial use of the band 2000-2020 MHz will be for uplink or downlink operations, noting that such decision would apply to all of Canada for the rest of the license term. The licensee had to notify ISED by May 20, 2016. The licensee elected to use the 2000-2020 MHz frequency band in the downlink direction, aligning with the U.S. licensee using the same band.

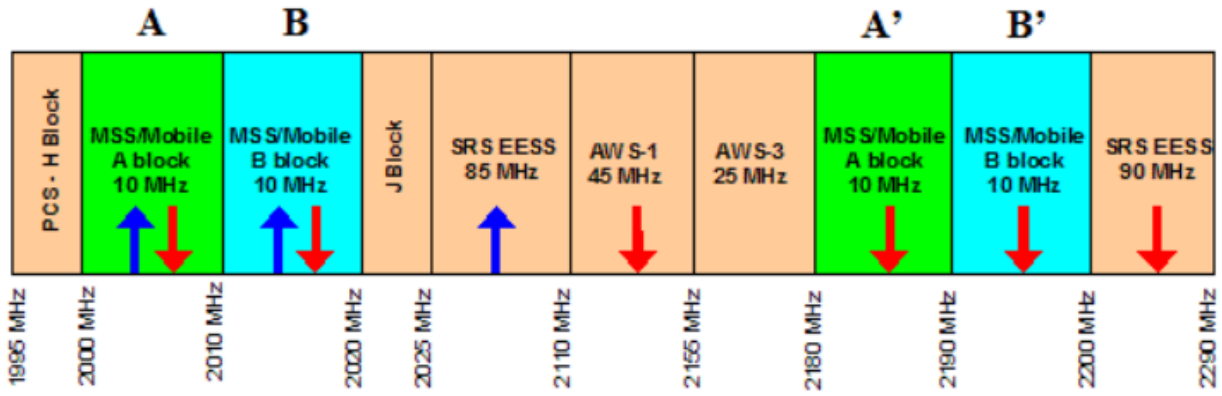


Figure 10.2 – Canada AWS-4 Band Plan (2000-2020 MHz and 2180-2200 MHz)

Figure 10.2 shows the block paring at 2 GHz. There are two 10 + 10 MHz paired blocks, labelled A (2000 – 2010 MHz) and A' (2180 – 2190 MHz), and B (2010 – 2020 MHz) and B' (2190 – 2200 MHz), with blocks A and B being Earth-to-space or space-to-Earth direction, and blocks A' and B' being space-to-Earth direction.

This includes providing licensees with the flexibility to select the duplex direction of the band 2000-2020 MHz for terrestrial use.

SRSP-519 and RSS-170 respectively establish the technical rules for systems operating the ATC of MSS Systems Operating in the AWS-4 band and serve for equipment certification.

11 2300-2800 MHz Frequency Band

11.1 United States 2300 MHz Allocation

The Wireless Communications Service (WCS) is in the 2305-2320 and 2345-2360 MHz spectrum range. The most common use of WCS spectrum is mobile voice and data services, including cell phone, text messaging, and Internet.

The WCS and the Satellite Digital Audio Radio Service (SDARS) occupy 55 MHz of RF spectrum, frequently referred to as the "2.3 GHz band" (2305-2360 MHz). The SDARS occupies the center portion of the 2.3 GHz band at 2320-2345 MHz, and this spectrum is divided evenly between two separate, but co-owned, SDARS networks (Sirius and XM), while the WCS occupies frequency bands on either side of the SDARS allocation. The WCS allocation consists of 4 blocks in the 2305-2320 and 2345-2360 MHz bands: two 10 MHz blocks (paired 5 MHz blocks) and two unpaired 5 MHz blocks as shown in Figure 11.1.

