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 INTERESTS REPLY COMMENTS

CBS Corporation, the National Association of Broadcasters, Fox Entertainment Group, 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 recent *Notice of Proposed Rulemaking and Order* ("*NPRM*") issued in the above-captioned proceeding.[1] In initial comments, members of the Content Interests expressed concern that certain proposals contained in the *NPRM* 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 of millions of consumers nationwide.[2] We therefore urged the Commission to carefully and thoroughly study the interference implications *before* giving further consideration to spectrum sharing in the bands adjacent to the C-Band. Indeed, these concerns are underscored by the attached report by Alion Science and Technology ("Alion"), which

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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*, 27 FCC Rcd 15594 (2012).

[2] Comments by Fox Entertainment Group, Inc., Time Warner Inc., Viacom Inc., and The Walt Disney Company in GN Docket No. 12-354 (filed Feb. 20, 2013); Comments of the National Association of Broadcasters in GN Docket No. 12-354 (filed Feb. 20, 2013).

concludes that the *NPRM*'s proposals pose significant risks for C-Band earth stations, such as those used by the Content Interests.

Following the initial round of comments, the Wireless Telecommunications Bureau and Office of Engineering and Technology held a March 13, 2013, workshop on the *NPRM.* [3] During the event, panelists expressed their views on how small cell wireless technology, when combined with database and dynamic spectrum sharing technologies, could be used to promote innovation in wireless technologies while protecting incumbent users of the 3550-3650 MHz band. While some panelists were optimistic that small cell technology would present less significant interference concerns for incumbent users as compared with existing wireless systems, few details were provided about the specific parameters of future small cell deployments or how they might affect incumbents in adjacent bands.

In light of our ongoing concerns about potential interference to content distribution satellite operations from 3700-4200 MHz,[4] the Content Interests retained Alion to evaluate the prospect of spectrum sharing from 3550-3700 MHz.[5] Alion's analysis is predicated on data from the *NPRM* itself, as well publicly available information about WiMAX, WiFi, and LTE systems, as a model for potential small cell wireless deployments.[6] Absent more concrete parameters from either the Commission or wireless industry interests, Alion's model represents

[3] *FCC Wireless Telecommunications Bureau and Office of Engineering and Technology Announce Agenda for Workshop on the 3.5 GHz Notice of Proposed Rulemaking*, DA 13-367 (rel. Mar. 7, 2013).

[4] We also note that television broadcasters use weather radar systems that operate at 3500-3600 MHz which could be impacted by the Commission's proposal regarding small cell technology. Any rules adopted in this proceeding must ensure that these important public safety services remain protected from interference. *See* Comments of Baron Services in GN Docket No. 12-354 (filed Feb. 20, 2013).

[5] *See* Attachment A.

[6] *Id*. at 1, 9-11.

the best available information today by which to perform interference analyses based on the *NPRM*'s proposals.[7]

Alion's report concludes that the *NPRM*'s small cell broadband deployments "have the potential to cause harmful interference to C-Band DOMSAT operations" and require distance separation ranging up to 33 km.[8] In some cases, interference "may lead to complete reception failure due to the bit error rate 'cliff.'"[9] Overall, the large protection distances needed to reduce interference, when combined with the thousands of incumbent C-Band earth stations nationwide, "are highly likely to create unacceptable encumbrances for small cell systems and risk to C-Band earth stations."[10]

The interference risk and distance separation requirements identified by the Alion report underscore the importance of the Commission carefully and thoroughly studying any proposed wireless deployments *before* moving forward with the spectrum sharing proposals outlined in the *NPRM*. Potentially affected parties, such as the Content Interests, should have ample opportunity to comment on *specific* proposed wireless implementations, and any related interference studies based on those detailed parameters. Simply put, we encourage the Commission to ensure that: (1) the record in this proceeding is both thorough and data-driven, and (2) that every effort is undertaken to avoid any negative impact on the delivery of news,

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[7] *Id*. at 4 ("For this study, every attempt has been made to ensure that the results are as realistic as possible and that the results are broadly applicable (generic) in nature").

[8] *Id*. at 3. The amount of distance separation required varies in part depending on whether filters are employed by the incumbent satellite systems. *Id*. at 1-2. As the report notes, many existing satellite systems used by the television industry cannot use filters. *Id*. at 1. Filters reduce the overall performance of dish efficiency for reception. Further, the simul-sat antennas typically used by multichannel video programming providers cannot use filters, which are physically incompatible with the geometry of the LNB feed horn assembly of the satellite dish. Replacement of these simul-sat antennas with multiple single antennas is physically impossible to achieve at receive locations with limited real estate, such as in urban areas.

[9] *Id*. at 3, 18.

[10] *Id*. at 18.

weather, and other television content important to hundreds of millions of consumers in this country. We look forward to working with the Commission to address the critical interference concerns outlined in the Alion report.

Respectfully submitted,

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April 5, 2013

ATTACHMENT A

Consulting Report

EFFECTS OF THE PROPOSED CITIZENS BROADBAND SERVICE TO C-BAND DOMSAT EARTH STATIONS.

Prepared for:

Content Companies

ESO-13-011-v3
April 2013

Use and Disclosure of Data

Approved for public release

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EXECUTIVE SUMMARY

The Federal Communications Commission (FCC) Notice of Proposed Rulemaking (NPRM) FCC 12-148 proposed a new small cell broadband service named the Citizens Broadband Service (CBS) to operate in the 3550-3650 MHz and 3650-3700 MHz frequency bands. The NPRM broadly outlines the service but does not give firm guidance regarding many technical parameters. Concerns have been identified regarding potential impacts of the proposed CBS system to highly sensitive Domestic Satellite (DOMSAT) earth station receivers of the Fixed Satellite Service that operate in the adjacent 3700-4200 MHz band at well over 5000 locations within the United States.

