Before the
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Utilities Telecom Council and Winchester Cator, LLC	)	
	)	RM - 11429
Petition for Rulemaking to Establish Rules Governing Critical Infrastructure Industry Fixed Service Operations in the 14.0–14.5 GHz Band	)	

REPLIES TO OPPOSITIONS AND REPLY COMMENTS

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REPLIES TO OPPOSITIONS AND REPLY COMMENTS

The Utilities Telecom Council ("UTC") and Winchester Cator LLC ("Winchester") hereby file these joint replies to oppositions to its petition for rulemaking ("UTC Petition")[1] to amend Parts 2 and 101 to permit shared, secondary terrestrial fixed service use of the 14.0–14.5 GHz band for critical infrastructure industry ("CII") communications.[2]

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[1] Utilities Telecom Council and Winchester Cator, LLC, *Petition for Rulemaking to Establish Rules Governing Critical Infrastructure Industry Fixed Service Operations in the 14.0–14.5 GHz Band*, RM-11429 (filed May 6, 2008).

[2] UTC is the international trade association for the telecommunications and information technology interests of electric, gas and water utilities, pipeline companies and other critical infrastructure industries (CII). UTC's members include large investor-owned utilities that serve millions of customers, to smaller cooperative or municipal utilities that serve everything from major American cities to rural communities and sparsely settled service territories. Although these utilities differ in size and services, they all have one thing in common: they own, manage and operate critical communications systems and networks that enable the safe, reliable and efficient delivery of essential water, gas, electric and other energy services to the public at large.

The satellite industry's predictions of interference from the proposed CII fixed service ("FS") operations are unfounded. In these replies, UTC and Winchester demonstrate that even using the assumptions made by various satellite industry representatives, the proposed FS operations would not interfere with existing satellite users of the band. Similarly, arguments that the proposed FS operations would suffer harmful interference from existing services in the 14.0–14.5 GHz band and that the proposed operations are not appropriate for a secondary allocation are both incorrect and do not recognize CII users' experience operating in shared bands.

After careful analysis, UTC concluded that the 14.0–14.5 GHz band is well suited to meet the growing needs of CII users. The UTC Petition set forth limitations on the proposed operations that will protect existing FSS services in the band, while giving CII users access to secondary use of the band for crucial operations that will serve the public interest by enabling more efficient operations by electric and other utilities. UTC and Winchester Cator urge the Commssion to continue its policy of encouraging spectrum sharing and more efficient use of spectrum by granting the UTC Petition and initiating a rulemaking proceeding in accordance with the Petition.

I. THE SATELLITE INDUSTRY'S FEARS REGARDING INTERFERENCE FROM THE PROPOSED OPERATIONS TO EXISTING SERVICES ARE UNFOUNDED, AS ARE ITS PREDICTIONS OF INTERFERENCE FROM EXISTING SERVICES TO THE PROPOSED CII USES

The most sustained criticism from the satellite industry in response to the UTC Petition is that the proposed FS operations do not adequately protect FSS and other existing services in the 14.0–14.5 GHz band, and that the proposed CII operations would in turn not be able to avoid interference from existing services. As explained in detail in the attached Technical Response,[3] such fears are unfounded. The attached Response demonstrates that the proposed FS stations will not exceed acceptable interference levels to FSS space stations and earth stations in the band, even using the worst case assumptions made by the satellite industry. The Response also demonstrates that the proposed CII FS operations will use reliable techniques to ensure that they can co-exist with the existing FSS and services in the 14.0–14.5 GHz band without suffering harmful interference from such services.

A. The Satellite Industry's Concerns of Interference from Proposed FS Operations are Unfounded.

Several satellite industry parties argue that the engineering analysis presented in the UTC Petition is flawed because it uses an incorrect interference criterion to protect FSS satellites from secondary services — specifically, these parties argue that a 1 percent $\Delta T/T$ criterion is the appropriate criterion per ITU-

R S.1432-1.[4] However, recommendation ITU R S. 1432-1 is a satellite system design guideline to be used by satellite operators and manufacturers, and does not specify an interference criterion. The Commission has categorically rejected the design guidelines of ITU-R S.1432-1 as suitable interference criteria. When the Satellite Industry Association last argued that the 1 percent ΔT/T figure from ITU-R S.1432[5] should be used as a protection criteria, the Commission responded:

> We find the protection criterion proposed by SIA to be overly conservative and unsupported by either measurement or operational experience. Further, the Commission has been consistent in its position that the specifications found in ITU-R S.1432 are design criteria for FSS earth stations, not interference protection criteria. Thus, as in the past, we categorically reject the use of these design guidelines as suitable interference criteria.[6]

Accordingly, the design guidelines cited by the satellite industry should not be used as interference protection criteria to measure the degree of

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[3] RKF Engineering, LLC, *Technical Response to Comments*, Attached as Appendix A ("Technical Response").

[4] *See* Opposition of the Satellite Industry Association at 6 ("SIA Opposition"); Opposition of Global VSAT Forum and European Satellite Operators Association at 10-11 ("GVF/ESOA Opposition"); Opposition of SES Americom, Inc. et al. at 8 ("SES Opposition"); Opposition of Seamobile Inc. at 6 ("Seamobile Opposition"); Opposition of Hispamar Satellites, S.A. at 3 ("Hispamar Opposition"); Opposition of Hispasat, S.A. at 3 ("Hispasat Opposition"); Opposition by the Satellite Users Interference Reduction Group at 8 ("SUIRG Opposition"); Opposition of Hughes Network Systems, LLC at 5 ("HNS Opposition").

[5] Note that S.1432 has been superceded by S.1432-1. However, for the purposes of this filing and the Commission's analysis of suitable interference criteria, the relevant technical guidelines remain unchanged.

[6] *Wireless Operations in the 3650-3700 MHz Band; Rules for Wireless Broadband Services in the 3650-3700 MHz Band*; Report and Order and Memorandum Opinion and Order, ET Docket No. 04-151, WT Docket No. 05-96, FCC 05-56, at 25, ¶ 63 (rel. Mar. 16, 2005).

protection required for primary services in the 14.0–14.5 GHz band.[7]

Similarly, the Commission has not used these design guidelines for fixed and mobile services currently operating on a secondary basis in the 14.2 – 14.4 GHz band.[8] The Commission's rules permit these stations to use 45 dBW EIRP without any pointing restrictions toward the GSO.[9] These constraints are consistent with the ITU Radio Regulations for co-primary fixed and mobile services that are also allocated in these bands.[10] As explained in more detail in the Technical Response,[11] the sharing criteria proposed in the UTC Petition are consistent with, and in fact more conservative than, those required by the Commission's rules and the ITU regulations.

As shown fully in the Technical Response, even with worst case assumptions modified to take into account concerns raised by the satellite industry parties, simulations demonstrate that over one million FS stations can be accommodated in the 14.0–14.5 GHz band without presenting a risk of

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[7] As explained in the Technical Response, UTC and Winchester continue to believe that it is reasonable to establish sharing criteria under the assumption that the aggregate interference created by all FS stations would be equivalent to single entry interference of 6 percent $\Delta T/T$. *See* Technical Response at 2-3.

[8] 47 C.F.R. § 2.106 NG 184 allocates land mobile stations and grandfathered fixed stations operating in accordance with Part 101 on a secondary basis.

[9] 47 C.F.R. §§ 101.113(a), 101.145.

[10] ITU Radio Regulation Article 21 RR 21.2, 21.3, 21.5, 21.6 and Tables 21-1 and 21-2 applicable to fixed and mobile services sharing the bands with equal rights with space stations, pursuant to RR 5.505 in 14.0- 14.25 GHz, RR 5.505. 5.508 and 5.509 for 14.25-14.3 GHz , Region 1 and 3 in 14.3- 14.5 GHz and worldwide in 14.4- 14.5 GHz.

[11] Technical Response at 2-3.

unacceptable interference to satellite services in this band.[12] The Technical Response further demonstrates the improbability of the proposed FS stations pointing even close to the limit of 5 degrees off-axis angle to the GEO arc.[13] Finally, as shown in the Technical Response,[14] given the likely high correlation between the terrestrial rain fade and the rain fade toward the satellite, the actual protection to the GEO satellite arc will be significantly greater than assumed in the initial simulations contained in the UTC Petition, which themselves established that the proposed FS terminals would present no risk of interference to FSS services.

Accordingly, neither the Commission nor the satellite industry need have fear that the proposed CII FS operations will pose a risk of harmful interference to the FSS services in the 14.0–14.5 GHz band.

B. Interference From Existing Services to Proposed CII FS Will Not Render the Band Unusable for CII. CII Users Will Have Access to Virtually All the Spectrum in the 14.0–14.5 GHz Band.

As discussed in full detail in the Technical Response, CII FS users will take appropriate measures to ensure that they co-exist with the existing FSS and other services in the 14.0–14.5 GHz band without suffering harmful interference from such services.[15]

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[12] *Id.* at 12-14.
[13] *Id.* at 15-17.
[14] *Id.* at 17.
[15] *Id.* at 18-22.

The proposed CII operations will use well-recognized and reliable cognitive radio techniques such as dynamic spectrum access to locate available spectrum, as well as other measures such as ARQ, error correction coding schemes, transmit power control, and/or adaptive coding and modulation.[16] As explained in the Technical Response, by taking these measures, the CII FS terminals will effectively mitigate the effects of interference from the primary services. Simulations show that even assuming worst case conditions, there is an extremely high probability that nearly all the 500 MHz Ku-Band spectrum will be available for CII deployments in any given location and point in time.[17]

II. THE PROPOSED USE OF THE 14 GHZ BAND IS CONSISTENT WITH A SECONDARY SPECTRUM ALLOCATION

Several opponents of the UTC Petition argue that, because of their critical nature, CII users will not be content with secondary status and that the proposals advanced in the Petition are somehow a precursor to a future upgrade to primary status and greater protection.[18] As explained below, these assumptions that underlie these arguments are incorrect and that the fears that they spawn are misplaced.

As shown in the attached Technical Response, and as discussed above, the CII FS users will take appropriate measures to ensure that they can co-exist with the FSS and other services in the 14.0–14.5 GHz band without suffering harmful

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[16] *Id.* at 18-19.
[17] *Id.* at 22.

interference from such services.[19] CII users are well aware that, as secondary services, they will be required to accept interference from primary services. They are, however, confident that the CII FS system parameters and design will ensure that CII communications will not be adversely affected by interference from primary services.

