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

In the Matter of	)	
	)	
Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands	)))	IB Docket No. 01-185

REPLY OF MOBILE SATELLITE VENTURES SUBSIDIARY LLC

Mobile Satellite Ventures Subsidiary LLC ("MSV") hereby responds to oppositions to its Petition for Partial Reconsideration and Clarification in the above-referenced matter that were filed by Inmarsat Ventures plc ("Inmarsat") and Aeronautical Radio Inc. ("Arinc"). Inmarsat's Opposition in particular is the latest in a series of attempts by Inmarsat to hinder MSV's ability to make more efficient use of spectrum and to offer better and more attractive services. As MSV demonstrated in its Petition, the Commission can modify and clarify its rules for operating an Ancillary Terrestrial Component ("ATC") in the L-band without adversely impacting other Mobile Satellite Service ("MSS") systems or their users. MSV's efforts are entirely consistent with the Commission's policy of improving spectrum efficiency and encouraging innovation, while protecting other spectrum users.[1]

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[1]*See Flexible Service Offerings in the Commercial Mobile Radio Services*, *First Report and Order*, 11 FCC Rcd 8965 (1996) (granting terrestrial CMRS carriers authority to provide fixed services in mobile service bands); *Amendment of Parts 2 and 25 of the Commission's Rules, First Report and Order*, 16 FCC Rcd 4096 (2000) (finding terrestrial facilities can operate in the 12.2-12.7 GHz band without causing harmful interference to incumbent Direct Broadcast Satellite (DBS) operations); *Amendment of Part 2 of the Commission's Rules, First Report and Order*, 16 FCC Rcd 17222 (2001) (adding a mobile allocation to the wireless cable frequency band (2500-2690 MHz band)); *XM Radio, Inc., Order and Authorization*, 16 FCC Rcd 16781 (Int'l Bur. 2001) (granting temporary authority to satellite radio licensee to use terrestrial repeaters to supplement satellite coverage in urban areas).

One of the major findings of the Commission's Spectrum Policy Task Force ("SPTF") is that "Advances in technology create the potential for systems to use spectrum more intensively and to be much more tolerant of interference than in the past." *Spectrum Policy Task Force*

Background

In February 2003, the Commission authorized MSS licensees to integrate ATC into their MSS systems.[2] MSV filed a Petition for Partial Reconsideration and Clarification of this decision asking the Commission to allow L-band MSS operators further flexibility to reuse their spectrum and to deploy base stations.[3] In particular, MSV proposed that it be permitted to operate ATC facilities that reuse spectrum that is co-channel with Inmarsat up to 14,785 times system-wide[4] and that it have additional flexibility with regard to its base station power levels, antennas, and siting. Inmarsat filed an opposition to MSV's Petition, objecting to every one of

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Report, ET Docket No. 02-135 (Nov. 1, 2002), at § 2. The SPTF concluded that "to increase opportunities for technologically innovative and economically efficient spectrum use, spectrum policy must evolve towards more flexible and market-oriented regulatory models." *Id*.

[2]*See Flexibility for Delivery of Communications by Mobile Satellite Service Providers*, *Report and Order*, 18 FCC Rcd 1962, FCC 03-15, IB Docket No. 01-185 (February 10, 2003) ("*ATC Order*"), amended by *Errata* (March 7, 2003).

[3]*See* MSV, Petition for Partial Reconsideration and Clarification, IB Docket No. 01-185 (July 7, 2003) ("*MSV Petition*").

[4]As discussed in Section 1.1 of the attached Technical Appendix, MSV has requested a system-wide co-channel frequency reuse factor of 14,785 by the ATC in the L-band. In the *ATC Order*, the Commission adopted Section 25.253(c) of its rules which specifies a U.S.-only co-channel reuse factor that is equal to one-half of the authorized system-wide reuse factor. To avoid any confusion, MSV hereby clarifies Appendix E of its *Petition* by specifying that the Commission should revise Section 25.253(c) of the rules in the following manner:

> "The maximum number of base stations operating in the U.S. on any one 200 kHz channel shall not exceed ~~{1725}~~**7,392**. During the first 18 months following activation for testing of the first ATC base station, the L-band ATC operator shall not implement more than ~~{863}~~**3,696** base stations on the same 200 kHz channel. . . ."