Alion Science and Technology Corporation (Alion) is a leader in the field of spectrum management. With over 70 years of experience, they have the tools in place to provide an abundance of spectrum services, including planning, management, modeling and simulation, measurement and testing, consultation and EMC design. Alion was contracted to conduct an analysis of the effects of FCC NPRM (FCC 12-148) on the domestic satellite (DOMSAT) fixed satellite service users in C-Band (3700-4200 MHz). Appropriate values for small cells were derived from various industry documents for Worldwide Interoperability for Microwave Access (WiMAX), WiFi, and Long Term Evolution (LTE) systems and from the NPRM itself. The analysis generally assumed that the small cell system duplexing method is Time Division Duplex (TDD), however, limited analysis was also performed assuming Frequency Division Duplex (FDD) to examine whether significant differences would occur.

Alion concludes that using the 3550-3650 MHz and the 3650-3700 MHz bands for small cell broadband applications would be very problematic for incumbent C-Band (3700-4200 MHz) users, which generally includes the entire video distribution industry -- both broadcast and cable -- throughout the United States. Spectrum sharing in these bands will require coordination with incumbent, adjacent band, DOMSAT users. The successful coordination will result in multi-km protection distances required that are significant, and when multiplied by the many thousands of C-Band earth stations, are highly likely to create unacceptable encumbrances for small cell systems and risk to C-Band earth stations.

The results of the supporting analysis (below) are summarized here for both filtered and unfiltered cases. However, it is noted that many of the antennas currently deployed cannot physically accept a filter between the feed and the amplifier, such as those with multibeam feeds.

For small-signal radio frequency interference (RFI), our results are summarized following:

1. For small cell interference sources operating within the 3550-3650 MHz band with 10 MHz bandwidths, potential for adjacent band interference with the following ranges is indicated:
   a. For filtered systems, the protection distances range from 0.6 to 9 km depending on the elevation angle and I/N threshold.

b. For unfiltered systems, the protection distances range from 19 to 33 km depending on the elevation angle and I/N threshold.

2. For small cell interference sources operating within the 3550-3700 MHz band with 10-MHz bandwidths, potential for adjacent band interference with the following ranges is indicated:
   a. For filtered systems, the protection distances range from 14 to 28 km depending on the elevation angle and I/N threshold.
   b. For unfiltered systems, the protection distances range from 19 to 33 km depending on the elevation angle and I/N threshold.

Results were also obtained for large signal (gain compression, third order intercept point, and intermodulation) interactions, as follows:

1. For small cell interference sources operating at 3550- 3650 MHz with 10 MHz bandwidth potential for intermodulation with the following ranges is indicated:
   a. For filtered systems, the protection distances range from 0.005 to 0.089 km depending on the elevation angle and I/N threshold.
   b. For unfiltered systems, the protection distances range from 0.5 to 10.8 km depending on the elevation angle and I/N threshold.

2. For small cell interference sources operating at 3550-3700 MHz with 10 MHz bandwidths and with filtering on the DOMSAT earth station, potential for large signal interactions with the following ranges is indicated:
   a. For filtered systems, the protection distances
      i. For intermodulation range from 0.5 to 10.8 km depending on the elevation angle and I/N threshold.
      ii. For gain compression range from 0.1 to 1.2 km
      iii. For TOI range up to 0.3 km
   b. For unfiltered systems, the protection distances
      i. For intermodulation range from 0.5 to 10.8 km depending on the elevation angle and I/N threshold.
      ii. For gain compression range from 0.1 to 1.2 km
      iii. For TOI range up to 0.3 km

For the small number of cases examined, it appears that FDD could reduce the protection zones depending on the actual implementation details (powers, frequencies, etc). The protection distances would still be significant, for example, for the worst case example the distance would be reduced from

33 to 22 km. In addition, the protection distances would be greater with higher power levels and for propagation percentages less than 50% (appropriate for low link margins).

It is concluded that the small cell broadband deployments proposed in NPRM FCC 12-148 have the potential to cause harmful interference to C-Band DOMSAT operations. Distances to mitigate RFI to C-Band DOMSAT systems for small-signal and large signal interactions were derived for multiple cases: varying the C-Band DOMSAT I/N thresholds and elevation angles, and the small cell deployment frequency band (per NPRM), and range up to 33 km. For operational systems with low link margins, interference levels exceeding the analyzed thresholds may lead to complete reception failure due to the bit error rate “cliff”.

BACKGROUND

The Federal Communications Commission (FCC) released a Notice of Proposed Rule Making (NPRM) NPRM 12-148[1] on December 12, 2012. It concerns potential use of the 3550-3650 MHz and 3650-3700 MHz bands for commercial small-cell broadband applications. The NPRM includes guidance regarding possible technical characteristics for a new small cell service, named the Citizens Broadband Service (CBS). Worldwide Interoperability for Microwave Access (WiMAX) systems are specifically identified as examples of systems already in use in these bands around the world based on IEEE STD 802.16. Among the many requests for comment asked in the NPRM are questions regarding the out-of-band performance of C-Band earth station Low Noise Amplifier (LNA) and Low Noise Block Downconverter (LNB) components, required protections, and potential for gain compression, TOI, and intermodulation.

Prior, related, proceedings FCC 05-56[2] and FCC-07-99[3] established rules for Wireless broadband services in the 3650-3700 MHz band. Under those rules, all fixed and base stations must be registered, while mobile stations operating with 1W/25 MHz are not registered. Mobile stations must verify that they are within range of a fixed or base station before operating. Protection distances for incumbent, in band, Fixed Satellite Service (FSS) earth station receivers were included in these proceedings. Terrestrial operations are permitted within these protection zones, so long as they negotiate agreements with the earth stations operators.

Alion was requested to determine appropriate protection distances for C-Band domestic satellite earth stations (DOMSAT) in the adjacent 3.7-4.2 GHz frequency band for adjacent (unwanted) emissions, gain compression, and LNB third order intercept point. For this study, every attempt has been made to ensure that the results are as realistic as possible and that the results are broadly applicable (generic) in nature.

