Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band	)	GN Docket No. 12-354

JOINT CONTENT REPLY COMMENTS

CBS Corporation, the National Association of Broadcasters, 21st Century Fox, Inc., Time Warner Inc., Viacom Inc., and The Walt Disney Company (together and on behalf of their affiliated businesses, the "Content Interests"), hereby submit reply comments in response to the *Further Notice of Proposed Rulemaking* ("*FNPRM*")[1] issued in the above-captioned proceeding. In various comments responding to the 2012 *Notice of Proposed Rulemaking* ("*NPRM*")[2] and related Public Notices in this proceeding,[3] the Content Interests expressed concern that certain proposals under consideration may interfere with incumbent C-Band satellite operations, which are a critical part of how we deliver television content to our affiliates and ultimately to hundreds

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[1] *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Further Notice of Proposed Rulemaking, 29 FCC Rcd 4273 (2014) ("*FNPRM*").

[2] *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking, 27 FCC Rcd 15594 (2012) ("*NPRM*").

[3] *Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band*, GN Docket No. 12-354 (rel. Nov. 1, 2013) ("*Licensing PN*"); *Wireless Telecommunications Bureau and Office of Engineering and Technology Call for Papers on the Proposed Spectrum Access System for the 3.5 GHz Band*, GN Docket No. 12-354 (rel. Nov. 18, 2013) ("*SAS PN*").

of millions of consumers nationwide.[4] We therefore appreciate the Commission's recognition of these concerns in the *FNPRM*,[5] and the opportunity to provide additional input on the revised framework now under consideration.

As confirmed by the attached report from Alion,[6] we continue to believe that small cell wireless operations in the 3.5 GHz band present out-of-band interference concerns for incumbent C-band receive sites. Alion bases its analysis on the updated technical parameters established in the *FNPRM* for Citizens Broadband Radio Service Devices ("CBSDs") and concludes that the proposed "CBSD deployments…have the potential to cause harmful interference to C-Band earth station operations."[7] Specifically, Alion performed a range of case studies using the *FNPRM* proposals, and in each scenario the protection distances needed to mitigate radio frequency interference to C-band satellite services were "significant."[8]

The latest Alion report also confirms our view that RF filters are largely ineffective in mitigating adjacent band interference from proposed CBSDs.[9] An IF filter, which is included as a component of the tuner, is a part of every C-band receive site. An IF filter is adaptable with frequency and is designed to reject energy immediately outside of the tuned channel. The characteristic of the IF filter is shown in the attached analysis. In all cases in the attached

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[4] Comments by Fox Entertainment Group, Inc., Time Warner Inc., Viacom Inc., and The Walt Disney Company in GN Docket 12-354 (filed Feb. 20, 2013); Reply Comments by CBS Corporation, the National Association of Broadcasters, Fox Entertainment Group, Inc., Time Warner Inc., Viacom Inc., and The Walt Disney Company in GN Docket 12-354 (filed April 5, 2013); Comments by Fox Entertainment Group, Inc., Time Warner Inc., Viacom Inc., and The Walt Disney Company in GN Docket 12-354 (filed Dec. 20, 2013).

[5] *FNPRM* at ¶¶153-154.

[6] *See* Attachment A.

[7] *Id.* at 16.

[8] *Id.*

[9] *Id.*

analysis, a typical IF filter was assumed. However, RF filters intended for C-band receive sites are designed so that they can be used in the service allocation with no expectation of transmitters operating in either the 3550-3650 or 3650-3700 MHz ranges. To the extent that filters may in some circumstances help prevent intermodulation and overdrive interference, it would necessitate at least 50 MHz of guard band protection to ensure C-band operations are not negatively impacted.

Absent a change in technical parameters for CBSDs, such as a more restrictive spectral emissions mask[10] or reduced power levels, we foresee only two options for protecting incumbent C-band operations. First, the Commission could establish protection by rule – essentially requiring no harmful interference to C-band. As supported by the attached Alion report, a mandatory separation distance of 9.5 km would be necessary under such a rule to ensure all C-band facilities are protected against interference. We recognize that this is a large separation distance, and one that would limit CBSD operations in some locations. We would welcome a dialogue with the Commission, network operators, and potential CBSD manufacturers to identify appropriate specifications that would both protect C-band and enable a robust 3.5 GHz broadband service.

Second, the Commission could protect incumbent C-band operations by instituting a Spectrum Access System ("SAS") database as it has proposed. We agree that a properly constructed SAS can afford more flexibility for CBSD operations as compared with a rule protection approach, while ensuring that current content distribution operations are fully protected. To achieve these dual goals, any final rules that the Commission adopts in the

[10] We note that emissions from transmitters generally "fall off" the further such emissions are from the actual transmitting frequency. Therefore, we believe that requiring CBSDs to meet a more stringent out-of-band emissions mask that continues to taper as the frequency separation from the intended transmission channel increases should be possible with no or little additional cost on such devices.

proceeding should contain a clear and unequivocal right for C-band operators to register and receive protection in the SAS.[11] Further, the SAS should incorporate sufficient technical detail about C-band operations so that appropriate exclusion zones can be calculated. As part of these calculations, the "look angle" of C-band earth stations should either be: (1) one of the actual parameters used by the SAS in calculating exclusion zones, or (2) presumed to be 5° to ensure the maximum level of protection given the meaningful number of C-band facilities that operate domestically and in Canada with elevation angles between 5-15°.[12] The SAS should also have a near real time refresh rate based on material changes to any technical parameter inputs to ensure the database contains current and accurate information.

As we noted in earlier comments, an SAS of the type contemplated in this proceeding is novel and significantly more complex than that used in connection with White Spaces. Any SAS should be sufficiently tested and proven to protect incumbent operations before CBSDs are deployed. Additional protection measures, such as incorporating geo-location capabilities in CBSDs to protect existing incumbent operations, as well as near real-time communications with the SAS, should also be required.

Finally, we strongly urge the Commission to keep the scope of any final rules it may adopt in this proceeding as narrowly tailored as possible – namely small cell implementations

[11] The analysis presented in the attached report is based on the performance of a 3.7 meter antenna, which represents the antenna size of the majority of C-band facilities that are currently in use. However, there is also in use a substantial universe of antennas that are as small as 3 meters. C-band facilities with smaller antenna sizes are potentially more susceptible to interference than that which is shown in the analysis. To avoid service disruptions, the SAS must allow for the registration and protection of C-band facilities which use a range of antenna sizes, including 4.5 meters, 3.7 meters, and those that are as small as 3 meters.