CII users are prepared to employ cognitive radio techniques such as dynamic spectrum access to locate available spectrum, as well as other measures such as ARQ, error correction coding schemes, transmit power control, and/or adaptive coding and modulation.[20] As discussed in greater detail in the Technical Response, by taking these measures, the CII FS terminals will be able to operate within the 14.0–14.5 GHz band without harmful interference from the primary satellite users of the band.

As UTC explained in its comments,[21] CII entities are accustomed to operating in shared frequency bands and have demonstrated that shared bands do not necessarily mean unreliable use — provided, as proposed in the Petition, appropriate technical criteria are used. Under Part 90 rules, CII users operate in several shared, non-dedicated bands.[22] Further, of course, UTC/Winchester would not be pursuing this rulemaking proceeding if they were not convinced

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[18] *See, e.g.*, GVF/ESOA Opposition at 18; HNS Opposition at 4; SES Opposition at 11.
[19] *See* Section I.B, *infra*.
[20] Technical Response at 18-19.
[21] Comments of Utilities Telecom Council, RM-11429, at 4 (filed June 26, 2008) ("UTC Comments"); *see also* Reply to Oppositions of the Utilities Telecom Council at 3-4 (filed Aug. 11, 2008) ("UTC Replies").

that the 14.0–14.5 GHz band can be used successfully for the intended purpose under the proposal outlined in the Petition.

Finally, to reiterate what UTC stated in its comments, and despite the disingenuous motives ascribed to UTC and Winchester by the satellite industry parties, there is no intention and no need to seek co-primary status for the proposed CII operations in the 14 GHz band.

III. THE 14.0-14.5 GHZ BAND IS BEST-SUITED FOR THE PROPOSED CII OPERATIONS

Several opponents argue that the proposed CII users should seek a different band, arguing that several unused or underused FS bands are available.[23] Of course, incumbent spectrum users always will prefer that new operations occur in other bands — this is a typical, and understandable "not in my backyard" position.

Nonetheless, as UTC has explained in a separate filing,[24] the critical infrastructure industry lacks dedicated spectrum, particularly spectrum that is suitable for high capacity links needed for future uses such as smart grid applications. The reality is that many FS services have been relocated out of their original bands, leaving the remaining bands congested or with high barriers to entry because of difficulties in coordinating individual FS stations (such as in the

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[22] UTC Comments at 4 n.5.
[23] *See, e.g.*, GVS/ESOA Opposition at 8, 15; HNS Opposition at 6; SIA Opposition at 16-18.
[24] UTC Replies at 2-3, 4-6.

C-band and the 10.7-11.7 GHz band). As far as the higher frequency bands suggested by some opponents, such as the 27 GHz, 38 GHz, and 71 GHz bands, the rain fade and other propagation losses mean that implementing CII operations of the type proposed would require significantly higher transmitter power and more expensive equipment in order to operate at such higher frequencies.[25]

As explained in the UTC Petition, one of the main reasons the critical infrastructure industry is requesting dedicated spectrum in the 14.0–14.5 GHz band is to implement high-capacity links that will be needed as part of a nationwide electronic smart-grid.[26] These proposed operations will require more than a few individual FS links, which current FS allocations might support. A single, dedicated band at 14.0–14.5 GHz will enable an inter-operable national network of FS links that will be required by CII users for smart grid applications. This is a critical need that is not possible to meet with a patchwork of disparate microwave stations.

As discussed in the Technical Response, the coordination requirements in other FS bands such as the C-band and the 10.7–11.7 GHz band, prevent these bands from being used when they are most needed because of delays in the coordination process.[27] To be clear, as explained further below in Section IV, CII

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[25] Technical Response at 5-6.
[26] UTC Petition at 5-8; *see also* UTC Replies at 5-6.
[27] Technical Response at 6.

FS stations will be coordinated by the CII coordinator, but such coordination will be limited to establishing system parameters and locations so as to ensure that certain federal users are protected and that the aggregate effect of the CII FS stations does not cause unacceptable interference to the primary services and that the CII FS stations are deployed most efficiently. Individual CII FS stations, however, will not need to undergo a time-consuming frequency coordination process as is the case in other shared FS bands.

UTC has demonstrated that the proposed services will not cause unacceptable interference to existing users of the 14.0–14.5 GHz band.[28] When a proposed service can operate on a non-interference basis *vis-à-vis* existing services, the Commission should continue its policy of encouraging spectrum sharing and more efficient use of spectrum — particularly when the proposed uses are strongly in the public interest.

Finally, in response to the argument made by several opponents that there are no fixed and mobile allocations in Region 2 between 14.0–14.4 GHz,[29] it is noted that, in the past, the U.S. has allocated radio services that are not in conformance with ITU Table of Allocations. As an example, in this very band, the current US allocations allow fixed and land mobile stations in 14.2-14.4 GHz pursuant to NG 184. There are other domestic allocations for which there is no comparable allocation in the ITU Table of Allocations — *e.g.*, co-primary

[28] *See* Section I.A, *infra*.

Radionavigation in the 24.75 – 25.0 5 GHz band or secondary MSS in the 7 and 8 GHz band.[30] In other words, the lack of an international allocation does not and should not be the determining factor as to whether the Commission should implement a radio service that is in the public interest.

IV. THERE IS A NEED FOR A SINGLE NATIONWIDE CII LICENSEE AND COORDINATOR, AND UTC IS THE APPROPRIATE LICENSEE

Several satellite industry parties argue that a single nationwide CII licensee pre-empts the responsibility of the Commission to address interference issues, and question the process of selecting a licensee and coordinator.[31] The rationale for a single licensee was explained in the UTC Petition. The proposed operations in the 14.0–14.5 GHz band are to be used by the critical infrastructure industries, and it follows that the licensee should have expertise in and experience dealing with utilities' communications needs. UTC is such an entity, with decades of experience advocating for and addressing the telecom and IT needs of CII users. A single licensee would be better able to address potential interference risks by coordinating use of the band and ensuring that worst case interference conditions are not approached. Moreover, the Commission would not be forgoing its responsibilities in any way — the eventual service rules are expected to limit the proposed services using the criteria discussed herein and in

[29] GVF/ESOA Opposition at 14; HNS Opposition at 6.
[30] 47 CFR § 2.106. *See* for example Table of Allocations 7450- 7550 MHz and 7550–7750 MHz.
[31] *See, e.g.*, GVF/ESOA Opposition at 8, 18.

the UTC Petition. A single licensee will enable the most flexible use of the spectrum by CII users nationwide while providing a single responsible party to coordinate use of the band and, should the need arise, address concerns of aggregate interference.

With respect to the role of the coordinator, several commenters appear to misunderstand what has been proposed. To be clear, under the instant proposal, individual FS links will not be coordinated with primary or secondary AMSS, VMES, MSS or VSATs; the coordination process will be internal to CII users and streamlined to allow rapid and efficient use of the 14.0–14.5 GHz band while protecting satellite users from aggregate interference. The technical limitations on the proposed operations will ensure that they will not interfere with existing operations, while CII users will take appropriate measures to mitigate the effects of received interference.[32] In other words, in contrast to other FS bands such as the C-band, individual FS links will not be coordinated with satellite and other non-CII users, eliminating the need for third-party frequency coordinators such as those used for operations in other bands.

However, this does not mean that individual CII FS stations will simply be able to operate whenever and wherever they choose. The CII coordinator will play an important coordination role before individual CII FS stations and links

[32] This means, of course, that there is no expectation that existing services will need to coordinate with the proposed operations.

are approved.[33] Such coordination will be limited to defining CII FS system parameters and technologies required to share the band, maintaining a database of installed FS links that include system parameters and locations,[34] estimating the aggregate interference to the GEO satellites from all deployed links to ensure that worst case interference assumptions are not reached, and approving new CII FS links. The CII coordinator will also approve any pre-emptible commercial FS operations and ensure that they are pre-empted whenever necessary.[35]

Finally, several commenters suggest that, despite all the details provided regarding the need for additional spectrum for CII operations, the UTC Petition represents nothing more than a "spectrum grab" by Winchester Cator.[36] Such fears are unfounded and do not credit the experience and intelligence of UTC. The UTC Petition made clear that any commercial use by a third party such as Winchester Cator would be on a preemptible basis, and would simply be a way to make more efficient use of the spectrum and secure the benefits of economy of scale in developing equipment and facilities for CII users, while providing needed backhaul and other service. The Commission has encouraged such

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[33] Because the CII coordinator will be coordinating internal CII use and approving individual CII FS stations before they begin operating, the CII coordinator should be an entity with experience in dealing with CII users.

[34] In keeping track of the locations of proposed CII FS terminals, the CII coordinator will ensure that all federal users of the 14 GHz band are protected in accordance with applicable requirements and agreements.

[35] Some opponents in the satellite industry, whose spectrum assignments are not subject to competitive bidding, argue that the proposed commercial FS operations cannot occur without competitive bidding. As explained in the UTC Petition, this is simply not true for preemptible operations that are themselves tied to a secondary use allocation.

intensive use of spectrum through its spectrum leasing policies and rules. It is presumed, of course, that the nationwide CII license will specify that any commercial use must be preemptible, and opponents' arguments seem to be nothing more than arguing that UTC and Winchester Cator are planning to violate the terms of a license that has not yet been issued.[37]

* * *

UTC and Winchester Cator urge the Commssion to grant the UTC Petition and initiate a rulemaking proceeding to amend Parts 2 and 101 to permit shared, secondary terrestrial fixed service use of the 14.0–14.5 GHz band by CII users. UTC and Winchester Cator remain willing to work with satellite industry representatives to seek a consensus on this proposal.

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[36] *See, e.g.*, GVF/ESOA Opposition at 19; HNS Opposition at 2, 8.

[37] To the extent that parties have additional concerns over the role of the single nationwide CII licensee and the CII coordinator, such concerns can of course be raised and addressed as needed during the rulemaking stage of this proceeding.

Respectfully submitted,

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Dated: August 11, 2008

APPENDIX A

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Technical Response to Comments

Executive Summary

RKF Engineering (RKF) has reviewed the comments filed in response to the UTC/Winchester Cator Petition for Rulemaking ("UTC Petition") to establish rules governing Critical Infrastructure Industry (CII) fixed service (FS) operations in the 14.0-14.5 GHz band. This filing responds to the questions raised by interested parties. It provides additional information, where necessary, to give the Commission the most up-to-date technical details of how the new FS CII proposal will be implemented and will not cause harmful interference to existing FSS (Fixed Satellite Service) users and secondary users of the 14 GHz band. This response also provides further information on how the CII will be capable of operating in the 14 GHz environment without being interfered with by the FSS earth stations currently in use, as well as existing secondary stations.