[1] *In the Matter of Amendment of the commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, FCC-12-148, December 12, 2012,
[2] *In the Matter of Wireless Operations in the 3650-3700 MHz Band Rules for Wireless broadband Services in the 3650-3700 MHz Band Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band Amendment of the Commission's Rules With Regard to the 3650-3700 MHz Government Transfer Band*, Report and Order and Memorandum Opinion and Order, FCC 05-56, Adopted March 10, 2005.
[3] *In the Matter of Wireless Operations in the 3650-3700 MHz Band Rules for Wireless Broadband Services in the 3650-3700 MHz Band Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, Memorandum Opinion and Order, FCC-07-99, released June 7, 2007

OBJECTIVE

The objective is to evaluate potential effects from the proposed Citizens Broadband Service to C-Band DOMSAT Earth Stations.

SYSTEM DESCRIPTION

C-Band Earth Stations

C-Band earth stations in the 3700 to 4200 MHz band are described. This band is used for satellite downlinks. A search of FCC database records indicates that approximately 5000 earth stations are licensed in the 3700-4200 MHz band[4] in the United States. Since receive only systems are not required to be licensed, there is an additional but largely unknown number of unlicensed earth stations. The spacecraft are channelized with 40 MHz channels spaced at 20 MHz intervals. Alternating polarizations are used to make this possible.

Earth station antennas are generally in the 3.5-4.5 meter diameter range, although larger antennas are common. This band has been in use for this service for many decades, and such earth stations are ubiquitous. Terminals range from broadcast network affiliates and cable operators to amateur (hobbyist) stations and home backyard dishes. Given the long legacy of use in this band the antenna patterns used for this study are modeled as having a sidelobe gain (in dBi) corresponding to 32-25 log10 (theta) for off-axis angles greater than 1 degree and -10 dBi for off-axis angles greater than 48 degrees. Newer, high-quality antennas may have better off-axis performance regarding attenuation of potential interfering signals. Antenna radiation centers are usually at about 4 meters above ground level (AGL), but may be higher.

An earth station receiver system typically employs a low-noise, high-gain preamplifier at the antenna feed. The preamplifier may produce output at the same frequencies as are received in the 4-GHz band, in which case it is designated an LNA. Or, the preamplifier may incorporate a mixer which downconverts the signal to a lower frequency band near 1000 MHz (e.g., 950-1450 MHz), in which case it is designated an LNB. A third preamplifier type designated LNC for low-noise converter, down converts frequencies from the 4-GHz band to a few hundred MHz (e.g., 270-770 MHz) output[5].

[4] FCC International Bureau site/frequency select performed 3/28/2013: http://fjallfoss.fcc.gov/General_Menu_Reports/engineering_search.cfm?accessible=NO

[5] F.H. Sanders, R.L. Hinkle, and B.J. Ramsey, *Analysis of Electromagnetic Compatibility Between Radar Stations and 4 GHz Fixed Satellite Earth Stations*, NTIA Report 94-313, July 1994.

The purpose of a front-end preamplifier is to provide high sensitivity to a weak input signal (which requires that the noise figure of the preamplifier be low) and to produce an output with enough gain to compensate for both the line loss between the antenna and the receiver and the noise figure of the receiver. To achieve this functionality, 4-GHz front-end preamplifiers are typically designed to operate with noise figures of about 0.4-0.7 dB (noise temperatures of about 30-50 K) and gain values of about 50-65 dB. Ideally, the frequency response range of such a preamplifier would be the same as the assigned operational band of the receiver (i.e., 3700- to 4200-MHz). If the frequency response of an amplifier is wider than the allocated band of the receiver, then the likelihood of overloading an earth station preamplifier by emissions from transmitters outside the receiver band is increased. (Sanders et al)

Figures 1 and 2 show typical LNA and LNB gain and noise figure characteristics. (Sanders et al) It is readily seen that the gain characteristics extend far beyond the nominal 3.7 to 4.2 GHz band. Direct waveguide connection from the antenna to the LNA/LNB is generally used.

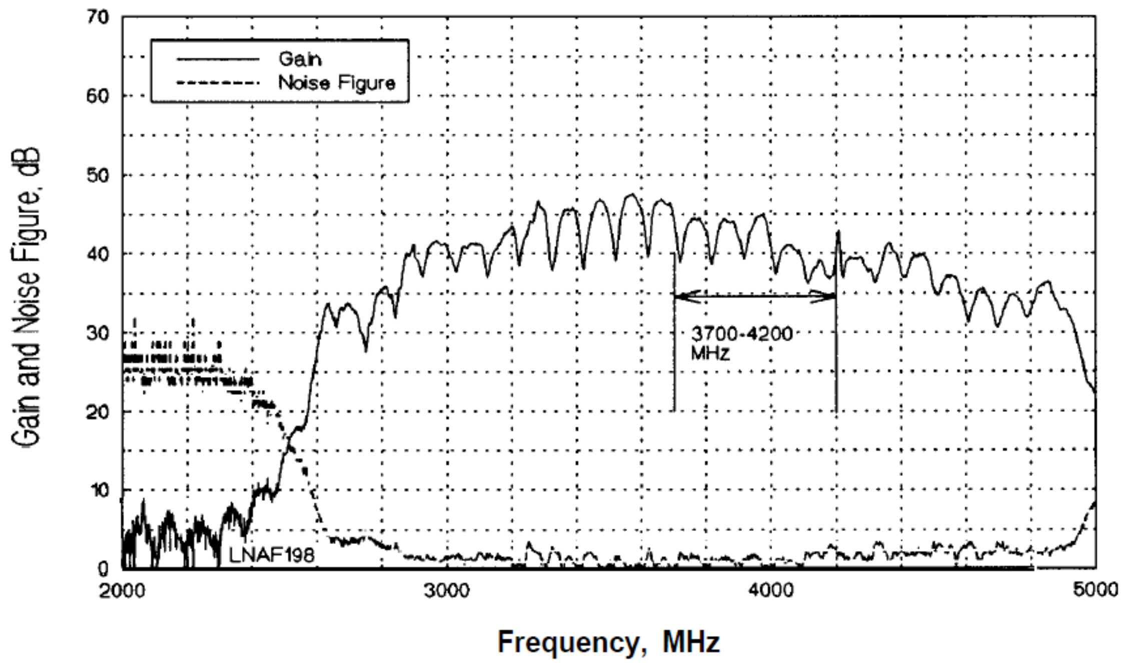

Figure 1. Typical LNA gain and noise figure (measured)