[12] The Content Interests distribute programming full time to receive sites with multiple antennas in fixed positions at various locations in the domestic arc. In addition, steerable antennas receiving and distributing content for breaking news and special events employ ad hoc satellite capacity across the domestic arc as needed. Further, several programmers distribute networks services into Canada, especially bordering cities in the Northeast and Northwest (*i.e.*, New Brunswick, southeastern Quebec, Vancouver) at low elevation angles. As a result, the 15° or greater assumption proposed in the FNPRM would result in interference to a meaningful number of receive facilities in both the US and Canada potentially impacting tens of millions of customers.

from 3550-3650 MHz only. The risk to C-band incumbents demonstrated by Alion's report is significant enough that the Commission should take due care before expanding any proposed operations, particularly those which would be directly adjacent to FSS C-band operations.

Respectfully submitted,

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August 15, 2014

ATTACHMENT A

ALION
SCIENCE AND TECHNOLOGY

Consulting Report

SHARING STUDY ON THE EFFECTS OF THE PROPOSED CITIZENS BROADBAND RADIO SERVICE TO C-BAND SATELLITE EARTH STATIONS

Prepared for:

Content Companies

RESED-14-006
August 14, 2014

Use and Disclosure of Data

Approved for public release

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EXECUTIVE SUMMARY

The Federal Communications Commission FCC 14-49 Further Notice of Proposed Rulemaking (FNPRM) released April 23, 2014 proposes to amend the commission's rules with regard to commercial operations in the 3550-3650 MHz band and the possible extension of the proposed rules to include the 3650-3700 MHz band. The FNPRM proposes specific rules for a new Citizens Broadband Radio Service in the 3.5 GHz Band. It also proposes baseline technical standards for the operation of Citizens Broadband Radio Service Devices (CBSDs) and End User Devices in the 3.5 GHz Band.

The FNPRM seeks further comment regarding the protection of Fixed Satellite Service (FSS) earth stations in the 3700-4200 MHz band. The incumbent commercial users of C-Band (Content Companies) currently utilize the adjacent frequency band (3700-4200 MHz) for satellite downlink of video and television broadcasts of programming materials in the United States. This study updates and expands on a previous sharing study Alion performed for the Content Companies in 2013. At that time, the FCC had not yet established technical parameters for the Citizens Broadband Radio Service. The Content Companies requested that Alion perform another sharing study to investigate the effect of the CBSD technical standards proposed in the FNPRM on C-Band satellite earth stations.

In this study, protection distances to mitigate Radio Frequency Interference (RFI) to C-Band satellite earth stations were determined for several parametric cases. The earth station I/N thresholds, antenna elevation angles, and use of RF filtering were varied. The CBSD channel tunings and base station antenna heights were also varied. Baseline and Rural Areas scenarios were analyzed. The Rural Areas scenario with an earth station antenna elevation angle of 5 degrees and a base station antenna height of 35 meters required the largest protection distance of 9.49 km. For the Baseline and Rural Areas scenarios with an earth station antenna elevation angle of 5 degrees, the protection distances ranged from 1.50 km to 9.49 km.

Since the analysis showed that protection distances were significant, it is concluded that the CBSD deployments proposed in FNPRM FCC 14-49 have the potential to cause harmful interference to C-Band earth station operations. Spectrum sharing in these bands will require coordination with incumbent, adjacent band, earth station users. In order to adequately protect C-Band satellite earth stations, protection distances up to 9.49 km will be necessary.

BACKGROUND

The Federal Communications Commission FCC 14-49[1] Further Notice of Proposed Rulemaking (FNPRM) released April 23, 2014 proposes to amend the commission's rules with regard to commercial operations in the 3550-3650 MHz band and the possible extension of the proposed rules to include the 3650-3700 MHz band. The FNPRM proposes specific rules for a new Citizens Broadband Radio Service in the 3.5 GHz Band. Specifically, the proposed rules would implement an innovative and comprehensive framework to authorize a variety of small cell and other broadband uses of the 3.5 GHz Band on a shared basis with incumbent federal and non-federal users of the band, with oversight and enforcement through a Spectrum Access System (SAS). It also proposes baseline technical standards for the operation of Citizens Broadband Radio Service Devices (CBSDs) and End User Devices in the 3.5 GHz Band as well as general rules for the operation of the SAS and approval of SAS Administrators.

The FNPRM seeks further comment regarding the protection of Fixed Satellite Service (FSS) earth stations in the 3700-4200 MHz band. The incumbent commercial users of C-Band (Content Companies[2]) currently utilize the adjacent frequency band (3700-4200 MHz) for satellite downlink of video and television broadcasts of programming materials in the United States. This study updates and expands on a previous sharing study Alion performed for the Content Companies in 2013[3]. At that time, the FCC had not yet established technical parameters for the Citizens Broadband Radio Service. The 2013 sharing study was based on assumptions about the technical characteristics of CBSDs. The Content Companies requested that Alion perform another sharing study to investigate the effect of the CBSD technical standards proposed in the FNPRM on C-Band satellite earth stations.

APPROACH

The analysis consisted of calculating C-Band satellite earth station protection distances for specific single-entry cases. These cases were based on the technical standards described in the FNPRM for the operation of CBSDs. Only small-signal interference interactions were analyzed. Large-signal interactions such as Low-Noise Block Downconverter (LNB) gain compression or receiver

[1] *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Further Notice of Proposed Rulemaking, Federal Communications Commission, FCC-14-49, GN Docket No. 12-354, April 23, 2014.

[2] These include CBS Corporation, National Association of Broadcasters, 21st Century Fox, Inc., Time Warner, Inc., Viacom, Inc., and The Walt Disney Company.

[3] Lloyd Apirian, Mark Gowans, Jason Greene, ***Effects of the Proposed Citizens Broadband Service to C-Band DOMSAT Earth Stations***, Alion Science and Technology Corporation, Consulting Report ESO-13-011-v3, April 2013.

intermodulation effects were not investigated. These large-signal effects typically require much smaller protection distances than small-signal interactions.

To determine protection distances, a single CBSD base station was placed along a path relative to an earth station location, with both antenna azimuths aligned. Emory, TX was chosen as the earth station location. This location was used for the previous Alion analysis (Reference 2), and was chosen as a representative location because of the surrounding moderate terrain characteristics. A location with moderate terrain characteristics was desired rather than a location with either predominantly mountainous or predominantly flat terrain.

Two adjacent-band cases were considered for this analysis. The FNPRM describes CBSD operation in the 3550-3650 MHz band. The 3650-3700 MHz band is not otherwise addressed in the FNPRM but it does request comment on possible extension of the band up to 3700 MHz and will be considered in this analysis. It was assumed that the base station is tuned to the closest adjacent-band channel to the lowest C-Band earth station receiver channel for both the 3550-3650 MHz and 3650-3700 MHz bands. The base station was moved along a path relative to the earth station, and protection distances were calculated based on the separation distance necessary to reduce the interference level below an interference threshold. Two interference thresholds were investigated; I/N = -10 and -20 dB, using the International Telecommunication Union (ITU) P.452 propagation model with a 20% propagation percentage.