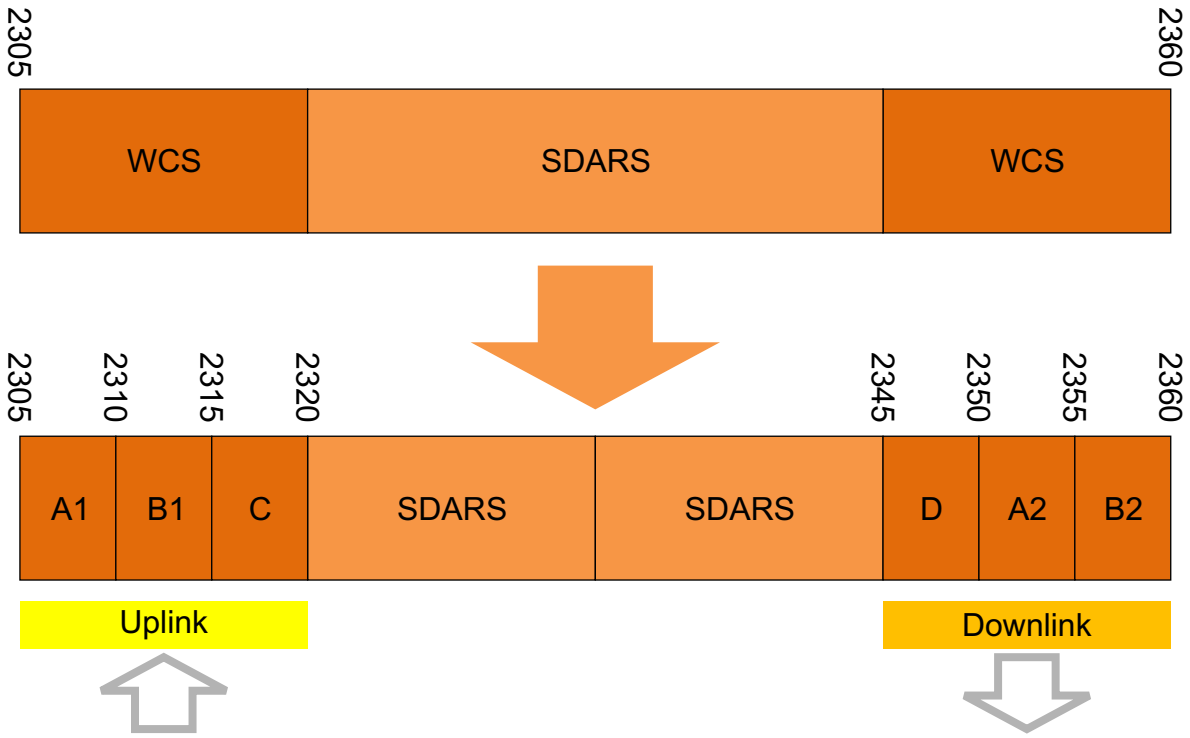


Figure 11.1 – United States WCS Band (2305-2360 MHz)

Table 11.1 – United States WCS Paired (FDD) & Unpaired Channel Blocks

Block Identifier	Frequency Range
Block A	2305-2310/2350-2355 MHz (2x5 MHz)
Block B	2310-2315/2355-2360 MHz (2x5 MHz)
Block C	2315-2320 MHz (5 MHz)
Block D	2345-2350 (5 MHz)

11.2 Canada 2300 MHz Allocation

In Canada, the frequency bands 2305-2320 MHz and 2345-2360 MHz is referred to as the WCS.

The frequency bands 2305-2320 MHz and 2345-2360 MHz are available as one paired block of 15 + 15 MHz as shown in Figure 11.2 and Table 11.2. Various channel sizes may be used within the blocks based on technology choices of the licensee.

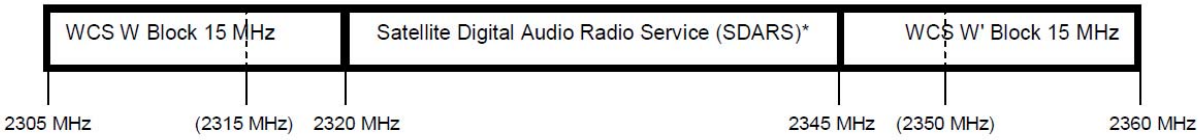


Figure 11.2 – Canada WCS Band (2305-2360 MHz)

Table 11.2 – Canada WCS blocks

Block	Frequencies
W	2305–2320 MHz
SDARS	2320–2345 MHz

Block	Frequencies
W'	2345–2360 MHz

Mobile and portable stations are prohibited from transmitting in the band 2315-2320 MHz of block W and band 2345-2350 MHz of block W'.

Mobile and portable stations using FDD technology are restricted to transmitting in the band 2305-2315 MHz.

Canadian licensees in the frequency bands 2305-2320 MHz and 2345-2360 MHz that operate stations near the Canada-United States border are subject to requirements to coordinate with U.S. licensees on the other side of the border

SRSP-516 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the WCS band. Equipment must be certified in accordance with RSS-195.

12 2500 MHz Frequency Band

12.1 United States 2500 MHz Allocation

The Broadband Radio Service (BRS), formerly known as the Multipoint Distribution Service (MDS)/Multichannel Multipoint Distribution Service (MMDS), is a commercial service. In the past, it was generally used for the transmission of data and video programming to subscribers using high-powered systems, also known as wireless cable. However, over the years, the uses have evolved to include digital two-way systems capable of providing high-speed, high-capacity broadband service, including two-way Internet service via cellularized communication systems. Such services provide consumers integrated access to voice, high-speed data, video-on-demand, and interactive delivery services from a wireless device.

The Educational Broadband Service (EBS), formerly known as the Instructional Television Fixed Service (ITFS), is an educational service that has generally been used for the transmission of instructional material to accredited educational institutions and non-educational institutions such as hospitals, nursing homes, training centers, and rehabilitation centers using high-powered systems.

The BRS and EBS band plan is shown in Figure 12.1.

