Technical Characteristics of Potential Commercial Systems Operating in Some or All of the U.S. 3100-3550 MHz Band

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TERMS, CONDITIONS & NOTICES

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Interim Release Status

This is the second of several planned interim releases in the development of this report. Interim releases are approved at the Committee level, but do not go through final Forum ballot. Accordingly, the contents of this document are not final and are subject to change as the project progresses.

Executive Summary

This document presents ranges of technical parameters for potential commercial systems that could be deployed in some or part of the U.S. 3100-3550 MHz band, under either shared use or cleared/exclusive use. All members[1] of WInnForum were invited to participate in the development of this document. These parameters should be useful for understanding co-existence opportunities in shared portions of the band.

1 https://www.wirelessinnovation.org/Current_Members

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Technical Characteristics of Potential Commercial Systems Operating in Some or All of the U.S. 3100-3550 MHz Band

1 Introduction

The U.S. Congress has directed the Secretary of Commerce to study the feasibility of allowing licensed and/or unlicensed shared access to some or all of the 3100-3550 MHz band.[2] A report on this study is to be conducted by the National Telecommunications and Information Administration (NTIA) and submitted to Congress by March 23rd, 2020.

To conduct the study, NTIA needs to be aware of the technical and deployment characteristics of broadband systems that could be deployed in the band. The purpose of this Request for Information (RFI) is to collect the relevant technical information from our members (potential users of the band) and make the information publicly available to NTIA and others. This information can be used toward NTIA's required study, and/or to future studies of shared use of the band.

This information in this RFI was drafted by the Wireless Innovation Forum's (WInnForum) Advanced Technology Committee (ATC), within a working group established to enable all interested members to participate. WInnForum believes that this group represents a significant cross-section of potential commercial users of shared spectrum in the 3100-3550 MHz band.

2 The 3100-3550 MHz Band

2.1 Allocation Status

The 3100-3550 MHz band is currently allocated in the U.S. as shown in Table 1:

Table 1: 3100-3550 MHz Allocations

Federal Table	Non-Federal Table	FCC Rule Part(s)
3100-3300 RADIOLOCATION G59 Earth exploration-satellite (active) Space research (active) US342	3100-3300 Earth exploration-satellite (active) Space research (active) Radiolocation US342	Private Land Mobile (90)
3300-3500 RADIOLOCATION US108 G2 US342	3300-3500 Amateur Radiolocation US108 5.282 US342	Private Land Mobile (90) Amateur Radio (97)

[2] Section 605.3 of Ray Baum's Act, https://www.congress.gov/115/bills/hr1625/BILLS-115hr1625enr.pdf, p. 753

3500-3550 RADIOLOCATION G59 AERONAUTICAL RADIONAVIGATION (ground-based) G110	3500-3550 Radiolocation	Private Land Mobile (90)

The referenced footnotes are as follows:

5.282 In the bands 435-438 MHz, 1260-1270 MHz, 2400-2450 MHz, 3400-3410 MHz (in Regions 2 and 3 only) and 5650-5670 MHz, the amateur-satellite service may operate subject to not causing harmful interference to other services operating in accordance with the Table (see No. 5.43). Administrations authorizing such use shall ensure that any harmful interference caused by emissions from a station in the amateur-satellite service is immediately eliminated in accordance with the provisions of No. 25.11. The use of the bands 1260-1270 MHz and 5650-5670 MHz by the amateur-satellite service is limited to the Earth-to-space direction.

G2 In the bands 216.965-216.995 MHz, 420-450 MHz (except as provided for in G129), 890-902 MHz, 928-942 MHz, 1300-1390 MHz, 2310-2390 MHz, 2417-2450 MHz, 2700-2900 MHz, 3300-3500 MHz (except as provided for in US108), 5650-5925 MHz, and 9000-9200 MHz, use of the Federal radiolocation service is restricted to the military services.