The FNPRM included CBSD and End User Device general radio requirements. CBSD technical characteristics were categorized by CBSD type: 1) Baseline, 2) Rural Areas, and 3) Fixed Point-to-Point (PTP) systems. Baseline was defined as all cases not qualified under Rural Areas or Fixed PTP. For this study, only Baseline and Rural Areas CBSDs were analyzed.

Some values used in this analysis were parameterized to allow flexibility in applying the results, and to allow for varying situations.

Table 1 shows the C-Band earth station technical characteristics that were used in this analysis.

Table 1. C-Band earth station technical characteristics

Parameter	Value
Bandwidth	36 MHz/channel
Channel frequency	3720 MHz (lowest channel in 3700-4200 MHz band)
Antenna gain	43.7 dBi mainbeam
Antenna model	ITU-R Recommendation S.465-6
Antenna elevation angle	5, 15, 25, and 35 degrees
Antenna azimuth	249 degrees
Antenna height above terrain	4 m
System noise temperature	78 K
System noise power	-104 dBm (calculated)
Cable/feed loss	0 dB

Table 2 shows the CBSD Base Station technical characteristics that were used in this analysis.

Table 2. CBSD Base Station technical characteristics

Parameter	FNPRM Baseline CBSD Analysis	FNPRM Rural Areas CBSD Analysis
Number of antenna sectors	1	3
Effective isotropic radiated power (EIRP)	30 dBm	47 dBm (per 10 MHz)
EIRP per sector	30 dBm	47 dBm
Antenna Gain	6 dBi	17 dBi
Antenna azimuth beamwidth	360 degrees	65 degrees
Antenna elevation beamwidth	27 degrees (calculated)	9.5 degrees (calculated)
Elevation angle	0 degrees	-6 degrees
Antenna height	5, 15, 25 meters	15, 25, and 35 meters
Channel frequency	3645, 3695 MHz	3645 and 3695 MHz
Bandwidth	10 MHz	10 MHz

Table 3 shows the general analysis parameters and assumptions used in this analysis.

Table 3. Analysis parameters and assumptions

Parameter	Value
Earth station antenna model	ITU-R Recommendation S.465-6
Base station antenna model	ITU-R Recommendation 1336-4
I/N	-10 and -20 dB
Propagation Model	ITU-R Recommendation P.452
Propagation Percentage	20 %

I/N Thresholds

For this study, two interference thresholds were investigated; I/N = -10 and -20 dB. FCC sharing studies commonly use an interference threshold of I/N = -10 dB for broadband system interference to satellite earth stations. The ITU commonly uses an interference threshold of I/N = -20 dB for long-term adjacent-band interference effects.

Apportionment of Interference

Apportionment is a term used to describe the division of allowable interference among different allocated services. It is important in a sharing study to apportion the interference attributed to the specific service being analyzed. As apportionment for the service under study becomes a smaller fraction of the total allowable interference, protection distances for that service will increase. For example, assuming 50% of the allowable interference to the C-Band earth station receiver is allocated to CBSD systems, for a total interference threshold, I_{total}, the interference threshold allowed for the CBSD system would be $I_{total} - 3$ dB. This results in a larger protection distance for CBSD systems. ITU recommendations such as ITU-R SA.1160 provide some representative examples of apportionment, including calculations. However, no apportionment was assumed for this study.

RF Filtering

For the analysis, protection distances were calculated with and without receiver front-end, radio-frequency (RF) filtering. The filter model MFC 13961W is taken as a representative RF filter.[4] Measured spectral response characteristics are shown in Figure 1.

[4] From Microwave Filter Co., Inc. web site: http://www.microwavefilter.com/pdffiles/13961W.pdf, Last visited August 14, 2014.

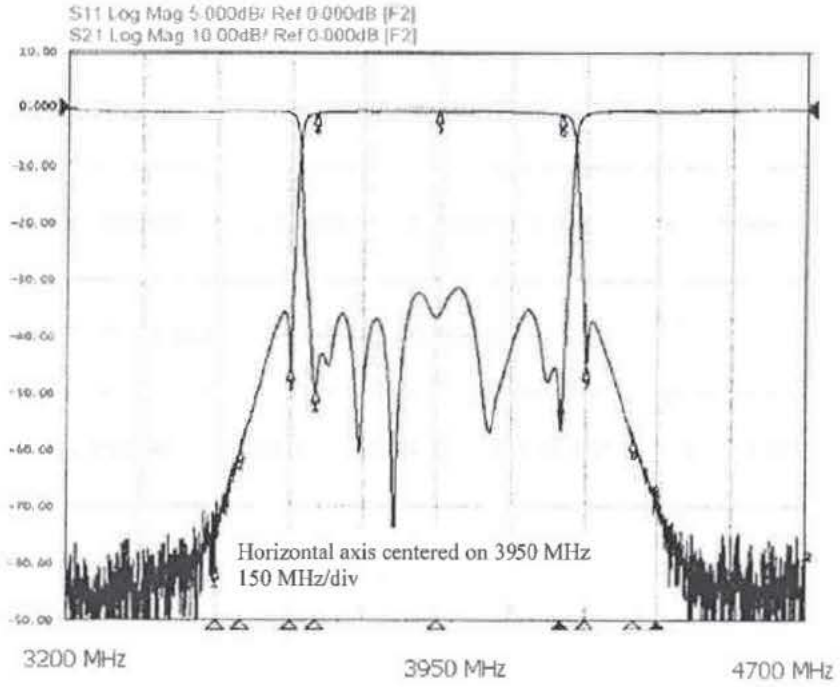

Figure 1. C-Band front-end filter characteristics

CBSD Out-of-Band Emissions

The FNPRM specifies limits on out-of-band emissions (OOBE). For CBSDs operating in the 3550 - 3650 MHz band, the power of any emission outside the fundamental emission (whether in or outside of the authorized band) shall be attenuated below the transmitter power (P), in watts, by at least 43 + 10 log10(P) dB. Also, the power of any emissions below 3520 MHz and above 3680 MHz shall be attenuated below the transmitter power by at least 70 + 10 log10(P) dB. Since this analysis also considered CBSDs operating in the 3650-3700 MHz band, it was assumed that the power of any emission outside the fundamental emission bandwidth would be attenuated below the transmitter power by at least 70 + 10 log10(P) dB. The CBSD fundamental emission was modeled assuming a 9 MHz, 0-dB bandwidth, dropping to the OOBE limit at the edge of the channel bandwidth of 10 MHz. Figures 2 and 3 show the emission masks for the Baseline and Rural Areas CBSD base stations.