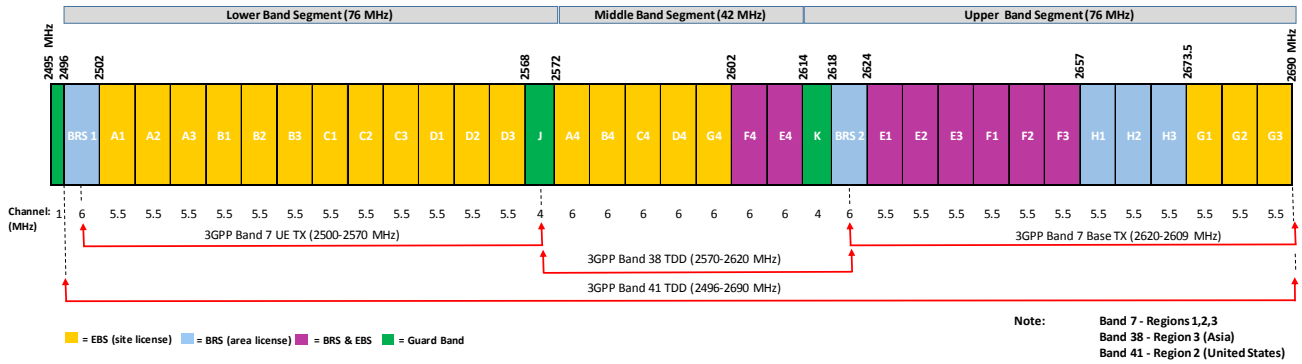


Figure 12.1 – United States EBS BRS Band Plan (2496-2690 MHz)

The width of a channel in the Lower Band Segment (LBS) and Upper Band Segment (UBS) is 5.5 MHz, with the exception of BRS channels 1 and 2, which are 6.0 MHz. The width of all channels in the Middle Band Segment (MBS) is 6 MHz.

The following Unpaired Channel Blocks (TDD) constitute the three different Band Segments:

Table 12.1 – United States BRS EBS Lower Band Segment Blocks

Channel Identifier	Frequency Range
BRS Channel 1	2496-2502 MHz
EBS Channel A1	2502-2507.5 MHz
EBS Channel A2	2507.5-2513 MHz
EBS Channel A3	2513-2518.5 MHz
EBS Channel B1	2518.5-2524 MHz
EBS Channel B2	2524-2529.5 MHz
EBS Channel B3	2529.5-2535 MHz
EBS Channel C1	2535-2540.5 MHz
EBS Channel C2	2540.5-2546 MHz
EBS Channel C3	2546-2551.5 MHz
EBS Channel D1	2551.5-2557 MHz
EBS Channel D2	2557-2562.5 MHz
EBS Channel D3	2562.5-2568 MHz
EBS Channel JA1	2568.00000-2568.33333 MHz
EBS Channel JA2	2568.33333-2568.66666 MHz
EBS Channel JA3	2568.66666-2569.00000 MHz
EBS Channel JB1	2569.00000-2569.33333 MHz
EBS Channel JB2	2569.33333-2569.66666 MHz
EBS Channel JB3	2569.66666-2570.00000 MHz
EBS Channel JC1	2570.00000-2570.33333 MHz
EBS Channel JC2	2570.33333-2570.66666 MHz
EBS Channel JC3	2570.66666-2571.00000 MHz
EBS Channel JD1	2571.00000-2571.33333 MHz
EBS Channel JD2	2571.33333-2571.66666 MHz
EBS Channel JD3	2571.66666-2572.00000 MHz

Table 12.2 – United States BRS EBS Middle Band Segment Blocks

Channel Identifier	Frequency Range
EBS Channel A4	2572-2578 MHz
EBS Channel B4	2578-2584 MHz
EBS Channel C4	2584-2590 MHz
EBS Channel D4	2590-2596 MHz
EBS Channel G4	2596-2602 MHz
BRS/EBS Channel F4	2602-2608 MHz
BRS/EBS Channel E4	2608-2614 MHz

Table 12.3 – United States BRS EBS Upper Band Segment Blocks

Channel Identifier	Frequency Range
BRS Channel KH1	2614.00000-2614.33333 MHz
BRS Channel KH2	2614.33333-2614.66666 MHz
BRS Channel KH3	2614.66666-2615.00000 MHz
EBS Channel KG1	2615.00000-2615.33333 MHz
EBS Channel KG2	2615.33333-2615.66666 MHz
EBS Channel KG3	2615.66666-2616.00000 MHz
BRS Channel KF1	2616.00000-2616.33333 MHz
BRS Channel KF2	2616.33333-2616.66666 MHz
BRS Channel KF3	2616.66666-2617.00000 MHz
BRS Channel KE1	2617.00000-2617.33333 MHz
BRS Channel KE2	2617.33333-2617.66666 MHz
BRS Channel KE3	2617.66666-2618.00000 MHz
BRS Channel 2	2618-2624 MHz or 2156-2162 MHz
BRS Channel 2A	2618-2624 MHz or 2156-2160 MHz
BRS/EBS Channel E1	2624-2629.5 MHz
BRS/EBS Channel E2	2629.5-2635 MHz
BRS/EBS Channel E3	2635-2640.5 MHz
BRS/EBS Channel F1	2640.5-2646 MHz
BRS/EBS Channel F2	2646-2651.5 MHz
BRS/EBS Channel F3	2651.5-2657 MHz
BRS Channel H1	2657-2662.5 MHz
BRS Channel H2	2662.5-2668 MHz
BRS Channel H3	2668-2673.5 MHz
EBS Channel G1	2673.5-2679 MHz
EBS Channel G2	2679-2684.5 MHz
EBS Channel G3	2684.5-2690 MHz

12.2 Canada 2500 MHz Allocation

In Canada, the frequency band 2500-2690 MHz (also known as the 2500 MHz band) is referred to as BRS.