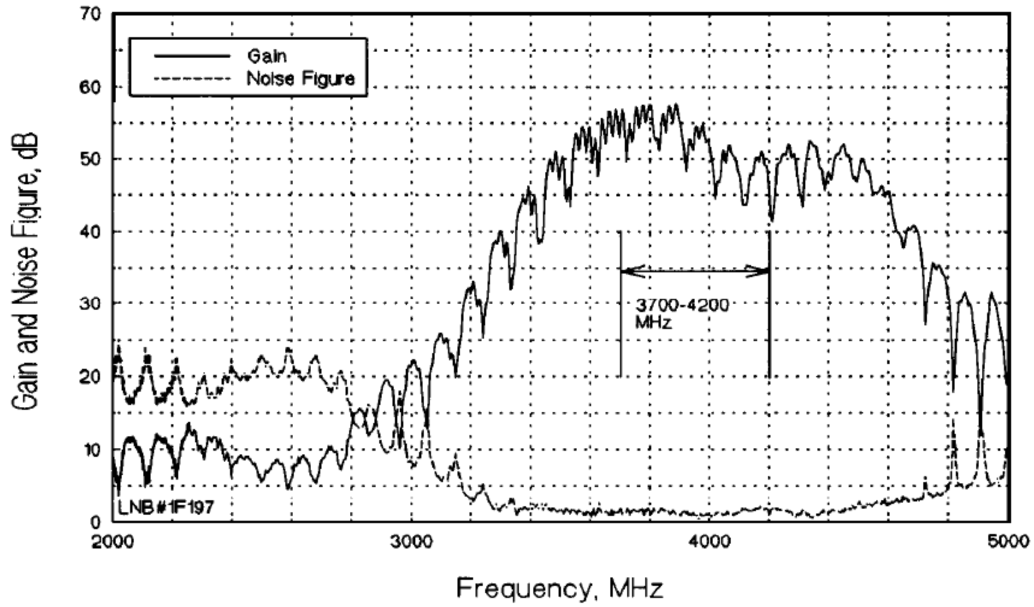

Figure 2. Typical LNB gain and noise figure (measured)

The satellite signals have a necessary bandwidth of 37.8 MHz. It is noted, however that virtually none of the C-Band earth stations utilize radio frequency (RF) filters prior to the LNA/LNB. Many of the antennas cannot physically accept a filter between the feed and the amplifier, such as those with multibeam feeds. For those that do use front end filters, the filter model MFC 13961W is taken as representative. Measured spectral response characteristics are shown in Figure 3.[6]

[6] From Microwave Filter Co., Inc. web site: http://www.microwavefilter.com/pdffiles/13961W.pdf, downloaded March 2013.

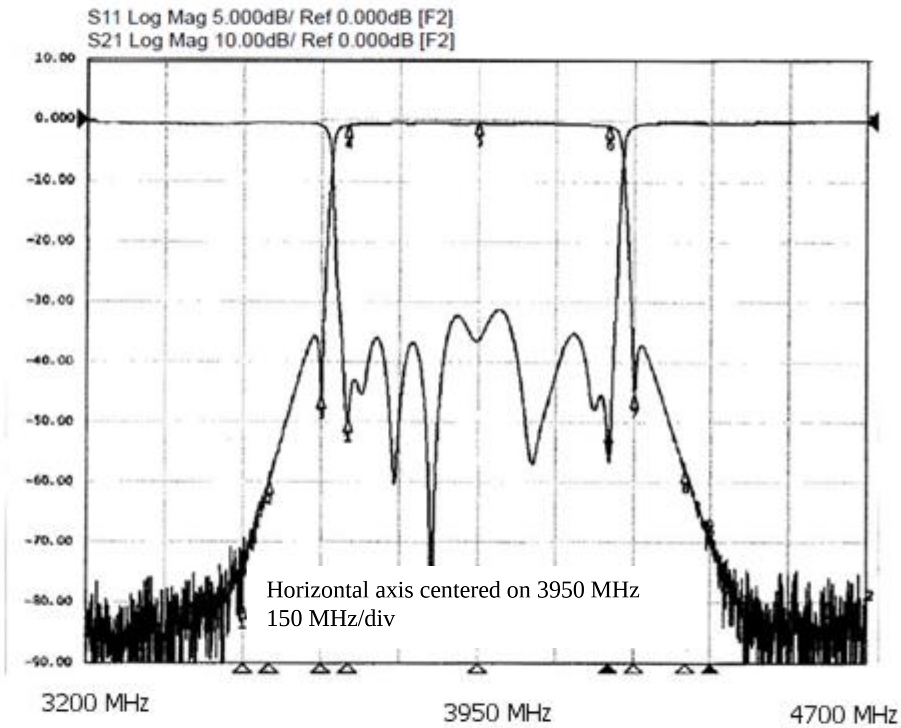

Figure 3. C-Band front end filter characteristics

A system noise level of -104 dBm was used in this study, based on a system noise temperature of 78 degrees and 3 dB bandwidth of 37 MHz.

The values used for the C-Band DOMSAT earth station interference threshold and receiver elevation angle were parameterized in order to allow flexibility in applying the results of this study and to allow for different situations. For example, earth stations in Maine could (and sometimes do) point at a domestic satellite far to the west on the geostationary arc, resulting in a low elevation angle of the antenna mainbeam. Thus the elevation angle was varied from 5 degrees to 35 degrees and the off-axis antenna gain computer as previously described. Also, different regions of country (in different regions of satellite antenna beams) and with different earth station implementations could have different link margins, leading to differing interference margins for a meaningful analysis of the potential for harmful interference. The analysis was performed both for interference-to-noise (I/N) thresholds of -10 dB and 0 dB. For operational systems with low link margins, exceeding even the I/N=0 dB threshold may lead to complete reception failure due to the bit error rate "cliff". The vast majority of the systems in this band do not use RF filtering. The analysis was performed both with, and without RF filtering. These results were determined with all terrain elevations set to zero, and without consideration of clutter. This is appropriate for generic radio frequency interference (RFI) analyses, but can be refined for specific situations.