MSV does not oppose the Commission's requirement that L-band ATC operators implement only 50% of their authorized co-channel reuse during the 18-month period following testing of the first ATC base station. The Commission should amend this requirement, however, to reflect 50% of the total co-channel reuse the Commission decides to permit.

MSV's requests for relaxation of the technical restrictions on L-band ATC.[5] Arinc also filed brief comments asking the Commission to deny MSV's Petition.[6]

I. THE COMMISSION SHOULD PERMIT MORE REUSE OF L-BAND SPECTRUM

MSV's Petition proposes several changes in the Commission's interference analysis. The first request is to de-link the assessment of MSV's *intra*system interference from any limit on *inter*system interference and not restrict MSV to an unnecessarily low level of intrasystem interference. The second request is to adjust the allowable level of potential interference to Inmarsat to no more than 0.17 dB loss of link margin, which is still a very low level. The third request is to recalculate the factor for half-rate vocoder use, to more accurately represent its effect. The fourth request is to clarify that MSV can operate a higher percentage of its ATC facilities in the United States than the fifty percent assumed in the Commission's analysis.

A. Additional Reuse Will Not Cause Unacceptable Interference to MSV's Own System

Inmarsat argues that MSV's proposals for more flexibility will result in MSV "cannibalizing" its satellite spectrum for the sake of deploying a predominantly terrestrial system. *Inmarsat Opposition* at 11-14, Annex § 2.2. Inmarsat's concerns are baseless for two primary reasons. The first reason is that MSV's next generation satellites will be built with at least 10 dB of link margin, which is more than sufficient to overcome the 2.4 dB rise in MSV's noise floor claimed by Inmarsat. *MSV Petition* at 10-11.[7] The second and key reason is that,

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[5] *See* Opposition of Inmarsat, IB Docket No. 01-185 (August 20, 2003) ("*Inmarsat Opposition*").

[6] *See* Comments of Arinc, IB Docket No. 01-185 (August 20, 2003) ("*Arinc Comments*").

[7] As MSV explained in its Opposition to Inmarsat's Petition, even if a peak antenna gain of 42.5 dBi is assumed for MSV's next-generation satellite in the Commission's self-interference analysis, MSV would experience a 2.4 dB rise in its noise floor, which is still acceptable to MSV

notwithstanding MSV's ability to accommodate even a 2.4 dB rise in its noise floor by expending link margin, MSV will use well-established signal processing (interference cancellation) techniques to mitigate interference effects from its ATC operations so that no more than a fraction of a dB of link margin will have to be expended to accommodate the effect of the larger ATC. The interference cancellation techniques that MSV will implement in its satellite receivers are described further in Sections 1.2 and 1.3 of the attached Technical Appendix. Given MSV's commercial incentive to provide high quality service and its ability to effectively manage its own ATC-induced interference, there is no need for the Commission to restrict MSV's terrestrial reuse in order to protect MSV.[8]

Inmarsat also argues that it is appropriate for the Commission to impose a self-interference cap on ATC in the L-band, despite not having imposed a self-interference cap on MSS licensees in other bands or, to MSV's knowledge, on any other Commission licensee, because of what Inmarsat says are unique intersystem interference concerns presented in the L-band. *Inmarsat Opposition* at 14. While this argument may be relevant to issues of *inter*system interference for those frequencies that MSV and Inmarsat share co-channel, it makes no sense as applied to *intra*system interference, since intrasystem and intersystem interference are largely independent of each other. Moreover, Inmarsat's argument breaks down completely for the vast majority of the L-band spectrum that MSV uses, which is not visible co-channel to any Inmarsat satellite operating within the radio horizon (*i.e.*, on the same side of the Earth).

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given its 10 dB of link margin. MSV, Opposition to Petitions for Reconsideration, IB Docket No. 01-185 (August 20, 2003) ("*MSV Opposition*"), at 7-8.