Based on the comments received, RKF modified its assumptions to take into account observations made by the FSS community. The updated analysis in Section 2 demonstrates that more than a million FS stations could be deployed in the 14.0-14.5 GHz band without exceeding permissible interference levels to FSS satellites and disputes the claim that less than a thousand FS stations can cause harmful interference to the FSS satellites.

Section 3 addresses how CII stations will avoid being interfered with by primary FSS and secondary MSS users in the band. Our analyses show that, even after avoiding co-channel interference from these users, there will be ample spectrum available to be shared among the CII FS stations.

Our response also discusses why the 14 GHz band was selected for this service as opposed to the other bands that those filing comments identified, including C-Band, 27 GHz, 38 GHz and 71 GHz. The difficulty for the CII operator using C-band is that the existing 14,000+ uplink stations have already been coordinated with one another and would not fit into the scheme used in UTC/Winchester Cator's avoidance-of-interference proposal. C-Band downlink bands have been avoided for CII use they do not work with RKF's avoidance technique where transmission of signals is required. Instead, the UTC/Winchester Cator approach is to have each CII station dynamically select its frequency of operation within the channel plan and without requiring the coordination of individual frequencies at specific locations with primary and secondary users. The 27 GHz, 38 GHz and 71 GHz bands have excessive losses, which will make equipment prohibitively expensive for longer links.

Finally, our response makes clear that although RKF has shown that a very large number of FS stations could be accommodated without causing harmful interference to FSS satellites, the actual number of operating stations is likely to be more modest. The concept of having a single CII Coordinator to monitor the use of the band in order to maximize spectrum use and limit interference toward the GEO arc is a vital part of the UTC Petition.

Section 1: Response to the Opposition's Comments

1.1 Interference Threshold

Several commenters argue that RKF's analysis is flawed in that it uses the incorrect interference criterion to protect the FSS satellites from secondary allocated services[38]. These comments cite a 1% ΔT/T criterion as recommended in ITU-R S.1432-1 as the appropriate interference protection criterion for secondary services to protect the FSS Satellites in this analysis[39]. Recommendation ITU- R S.1432-1 is a satellite system design guideline to be used by satellite operators and manufacturers. It is **not** an interference criterion. The Commission has categorically rejected the design guidelines of ITU-R S.1432-1 as suitable interference criteria.[40] The Commission noted that these design guidelines were overly conservative as interference criteria and were not supported by measurement or operational experience. We do not believe these design guidelines are the appropriate interference protection criterion to determine the appropriateness of the UTC Petition. We believe that it is reasonable that the aggregate interference created by all FS stations would be equivalent to a single entry interference of 6% ΔT/T. A 6% ΔT/T translates to a modest degradation of 0.25 dB to the satellite link. Based on the results of this analysis and associated worst case assumptions, the expected modest number of terminals will not be expected to approach this level of interference.

In addition, the Commission has **not** used these design guidelines for fixed and mobile services currently operating on a secondary basis in the 14.2 – 14.4 GHz band.[41] The Commission's rules permit these stations to use 45 dBW EIRP without any pointing restrictions toward the GSO.[42] These constraints are consistent with the ITU Radio Regulations (RR) for co-primary fixed and mobile services that are also allocated in these bands.[43] The sharing criteria proposed by the UTC

[38] Satellite Industry Association (SIA) comments at p. 6, Global VSAT Forum (GVF)/European Satellite Operators Association (ESAO) comments at pp. 10 -11, Hispasat comments at pp. 3-4, Hispamar comments at p. 3, Satellite Users Interference Reduction Group (SIURG) comments at p. 8, Hughes Network Systems (HNS) comments at p. 5, SeaMobile comments at p. 2, SES at p. 8, SATMEX at p. 2.
[39] Recommendation ITU-R S.1432-1 "Apportionment of the allowable error performance degradations to fixed- satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz," 2006. Also some comments propose that the 0.5 % ΔT/T be used as an interference criterion instead of the 1% ΔT/T to provide an allowance from other unallocated or secondary services in the band. (See SES at p. 8). ITU-R S.1432 -1 states that there are no Recommendations pertaining to the amount of interference that a digital satellite circuit will receive from systems that share frequencies on non- primary basis. It recognizes that pursuant to the RR non- primary allocated services and all other emissions must operate on a non interference basis.
[40] Report and Order and Memorandum, Opinion and Order ET Docket 04-151, WT Docket 05-96, ET Docket 02-380 and ET docket 98-237 March 16, 2005, par 63.
[41] 47 CFR 2.106 NG 184 allocates land mobile stations and grandfathered fixed stations operating in accordance with Part 101 on a secondary basis.
[42] 47 CFR 101.113(a) and 101.145.
[43] ITU Radio Regulation Article 21 RR 21.2, 21.3, 21.5, 21.6 and Tables 21-1 and 21-2 applicable to fixed and
(footnote cont'd on next page)

Petition for these terrestrial stations are also consistent with, and more conservative than, these FCC Rules and ITU-RR in that all fixed stations will have EIRP or transmitter density requirements that do not exceed a maximum EIRP density of 28 dBW/MHz. All such fixed stations with this power (and lower powers) will avoid pointing closer than 5 degrees to the visible GEO arc. Additional power control and antenna size and gain requirements have also been proposed to mitigate the interference potential of these stations toward the GEO arc.

The Commission normally establishes on a case-by-case basis the appropriate sharing criteria to avoid harmful or unacceptable interference to services allocated to a frequency band on a co-equal basis or on a secondary non-conforming use basis. It has previously authorized secondary AMSS and LMSS services in this 14.0-14.5 GHz band based upon sharing and interference protection criteria that is appropriate for the services being requested.[44] These sharing requirements are also different from the design guidelines provided in ITU-R S.1432-1.

1.2 Interference From the CII FS to FSS, other FS & MSS Satellites

Several commenters had the concern that only a small number of CII stations can operate without causing harmful interference to the FSS satellites. In general, these parties objected to analyses in RKF's technical statement in support of the UTC Petition as being incomplete or faulty. The opponents' claim that a limited number of terminals can cause harmful interference is flawed because they make extreme assumptions that do not represent realistic scenarios for the deployment of FS stations in this band. Further, the CII Coordinator will ensure that FS systems will be deployed so as to minimize the impact to the FSS.

In this filing, opponents' concerns are addressed and incorporated into our analyses. The updated results of our analyses are detailed in Section 2. Sections 2.1 and 2.2 provide link analyses and simulations demonstrating that more than a million CII stations can be accommodated in the 14.0-14.5 GHz band. To further address the concerns raised we randomly distributed the CII FS stations proportional to population density. The number of satellites simulated was increased from the three originally selected to those in the entire GEO arc from 0W to 180W, spaced every 5 degrees. In addition, the satellite's receive beam gain was increased from 31 dBi to 34 dBi.

Section 2.3 provides histograms of antenna off-axis angles, toward 3 GEO satellite locations, for the simulated random deployment of CII FS stations. This section shows that in contrast to the worst case

mobile services sharing the bands with equal rights with space stations, pursuant to RR 5.505 in 14.0- 14.25 GHz, RR 5.505. 5.508 and 5.509 for 14.25- 14.3 GHz, Region 1 and 3 in 14.3- 14.5 GHz and worldwide in 14.4- 14.5 GHz.

[44] FCC did not use ITU-R S.1432-1 when it authorized AMSS or LMSS on a secondary basis and on a non-conforming/ unallocated basis in this band. See In the matter of The Boeing Company, Application for Blanket Authority to Operate Up to Eight Hundred Technically Identical Transmit and Receive Mobile Earth stations Aboard Aircraft in the 14.0 – 14.5 GHz and 11.7-12.2 GHz Frequency bands (Boeing Order and Authorization) Dec 21,2001; More recently, the RaySat Antenna Systems LLC Order and Authorization February 15, 2008.

assumptions stated by opponents of UTC Petition, it is very unlikely that an FS station would point close to the GEO arc. Instead, most FS stations point more than 60 degrees from the GEO arc.

In the RKF proposal, the worst case assumption was that when a rain fade occurs on the terrestrial path, there is no fade on the satellite path. Section 2.4 presents the calculation of the correlation between the terrestrial rain fade and the rain fade toward the satellite. This analysis demonstrates that when there is a deep terrestrial fade, there will also be with high probability, a deep fade of the terrestrial FS station's

transmissions toward the satellite. As a consequence, the satellite will see significantly less interference than what our analyses show.

The opposition is also concerned that antenna pointing errors will cause FS stations to violate the 5 degree GEO arc avoidance limit. It is the responsibility of the CII Coordinator to ensure that FS stations maintain the 5 degree avoidance considering all factors including pointing error.

1.3 Interference from FSS and MSS Earth Stations into the CII FS

Opponents raised concerns that the CII stations would receive unacceptable levels of interference from FSS and MSS earth stations. The analyses in Section 3 demonstrate that CII stations can mitigate interference from all services deployed now and in the future. By utilizing interference avoidance technologies, CII stations can find clean spectrum in which to operate. Such technologies have been proven viable by **Shared Spectrum Company**[45], and have been demonstrated in field tests to the military in a DARPA project[46]. Unused or lightly used frequency bands can be identified and utilized within a fraction of a second. Using simple retransmission protocols such as Automatic Repeat reQuest (ARQ), quasi error free (QEF) transmissions can be supported in a dynamic interference environment. This interference mitigation approach is effective against any interference source whether an FSS, AMSS, MSS or any secondary FS.

The analysis described in Section 3 assumed that all FSS satellites were fully utilized and estimated the available spectrum in the simulated random deployment of CII FS stations. The FSS and MSS earth stations were randomly deployed based on a realistic distribution of stations, e.g., distributed by population density where applicable (see Section 3 for a detailed description).

Figure 1.1 shows the cumulative distribution function (CDF) of the spectrum (out of 500 MHz) that is available for use by FS stations after taking into account the potential interference from primary and secondary satellite services. There is an extremely high probability that nearly all the 500 MHz Ku-Band spectrum will be available for CII deployments in any given location and point in time. For example, with 0.001% probability there would be at most 372 MHz bandwidth (74.4% of 500MHz) available to a CII FS station at any given location and point in time.

[45] http://www.sharedspectrum.com
[46] M. McHenry, E. Livsics, T. Nguyen, and N. Majumdar, "XG Dynamic Spectrum Access Field Test Results," IEEE Communications Magazine, vol. 45, no. 6, pp. 51-57, June 2007.