Table 1 summarizes the C-Band earth station characteristics used in this study.

Table 1. C-Band Earth Station technical characteristics

Parameter	Value
Bandwidth	37 MHz/channel
Frequency	3720 MHz (lowest channel in 3700-4200 MHz)
Antenna gain, dBi	43.7 dBi Mainbeam 32-25Log(theta) for theta <=48 degrees -10 for theta > 48 degrees
Antenna elevation angle	5 degrees, minimum
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
LNB Gain	63 dB (typical)
Gain compression	2 dBm (at LNB output)
Third order intercept point	15 dBm (at LNB output)

Citizens Broadband Service System Technical Characteristics

The CBS technical characteristics are broadly outlined in the NPRM (FCC 12-148). The specified frequency band is 3550-3650 MHz, with comments requested regarding whether to extend the rules to include the 3650-3700 MHz band. The 3550-3650 MHz band was identified by NTIA for consideration in the "Fast Track Report."[7] The band is expected to be used by small cell broadband systems. The specific technology is not prescribed, but WiMAX is mentioned as an example in the NPRM several times because it already exists in this band in other parts of the world. Time division duplexing (TDD) WiMAX implementations are available in the 3550-3650 MHz band[8]. WiMAX duplexing assignments for 3400-3600 MHz are both TDD and FDD (3400-3500 MHz uplink/3500-3600 MHz downlink) and the band 3600-3800 MHz is TDD[9]. For Long Term Evolution (LTE) systems, the frequency bands 3400-3600 MHz and 3600-3800 MHz are allocated for TDD[10]. WiFi is based on IEEE standards 802.11 and uses TDD (half-duplex)[11]. This study generally assumes that the implementation is TDD. It is also possible that frequency division duplexing (FDD) could be used in this band, however, and portions of this study take that into account. The characteristics used herein were derived from various sources and reflect WiMAX and other small cell technologies.

[7] Obtained from http://www.ntia.doc.gov/files/ntia/publications/fasttrackevaluation_11152010.pdf, March 2013.
[8] As an example, see http://www.wimax-industry.com/3.5ghzwimax.htm retrieved 3/25/2013.
[9] WiMAX forum Mobile Radio Specifications Release 2, DRAFT-T23-005-R020v01-H, working draft 19 September, 2011
[10] 3GPP TS 36.101 V11.4.0, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); ser Equipment (UE) radio transmission and reception (Release 11), March 2013.
[11] IEEE 802.11, retrieved 27 March 2013; http://en.wikipedia.org/wiki/IEEE_802.11

The NPRM (FCC-12-148) gives a tentative base station power of 200 mW, and a mobile station power of greater than 1 mW. The base station antennas are proposed at 7 dBi gain, giving a maximum EIRP of 30 dBm.

The NPRM requests comments on whether out of band emissions (OOBE) limits are needed to protect incumbents in adjacent bands, and discusses the existing 43+10*log(P) limit used in the 3650-3700 MHz band. For this study the emissions mask for WiMAX was used.[12] Outside of the mask, an emissions roll-off of 20 dB/decade was assumed. A 10 MHz small cell channel was assumed. Each small cell modeled was assumed to use one of the fifteen 10 MHz channels across the 3550 – 3700 MHz band. Mobile stations were not modeled for this investigation, except for one excursion.

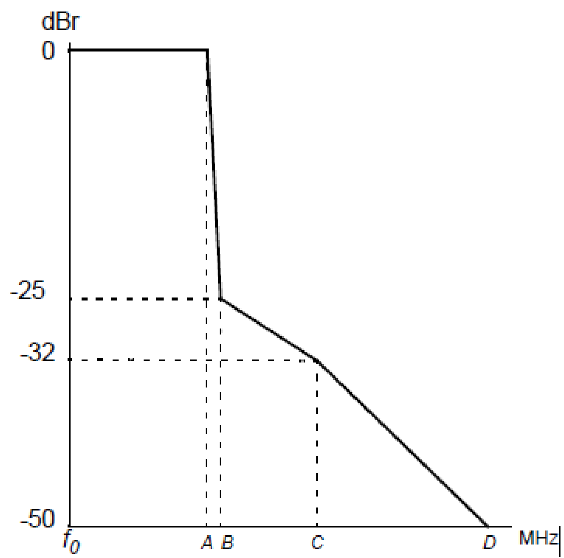

Figure 4. Emissions mask for WiMAX

Table 2. Parameters for emissions mask

Channelization, MHz	A	B	C	D
10	4.75	5.45	9.75	14.75
20*	9.5	10.9	19.5	29.5

*20MHz bandwidth was not covered in this analysis.

The CBS system characteristics are summarized in Table 3.

[12] IEEE Standards Association, *IEEE Standard for Air Interface for Broadband Wireless Access Systems*, IEEE STD 802.16TM-2012, 17 August 2012.

Table 3. CBS system characteristics

Parameter	Value
Type	Generic urban small cell scenario (no terrain). Cells arranged in uniform grid.
Small cell intersite distance (ISD)	600 m (9078 cells within 30 km radius)
Base station (BS) height	6 m
BS Antenna Gain	7 dBi
BS downlink/uplink ratio (duty cycle)	1 active base station channel per small cell, 0.667 fraction of time
Wireless service modeled as interference source	WiMAX (TDD) fifteen 10 MHz channels across 3550 - 3650 - 3700 MHz band
Base station transmit power	200 mW (EIRP = 30 dBm)
Antenna elevation angle	0 deg
Cable loss	0 dB

The small cell technical characteristics assumed for this study may differ from those eventually adopted by the rulemaking, or as implemented. This would potentially require re-evaluation.