G59 In the bands 902-928 MHz, 3100-3300 MHz, 3500-3650 MHz, 5250-5350 MHz, 8500-9000 MHz, 9200-9300 MHz, 13.4-14.0 GHz, 15.7-17.7 GHz and 24.05-24.25 GHz, all Federal non-military radiolocation shall be secondary to military radiolocation, except in the sub-band 15.7-16.2 GHz airport surface detection equipment (ASDE) is permitted on a co-equal basis subject to coordination with the military departments.

G110 Federal ground-based stations in the aeronautical radionavigation service may be authorized between 3500-3650 MHz when accommodation in the band 2700-2900 MHz is not technically and/or economically feasible.

US108 In the bands 3300-3500 MHz and 10-10.5 GHz, survey operations, using transmitters with a peak power not to exceed five watts into the antenna, may be authorized for Federal and non-Federal use on a secondary basis to other Federal radiolocation operations.

US342 In making assignments to stations of other services to which the bands:
…
3260-3267 MHz*
3332-3339 MHz*
3345.8-3352.5 MHz*
…
are allocated (*indicates radio astronomy use for spectral line observations), all practicable steps shall be taken to protect the radio astronomy service from harmful interference. Emissions from spaceborne or airborne stations can be particularly serious sources of interference to the radio astronomy service (see ITU Radio Regulations at Nos. 4.5 and 4.6 and Article 29).

The band is immediately below the 3550-3700 MHz band, which is used by the Citizens Broadband Radio Service (CBRS) under shared use with federal government operations similar to those in the 3500-3550 MHz band. CBRS operates under co-primary allocations to the non-federal fixed and mobile services. The band is immediately above the 2900-3100 MHz band, which is extensively used by both federal and non-federal users for marine and weather radars, among other applications.

In some parts of the world, portions of the 3100-3550 MHz band are allocated to the fixed and mobile services to support 4G and 5G networks. The segment 3400-3600 MHz is a 3GPP 4G and 5G band (band designations B42 and N42, respectively).

2.2 Band Use

2.2.1 Federal Government Use

Federal government use of the 3100-3550 MHz band is described in the NTIA's *Quantitative Assessment of Spectrum Usage*[3] and *Federal Government Spectrum Compendium*.[4] In those reports, NTIA breaks the band use into three sub-bands, 3100-3300 MHz, 3300-3500 MHz, and 3500-3650 MHz. The content of the Spectrum Compendium is summarized here. The user is advised to refer to the complete reports for further detail. The appendices of the Quantitative Assessment document include maps purporting to show the geographic areas in which incumbent operations are active; however, maps in that report for the 3500-3550 MHz band are known to understate the federal incumbent impacts based on actual protections established for adjacent band emissions from CBRS. The user is cautioned not to rely on the maps in the Quantitative Assessment to assess the actual incumbent impact, which may be greater than shown.

2.2.1.1 Shipborne

The Navy uses 3100-3500 MHz for shipborne radar along the coasts of the United States and on the high seas. The range of the radars is as great as 300 nautical miles. The radars are also used in port for test and measurements. The technical characteristics of the U.S. Navy's radars in this band are consistent with those listed in ITU-R Recommendation M.1465-1 and summarized in Table 1 of the 3100-3300 and 3300-3500 MHz band reports in the NTIA *Spectrum Compendium*. According to the NTIA, "the radiolocation radars in this band are nearly always mobile (on ships transiting littoral waters), and there is no way to know exactly where and when they will operate or what frequencies they will use."