The 2500 MHz band, previously allocated to the fixed and/or broadcasting services, has been licensed to Multipoint Communication Systems (MCS) operators in the bands 2500-2596 MHz and 2686-2688 MHz, and to MDS operators in the bands 2596-2686 MHz and 2688-2690 MHz.

In November 2001, ISED indicated that the fixed and mobile services would be allocated throughout the band 2500-2690 MHz, as shown in Figure 12.2. ISED decided to adopt the ITU band plan for the 2500 MHz band.

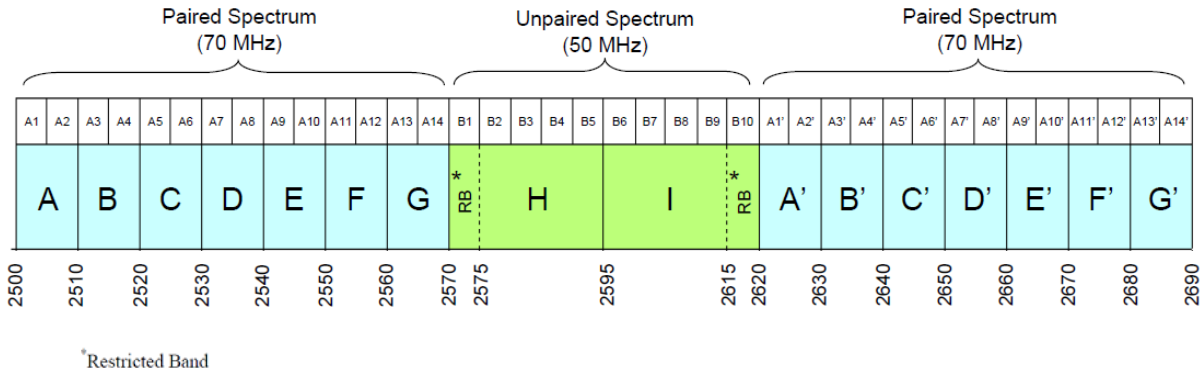


Figure 12.2 – Canada BRS Band Plan (2500-2690 MHz)

Table 12.4 – Canada 2500 MHz Blocks

Block	Frequencies	Total Spectrum	Pairing
A / A’	2500-2510 MHz / 2620-2630 MHz	10 + 10 MHz	paired
B / B’	2510-2520 MHz / 2630-2640 MHz	10 + 10 MHz	paired
C / C’	2520-2530 MHz / 2640-2650 MHz	10 + 10 MHz	paired
D / D’	2530-2540 MHz / 2650-2660 MHz	10 + 10 MHz	paired
E / E’	2540-2550 MHz / 2660-2670 MHz	10 + 10 MHz	paired
F / F’	2550-2560 MHz / 2670-2680 MHz	10 + 10 MHz	paired
G / G’	2560-2570 MHz / 2680-2690 MHz	10 + 10 MHz	paired
H	2570-2595 MHz	25 MHz (includes 5 MHz restricted band)	unpaired
I	2595-2620 MHz	25 MHz (includes 5 MHz restricted band)	unpaired

The band 2500-2570 MHz, which is paired with the band 2620-2690 MHz, is divided into seven 10 + 10 MHz paired blocks with a frequency separation of 120 MHz. The band 2570-2620 MHz is divided into two 25 MHz unpaired blocks. The unpaired blocks will each include a 5 MHz restricted band separating the paired and unpaired spectrum (i.e., 2570-2575 MHz and 2615-2620).

Time Division Duplex (TDD) operations by licensees within the restricted bands 2570-2575 MHz and 2615-2620 MHz are permitted on a no-protection, no-interference basis with respect to FDD operations in the paired spectrum.

ISED imposed two 5 MHz restricted bands, 2570-2575 MHz and 2615-2620 MHz, to mitigate interference between systems operating in the paired and unpaired spectrum.

SRSP-517 has been released establishing the technical rules for systems operating in the commercial mobile spectrum in the BRS band. Equipment must be certified in accordance with RSS-19.

13 3400-3800 MHz Frequency Band

13.1 United States 3400 MHz Allocations

NTIA performed a “fast track” review of some of these bands to determine whether any spectrum could be made available for wireless broadband within five years of October. At that point NTIA initially identified 100MHz from 3550-3650 MHz be made available for wireless broadband in the next five years from October 2010. For context, the broader 3400-3800 MHz band is shown in Figure 13.1.