ANALYSIS

The goal of this analysis is to create a generic protection zone that uses beyond line-of-sight propagation modeling (Longley-Rice) and eliminates local terrain effects by using all zero terrain elevations. While recognizing that it is impossible to cover every possible situation that applies to the thousands of C-Band terminals currently in place in the 3700-4200 MHz band in the USA, this analysis includes parameterization of some key values, including the interference threshold and the earth station elevation angle. It is also recognized that the results of this study may be modified for specific earth stations that, for example, have significant terrain shielding or nearby buildings, or that may have roof-mounted antennas. These modifications should be part of any coordination proceedings.

This analysis assesses small-signal interactions (RFI) and large-signal interactions (gain compression, third order intercept (TOI) point, and intermodulation (IM)).

Small Signal Analysis

RFI analysis was performed for an array of interfering base stations. The base stations were spaced 0.6 km apart in a grid. Each simulation assumed a frequency range of 3550-3700 MHz or a range of 3550-3650 MHz. The assumed small cell bandwidth was 10 MHz, so the channels were spaced at 10 MHz intervals starting at a center frequency of 3555 MHz. Mobile stations were not modeled because of their expected low power. The characteristics in Tables 1 and 3 were used.

The C-Band receiver was spaced at the center of a ring of base stations. The outer radius was set at 30 km (this outer radius was extended to 40 km for cases where the protection distance approached 30 km). The C-Band system characteristics are given in Table 1. Each simulation was performed for C-Band antenna elevations angles of 5, 15, 25, and 35 degrees.

The analysis was performed using a modified version of the model developed by NTIA for the fast-track analysis[13]. The model was modified for more general analysis use. Modifications included:

- frequency-dependent rejection capability
- additional flexibility in defining the base station and user equipment scenarios
- Longley-Rice propagation (ITM with delta h = 0 and median (50%) probability of loss not exceeded)
- additional antenna models

Model results were validated by comparison with identical scenarios run using Visualyse.

In this analysis, the environment is assumed to be urban, with closely spaced small cells. Rural environments were not analyzed because these systems are not expected to be widely deployed outside cities. Additional analysis may be required if these systems are deployed in rural areas.

For the consideration of those DOMSAT systems with front-end filters, frequency dependent rejection (FDR) was included in the analysis based on the characteristics of the C -Band front end filter and the CBS emissions spectrum (Figure 3 and Table 2). The calculated FDR is presented in Figure 5. Note that the C-Band RF filter is centered on 3950 MHz. Thus the band edge at 3700 MHz is at an off-tuning of 250 MHz, and 3550 MHz corresponds to an off-tuning of 400 MHz. For the unfiltered system analysis, the FDR was set to zero.

[13] 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.

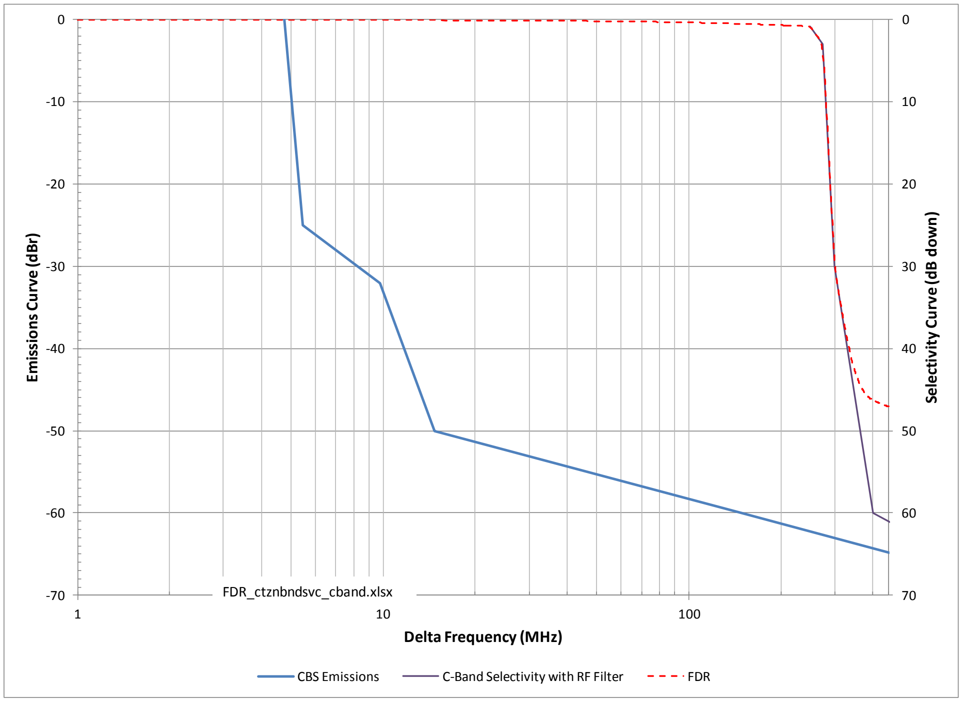

Figure 5. FDR between CBS emissions and DOMSAT selectivity (with RF filter)

For each model iteration, the frequency for each modeled base station was randomly selected from the available pool, and whether each base station was transmitting was randomly chosen based on the duty cycle as specified in Table 3. After some experimentation, it was found that 100 iterations of the model were sufficient. For some runs 500 iterations were used. Sufficient iterations were run so that the differences were less than 1 km in the resulting protection zones (with added iterations).

The analysis results are presented in the following Tables for the cases of filtered and unfiltered C-Band receivers with two interference thresholds and 4 elevation angles; and for small cells operating in the 3550-3650 MHz band or the 3550-3700 MHz band.

Results for the filtered and unfiltered cases for the 3550-3700 MHz band are presented in Tables 4 and 5.