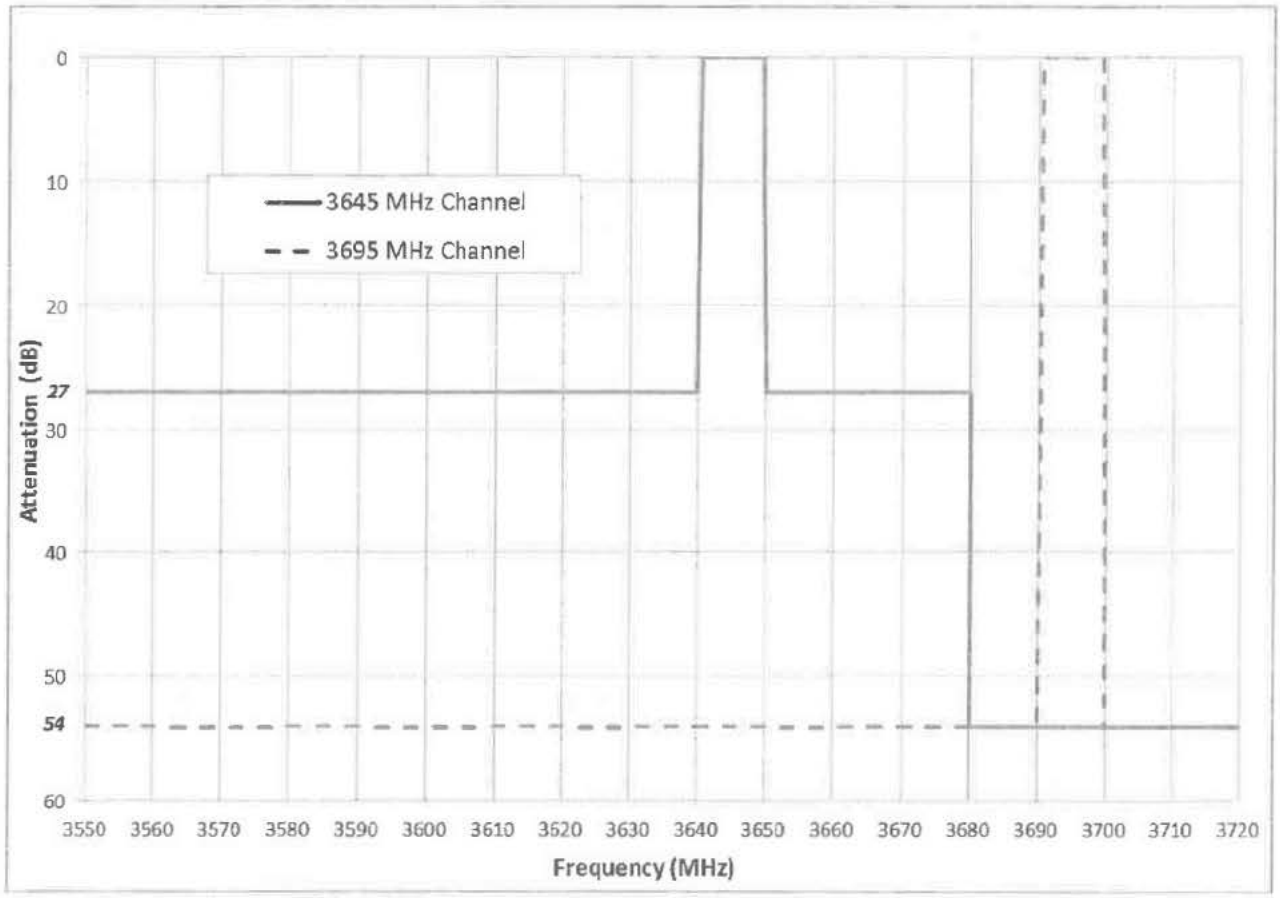

Figure 2. FNPRM Baseline CBSD base station emission masks

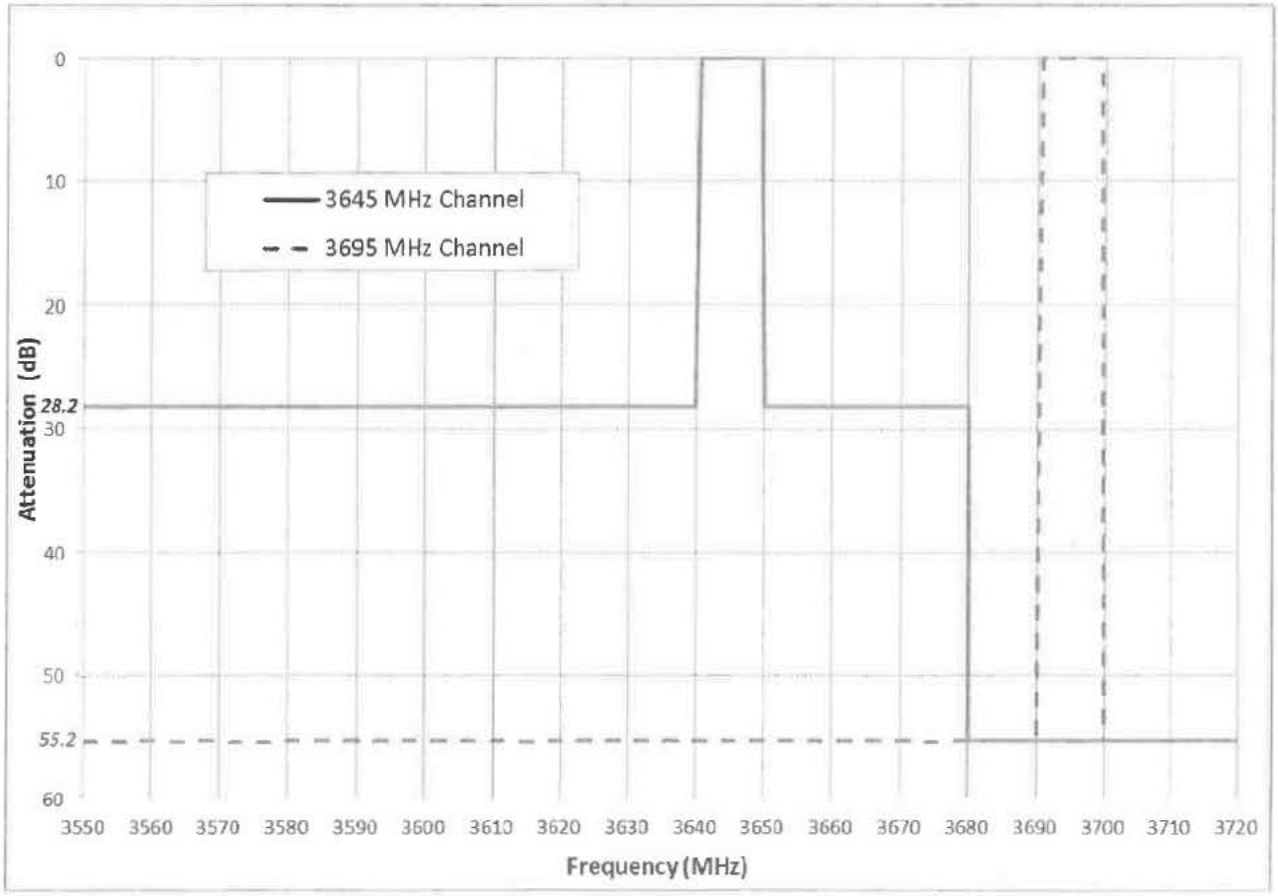

Figure 3. FNPRM Rural Areas CBSD base station emission masks

Frequency-Dependent Rejection

Frequency-dependent rejection (FDR) is the mutual coupling between the interferer (source) and receiver (victim). In other words, FDR is a measure of the rejection produced by the receiver selectivity to unwanted transmitter emission spectra. FDR was used in the computation of received interference levels. More information on FDR can be obtained from ITU-R Recommendation SM.337-6. FDR computations were performed using numerical integration techniques and software.