For reference, the 3500-3650 MHz band is critical to DOD radar operations for national defense. The DOD operates high-powered defense radar systems on fixed, mobile, shipborne, and airborne platforms in this band.

The radiolocation systems in this band are high-powered surveillance radars, which detect airborne objects. These radars measure target altitude, range, and bearing. Some of the airborne targets are small and some targets must be detected at ranges as great as 300 nautical miles. Therefore, these radars shall have great sensitivity and shall provide a high degree of suppression for all forms of clutter return, including that from sea, land, and precipitation.

As of the establishment of the United States Citizens Broadband Radio Service (CBRS), the 3550-3650 MHz spectrum referenced above is included as the lower 100MHz part of the total 150MHz CBRS band, which runs from 3550-3700 MHz. 70MHz of the 100MHz in the 3550-3650 MHz range will be made available for CBRS Priority Access Licenses (Tier 2 Secondary User); where seven 10 MHz channels will be auctioned. Within a given area, spectrum in this 100 MHz range that is currently unused by both incumbents (Federal Radiolocation or Incumbent Fixed Satellite Stations) and Priority Access Licensees will be made available for CBRS General Authorized Access (Tier 3 Secondary User) and licensed-by-rule. Note, within the CBRS model, these incumbents are termed “Tier1” and are the Primary Users of the spectrum. The upper 50 MHz of the CBRS Band, from 3650-3700 MHz, is only available for Tier 1 Incumbents and Tier 3 General Authorized Access Users, and not available for licensing as Tier 2 Priority Access Licenses. See Clause 13.2 for further information.

NTIA also recommends that the FCC requires a specification for radio frequency front-end filters. If the base and mobile front-end filters are too wide, radar systems operating below 3550 MHz can also cause receiver saturation to occur. Installing RF filters with sufficient rejection to signals below 3550 MHz should mitigate the problem. The RF filter will need to provide 30 to 40 dB of attenuation at 3500 MHz (approximately 50 MHz below the band of interest, 3550-3650 MHz).

This 100 MHz spectrum block is part of the larger 3500-3650 MHz band, which is allocated to the radiolocation and aeronautical radio navigation (ground-based) services on a primary basis for Federal use and to the radiolocation service on a secondary basis for non-Federal use. The 3600-3650 MHz band is also allocated to the fixed-satellite service (space-to-earth) on a primary basis for non-Federal use, limited to international inter-continental systems.

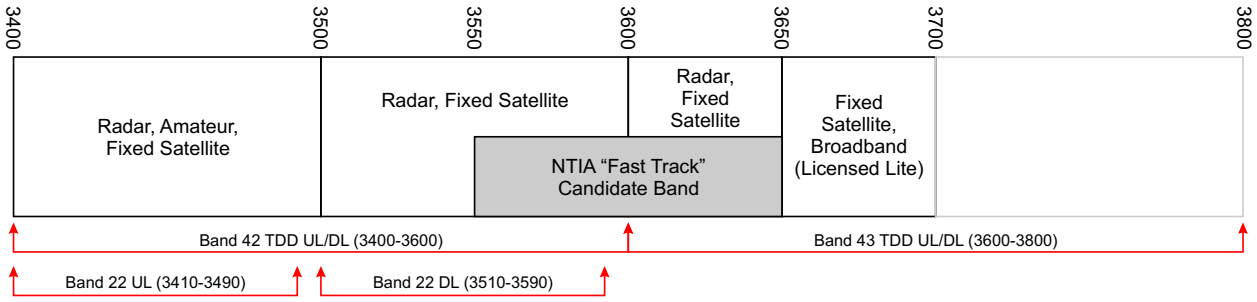


Figure 13.1 – United States 3400 MHz Band Plan

13.2 United States Citizens Broadband Radio Service Band (3550-3700 MHz)

The Citizens Broadband Radio Service is governed by a three-tiered spectrum authorization framework to accommodate a variety of commercial uses on a shared basis with incumbent federal and non-federal users of the band. More specifically, spectrum access will be amongst incumbent military radars, satellites and commercial users new to this spectrum allocation. Access and operations will be managed by a dynamic Spectrum Access System

(SAS). The three tiers are: Incumbent Access (Tier 1 Primary Users), Priority Access (Tier 2 Secondary Users), and General Authorized Access (Tier 3 Secondary Users).

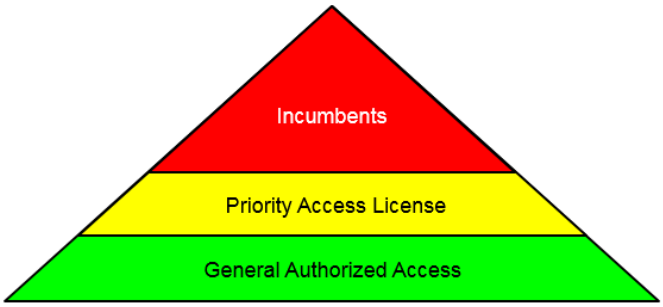


Figure 13.2 – Three tiers of users in CBRS Band

Incumbent Access users include authorized federal, Fixed Satellite Service, and Grandfathered Wireless Broadband Service (3650-3700 MHz) users currently operating in the 3.5 GHz Band. Such Tier 1 Incumbents generally are located along the coastal areas, though there are some inland. These Tier 1 users will be protected from harmful interference from Priority Access and General Authorized Access users.