Table 4. RFI from CBS base stations 3550-3700 MHz to C-Band earth stations, with filtering

Receiver Antenna Elevation Angle, Deg	Threshold I/N, dB	Single Base Station Protection Distance, on azimuth, km	Modeled Aggregate Protection Distance, km
5	-10	21.2	28
15	-10	14.8	23
25	-10	12.1	21
35	-10	10.5	20
5	0	15.7	21
15	0	10.2	16
25	0	8	15
35	0	6.7	14

Table 5. RFI from CBS base stations 3550-3700 MHz to C-Band earth stations, without filtering

Receiver Antenna Elevation Angle, Deg	Threshold I/N, dB	Single Base Station Protection Distance, on azimuth, km	Modeled Aggregate Protection Distance, km
5	-10	22	33
15	-10	15.4	29
25	-10	12.7	27
35	-10	11.1	26
5	0	16.4	26
15	0	10.7	22
25	0	8.5	20
35	0	7.2	19

Results for the filtered and unfiltered cases for the 3550-3650 MHz band are presented in Tables 6 and 7.

Table 6. RFI from CBS base stations 3550-3650 MHz to C-Band earth stations, with filtering

Receiver Antenna Elevation Angle, Deg	Threshold I/N, dB	Single Base Station Protection Distance, on azimuth, km	Modeled Aggregate Protection Distance, km
5	-10	6.9	9
15	-10	3.6	6
25	-10	1.89	5
35	-10	1.24	5
5	0	4.0	5
15	0	1.13	2
25	0	0.60	0.8
35	0	0.4	0.6

Table 7. RFI from CBS base stations 3550-3650 MHz to C-Band earth stations, without filtering

Receiver Antenna Elevation Angle, Deg	Threshold I/N, dB	Single Base Station Protection Distance, on azimuth, km	Modeled Aggregate Protection Distance, km
5	-10	22	33
15	-10	15.4	29
25	-10	12.7	27
35	-10	11.1	26
5	0	16.4	26
15	0	10.7	22
25	0	8.5	20
35	0	7.2	19

FDD Small Signal Analysis. A limited analysis was performed for an FDD system. The FDD system used the frequency bands 3550-3625 MHz for the uplink (BS's), and 3625-3700 MHz for the downlink (UE's). Two UEs per small cell were assumed with power of 7 dBm. The FDD BS and UE activity levels used were 0.67 (67%). For this analysis an antenna elevation of 15 degrees was used for the C-Band earth station. Otherwise the parameters were the same as for the TDD small signal analysis.

These results are presented in Table 8. FDD may be advantageous to reduce adjacent channel RFI mainly due to the lower power assumed for the UEs (as compared to the TDD base station power), but the protection distances remain significant.

Table 8. FDD small signal analysis results

C-Band Elevation Angle, deg	RF Filter	CBS Scenario	Threshold I/N, dB	Aggregate Protection distance, km
15	Unfiltered	FDD BS & UEs	0	22
15	Unfiltered	FDD UEs	0	4
15	Filtered	FDD BS & UEs	0	2.5

Large Signal Analysis

Large-signal interactions including receiver intermodulation, gain compression, and TOI were analyzed. The intercept point is a purely mathematical concept, and does not correspond to a practically occurring physical power level. In many cases, it lies beyond the damage threshold of the device[14]. Both filtered and unfiltered cases were considered for the large-signal interactions.

Intermodulation (IM) was considered using standard techniques based on the third order intercept point, and the fact that the response slope for the desired RF input is 1, while the slope for 3rd order IM is 3. The individual input IM power levels at which the RF interference threshold is just equaled is the desired result. This is illustrated in Figure 6. Tables 9-11 present the results for the intermodulation protection distances required.

Distances to mitigate potential gain compression and TOI were determined, based on the levels presented in Table 1. Due to the low distances expected, these calculations were performed using free-space path loss. Tables 12-14 present the results for gain compression and TOI protection distances.

[14] Third-order Intercept Point, retrieved from web page: http://en.wikipedia.org/wiki/Third-order_intercept_point, March 2013

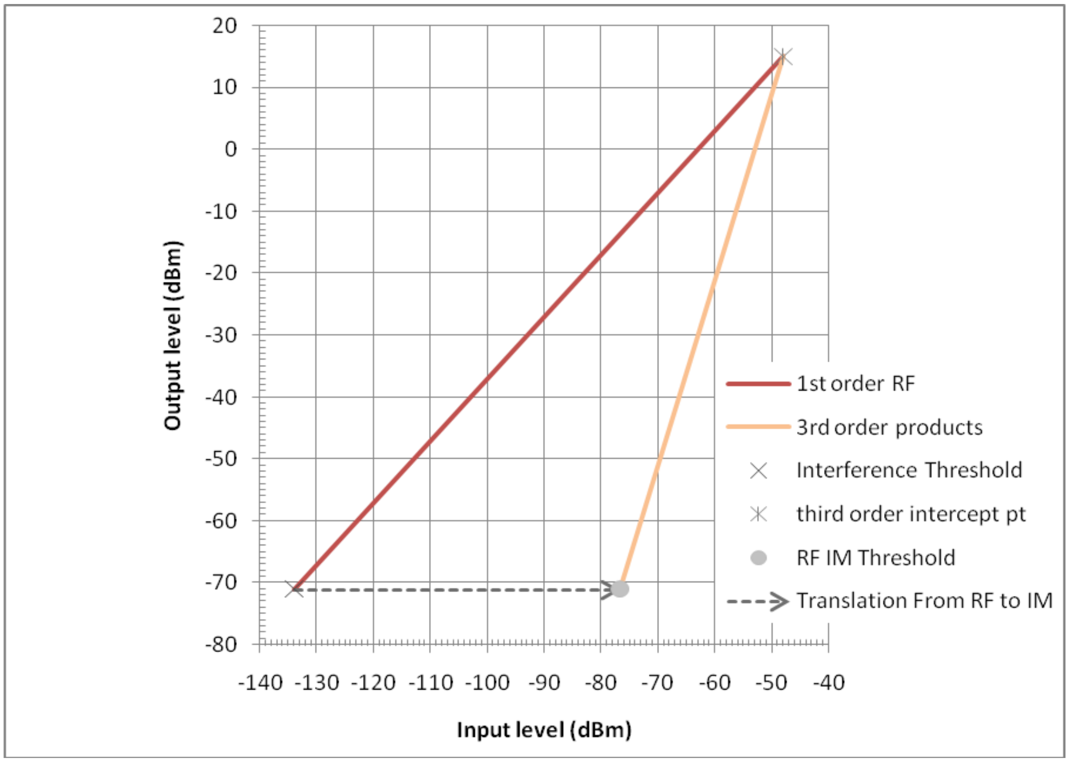

Figure 6. Intermodulation analysis

Table 9. IM protection zones for unfiltered C-Band systems (two base stations in 3550-3650 or 3550-3700 MHz)