The CBSD base station emission spectrum was modeled as previously described, based on the FNPRM OOBE limits. For the C-Band earth station receiver, RF filtering was modeled based on the measured characteristics of a representative RF filter (Figure 1). The IF selectivity was modeled based on the C-Band earth station receiver 3-dB channel bandwidth of 36 MHz, and channel width of 40 MHz. It was assumed that at the edges of the channel, the IF selectivity would be 60 dB. Outside the channel a 20 dB per decade roll-off was assumed for the filtering.

Figures 4 through 7 show the CBSD system emissions, the C-Band earth station receiver RF and IF filter characteristics and receiver selectivities, and the resultant FDR curves.

Figure 4 shows the FDR curve based on the Baseline CBSD system emissions for the 3645 MHz channel. Since the earth station is tuned to 3720 MHz, the difference between center frequencies is 75 MHz. This difference frequency was used to determine the FDR used in the analysis.

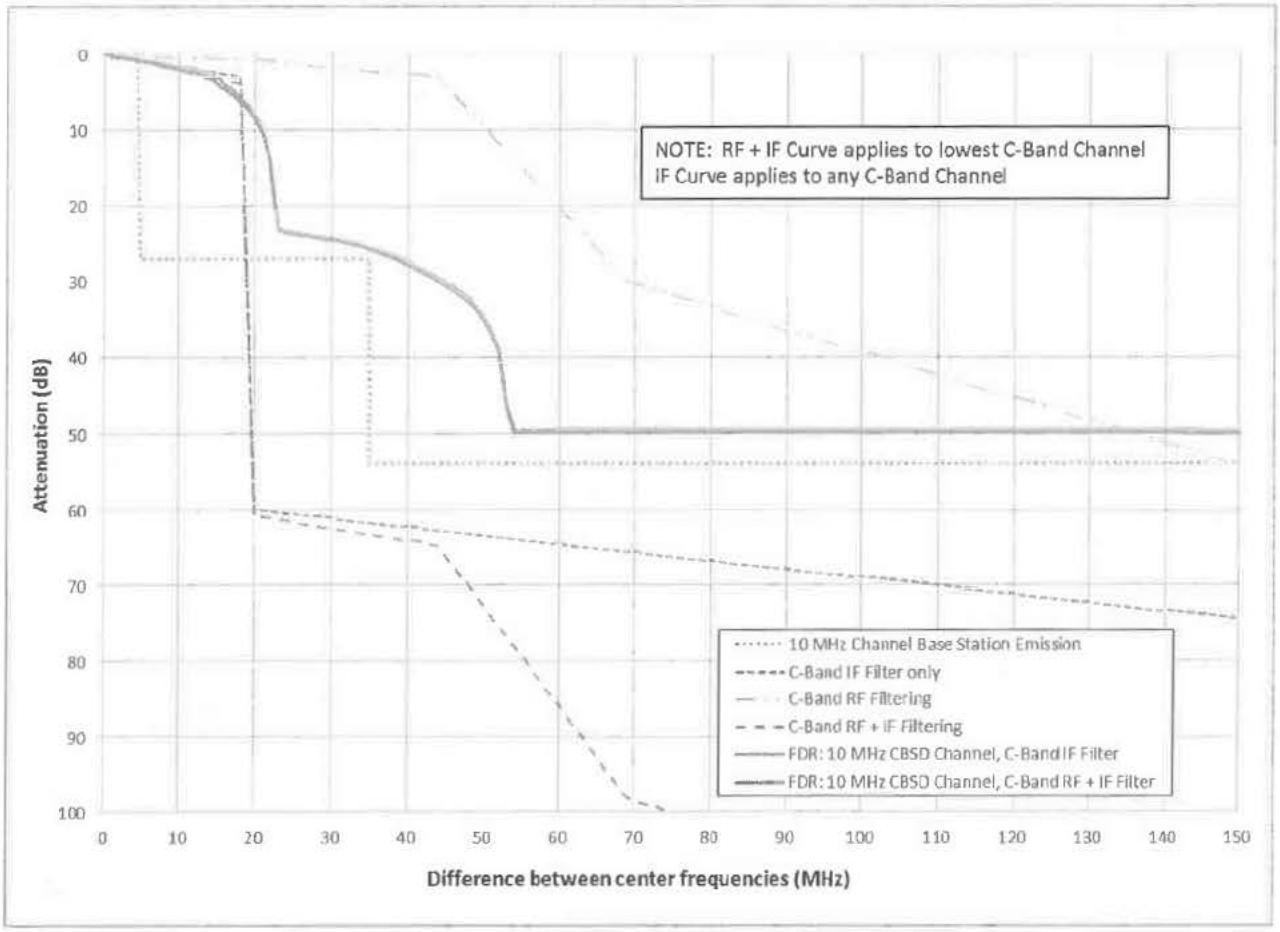

Figure 4. FDR for Baseline CBSD, 3645 MHz channel

Figure 5 shows the FDR curve based on the Rural Areas CBSD system emissions for the 3645 MHz channel. Since the earth station is tuned to 3720 MHz, the difference between center frequencies is 75 MHz. This difference frequency was used to determine the FDR used in the analysis.