Tier 1 Incumbent Access Users are primary users and enjoy dynamic priority spectrum access over all secondary users – i.e., during their operating times.

> NOTE: Grandfathered Wireless Broadband Services currently operating in the frequency range 3650-3700 MHz are required to transition over to Priority Access or General Authorized Access starting in year 2020 and as their existing licenses expire.

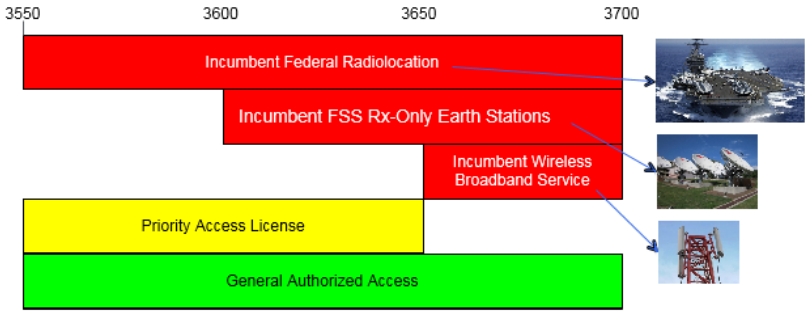


Figure 13.3 – Spectrum allocations for each tier of CBRS users

The Priority Access tier consists of Priority Access Licenses (PALs) within the 3550-3650 MHz portion of the band. Each PAL is defined as a non-renewable authorization to use a 10 megahertz channel in a single census tract for three-years.

> NOTE: Renewability, geographic license sizing, and other parameters are currently being reconsidered by the FCC via NPRM (FCC 17-134). PALs reside at Tier 2 and can presume interference protection from Tier 3, General Authorized Access (GAA).

The GAA tier is licensed-by-rule to permit open, flexible access to the band for the widest possible group of potential users. General Authorized Access users are permitted to use any portion of the 3550-3700 MHz band (as determined by the SAS) provided they do not interfere with a higher tier user and may also operate opportunistically on unused Priority Access channels. GAA is also recognized as Tier 3 and provides at least 80MHz of commercial use within the overall 150MHz allocation. GAA users have no presumption of interference protection from one another (or higher tiers), though they may choose to take advantage of optional interference optimization information made available to them by the SAS, as well as optionally choose to cooperate in other manners to mitigate GAA/Tier

3 interference. While a GAA license does have some broad similarity to Part 15, Citizens Broadband Radio Service Device (CBSD) operations must be authorized initially and on-going by the SAS.

Priority Access Licensees and General Authorized Access Users are permitted to provide services on a non-common carrier and/or on a common carrier basis. An authorized Citizens Broadband Radio Service user may render any kind of communications service consistent with the regulatory status in its authorization and with the Commission's rules applicable to that service.

Frequencies:

- The Citizens Broadband Radio Service is authorized in the 3550-3700 MHz frequency band.
- General Authorized Access Users may operate in the 3550-3700 MHz frequency band.
- Priority Access Users may operate in the 3550-3650 MHz frequency band.

The CBRS band plan is shown in Figure 13.4.

CBSDs may be used in the frequency bands above. The operation of all CBSDs shall be coordinated by one or more authorized SASs.

NOTE: E-UTRA Band 48 also maps to the CBRS authorization in the 3550-3700 frequency band, in this case subsuming Band 42 and part of Band 43.

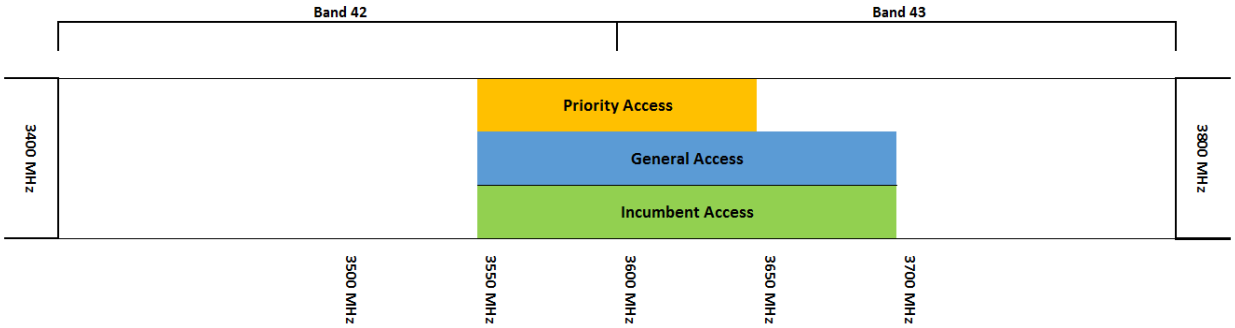


Figure 13.4 – 3.5 GHz Band Plan

There are three types of CBSDs:

- End User Devices
- Category A CBSD
- Category B CBSD

The End User Devices may be fixed or mobile. The device is authorized and controlled by an authorized CBSD. These devices may not be used as intermediate service links or to provide service to other End User Devices or CBSDs.