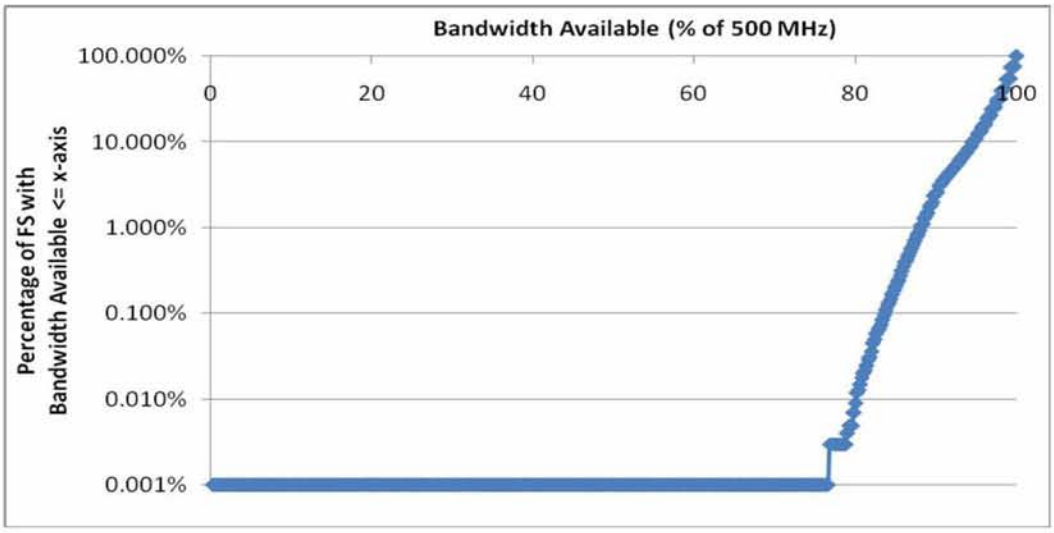


Figure 1.1. CDF of non-interfering bandwidth available for FS operations

1.4 International Allocations

Several parties oppose the UTC Petition based upon the fact that there are no fixed and mobile allocations in Region 2 between 14.0–14.4 GHz.[47] Although there are no allocations for fixed and mobile services in 14.0–14.4 GHz for Region 2, the US has in the past allocated radio services that are not in conformance with ITU Table of Allocations. As an example, the current US allocations allow fixed and land mobile stations in 14.2-14.4 GHz pursuant to NG 184. There are other domestic allocations for which there is no comparable allocation in the ITU Table of Allocations, e.g., co-primary Radionavigation in the 24.75 – 25.05 GHz band or secondary mobile satellite services in the 7 and 8 GHz bands[48]. Thus the lack of an international allocation should not be the determining factor as to whether the US should implement a radio service that is in the public interest.

1.5 Other CII Band Options

The UTC Petition to establish dedicated bands for the nation's CII was based on a need to satisfy current and future requirements for CII FS. It was not based on an analysis of finding individual frequencies for specific locations by searching many separate FS bands whenever new links were required. On the contrary, electric, gas, and water utilities, petroleum and pipeline companies, public transportation entities, public safety agencies and other CII need to establish new microwave connections without delay. As long as the CII FS station operation is consistent with requirements to protect existing primary and secondary services in the band, the FS station can be quickly deployed in any location. The FS station, within the channelization plan established by the CII Coordinator, would then have the flexibility to choose its operating frequency dynamically.
Commenters have suggested that the CII should rely on existing bands for their FS links and specifically

[47] GVF/ESOA comments at p. 14, HNS comments at p. 6.
[48] 47 CFR 2.106 See for example Table of Allocations 7450- 7550 MHz and 7550–7750 MHz

recommended C-Band, 27 GHz, 38 GHz and 71 GHz[49]. Their comments indicated that the last three bands are available and are not close to full capacity.

In fact, in the last 20 years the FCC has relocated many FS services out of their original bands. Point-to-point microwave systems in the 12 GHz band were relocated to make way for BSS and other systems. The 2 GHz band, formally the long haul FS band, was reallocated to PCS, AWS and MSS. More recently the 18.3 - 19.3 GHz band was reallocated to FSS band users and others. As one commenter noted[50], many 2 GHz long haul operators tried unsuccessfully to relocate in the 4 and 6 GHz bands, which are the next-best options for long links. The 4 GHz band, which is used for receiving signals from satellites, has fewer FS stations due to difficulties in coordinating with satellite receive earth stations. This is also true for the 10.7-11.7 GHz band where coordination with existing FS stations and FSS earth stations is currently required everywhere. However, deployment in this band would not be conducive to the proposed method of operation that would allow each CII station to select its frequency of operation within the channel plan dynamically, and without coordinating individual frequencies at specific locations.

The C-Band uplink spectrum 5925-6425 MHz presently has 14,651 active FS links, demonstrating that coordination with satellite uplink earth stations has not been a constraint; it is for analogous reasons that UTC/Winchester Cator selected an uplink satellite band for a secondary CII FS use[51]. The difficulty for the CII operator using this band is that the existing 14,000+ stations have already been coordinated with one another and would not fit into the scheme used in UTC/Winchester Cator's avoidance of interference proposal. Instead, as noted above, the UTC/Winchester Cator approach is to have each CII station dynamically select its frequency of operation within the channel plan and without coordinating individual frequencies at specific locations.

The other suggested bands of 27 GHz, 38 GHz and 71 GHz have significant additional losses which would require much higher powers. Based on an availability of 99.999%, and an average 10 km link in Miami, analysis of those frequencies shows that operations will experience significant rain and multipath losses[52]. For example, there is a rain fade loss at:

- 27 GHz of 113 dB
- 38 GHz of 160 dB
- 71 GHz of 208 dB
- 14 GHz of 43 dB

Thus, using the bands suggested by certain parties would provide spectrum that would be very difficult for the CII to use. The rain fade losses at 14 GHz on the other hand, are much less than the other bands noted above and therefore the FS links require less transmitter power and less expensive equipment.

[49] HNS comments on p. 6, Section II.B, and GVF/ESOA on p. 16, Section II. C.
[50] Comments of the Fixed Wireless Communication Coalition (FWCC) in RM-11428.
[51] It is worth mentioning that with the 14,651 links operating in the C-Band uplink frequencies, there are no cases of interference to C-Band earth stations or satellites even with a 2 degree avoidance angle from the GEO (the avoidance angle proposed to be used by the CII Coordinator is more than double this value).
[52] ITU-R P.530-11 model was used to calculate terrestrial rain and multipath fades all throughout the simulations.

1.6 Qualcomm Downlink Interference

Qualcomm, who operates OmniTracs outfitted trucks and other vehicles, has raised the concern that the new FS stations would interfere with 11.7-12.2 GHz receivers when they were driven directly into a 14 GHz FS station main beam. OmniTracs operates like other earth stations in Ku-Band. It transmits to the satellite at 14.0-14.5 GHz and receives signals from the satellite in the 11.7-12.2 GHz band. Since the CII FS links would not be in the 11.7-12.2 GHz band, there would be no more interference than what they are already receiving from existing 14 GHz operators. Since the OmniTracs mobile earth stations are not using 14.0-14.5 GHz receivers, there will be no interference to OmniTracs stations in that band.

If Qualcomm is referring to earth station receiver overload, it must be receiving overload interference from other FS bands closer to their operating receive frequency (e.g., 12.75-13.25 GHz). The 14.0-14.5 GHz band is 1.8 GHz removed from their 11.7-12.2 GHz earth station receive frequency band.

1.7 Duplex Link Off-Pointing

The opponents raised the issue of interference due to duplex FS links. More specifically, the concern was that if one transmitter was off-pointing from the GEO arc by 5 degrees, it does not ensure that the second transmitter in the link is off-pointed by more than 5 degrees. The UTC Petition states that all transmitters off-point by at least 5 degrees away from the GEO arc. Thus, if a duplex FS link were to be established and if one of the two transmitters were to point within 5 degrees of the GEO arc, an intermediary hop would be placed between these desired stations to maintain a 5 degree avoidance angle for all transmitters in the FS link. The CII Coordinator will ensure that all FS transmit stations are off-pointed by at least 5 degrees from the GEO arc.

1.8 CII Coordinator

The CII Coordinator will play a key role in successful deployment of this CII system. The CII Coordinator will ensure that the fixed stations will be deployed in a manner that will achieve FS link requirements while minimizing impact to the FSS and maximizing the number of FS systems that can share the band. The CII Coordinator is envisioned to perform the following functions:

- Define CII FS system requirements including system parameters (e.g. transmit power, bandwidth, dish size, etc.) and technologies required to share the band
- Maintain a database of installed CII FS links that include all system parameters
- Estimate the aggregate interference to all the GEO satellites from all FS links deployed
- Approve all new CII FS links prior to deployment
- Monitor a significant sampling of installations to verify the accuracy of model assumptions used in predicting FS interference to GEO satellites

By defining a consistent set of technologies and through the approval of new FS links, the CII Coordinator will ensure that the permissible aggregate interference levels to GEO satellites are not exceeded. To achieve these requirements, the CII Coordinator may place restrictions on FS instillations including:

- Dish Size: larger FS dishes may be used to improve the link margin and reduce required FS transmit power
- Link distance: the maximum FS link distance may be limited in high fade areas
- Coding and modulation: adaptive coding and modulation will be used to reduce FS transmitter power requirements when fades are high
- Bandwidth: if the data throughput requirement of the FS station requires less bandwidth than 50 MHz, there is correspondingly less transmitter power required

1.9 Non-Geostationary Orbit NGSO Sharing

Since there are primary FS allocations in various parts of the world in the 14.0-14.5 GHz band and NGSO satellite systems are normally deployed for worldwide operations, mitigation techniques will need to be implemented on these NGSO systems. NGSO FSS satellites can share with the FS using angle avoidance techniques that are analogous to those currently used to share with GSO FSS systems. Since the majority of terrestrial systems have low elevation angles, NGSO systems can limit their service to higher elevation angles in order to mitigate the potential interference from the terrestrial stations.

The CPM Text in support of WRC-2000[53] addressed sharing between NGSO systems and FS systems in the 12.75-18.1 GHz frequency range. From studies that were undertaken based on typical FS point-to-point systems and on the characteristics of the space stations of F-SAT MULTI 1B NGSO FSS system, the CPM "…concluded that, even under pessimistic assumptions, the interference from FS systems into NGSO FSS (Earth-to-space) in the 12.75-18.1 GHz frequency range would be acceptable."