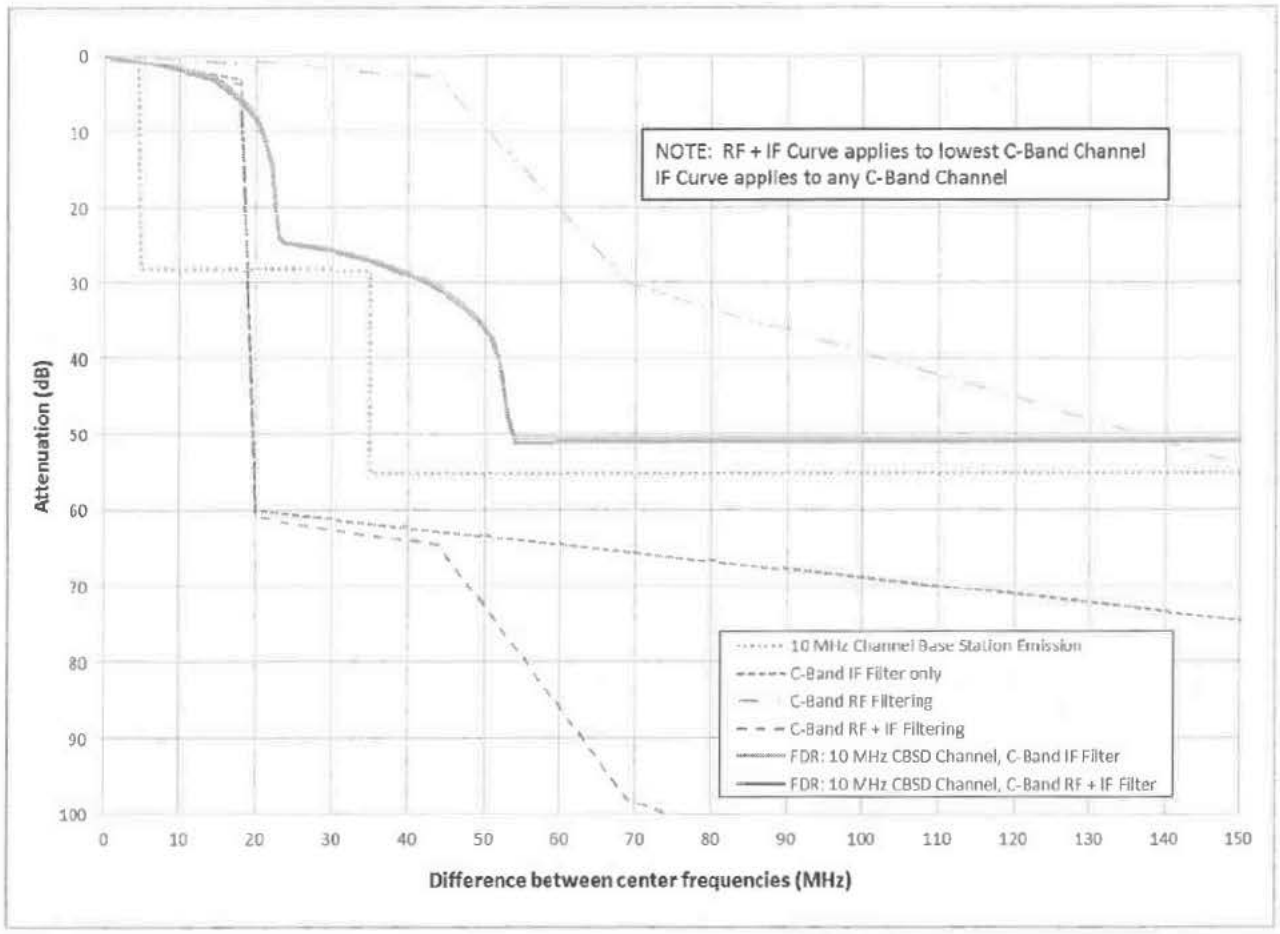

Figure 5. FDR for Rural Areas CBSD, 3645 MHz channel

Figure 6 shows the FDR curve based on the Baseline CBSD system emissions for the 3695 MHz channel. Since the earth station is tuned to 3720 MHz, the difference between center frequencies is 25 MHz. This difference frequency was used to determine the FDR used in the analysis.

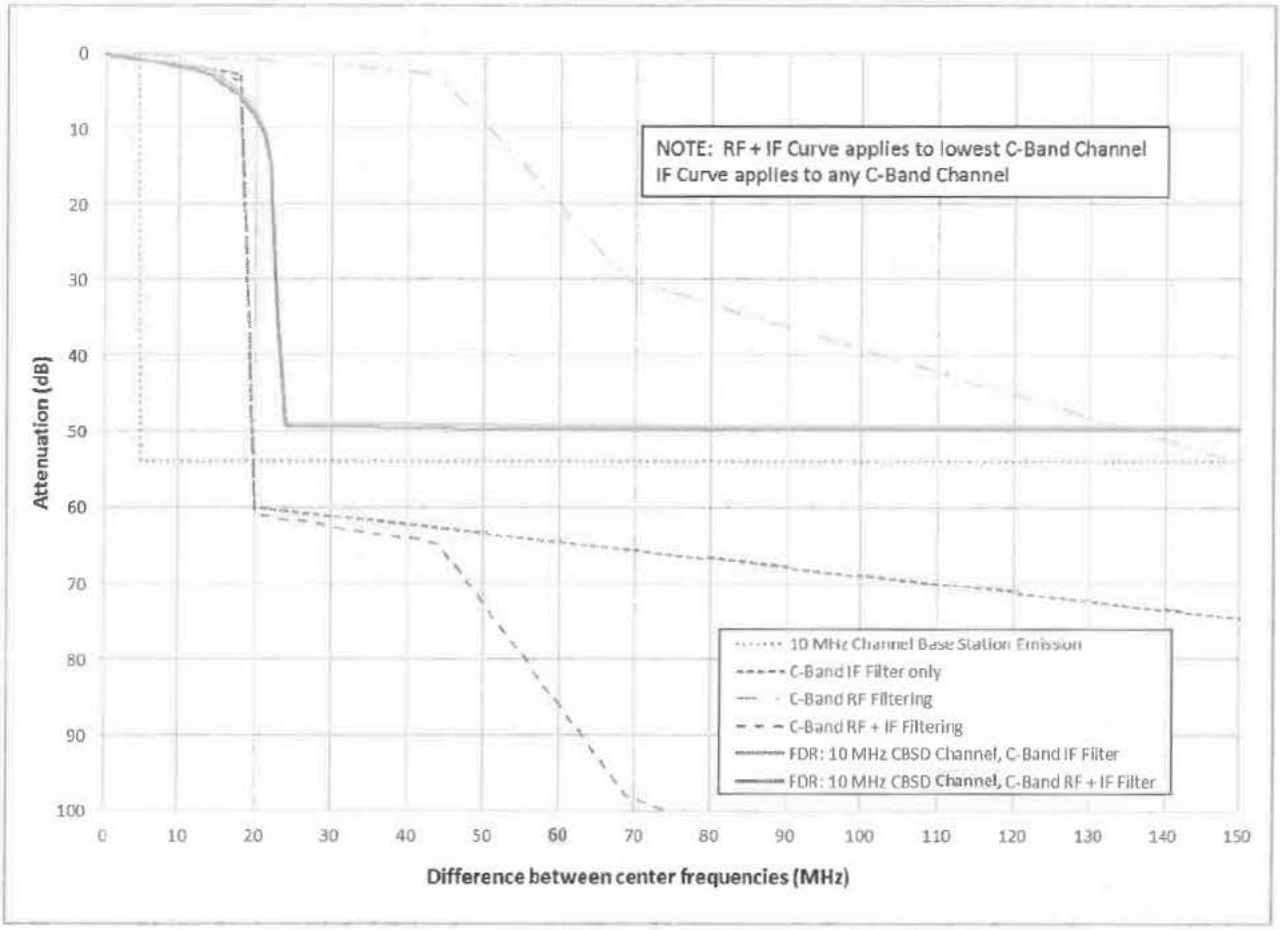

Figure 6. FDR for Baseline CBSD, 3695 MHz channel

Figure 7 shows the FDR curve based on the Rural Areas CBSD system emissions for the 3695 MHz channel. Since the earth station is tuned to 3720 MHz, the difference between center frequencies is 25 MHz. This difference frequency was used to determine the FDR used in the analysis.