[8]Inmarsat claims that MSV "promised" to limit self-interference to 6% ΔT/T. *Inmarsat Opposition* at 11-12. What Inmarsat considers to be a commitment was only an illustrative, baseline proposal, which MSV accurately described as limiting self-interference to 6% ΔT/T. To be sure, MSV continues to have a design goal of limiting self-interference to approximately 6% ΔT/T and is comfortable that it will be able to meet that goal with the use of various interference mitigation techniques, without compromising its other goals for maximizing spectrum efficiency.

B. MSV Should Be Permitted to Operate ATC Facilities That Will Produce No More than a Six Percent Increase in the Noise Floor of Inmarsat Satellite Receivers

Inmarsat continues to claim, without support, that it cannot tolerate ATC operations that cause up to the 6% increase in its noise floor that MSV has proposed as an acceptable limit. *Inmarsat Opposition* at 9-11, Annex § 2.2. Inmarsat does not dispute that this level of intersystem interference on co-channel frequencies results in only 0.17 dB loss in Inmarsat's link margin. *MSV Petition*, Appendix A.[9] Inmarsat should be able to accommodate this impact in the 1 dB it claims to allocate for all intersystem interference sources. *Inmarsat Opposition*, Annex § 2.2. Moreover, it bears emphasizing again that this impact on link margin only applies to those relatively few frequencies that MSV and Inmarsat share co-channel. The benefits of allowing MSV to increase reuse of L-band spectrum far outweigh the costs of the miniscule 0.17 dB reduction in Inmarsat's link margin. Allowing MSV to increase reuse as it requested in its Petition will allow MSV to dramatically increase efficient use of L-band spectrum and provide a more integrated and valuable service to the public.

C. Use of a Half-Rate Vocoder Will Reduce Potential Interference by at least 3.5 dB, Independent of Power Control

Inmarsat argues without any substantiation that MSV's analysis demonstrating that an interference reduction factor of 3.5 dB applies to half-rate vocoders improperly "double counts" by somehow including the interference reduction due to power control. *Inmarsat Opposition* at 13, Annex § 3. As discussed in Section 2 of the attached Technical Appendix, however, the 3.5 dB reduction is attributed solely to the use of a half-rate vocoder.

[9] Inmarsat claims that MSV committed to protecting Inmarsat to a level of 1% $\Delta T/T$. *Inmarsat Opposition* at 5. In fact, MSV only demonstrated based on one illustrative system design that it could limit intersystem interference to this level. This illustrative design was proposed before MSV fully developed its self-interference mitigation techniques that allow MSV to dramatically increase terrestrial reuse while limiting self-interference to an acceptable level. The Commission's rules should be able to accommodate this type of technological advancement.

D. The Apportionment of ATC Inside and Outside of the United States Has No Impact on Intersystem Interference

Inmarsat argues that the Commission should rigidly limit one-half of permitted ATC operations to the United States. *Inmarsat Opposition* at 6-8. Inmarsat's argument, however, does nothing to refute the fundamental technical point that ATC operations will have the same impact on Inmarsat regardless of whether the base stations are in the United States or elsewhere in North America. Inmarsat's only technical claim has to do with the potential for increased *intrasystem* interference. *Inmarsat Opposition* at 7, Annex § 2.1. As discussed above, however, MSV will use interference cancellation techniques to maintain reasonable intrasystem interference levels.

Inmarsat also argues that the Commission cannot enforce an allocation of 80 percent of ATC operations to United States operations. *Inmarsat Opposition* at 7-8, Annex § 2.1. In fact, the allocation is easily enforced. MSV reasonably expects to know and have control of any ATC operations on the frequencies it uses and will be able to account for operations on those frequencies both in the United States and outside the United States. To ensure that MSV does not exceed the system-wide reuse allowance, the Commission need only condition MSV's ATC license on MSV not exceeding this allowance.[10]

[10]Inmarsat claims that MSV is ignoring the possibility that ATC might be offered outside of the United States. *Inmarsat Opposition*, Annex § 2.1. This is inaccurate. As MSV stated in its Petition, it expects that no more than 80% of ATC operations on a given frequency will be within the United States and the other 20% will be outside of the United States, resulting in a U.S.-wide co-channel reuse factor of 2760 (*i.e.*, 3450 × 80%). *MSV Petition* at 6. Whatever the actual deployment, MSV is prepared to accept the need for an overall limit on ATC operations on frequencies that are co-channel with visible Inmarsat satellites.