Operating at a lower power, the Category A CBSD can be used indoors or outdoors. When considered for outdoor usage, the antenna cannot exceed 6 meters height above average terrain (HAAT). If the antenna height is greater than 6 meters HAAT, the device will be reclassified as a CAT-B CBSD.

A Category B CBSD is a higher-powered CBSD, must be professionally installed, and is limited to outdoor operations only.

13.3 Canada 3400-3800 MHz Allocation

The 3400-3800 MHz frequency range, often referred as the 3500 MHz band, has multiple primary uses in Canada:

- 3400-3450 MHz is for radiolocation and reserved for government use.

- 3450-3500 MHz is for fixed and radiolocation where radiolocation has priority over fixed service used for fixed wireless access (FWA) application primarily in coastal zones.
- 3500-3650 MHz is for fixed and fixed satellite service (FSS) where FSS has to be located in areas not constraining the implementation of FWA.
- 3650-3700 MHz is for fixed, FSS, and mobile with FSS limitations to allow implementation of Wireless Broadband Service (WBS) application in the mobile service.
- 3700-3800 MHz is for fixed and FSS.

In its 2014 decision, ISED indicated its intent to re-allocate the frequency range 3475-3650 MHz from fixed to mobile services. A consultation is expected in the near future to address this proposed allocation change. SRSP or RSS standards are expected to be available shortly after consultation's decision.

14 24 GHz Frequency Band

On November 22, 2017, the FCC released a *Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order*. In this release, the FCC made available an additional 700 megahertz of millimeter spectrum for flexible wireless use in the 24 GHz band.

The 24 GHz band is split into the "lower segment" from 24.25-24.45 GHz and the "upper segment" from 24.75-25.25 GHz with a 300 MHz separation between the two segments of the band. The 24 GHz band is licensed uniformly in 100 megahertz blocks, with the lower segment (24.25–24.45 GHz) licensed as two 100 megahertz blocks, and the upper segment (24.75–25.25 GHz) as five 100-MHz blocks. Each block will be licensed on an unpaired basis. The 24 GHz band plan is shown in Figure 14.1.

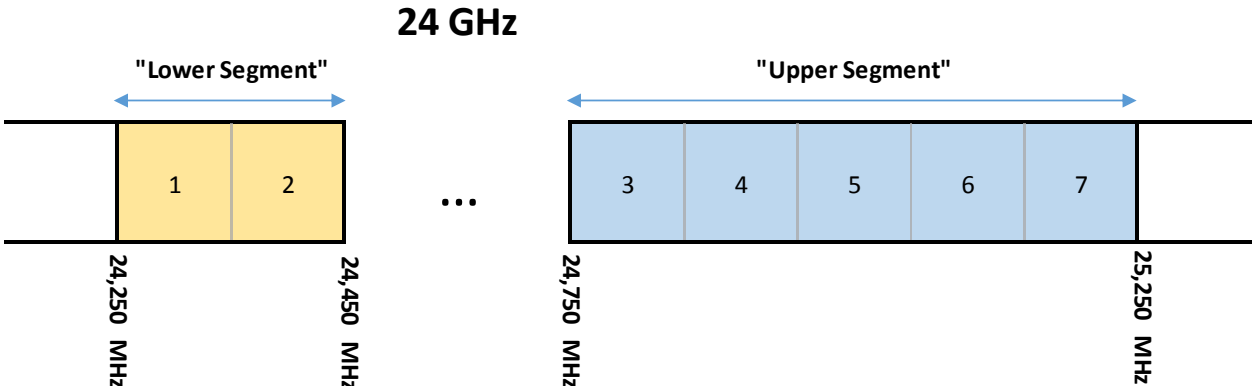


Figure 14.1 – 24 GHz Band Plan

Table 14.1 – 24 GHz Frequency Blocks

Block	Frequencies (MHz)	Bandwidth (MHz)	Geographic Area Type	Number of Licenses
1	24,250–24,350	100	PEA	416
2*	24,350–24,450	100	PEA	416
3	24,750–24,850	100	PEA	416
4	24,850–24,950	100	PEA	416
5	24,950–25,050	100	PEA	416
6	25,050–25,150	100	PEA	416
7*	25,150–25,250	100	PEA	416

*Includes some markets with incumbents

15 Upper Microwave Flexible Use Service

15.1 United States Upper Microwave Flexible Use Service Allocations (Preliminary)

The next generation of wireless connectivity—the fifth generation, or 5G—will utilize high-band millimeter wave spectrum. The FCC's Spectrum Frontiers report and order (July 14, 2016) makes available 3.25 GHz of licensed, flexible use spectrum in the millimeter wave region of the radio spectrum. The report and order created a new Upper Microwave Flexible Use Service (UMFUS) in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands.