Section 2: Uplink Interference

The satellite opponents to the UTC Petition provided several analyses intended to show that a small number of FS stations will exceed interference thresholds at the GEO FSS satellite. In order to further clarify our arguments which show that potential aggregate interference from the FS stations to GEO FSS satellites will not exceed the 6% $\Delta T/T$ interference criterion, we have extended our analyses and simulations. The UTC Petition states that a worst case (i.e., rain fade that occurs only 0.001% of the time[54] in Florida, 45cm dishes on both ends of the FS link, a maximum 20 km FS link path length) link would require approximately 45 dBW EIRP in order to close the link, assuming a required C/N of 15 dB. For this reason, an EIRP limit is set at 45 dBW in order to be consistent with ITU Radio Regulations. The opponents extrapolate that every single P2P (point-to-point) station will be transmitting at this EIRP, although the UTC Petition clearly states that these values are only limits and that on average the EIRP will be much lower than this limit. In other words, the opponents' assumptions were that every single FS link would be subject to a fade that is only exceeded 0.001% of the time in the worst case rain region, both FS stations in a link would use a 45 cm dish, the path length would be 20 km, and every FS transmit antenna would be pointed exactly 5 degrees

[53] CPM Report On Technical, Operational And Regulatory/Procedural Matters To Be Considered By The 2000 World Radiocommunication Conference, Non-GSO FSS issues, WRC-2000 agenda item 1.13, Section 3.1.4.2.

[54] A link designed such that it can overcome a fade that is not exceeded for 0.001% of the time has a link availability of 99.999%. Such a fade condition is referred to as "0.001% fade." The link that can overcome this fade is referred to as having "99.999% link availability."

away from a GEO satellite. These assumptions are clearly unrealistic for actual FS deployment.

2.1 A Very Large Number of Low Probability Events Must Occur Simultaneously for FS Stations to Transmit at Peak Power Level

To control the interference level toward the GEO satellites, microwave stations currently operating in certain frequency bands need to be properly sited to avoid the GEO arc. In addition, the number of long distance links in high fade areas may need to be limited and appropriate link parameters need to be selected (e.g., bandwidth, coding/modulation, dish size, etc.). As proposed in UTC Petition, it will be the responsibility of the CII Coordinator to monitor the deployment of FS stations in the 14.0 – 14.5 GHz band and ensure that the permissible aggregate interference level toward the GEO satellite arc is not exceeded. Feedback to the CII Coordinator can be provided from a representative sample of FS stations to determine the accuracy of aggregate interference estimates. The CII Coordinator will undertake aggregate interference calculations which will use deployed FS link parameters, and include pointing error allowances.

Note that the **minimum** antenna diameter considered for the FS station is 0.45 m (Section 2). With a 5 degree avoidance angle, the 0.45 m antenna main beam is outside the GEO arc (the one-sided 10 dB beamwidth is ~3˚ with a null at ~5˚ from beam peak). Note that these are worse case assumptions and that larger FS station dish sizes and lower required C/N values (we assume 15 dB) would allow more FS stations to be deployed.

The FCC FS station EIRP density limit is 45 dBW/channel. Since a 0.45 meter dish has a gain of 34.7 dBi the corresponding maximum allowed transmit power for the links in this analysis is 10 dBW. Only 20 km links in the higher rain zones, operating at 99.999% availability, require this much transmit power.

Figures 2.1 and 2.2 are plots of required FS station transmitter power versus FS link availability as a function of FS link distance for Miami and LA, respectively. Figures 2.1 and 2.2 indicate that when power control is used, the maximum FS transmit power required for a given percentage of the time (availability). For example, a 10 km link in Miami requires less than 0 dBW/50 MHz for 99.999% of the time and less than -42 dBW/50 MHz for 90% of the time.

Notice that FS links require exponentially higher power for very small percentages of time. Furthermore, Figure 2.3 shows that longer links in high fade conditions require disproportionately more power than shorter distance links. Since we expect more FS links to be implemented at shorter distances and operate most of the time in unfaded or low fade conditions, the required transmit power on average will be significantly lower than the maximum transmit power allowed (45 dBW/50 MHz).

Opponents have assumed that every FS transmit station will be subject to all conditions that have to occur simultaneously in order to cause worst case interference to FSS satellites. Table 2-1 lists all these events and highlights that each consideration is a low probability event and the total probability of these simultaneous events occurring is extremely low. In addition, the CII Coordinator can establish requirements to ensure that these worst case events cannot occur. For example, FS links in high fade regions can use dishes larger than 0.45 m.

Table 2.1: Considerations related to worst case interference event to FSS satellites

Parameters	Condition
Fade on the terrestrial link	The maximum FS transmit power is required for very low percentages of the time (~0.001%) to overcome fade.
Fade in the direction of the satellite	The satellite only receives maximum interference level from an FS station when there is a high fade on the terrestrial path, but no or little fade on the satellite path (See section 2.4).
High fade area	The FS link has to be in a high fade area to cause the maximum interference. This is a small percentage of the country.
Spatial Fade Correlation	Deep fades occur spatially over small areas.
Distance between stations	FS links have to be greater than about 15 km to cause the maximum interference. Most links are expected to be deployed at shorter distances.
Off-axis angle	The maximum interference occurs when the FS Transmit antenna boresite is pointed near the GEO arc (See Section 2.3).
Dish size	The maximum interference to the GEO arc only occurs for the minimum FS station antenna size (0.45 m). Longer distance FS links in high rain regions can use larger FS Station dishes, which require less transmit power and correspondingly less power toward the GEO arc.
Bandwidth	If FS stations use smaller bandwidths than 50 MHz, for a total specific FS station ensemble, then the probability of interference to a satellite operating on any specified frequency is reduced.

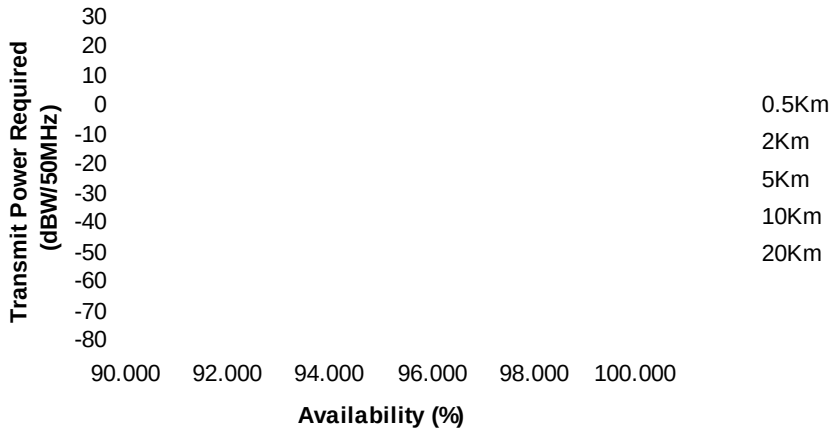


Figure 2.1. Transmit power versus link availability and link distance for Miami

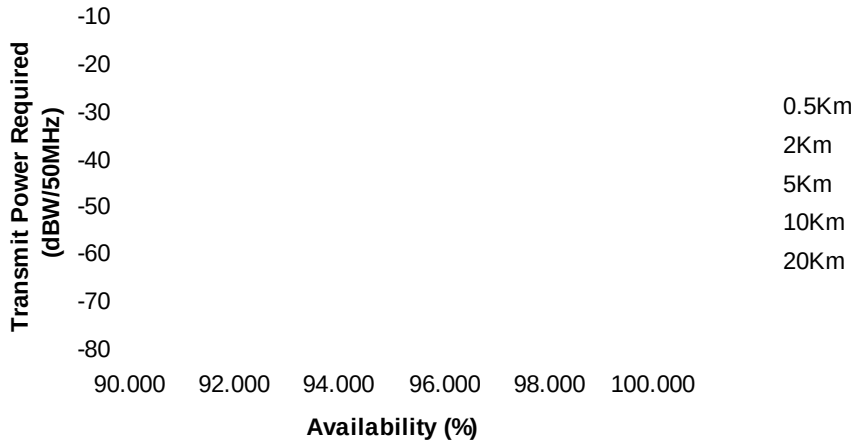


Figure 2.2. Transmit power vs. link availability and link distance for Los Angeles

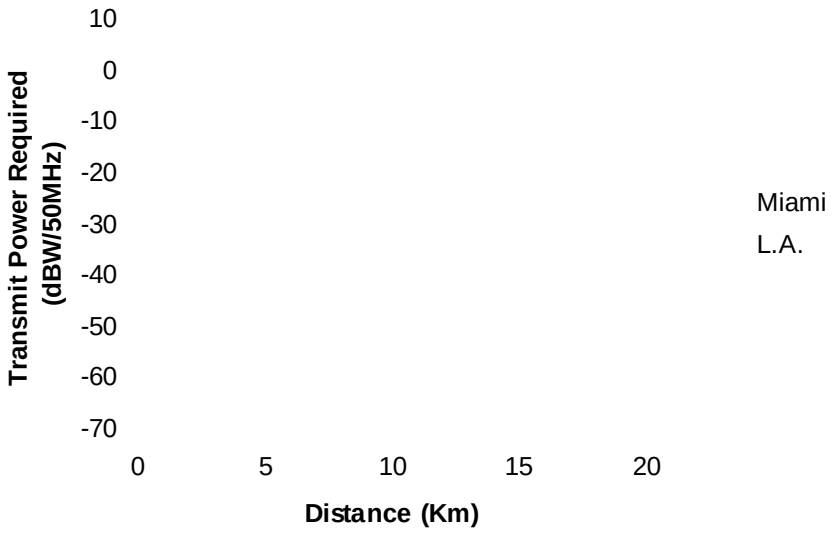


Figure 2.3. Link separation distance versus required transmit power for an availability of 99.999%

2.2 Link Analysis and Simulation Results demonstrate that, even with worst case rain and multipath in the ground path, no multipath or rain attenuation in the satellite signal, the smallest FS dish size, FS elevation angles of up to 30 degrees, and placing FS receivers up to 20 km away, over a million CII P2P stations can share the 14.0 to 14.5 GHz band with the GEO FSS.

RKF's initial analyses provided simulation results to demonstrate that over a hundred thousand P2P CII links could operate in each 50 MHz band without causing aggregate interference to the GEO satellites that exceeds 6% $\Delta T/T$. New worst case assumptions identified by the opposition in their comments were included in these analyses in order to alleviate those concerns. The simulations for Point to Multipoint (P2MP) Base Stations and Transportable Fixed Stations are not included because given the updated

assumptions the limiting case is still P2P links.

In these simulations, we randomly distribute FS transmitter locations **proportional to population density**[55] and determine the level of aggregate interference received at each GEO satellite located **at every 5 degrees along the GEO arc, ranging from 0°W to 180°W**. Each of the FS transmit stations are pointed in a random direction, chosen uniformly in azimuth from 0 to 360 degrees and uniformly in elevation from 0 to 30 degrees (modeled in accordance with the original proposal). Consistent with the previous analysis, the increase in the satellite noise floor due to FS aggregate interference is $\Delta T/T = 6\%$ and the required FS station C/N is 15 dB[56]. Lastly, based on the comments, the **satellite receive gain is increased from 31 dBi to 34 dBi**.