The Navy uses 3500-3650 MHz for air traffic control radars on aircraft carriers and large amphibious assault ships (CV and LH class). According to NTIA, "the radars operate in and around ports and in close proximity to United States and possessions coastlines…". Although the band reports don't mention it, the DoD has several inland sites at which radars in this band are used, and are protected from interference caused by CBRS. Coastal and inland use of the band is documented in GIS files maintained by NTIA.[5]

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[3] https://www.ntia.doc.gov/report/2016/quantitative-assessments-spectrum-usage (2016)
[4] https://www.ntia.doc.gov/other-publication/2017/federal-government-spectrum-compendium (2015)
[5] https://www.ntia.doc.gov/fcc-filing/2015/ntia-letter-fcc-commercial-operations-3550-3650-mhz-band (files e-dpas.kml and p-dpas.kml)

2.2.1.2 Land-Based

The Army uses the 3100-3500 MHz band throughout the U.S. for high-power transportable radar. The technical characteristics of the Army's radars in this band are consistent with those listed in ITU-R Recommendation M.1465-1 and summarized in Table 2 of the 3100-3300 and 3300-3500 MHz band reports in the NTIA Spectrum Compendium. The tuning range of the radar used in the U.S. is 3100-3500 MHz, not 3100-3700 MHz as listed in Recommendation M.1465-1. According to NTIA, the land-based radars are likely to operate only a small percentage of the time except in a few fixed areas.

The Air Force operates station keeping equipment (ground and airborne components) in the 3300-3510 MHz range.

In 3500-3600 MHz, NTIA states that "the Military is in the process of fielding a new radar system… The Marine Corps also operates a multi-function radar systems that provides surveillance, air traffic control and fire quality data."

2.2.1.3 Airborne

DoD uses airborne radar in the 3100-3450 MHz range throughout the U.S. and possessions. The technical characteristics are given in ITU-R Recommendation M.1465-1, and also in Table 3 of the 3100-3300 and 3300-3500 MHz band reports.

According to NTIA, in 3100-3300 MHz, "the Air Force operates systems in this band designed for airborne target gunnery weapon system evaluation and training" in California, New Mexico, and Florida.

The Air Force operates station keeping equipment (ground and airborne components) in the 3300-3510 MHz range.

2.2.2 Non-government Use

All non-federal-government use of the 3100-3550 MHz band is on a secondary basis.

Some earth observation systems make use of the 3100-3300 MHz portion of the band. For example, S-band Synthetic Aperture Radar (SAR-S) is often designed to operate in this band, and is used from satellites[6] and airborne platforms[7] for ship detection, ice mapping, oil spill detection, flood mapping, forestry mapping, and crop classification.[8] S-band SAR performs

[6] https://www.wmo-sat.info/oscar/instruments/view/1197

[7] https://www.researchgate.net/publication/262731857_NovaSAR-S_and_Maritime_Surveillance

[8] https://research.csiro.au/cceo/novasar/novasar-introduction/satellite-specifications-capabilities/sar-overview/

better in adverse weather conditions, has better ground penetration, and can discriminate between different vegetation better than higher-frequency radars.[9]

Various terrestrial radar systems make use of the secondary radiolocation allocation in the 3100-3300 MHz portion. For example, one power company uses 3100-3300 MHz radars to provide security to transmission substations in Alabama and Georgia.[10] Low-power 3200 MHz motion sensing radar modules are available online to hobbyists and experimenters for less than $2.[11]

Radio astronomers use frequencies in the range of 3260 - 3353 MHz by virtue of US342 to observe certain spectral line emissions. Their use of these frequencies is highly sensitive to interference, but is limited to a small number of isolated radio astronomy sites.

Amateur radio operators use the 3300-3500 MHz range for terrestrial communications and experimentation. Amateur satellite operations are permitted in the 3400-3410 MHz sub-band on a non-interference basis to other services.

Within the past few years, the FCC has licensed five high-power weather radars in the 3500-3550 MHz band.[12] These radars are licensed for over 10 gigawatts of peak EIRP.

3 Technical Characteristics of Potential Commercial Systems

The following sections describe the range of characteristics of commercial systems that could be deployed in some or all of the 3100-3550 MHz band. This document represents the interests of a wide range of potential band users and does not advocate for any one technology or application in the band. To the extent that a specific technology is mentioned, it is because at least one potential band user has expressed interest in deploying that application in the band. The data included in this section are believed to be the most relevant to compatibility analysis.