BS EIRP, dBm	I/N, dB	off-axis angle, deg	E/S antenna gain, dBi	Threshold level at LNA input, dBm	Required Protection distance, km
30	-10	5	14.5	-80	10.8
30	-10	15	2.6	-80	2.8
30	-10	25	-2.9	-80	1.5
30	-10	35	-6.6	-80	1
30	0	5	14.5	-76.7	7.4
30	0	15	2.6	-76.7	1.9
30	0	25	-2.9	-76.7	1
30	0	35	-6.6	-76.7	0.7
30	0	45	-9.3	-76.7	0.5

Table 10. IM protection zones for filtered C-Band systems (assumes 3550-3650 MHz CBS) (two base stations)

BS EIRP, dBm	I/N, dB	off-axis angle, deg	E/S antenna gain, dBi	Threshold level at LNA input, dBm	FDR, dB	Required Protection distance, km
30	-10	5	14.5	-80	31.7	0.089
30	-10	15	2.6	-80	31.7	0.023
30	-10	25	-2.9	-80	31.7	0.012
30	-10	35	-6.6	-80	31.7	0.008
30	0	5	14.5	-76.7	31.7	0.061
30	0	15	2.6	-76.7	31.7	0.015
30	0	25	-2.9	-76.7	31.7	0.008
30	0	35	-6.6	-76.7	31.7	0.005

Table 11. IM protection zones for filtered C-Band systems (assumes 3550-3700 MHz CBS) (two base stations)

BS EIRP, dBm	I/N, dB	off-axis angle, deg	E/S antenna gain, dBi	Threshold level at LNA input, dBm	Required Protection distance, km
30	-10	5	14.5	-80	2.0
30	-10	15	2.6	-80	0.5
30	-10	25	-2.9	-80	0.3
30	-10	35	-6.6	-80	0.2
30	0	5	14.5	-76.7	0.19
30	0	15	2.6	-76.7	3.0
30	0	25	-2.9	-76.7	0.8
30	0	35	-6.6	-76.7	0.4

Table 12. Gain compression and TOI protection zones for unfiltered C-Band systems (3550-3650 or 3500-3700 MHz CBS)

Gain compression (GC) computation				
Off-axis angle, deg	E/S antenna gain, dBi	Threshold level at LNA input, dBm	Threshold level at LNA input, dBW	Required distance to mitigate, km
5	14.5	-61	-91	1.216
15	2.6	-61	-91	0.309
25	-2.9	-61	-91	0.164
35	-6.6	-61	-91	0.107
TOI computation				
5	14.5	-48	-78	0.272
15	2.6	-48	-78	0.069
25	-2.9	-48	-78	0.037
35	-6.6	-48	-78	0.024

Table 13. Gain compression and TOI protection zones for filtered C-Band systems (assumes 3550-3700 MHz CBS)

GC computation					
off-axis angle, deg	E/S antenna gain, dBi	IM threshold level at LNA input, dBm	IM threshold level at LNA input, dBW	FDR, dB	Required distance to mitigate, km
5	14.5	-61	-91	1.3	1.047
15	2.6	-61	-91	1.3	0.266
25	-2.9	-61	-91	1.3	0.141
35	-6.6	-61	-91	1.3	0.092
TOI computation					
5	14.5	-48	-78	1.3	0.234
15	2.6	-48	-78	1.3	0.06
25	-2.9	-48	-78	1.3	0.032
35	-6.6	-48	-78	1.3	0.021

Table 14. Gain compression and TOI protection zones for filtered C-Band systems (assumes 3550-3650 MHz CBS)

GC computation					
off-axis angle, deg	E/S antenna gain, dBi	IM threshold level at LNA input, dBm	IM threshold level at LNA input, dBW	FDR, dB	Required distance to mitigate, km
5	14.5	-61	-91	31.7	0.032
15	2.6	-61	-91	31.7	0.008
25	-2.9	-61	-91	31.7	0.004
35	-6.6	-61	-91	31.7	0.003
TOI computation					
5	14.5	-48	-78	31.7	0.007
15	2.6	-48	-78	31.7	0.002
25	-2.9	-48	-78	31.7	0.001
35	-6.6	-48	-78	31.7	0.001

CONCLUSIONS

Alion concludes that using the 3550-3650 MHz and the 3650-3700 MHz bands for small cell broadband applications would be very problematic for incumbent C-Band (3700-4200 MHz) users, which generally includes the entire video distribution industry -- both broadcast and cable -- throughout the United States. Spectrum sharing in these bands will require coordination with incumbent, adjacent band, DOMSAT users. The successful coordination will result in multi-km protection distances required that are significant, and when multiplied by the many thousands of C-Band earth stations, are highly likely to create unacceptable encumbrances for small cell systems and risk to C-Band earth stations.

It is concluded that the small cell broadband deployments proposed in NPRM FCC 12-148 have the potential to cause harmful interference to C-Band DOMSAT operations. Distances to mitigate RFI to C-Band DOMSAT systems for small-signal and large signal interactions were derived for various parametric cases: varying the C-Band DOMSAT I/N thresholds and elevation angles, and the small cell deployment frequency band (per NPRM). The required separation distances range up to 33 km. For operational systems with low link margins, interference levels exceeding the analyzed thresholds may lead to complete reception failure due to the bit error rate "cliff". In addition, the protection distances would be greater with higher power levels and for propagation percentages less than 50% (appropriate for low link margins).

The majority of the analysis assumed a TDD implementation in these bands. If FDD is used, further study will be required to establish protection zones. For the small number of cases examined it appears that FDD could reduce the protection zones depending on the actual implementation details (powers, frequencies, etc).

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