The simulation results are supported by the simple link analysis shown below. This FS link budget uses average transmit power levels and average antenna discrimination determined from the simulations. The FS link budget and the simulations show that **more than one hundred thousand stations** can be supported **per 50 MHz**, and even more FS stations can be supported if less stringent assumptions are considered (such as FS station required C/N < 15 dB, inclusion of rain fade in the direction of the satellite, usage of less bandwidth per FS link, and usage of larger FS station dishes).

This illustrative link budget below applies to a satellite at 60W and shows the number of stations that can be supported for this satellite assuming that only 0.45 meter dishes are used. When another satellite location is selected, some link budget parameters change according to the geometry of the FS stations and the satellite location. Figure 2.4 shows the results of simulations for all satellites with longitudes ranging from 0W to 180W. Results are shown as a function of FS station dish size. Note that if both transmit and receive FS stations dishes are doubled in diameter to 0.9 meters, the FS transmit power required is reduced by 12 dB.

The following is a list of assumptions used in the analysis. Some specific values apply only to a satellite at 60W, while others apply to all satellite locations.

1. Satellite longitude: 60W
2. P2P stations are located according to non-uniform population density profiles.
3. FS transmit bandwidth: 50 MHz
4. Center Frequency: 14.25 GHz
5. FS antenna size, Peak Gain: 45cm, 34.67 dBi
6. FS C/N required: 15 dB
7. FS station noise temperature: 290 K
8. Satellite receiver noise temperature: 600 K
9. Satellite receiver antenna gain: 34 dBi
10. Average effective FS station antenna gain towards satellite: -8.38 dBi
11. Maximum FS free space path loss (20 km link): 141.56 dB

[55] Proportional to population density means that if for example a large city has 5% of the US population, we would expect 5% of the total number of links to be in that city.
[56] The DVB-S2 specification [ETSI EN 302 307 v1.1.1] shows link performance for a variety of different modulations using LPDC codes. A C/N= 9dB can support 16-APSK with a LDPC code rate of 2/3 and QPSK with LDPC code rate ½ requires a C/N = 1 dB.

12. Average FS free space path loss (assuming uniform distances from 0 to 20 km): 136.75 dB
13. Average multipath/rain fade assuming bottom 3% of country, (i.e. below 31 degrees N latitude) is covered in 0.001% rain fade, and the rest of the country's fade is calculated from [max(rain fade, multipath fade)] and integrated over all link distances and availabilities from 0 to 99.999%: 37.28 dB.
14. All P2P stations off-point by at least 5 degrees from the GEO satellite arc.
15. FS earth stations are not considered interferers if the path between the FS station and the GEO satellite is blocked by the earth.

Table 2.2. Link Analysis

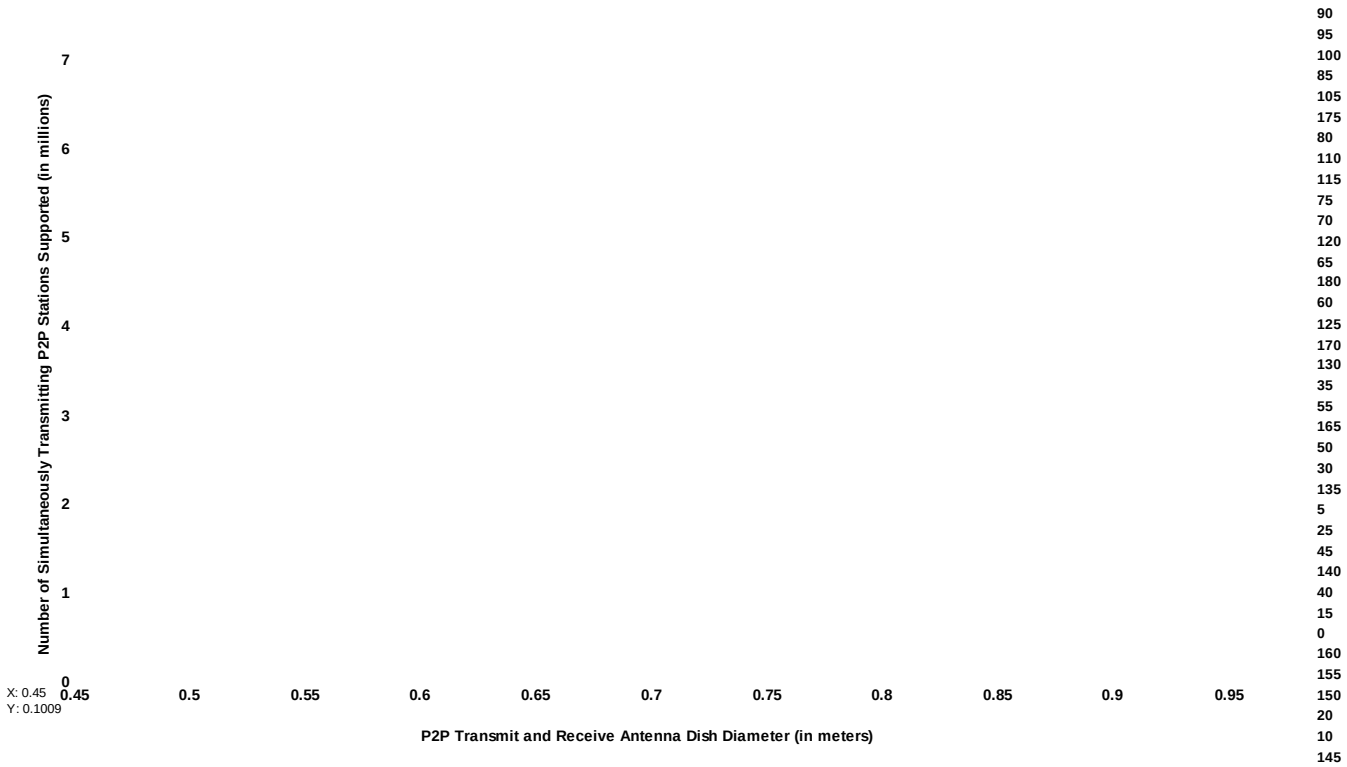
Parameter	Units	Comment	Value
FS Tx Antenna Gain	dBi	*TxGain* (0.45 m antenna diameter)	34.67
FS Rx Antenna Gain	dBi	*RxGain*	34.67
Average P2P Free Space Path Loss	dB	*AvPathLoss* (Assumes link distances distributed uniformly between 0 and 20 km)	136.75
C/N required	dB	*C/Nreq*	15
Average Terrestrial Rain/Multipath Fade	dB	*Fade*	37.28
Boltzmann's Constant	dBW/K/Hz	*K*	-228.6
FS Station Bandwidth	MHz	*B*	50
FS Rx Noise Temperature	K	*T*	290
FS Rx Noise Power integrated over 50 MHz	dBW	*N = 10*log10(kTB)*	-126.98
Average FS Transmit Power Required (over 50 MHz)	**dBW**	***AvTxPower = C/Nreq + N - TxGain - RxGain + AvPathLoss + fade***	**-7.29**
Average FS EIRP Required	**dBW**	***AvEIRP=AvTxPower + TxGain***	**27.38**
Average FS Effective Antenna Gain Towards Satellite (Sat@60W)	dBi	*AvEffGain*	-8.38
Average Free Space Path Loss Towards Satellite (Sat@60W)	dB	*AvPathLossSat*	207.2
Satellite Rx Noise Temperature	K	T_{Sat}	600
Satellite Rx Noise Power integrated over 50 MHz	dBW	$N_{Sat} = 10*\log10(k\ T_{Sat}\ B)$	-123.82
Satellite Rx Antenna Gain	dBi	*SatRxGain*	34

Average I/N at satellite due to single FS transmitter	dB	*AvI/NsingleFS = AvTxPower + AvEffGain – AvPathLossSat + SatRxGain – N_{Sat}*	-65.05
Maximum aggregate I/N due to FS stations	dB	*MaxI/N = 10*log10(0.06)*	-12.21
Number of FS Transmitters Required to reach I/N limit per 50 MHz		***10^((MaxI/N – AvI/NsingleFS)/10)***	**192,310**

Figure 2.4 shows the results, for **all simulated satellites**, of randomly placing P2P transmitters around the US weighted according to population density. The same dish size was assumed for both transmit and receive FS stations. For each FS station the azimuth pointing direction was uniformly distributed from 0 to 360 degrees and the elevation angle was distributed uniformly between 0 and 30 degrees.

This figure shows the number of P2P simultaneous transmitters that can be supported, without exceeding the aggregate interference criterion at the GEO satellite located at the specified longitude, as a function of the P2P transmitter and receiver dish diameter. It demonstrates the number of FS stations that can be deployed without exceeding the 6% ΔT/T aggregate interference criterion at the GEO satellite orbit locations spaced at 5 degrees between 0 to 180 degrees West Longitude. Each line corresponds to a satellite location. The line colors vary from red (less FS stations can be supported) to blue (where more FS stations can be supported). The legend, on the right and underneath, provides the corresponding satellite longitudes for the individual lines. The figure indicates that based on these assumptions, the satellite located at 145W supports the fewest amount of terminals (100,900 stations per 50 MHz) for the smallest FS dish size. We believe this is due to non-uniform population density. That is, since a great portion of the US population is on the east coast and the elevation angles from the east coast are low to GEO satellites far East and far West, many FS station boresights are in the direction of Eastern and Western satellites. GEO satellites which have high elevation angles to the US are able to support more FS stations.

The simulations were based on a specific set of worst case assumptions. If any of these assumptions were relaxed (such as increasing FS antenna size, decreasing FS station C/N requirements, and reducing maximum FS link distance), then more FS stations could be deployed without exceeding the aggregate interference criterion used in this analysis.



Legend

90	75	35	140
95	70	55	40
100	120	165	15
85	65	50	0
105	180	30	160
175	60	135	155
80	125	5	150
110	170	25	20
115	130	45	10
75	35	140	145

The legend indicates the nominal GEO satellite longitude (degrees West)

Figure 2.4. Number of P2P simultaneous transmitters supported as a function of the P2P transmitter and receiver dish diameter (ranging from 0.45 to 0.95 m)

2.3 P2P Antenna Off-Axis Angle Histogram

Figures 2.5, 2.6 and 2.7 show histograms of P2P antenna off-axis angles into each of three GEO satellite locations for FS stations deployed according to a non-uniform population density profile. These figures indicate that all of the off-axis angles toward the specific GEO satellite are greater than 5 degrees, and most

are greater than 60 degrees for of the three satellite locations as opposed to the worst case assumptions used by members of the FSS industry in their replies.