3.1 Explanation of Parameters and their Descriptions

3.1.1 Meaning of Min Usable Values

Minimum usable values of various parameters are provided. The values represent the minimum levels that should be used for compatibility analysis. They do not necessarily indicate minimum levels for commercial viability, but limiting quantities to below the minimum values may result in undesired constraints on the variety of possible commercial offerings.

[9] Ibid.
[10] E.g. https://wireless2.fcc.gov/UlsApp/UlsSearch/license.jsp?licKey=3781475
[11] E.g. https://www.mpja.com/Doppler-RADAR-Motion-Sensor-32GHz/productinfo/34685%20MP/
[12] FCC call signs WPSM233, WQVR961, WQDF801, WNAN640, and WPYY795.

3.1.2 Meaning of Typical Values

Values of parameters that may represent typical use have been provided, to the extent that "typical" can be defined at this early stage. For compatibility studies, the typical use is recommended when computing aggregate interference.

3.1.3 Meaning of Max Value

The maximum value of a parameter is the greatest value that is currently envisioned being used for a commercial service, assuming co-existence must be considered. That is, if the band was cleared and there were no issues in dealing with compatibility with incumbent systems, the max value may be higher.

3.1.4 Min/Typical/Max Values are Independent Across Parameters

The listed range of values for each parameter is independent across parameters. For example, a viable compatibility simulation could combine the max power spectral density, the typical channel bandwidth, and the minimum deployment density.

3.1.5 Indoor vs Outdoor

Different ranges are provided for indoor vs outdoor applications. Indoor use could include (but will not be limited to) enterprise (e.g., offices), consumer (e.g., home), and industrial (e.g., factory) applications. Outdoor use could include (but will not be limited to) services such as macro networks, rural broadband networks, campus networks, etc.

3.2 Effective Isotropic Radiated Power Spectral Density (EIRPSD)

3.2.1 Indoor Use

- Minimum usable value: 30 dBm per 10 MHz (base station); 23 dBm per 10 MHz (user device)
- Typical value: 36 dBm per 10 MHz (base station); 24 dBm per 10 MHz (user device)
- Max value: 47 dBm per 10 MHz; 24 dBm per 10 MHz (user device)

3.2.2 Outdoor Use

- Minimum usable value: 36 dBm per 10 MHz (base station); 30 dBm per 10 MHz (fixed user device); 23 dBm per 10 MHz (mobile user device)
- Typical Value: 47 dBm per 10 MHz (base station)[13]; 36 dBm per 10 MHz (fixed user device); 24 dBm per 10 MHz (mobile user device)
- Max value: 72 dBm per 10 MHz (base station) [14]; 47 dBm per 10 MHz (fixed user device); 30 dBm per 10 MHz (mobile user device)

[13] This value is consistent with CBRS rules for Category B devices.
[14] Note that the power is consistent with other CMRS rules and also with rules proposed for another mid-band spectrum application, i.e., flexible use in some or parts of the 3700-4200 MHz band ("C-band"). However, the

3.3 Channel Bandwidth

3.3.1 Indoor & Outdoor Use

- Minimum assignable value: 10 MHz
- Typical Value: Indeterminate
- Max value: 100 MHz

3.4 Antenna Height Above Ground Level

3.4.1 Indoor Use

- Height distribution is same as distribution of U.S. building heights

3.4.2 Outdoor Use

- Minimum assignable value: Unconstrained
- Typical value: 20 m (for base stations); 3 m (fixed user equipment); 1.5 m (mobile user equipment)
- Max value: Unconstrained

3.5 Deployment Density

Note: The listed values are the total number of base stations per population, not the number of users per base station. Any simulation should distribute the base stations proportionate to the distribution of population. For example, in a census tract with 4000 people, and a proportion of 1 base station per 250 people, there would be 16 total base stations distributed around that census tract for the purpose of the simulation. Increased uptake of 3.1 GHz technology in the future could cause the deployment density to increase.