II. THE COMMISSION SHOULD PROVIDE ADDITIONAL FLEXIBILITY TO ATC OPERATIONS IN THE DOWNLINK DIRECTION

A. MSV Should Be Permitted to Protect Inmarsat Land-Mobile and Maritime METs to an Overload Threshold of -45 dBm

MSV has conducted extensive testing of Inmarsat land-mobile and maritime METs showing that the 1 dB compression point of the most sensitive of these terminals is -43 dBm. *MSV Petition*, Appendix C. Inmarsat does nothing to show that MSV's tests are inaccurate. Rather, Inmarsat now argues that the 1 dB compression point is not the only relevant parameter for assessing overload. *Inmarsat Opposition*, Annex § 4. In making its argument, Inmarsat ignores that the Commission in the *ATC Order* relied on the Arinc overload specification for airborne METs[11] which also uses the 1 dB compression point as the measure for determining the overload threshold of a mobile terminal. *ATC Order* ¶ 151, Appendix C2 § 1.12.

Inmarsat claims that MSV's testing is incomplete because MSV did not test the entire receiver chain of an Inmarsat MET. *Inmarsat Opposition*, Annex § 4. In fact, MSV previously submitted to the Commission the results from testing the entire receiver chain of Inmarsat METs.[12] These tests entailed subjectively determining the onset of degradation in the received speech of an Inmarsat MET as a function of interfering signal level. Both this subjective testing and the objective testing of the 1 dB compression point concluded that the worst-case overload threshold for an Inmarsat MET can be set conservatively at -45 dBm.

Inmarsat also contends that the testing MSV conducted is incomplete because MSV did not test a new kind of Inmarsat terminal, which Inmarsat claims is the most susceptible to overload of all of its terminals. *Inmarsat Opposition*, Annex § 4. MSV previously demonstrated that Inmarsat's claims regarding the sensitivity of these new terminals are inaccurate. *MSV*

[11] Arinc Characteristic 741, Part 1-9 (November 1997) at ¶ 2.2.4.2 and ¶ 2.2.4.5.

[12] *See* Reply Comments of MSV, IB Docket No. 01-185 (November 13, 2001), Technical Appendix 12-15.

Opposition, Appendix B. Inmarsat now adds that the new terminals are necessarily more sensitive to overload because of their wide receive-filter bandwidth. *Inmarsat Opposition*, Annex § 4. As discussed in Section 3 of the attached Technical Appendix, a wide receive-filter bandwidth, however, does not necessitate a high susceptibility to overload. There is no reason why the new terminals cannot be manufactured to meet at least the worst case overload threshold for other Inmarsat METs, which MSV has demonstrated to be -45 dBm.

By using a conservative overload threshold of -45 dBm in its overload analysis, the Commission can authorize the power per sector of at least some L-band base stations to increase,[13] resulting in an expanded base station service area and thus facilitating the deployment of base stations in areas where base station sites are scarce.

B. MSV Can Reduce Base Station Overhead Gain Suppression Without Any Increase in Interference

MSV has demonstrated that an eight to ten dB reduction (depending upon the elevation angle) in the required overhead gain suppression of L-band ATC base stations will make base station deployment substantially less expensive and cause no more than a 0.03 dB increase in potential interference. *MSV Petition* at 19-20, Appendix C.[14] Inmarsat does not challenge MSV's analysis. The only objection Inmarsat raises is the essentially irrelevant one that MSV's proposal is not consistent with the antenna pattern MSV proposed to the Commission two years ago. *Inmarsat Opposition* at 17-18, Annex § 5.[15]

[13]The aggregate EIRP from all L-band base stations within a 50-mile radius will be capped to avoid overload of airborne Inmarsat METs. *MSV Petition* at 18-19.

[14]Section 4 of the attached Technical Appendix contains a mathematical analysis supplementing this demonstration.