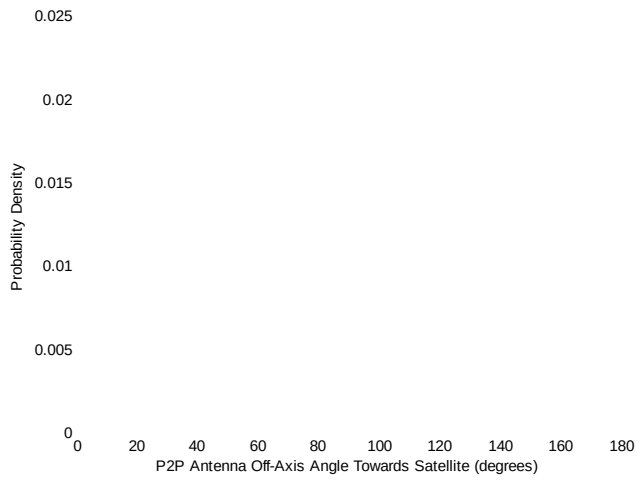


Figure 2.5. Distribution of FS Station Antenna Off-Axis angles towards the GEO satellite at 60W

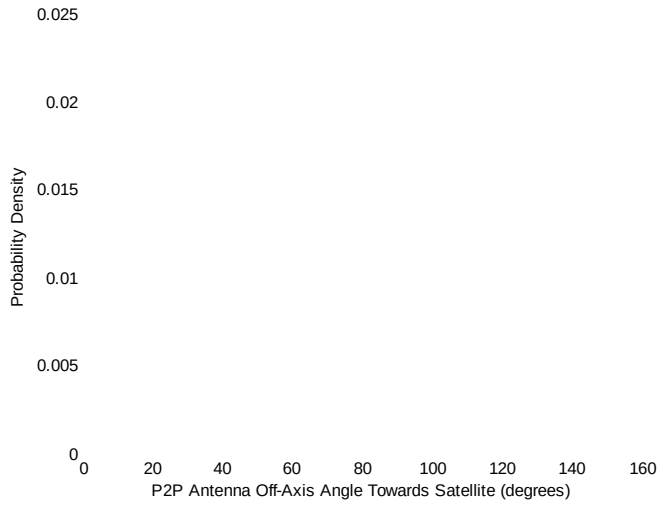


Figure 2.6. Distribution of FS Station Antenna Off-Axis angles towards the GEO satellite at 95W

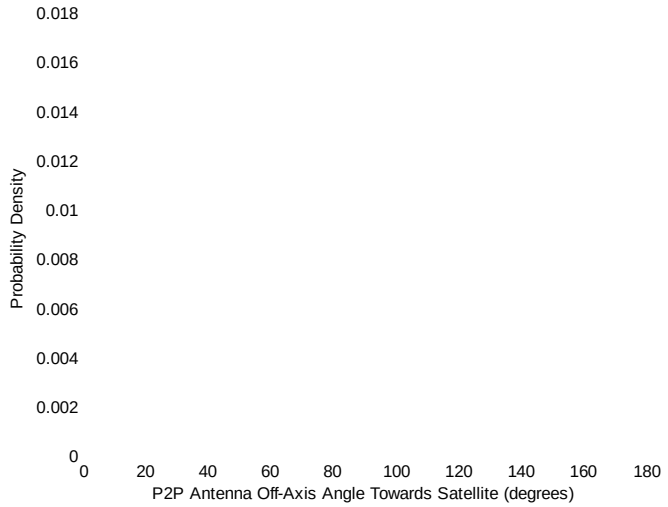


Figure 2.7. Distribution of FS Station Antenna Off-Axis angles towards the GEO satellite at 135W

2.4 Prediction of Differential Rain Attenuation

In all previous analyses we have assumed that although the terrestrial path is faded due to rain, the satellite path is unfaded. This is a worse case assumption and overestimates the interference potential of the FS faded link toward the satellite. The plot in Figure 2.8 was calculated based on the methodology described in reference paper below[57], and shows that there is a high degree of correlation between fading on terrestrial and satellite paths from the same FS station location. Assuming that the terrestrial FS path is operating in a 0.001% fade, we see that the predicted fades on the satellite path[58] are as shown in Figure 2.8. Thus, in high rain regions the rain fade on the satellite path will be significant (e.g. 30 dB in Miami) with very high probability when there is a 0.001% fade on the terrestrial path. The fade on the satellite path from the FS station provides significant additional protection to the satellite.

[57] Kanellopoulos and Livieratos, "A Modified Analysis for the Prediction of the Differential Rain Attenuation between a Satellite Path and an Adjacent Terrestrial Microwave System," IEEE Ninth International Conference on Antennas and Propagation, vol. 2, pp. 267-270, April 1995.
[58] Based on satellite path rain fade model ITU-R P.618-8.

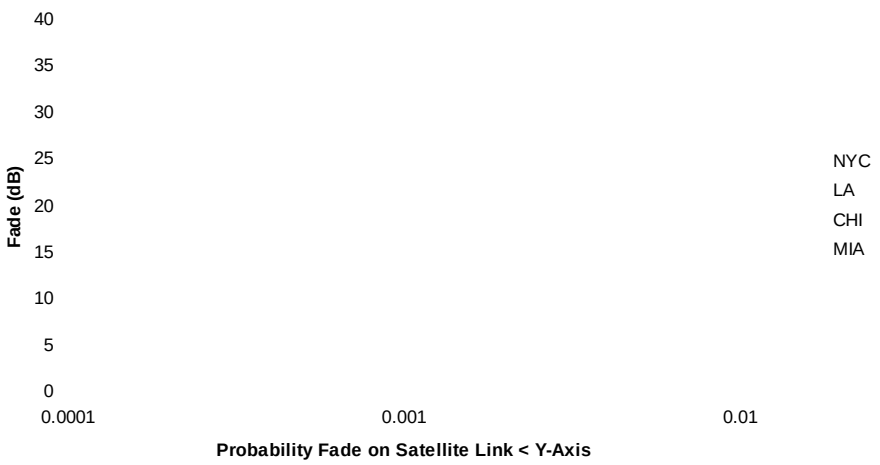


Figure 2.8. The probability (x-axis) that the fade on the satellite path is less than Y-axis, given a 0.001% fade on the terrestrial path

Section 3: CII Interference Mitigation

This section addresses the issue on "Interference to CII FS Links." Here we show how the interference to CII stations from primary and secondary satellite users in the 14.0-14.5 GHz can be mitigated. In the original RKF proposal, it was shown how narrowband interference from VSAT earth stations can be mitigated. Narrowband earth stations are the most widely deployed, and therefore, the most likely source of interference.

Several commenters[59] were concerned whether CII would receive unacceptable levels of interference from the FSS and MSS with wideband transmission. For instance, VSAT hub stations have a wider bandwidth than remote VSAT stations, and ESV, VMES (OmniTRACS), and AMSS stations employ spread-spectrum techniques over a wide bandwidth (using at most a satellite transponder (24 to 48 MHz)).

We agree that VSAT hub stations and the above MSS services (including AMSS) can have a wider bandwidth and that there can be continuous broadband services transmitted through some of the VSAT stations. In the proposal, we had mentioned that "to mitigate interference from MSS, FS receiver stations must be able to quickly adapt to a dynamically changing interference environment." In this report, we detail our proposed solution and address the issue of spread-spectrum techniques.

3.1 FS Interference Mitigation Technique

CII FS stations can mitigate interference from all the primary FSS and prior secondary MSS services by using Cognitive Radio in an OFDM-based system (such as 802.16 or WiMAX). As we discussed in Section 1.3, such technology has been proven viable by **Shared Spectrum Company**, and has been demonstrated in field test results to the military in a DARPA project. Shared Spectrum's Dynamic Spectrum Access (DSA), is a variant of Cognitive Radio technology. Each FS station can scan a 500 MHz band (14.0-14.5 GHz), or

[59] GVF/ESOA p. 18, HNS p .7, SES p. 11, ViaSat p. 6-7, QualComm p. ii, Boeing p. 8-10.

any fraction of that band, dynamically in real-time in a search for spectrum that is unused or that has an acceptable level of Interference-to-Noise ratio (I/N). It provides an efficient use of a licensed spectrum by secondary users without cooperation with the primary services, while avoiding any harmful interference to them. The DSA software is flexible and can accept parameters such as which type of interfering signals to avoid and thresholds on transmit power, along with any spectrum policies on operation in the band. It uses an energy detection scheme to detect the presence of interfering signals. In addition, the time it takes to detect an interfering signal and perform an appropriate action (such as cease transmission in that band and move to another channel) is at most 0.5 seconds.

Furthermore, small disruptions in CII service can be mitigated using approaches such as ARQ (Automatic Repeat reQuest), which retransmits data if it was not received. In this way, critical data can be transmitted in a dynamically changing interference environment with no lost data.

Using Dynamic Spectrum Access technology, CII FS stations can avoid transmitting in bands with high I/N. In cases where I/N is below a threshold, the CII FS station can share the spectrum by using strong Error Correction Coding schemes, Transmit Power Control, and/or Adaptive Coding and Modulation. Hence, what remains to prove is that there will be sufficient useable bandwidth for CII FS stations. This is shown by Monte Carlo simulations, where the various primary, and secondary satellite earth station transmitters and CII FS station receivers are placed randomly across CONUS (Continental US) according to a non-uniform population density profile (as used in the simulation of Section 2.2).

3.2 Overview of Simulation Methodology of Interference to FS Stations

Simulation is performed to determine the worst case interference impact of FSS and MSS earth stations on newly installed FS stations. Technologies such as Shared Spectrum's Dynamic Spectrum Access (DSA) searches for useable frequencies within a designated frequency band in a geographic area surrounding the FS station. As a consequence, this simulation also searches for useable frequencies at specified FS station locations . In order to determine the maximum interference level to FS stations, it is assumed that all 14 GHz GEO satellites are fully utilized. Thirty GEO satellites are assumed to utilize the full 500 MHz in both polarizations, resulting in 30,000 MHz total bandwidth. These satellites are spaced at 2 degrees over 60 degrees of GEO satellite arc. The simulation models the maximum number of simultaneously transmitting earth stations to the GEO satellites from locations throughout the US.