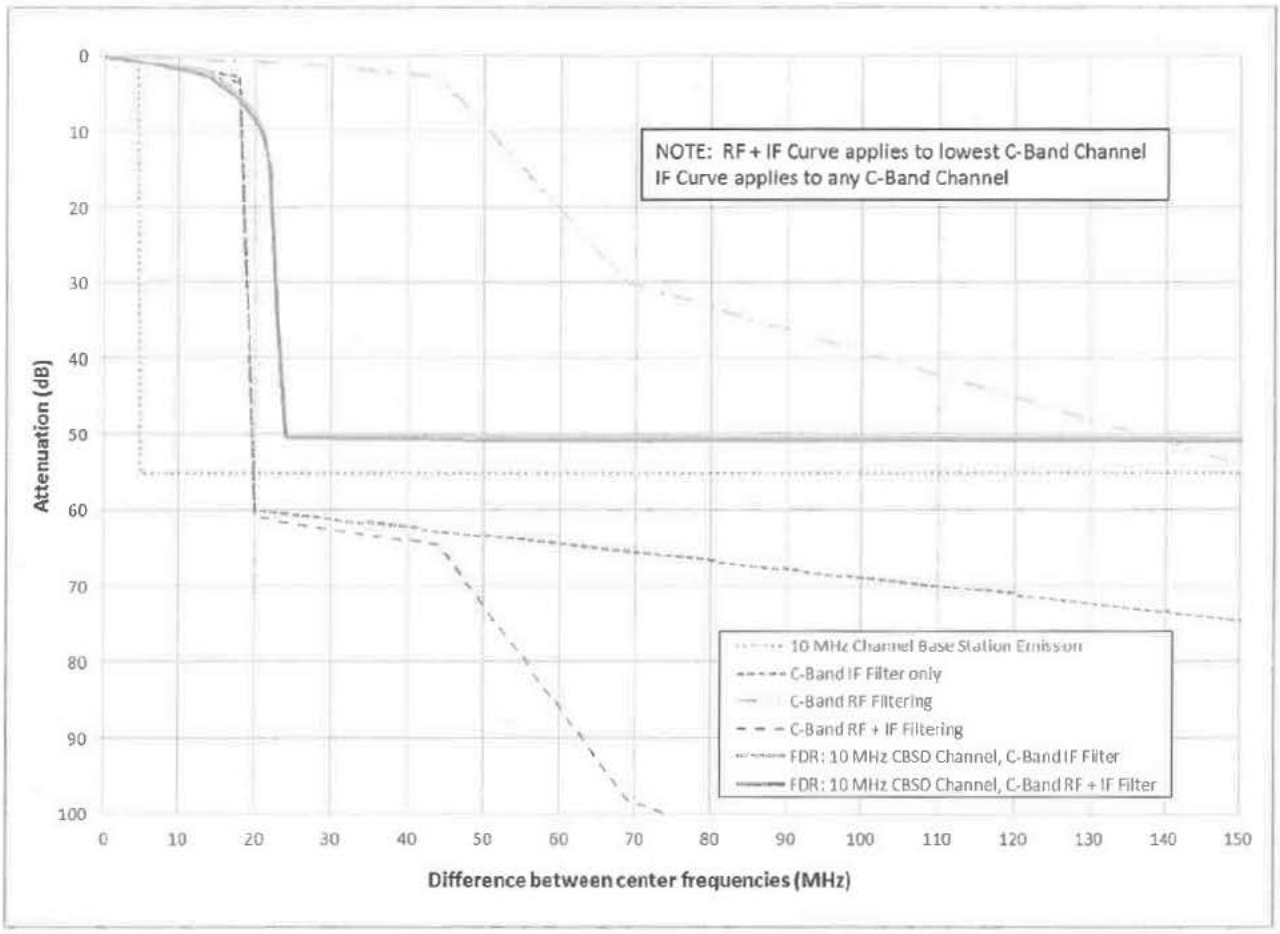

Figure 7. FDR for Rural Areas CBSD, 3695 MHz channel

ANALYSIS

For this analysis, a single CBSD base station was placed along a path relative to the earth station location, aligned with the antenna azimuth. Two adjacent-band cases were considered, with the CBSD tuned to 3645 MHz, and 3695 MHz. The CBSD base station was moved along the path and a protection distance was determined based on the separation distance necessary to reduce the interference level below the interference threshold. Figure 8 shows the terrain profile for the single-entry path of the base station relative to the C-Band earth station.

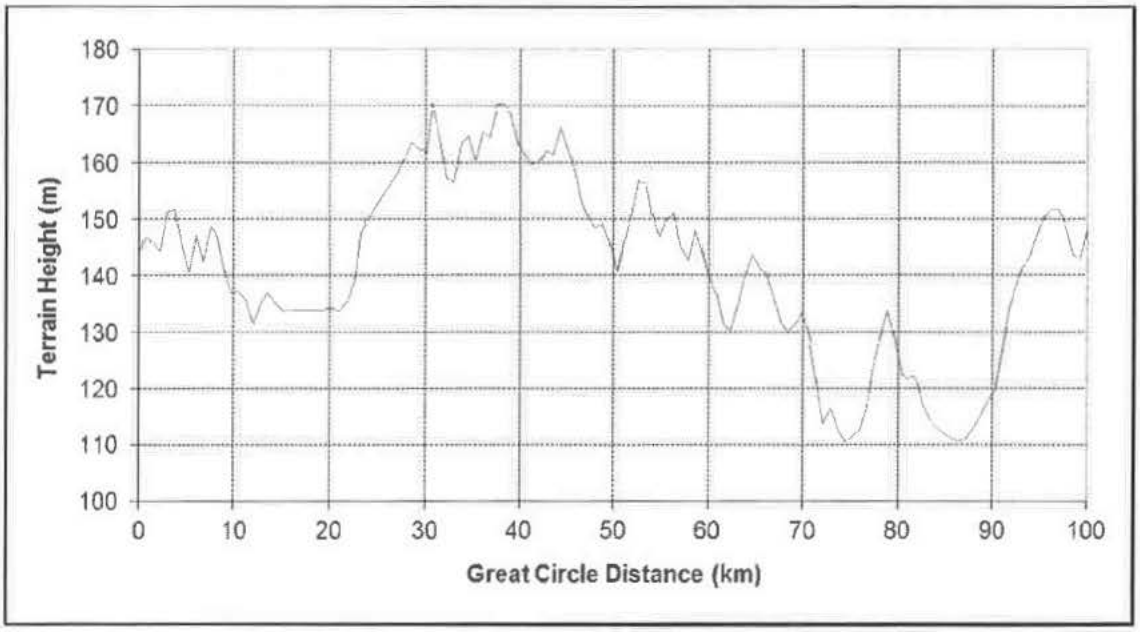

Figure 8. Terrain profile for single-entry analysis

The analysis was performed using a modified version of a model developed by the United States National Telecommunications and Information Administration (NTIA) for the fast-track analysis.[5]