3.5.1 Indoor Use

- Minimum usable value: 1 per 250 people
- Typical value: 1 per 100 people
- Max value: 1 per 10 people

3.5.2 Outdoor Use

- Minimum usable value: 1 per 1000 people
- Typical value: 1 per 500 people
- Max value: 1 per 200 people

3.6 Traffic Level

- Minimum usable value: 10% load
- Typical value: 40% load
- Max value: 80% load

incumbency and adjacency issues are different in those bands than they are in 3100-3550 MHz. Also, some CMRS rules have lower allowed power levels as antenna heights become greater.

3.7 Out-of-Band Emissions

For the purpose of simulation, unwanted emissions outside the band of shared operation should be assumed to be -13 dBm/MHz conducted within 20 MHz of the edge of the shared band, and -25 dBm/MHz conducted power beyond that, for all devices.

4 Frequency Control and Coordination

If access to the band by new services is managed by an automated admission system,[15] the nature and complexity of the automated system will depend on the nature and extent of incumbent operations in the band. Generally speaking, the more dynamic the incumbent systems are, the more complex the automated admission system will be. The timescale of dynamic operations and the related reconfiguration requirements of underlay services are also an important factor: the faster an automated system must detect an incumbent signal and reconfigure managed devices, the more constraints are placed on the operation of both the automated system and the hardware (e.g., base stations and user terminals) that operate in the band. Further, the variety of incumbent operations as a function of frequency, time, and geography will, to some extent, impact the complexity of the automated admission system, and also impact the ability of potential users of the band to understand the exact nature of restrictions on their desired operations. It is important that as much information as possible regarding incumbent operations is available early on. The automated admission systems can be kept apprised of the evolution of incumbent operations over time.

Another factor that can complicate the use of automated admission systems is the requirements and design of aggregate interference management. Unless designed carefully, such management could potentially impose complexity on the automated admission systems. However, simpler methods could be used, such as the use of multiple exposure factors, however such methods may not optimize spectrum use. We expect that experience gained from CBRS and potential future AFC operations may provide insight into improved techniques for management of aggregate interference.

5 Incumbent Detection and Informing Incumbent

Incumbent detection systems have a number of characteristics that are problematic for use in shared bands.

1. Sensing systems may create substantial operational security requirements, depending on the nature of the incumbent and their operations, and could potentially even provide less security for incumbent operations because the actual operations must be sensed by (often multiple) third parties. Simpler and more effective methods, such as informing-incumbent systems, may provide a more effective and secure means of protecting incumbent operations by allowing the incumbent to control the flow of information.
2. Sensing networks negatively impact shared use of the band. Because the sensors themselves must be protected from interference caused by underlay services so that they can achieve appropriate sensitivity to incumbent operations, “quiet zones” must be

[15] Examples of automated admission systems include the 3.5 GHz CBRS Spectrum Access Systems (SASs) and the Automatic Frequency Coordination (AFC) systems proposed for unlicensed use in the 6 GHz band.

established around every sensor site. To avoid interference, underlay services may be restricted from operating within the quiet zones.

3. Sensing systems are expensive to deploy and operate. Besides hardware costs, each sensor site requires all of the considerations and complications related to all wireless siting instances, including the identification of suitable structures on which to install the equipment, permitting, leasing, and all of the challenges associated with public perception of the harmful effects of radio waves, a consideration that is growing as 5G deployments increase. The latter concern is relevant despite the fact that sensor systems do not transmit, as some members of the general public do not understand or care about the distinction. Besides the expenses of the hardware and initial deployment, ongoing operations and maintenance costs can be considerable as well. The total cost of a sensor system may exceed the costs of building and supporting an informing incumbent framework, including the support and operations costs incurred by the incumbents. For competitive reasons, multiple sensor networks may be required to be deployed, increasing total costs proportionately.

Informing incumbent systems avoid all of the listed challenges and are the preferred option for dynamic spectrum sharing in the 3100-3550 MHz band.

6 Sharing Architecture

More information on the nature of incumbent operations is needed before the architecture of any sharing systems can be defined. A future release of this document, after such information becomes available, will provide more information and discussion.