The general rules and regulations for the UMFUS are governed under part 30 of title 47, Code of Federal Regulations. Previously the 28 GHz band was licensed for the Local Multipoint Distribution Service (LMDS). The 28 GHz UMFUS Band plan is shown in Figure 14.1. The LMDS licenses for the 27.5-28.35 GHz band, and licenses issued the 38.6-40 GHz band under the rules in part 101 are reassigned to the UMFUS.

The 37-37.6 GHz band will be available for site-based registrations on a coordinated basis with co-equal eligible Federal entities. This is dynamic shared access between different commercial users, and commercial and federal users. The 37/39 GHz band plan is shown in Figure 14.2.

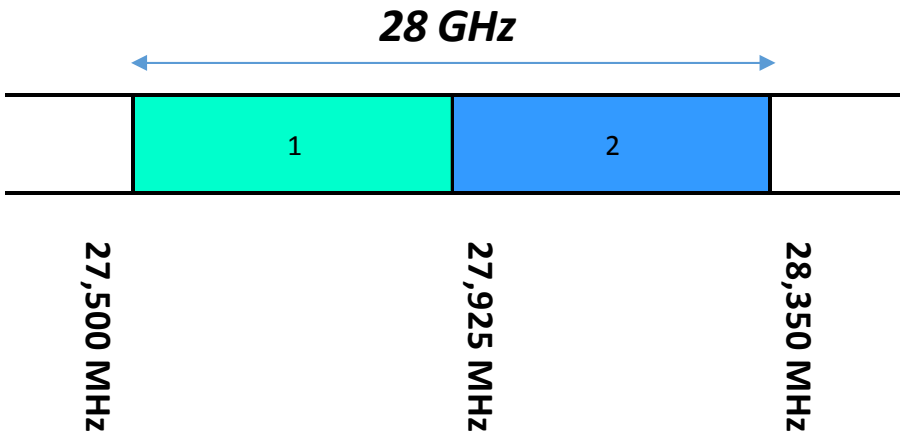


Figure 15.1 – United States 28 GHz UMFUS Band Plan

Table 15.1 – United States 28 GHz Channel Blocks (Unpaired)

Block Identifier	Frequency Range
Block 1	27,500 – 27,925 MHz
Block 2	27,925 – 28,350 MHz

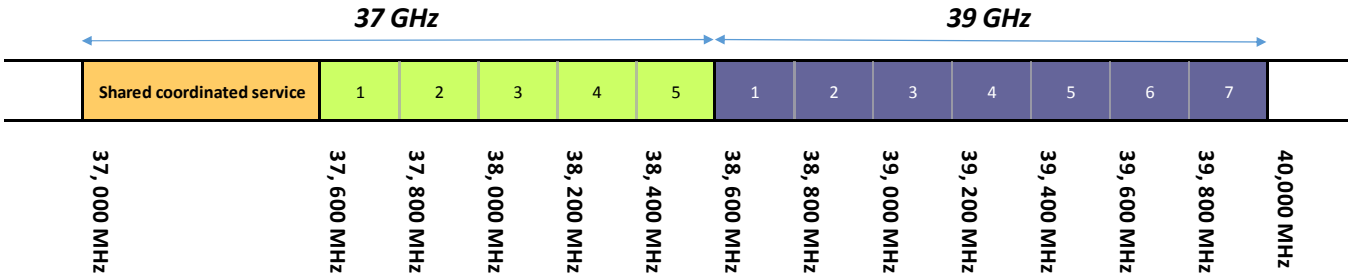


Figure 15.2 – United States 37 and 39 GHz Band Plans

Table 15.2 – United States 37 GHz Channel Blocks (Unpaired)

Block Identifier	Frequency Range
Block 1	37,600-37,800 MHz
Block 2	37,800-38,000 MHz
Block 3	38,000-38,200 MHz
Block 4	38,200-38,400 MHz
Block 5	38,400-38,600 MHz

Table 15.3 – United States 39 GHz Channel Blocks (Unpaired)

Block Identifier	Frequency Range
Block 1	38,600-38,800 MHz
Block 2	38,800-39,000 MHz
Block 3	39,000-39,200 MHz
Block 4	39,200-39,400 MHz
Block 5	39,400-39,600 MHz
Block 6	39,600-39,800 MHz
Block 7	39,800-40,000 MHz

15.2 Canadian Use of the 28, 37, & 39 GHz Frequency Ranges

In June 2017, ISED issued a consultation on “Releasing Millimetre Wave Spectrum to Support 5G”. Among other bands, ISED was seeking views of the potential use of the 28 GHz and 37-40 GHz frequency bands to support the deployment of 5th generation (5G) wireless networks and systems. A decision is awaited in the near future.