The analysis results are presented in Tables 4 through 7 for the following cases:

- Base station channels 3645 MHz and 3695 MHz
- Earth station receivers with, and without RF filters
- Earth station elevation angles of 5, 15, 25, and 35 degrees
- Interference thresholds of I/N = -10 dB and -20 dB
- Base station antenna heights for the Baseline case of 5, 15, and 25 meters, and for Rural Areas of 15, 25, and 35 meters

[5] E.F. Drocella, L. Brunson, C.T. Glass, *Description of a Model to Compute the Aggregate Interference From Radio Local Area Networks Employing Dynamic Frequency Selection to Radars Operating in the 5 GHz Frequency Range*, NTIA Technical Memorandum 09-461, May 2009.

Table 4. Protection Distances for CBSD base station at 3645 MHz to C-Band earth station with RF filter

Receiver Antenna Elevation Angle, deg	Threshold I/N, dB	Baseline Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:			Rural Areas Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:		
		5 m	15 m	25 m	15 m	25 m	35 m
5	-10	1.50	1.90	2.07	4.59	6.51	7.98
15	-10	0.45	0.50	0.55	1.85	1.97	2.10
25	-10	0.24	0.26	0.29	1.08	1.16	1.24
35	-10	0.16	0.17	0.19	0.72	0.80	0.87
5	-20	3.75	4.50	6.19	6.26	8.62	9.27
15	-20	1.44	1.49	1.53	4.49	6.01	6.14
25	-20	0.76	0.79	0.81	3.14	3.25	3.36
35	-20	0.49	0.51	0.53	1.99	2.10	2.21

Table 5. Protection Distances for CBSD base station at 3645 MHz to C-Band earth station without RF filter

Receiver Antenna Elevation Angle, deg	Threshold I/N, dB	Baseline Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:			Rural Areas Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:		
		5 m	15 m	25 m	15 m	25 m	35 m
5	-10	1.50	2.00	2.17	4.73	7.78	8.28
15	-10	0.48	0.52	0.57	1.92	2.06	2.19
25	-10	0.25	0.27	0.30	1.12	1.21	1.28
35	-10	0.17	0.18	0.19	0.75	0.83	0.90
5	-20	3.75	4.50	6.36	6.28	8.69	9.49
15	-20	1.48	1.55	1.60	4.50	6.27	6.39
25	-20	0.80	0.82	0.85	3.29	3.40	3.51
35	-20	0.52	0.54	0.55	2.09	2.21	2.31

Table 6. Protection Distances for CBSD base station at 3695 MHz to C-Band earth station, with RF filter

Receiver Antenna Elevation Angle, deg	Threshold I/N, dB	Baseline Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:			Rural Areas Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:		
		5 m	15 m	25 m	15 m	25 m	35 m
5	-10	1.50	1.98	2.14	4.73	7.78	8.28
15	-10	0.47	0.52	0.56	1.92	2.06	2.19
25	-10	0.24	0.27	0.30	1.12	1.21	1.28
35	-10	0.16	0.18	0.19	0.75	0.83	0.90
5	-20	3.75	4.50	6.34	6.28	8.69	9.49
15	-20	1.48	1.54	1.58	4.50	6.27	6.39
25	-20	0.79	0.82	0.84	3.29	3.40	3.51
35	-20	0.51	0.53	0.55	2.09	2.21	2.31

Table 7. Protection Distances for CBSD base station at 3695 MHz to C-Band earth station without RF filter

Receiver Antenna Elevation Angle, deg	Threshold I/N, dB	Baseline Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:			Rural Areas Single-Entry Base Station Protection Distance, on Azimuth, km, for Base Station Height of:		
		5 m	15 m	25 m	15 m	25 m	35 m
5	-10	1.50	2.08	2.24	4.74	7.81	8.56
15	-10	0.49	0.54	0.59	2.02	2.16	2.30
25	-10	0.26	0.28	0.31	1.16	1.25	1.33
35	-10	0.17	0.19	0.20	0.78	0.87	0.94
5	-20	3.75	4.50	6.39	7.76	8.76	9.49
15	-20	1.48	1.61	1.65	4.50	6.37	6.67
25	-20	0.82	0.85	0.88	3.44	3.56	3.66
35	-20	0.54	0.56	0.57	2.20	2.32	2.42

RESULTS SUMMARY AND CONCLUSION

In this study, protection distances to mitigate Radio Frequency Interference (RFI) to C-Band satellite earth stations were determined for several parametric cases. The earth station I/N thresholds, antenna elevation angles, and use of RF filtering were varied. The CBSD channel tunings and base station antenna heights were also varied. Baseline and Rural Areas scenarios were analyzed. The Rural Areas scenario with an earth station antenna elevation angle of 5 degrees and a base station antenna height of 35 meters required the largest protection distance of 9.49 km. For the Baseline and Rural Areas scenarios with an earth station antenna elevation angle of 5 degrees, the protection distances ranged from 1.50 km to 9.49 km.

The use of RF filtering was not an effective mitigation tool in this study. Interference rejection due to the RF filter was less than 0.5 dB, which corresponded to only small changes in the protection distances. The main reason that the RF filter provided so little rejection was that the emissions spectrum for the base station was modeled based on the FNPRM OOBE limits, which are flat through the 3700-4200 MHz C-Band,. The RF filter does attenuate the energy of the CBSD emission fundamental at 3645 MHz. However, the energy received at the 3720 MHz receiver channel is based on the OOBE limit and does not change as a function of the CBSD channel frequency. This limits the amount of rejection provided by the RF filter.

Since the analysis showed that protection distances were significant, it is concluded that the CBSD deployments proposed in FNPRM FCC 14-49 have the potential to cause harmful interference to C-Band earth station operations. Spectrum sharing in these bands will require coordination with incumbent, adjacent band, earth station users. In order to adequately protect C-Band satellite earth stations, protection distances up to 9.49 km will be necessary.