Because many of the fixed satellite services transmit with a limited duty cycle, the total number of earth stations potentially interfering with the FS stations may be higher than the number assumed in this simulation. However, technologies such as Shared Spectrum's DSA can adapt to an ever changing interference environment at an FS station. Thus, the instantaneous interference environment simulated for the FS stations will provide a bound on the worst case expected interference level into the new FS stations.

We simulate potential interference from four types of satellite uplink earth stations (VSAT, ESV, VMES and AMSS) to CII FS stations. We then calculate the amount of spectrum available in the 500 MHz Band (14.0-14.5 GHz) for each FS station at any given time. The results are shown in the Simulation Results section.

In each simulation ensemble iteration, FS links are placed randomly over CONUS according to a non-uniform population density profile. Next, at random (by population density), we choose a location on

CONUS (or Ocean for an ESV) and assign the earth station at that location to one of the four satellite services mentioned above. Depending on the bandwidth requirements of the chosen satellite service, a percentage of the total spectrum will be occupied by this service and assigned to that earth station. We repeat these steps until all the 30,000 MHz available (i.e. 30 satellites times 500MHz times 2 polarizations) to satellites in the band is occupied by the satellite services in the aggregate from various randomly located earth stations throughout CONUS. The satellite services are chosen such that at any given point in time, the following earth stations are operating:

- 750 VMES (e.g. OmniTRACS) earth stations using 3 transponders of any one satellite (250 earth stations share 48 MHz bandwidth of a single transponder through Direct Sequence and Frequency Hopping Spread Spectrum techniques)
- 333 ESV earth stations using one entire satellite transponder (assuming that each ESV earth station uses 3 MHz per transmission)
- 33 AMSS stations using one entire satellite transponder (assuming that each AMSS earth station uses 30 MHz per transmission)
- The remaining bandwidth (of the 30,000 MHz) is assigned to VSAT earth stations and VSAT hub stations (which are 10% of total VSAT stations)

Finally, for each FS station location, we calculate Interference-to-Noise ratio (I/N) in each 1 MHz of the 500 MHz spectrum from all the satellite services transmitting simultaneously. The calculation takes into account the location of each FS station receiver and satellite earth station transmitter, their distance from each other, their respective antenna gains and sidelobe attenuations, and the power transmitted by the satellite service earth station. In other words, I/N of the ith FS station in each 1 MHz sub-band is:

$$\text{I/N (for } i^{th} \text{ FS in 1 MHz)} = \sum_{j=1}^{\#\text{ of Interferers}} (P_j + G_{tx,j} + PL(\lambda, d) + G_{rx,i}) \quad ,$$

where

P_j (dBW/Hz): transmit power density of jth interferer
$G_{tx,j}$ (dBi): transmit antenna gain of jth interferer
$PL(\lambda, d)$ (dB): free space propagation path loss = $20\log_{10}(\lambda/(4\pi d))$
λ (carrier wavelength), d (distance between FS_i and $Interferer_j$)
$G_{rx,i}$ (dBi): receive antenna gain of ith FS station

In addition, the interferers are assumed to be blocked (by objects in the non line of sight propagation path such as buildings, trees, etc.) according to the following blockage rule:

If d > 1 km → 30% probability of blockage
If d > 5 km → 50% probability of blockage

Next, from the I/N values in each 1 MHz sub-band, the sub-band is marked as “Unavailable” or “Available” for use by the FS station, according to the following rule:

If I/N (over that 1 MHz) > 0 → Unavailable
Else → Available

In other words, when I/N ≤ 0 which translates to requiring at most 3 dB more transmit power at an FS station in order to operate**,** the FS station can also share the spectrum with the interferers through some of the techniques we discussed above (strong error correction technique, transmit power control, adaptive coding and modulation, ARQ).

The next two sections describe system characteristics of the CII FS stations and FSS and MSS stations as used in the simulation.

3.2.1 CII System Characteristics

Table 3.1 shows CII FS stations' system characteristics. The FS stations' receiver antenna patterns were modeled using ITU recommendation ITU-R F.1245-1[60].

Table 3.1. CII System Characteristics

Parameter	Units	Value
Altitude	km	0.03
Antenna Dish Diameter	m	0.45
Rx Antenna Elevation	degrees	Uniformly selected over [0,30]
Rx Antenna Azimuth	degrees	Uniformly selected over [0,360]
Rx Noise Power Density	dB/Hz	$-203.98 = 10*\log_{10}(kT)$ T: Noise Temperature (290K) k: Boltzmann's Constant (-228.6 dB/K/Hz)

3.2.2 Satellite Earth Station Assumptions and Uplink Characteristics

Table 3.2 describes system characteristics of FSS and MSS stations assumed in this simulation. As indicated in this table, we are using the maximum allowable transmit power density of primary FSS users for MSS users to simulate a worst case scenario.

Each satellite earth station points toward one of the 30 GEO satellites. These satellites are placed on the GEO arc with 2° spacing from 69W to 129W. Furthermore, the transmitter antenna patterns of these satellite earth stations are modeled using FCC Rule 25.209(a)(2)[61].

Table 3.2. Satellite Uplink Earth Stations System Characteristics

System Parameter	Unit	VSAT	ESV	AMSS	VMES
Minimum Altitude	km	0.005	0.007	9.3	0.002

[60] ITU-R F.1245-1:"Mathematical model of average and related radiation patterns for line-of-sight point-to-point radio-relay system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz."
[61] 47 CFR 25.209 (a)(2): Antenna Performance Standards.

Maximum Altitude	km	0.030	0.034	12	0.018
System Parameter	**Unit**	**VSAT**	**ESV**	**AMSS**	**VMES**
Bandwidth per station	MHz	3 8 (for VSAT-hub)	3	30	48
Antenna Dish Diameter	m	0.75[62]	1.2	0.38	0.254
Tx Power Density	dB/Hz	-50.02 (-14 dBW/kHz[63])	-50.02	-50.02	-76.81 (0 dBW/48 MHz[64])

3.3 Simulation Results

Figure 3.1 shows the simulated Cumulative Distribution Function (CDF) of the percentage available spectrum (out of 500 MHz) that is usable by FS stations in CONUS after taking into account the interference from primary and secondary satellite services. The CDF is the percentage of FS stations whose available bandwidth is less than or equal to the value on the x-axis.

The results indicate that with an extremely high probability, nearly all the 500 MHz Ku-Band spectrum will be available for CII deployments in any given location. In particular, at any given point in time, 50% of the FS stations can use 98.7% or more of the 500 MHz band at any location, 90% (or equivalently CDF = 10%) of the FS stations can use 94.8% or more of the 500 MHz band at any location, and 99.999% (CDF = 0.001%) of the FS stations can use 74.4% of the 500 MHz band at any location. Hence, these simulation results indicate that sufficient bandwidth is available within 14.0-14.5 GHz for use by a full deployment of CII FS stations.

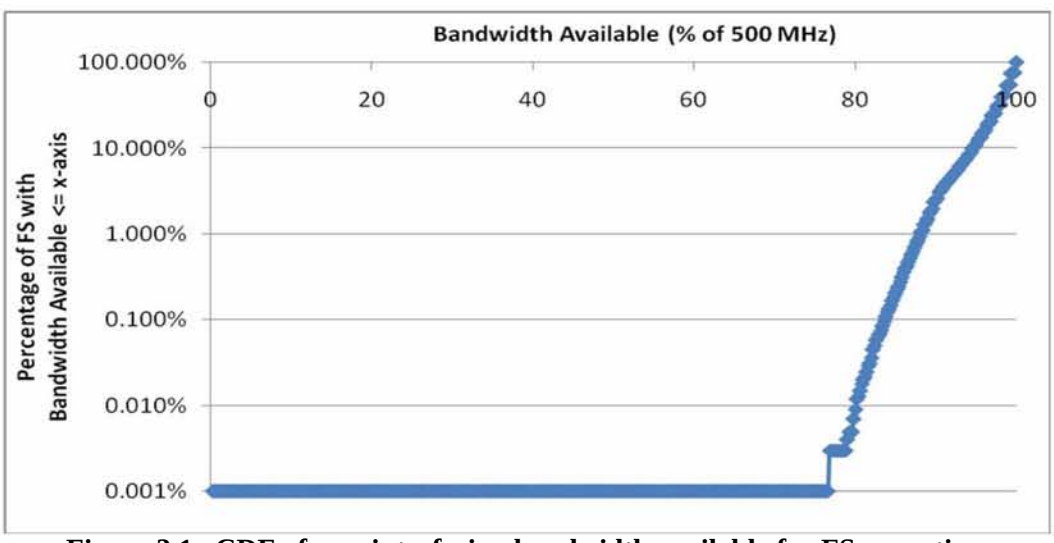


Figure 3.1. CDF of non-interfering bandwidth available for FS operations

[62] Note that antenna dish diameter of 0.75 m is not the routinely licensed VSAT earth station antenna size. Instead, 1.2 m is routinely authorized for Alsat operations. Here, we have chosen 0.75 m to simulate a worst case scenario.
[63] 47 CFR 25.134 (g)(1).
[64] F. P. Antonio, K. S. Gilhousen, I. M. Jacobs, and L. A. Jr. Weaver, "OmniTRACS: a commercial Ku-band mobile satellite terminal and its applicability to military mobile terminals," IEEE Military Communications Conference, vol. 3, pp. 761-764, Oct. 1988.

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CERTIFICATION OF PERSONS RESPONSIBLE FOR PREPARING THE ENGINEERING INFORMATION SUBMITTED IN THIS APPLICATION

I hereby certify that I am a technically qualified person responsible for the preparation of engineering information contained in this filing, that I am familiar with Part 2, 25 and 101 of the Commission's rules, that I have prepared or reviewed the engineering information submitted in these reply comments, and that it is complete and accurate to the best of my knowledge. I am a registered Professional Engineer. My seal is attached.

By: _____

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I hereby certify that I am a technically qualified person responsible for the preparation of engineering information contained in this filing, that I am familiar with Parts 2, 25 and 101 of the Commission's rules, that I have prepared or reviewed the engineering information submitted in these reply comments, and that it is complete and accurate to the best of my knowledge.

By: _____

Jeffrey Freedman, PhD
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RKF Engineering, LLC

I hereby certify that I am a technically qualified person responsible for the preparation of engineering information contained in this filing, that I am familiar with Part 2, 25 and 101 of the Commission's rules, that I have prepared or reviewed the engineering information submitted in these reply comments, and that it is complete and accurate to the best of my knowledge.

By: _____

Ted Kaplan
Chief Operating Officer
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August 11, 2008

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing Motion for Extension of Time was sent by first class mail, this 11th day of August, 2008, to each of the following:

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