[15]MSV's initial proposal relied on statements by CSS Antenna, Inc. *See* Reply Comments of MSV, IB Docket No. 01-185, Statement of CSS Antenna, Inc. (November 13, 2001). Those statements were made before the Commission required L-band ATC base stations to use left-hand circular polarization ("LHCP").

C. Inmarsat Has Failed to Justify the Need for Both a PFD and a Separation Distance Restriction on Base Stations near Airports

Inmarsat argues that it is necessary to impose both a separation distance and a PFD restriction on L-band base stations located near airports to protect Inmarsat METs located in or around airports, largely because (according to Inmarsat) MSV may not comply with the PFD restriction. *Inmarsat Opposition* at 18-19, Annex § 6.[16] Here again, Inmarsat has no basis for its alleged concern. MSV will perform the necessary calculations to ensure that its base stations operate without exceeding the PFD level specified in the rules.[17] This is precisely how other licensees comply with similar technical rules. Moreover, MSV is willing to provide an appropriate showing in cases where it operates closer than 470 meters from an airport.

For a base station located greater than 470 meters from an airport runway, Inmarsat argues that an L-band ATC operator must still calculate the PFD level because "distance alone" will not guarantee that the L-band base station will avoid interfering with Inmarsat METs. *Inmarsat Opposition* at 19. The Commission has reasonably concluded the opposite. Using a worst case, free space propagation model, the Commission calculated that 470 meters is the maximum separation distance needed between an ATC base station and an Inmarsat MET to avoid overload interference. *See ATC Order*, Appendix C2 § 2.2.1.3. The Commission has effectively established a safe harbor zone with a radius of 470 meters surrounding airport runways beyond which an ATC operator should not be mandated to calculate the PFD level. Under these circumstances, no further showing should be required.

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[16] Arinc argues that there is no need to locate base stations near airports because MSV's satellite will be in view. *Arinc Comments* at 1. It is obvious that MSV would not ask to place base stations within 470 meters of airports if there was not a need for this type of flexibility.

[17] In its Petition, MSV asked the Commission to amend its rules to specify a PFD level for L-band base stations of -58 $dBW/m^2/200$ kHz at the edge of runways. *MSV Petition* at 19.

III. THE COMMISSION SHOULD ALLOW L-BAND ATC OPERATORS TO APPLY FOR NON-FORWARD-BAND ATC SYSTEMS

In its Petition, MSV asked the Commission to clarify that non-forward-band ATC is permitted in the L-band provided an applicant demonstrates that this system architecture will produce no greater potential interference than that allowed by implementing the forward-band system architecture contemplated by the Commission's rules. *MSV Petition* at 23. Inmarsat characterizes this proposal as "extreme" and argues that non-forward-band ATC will result in "catastrophic" interference. *Inmarsat Opposition* at 19-21, Annex § 7. Inmarsat's rhetoric notwithstanding, MSV reiterates that it is simply asking the Commission to clarify that a non-forward-band ATC system is not flatly prohibited and that an applicant will have the opportunity to seek approval for such a system by demonstrating that no greater potential interference will be caused than that contemplated by the rules. The interference concerns Inmarsat raises are premature and can be adequately addressed in reviewing a specific application for a non-forward-band ATC system.

Conclusion

MSV requests that the Commission act consistently with the views expressed herein.

Very truly yours,

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TECHNICAL APPENDIX

1. THE INTER- AND INTRA-SYSTEM IMPACT OF A LARGER ATC.

1.1 The Size of the ATC.

Inmarsat has misunderstood MSV's request for an increase in co-channel frequency reuse by the ATC. Inmarsat states that MSV is requesting "up to 17 times increase in the limit for co-frequency ATC base station transmissions." *Inmarsat Opposition*, Annex § 2. This is not true. The Commission authorized 1,725-fold co-channel frequency reuse by a US-wide ATC and concluded that such an ATC would impact Inmarsat-4 satellite receivers by no more than 0.7% ΔT/T. In addition, the Commission allowed for an equal amount of ATC reuse outside of the United States and concluded that this additional frequency reuse by a non-US ATC would, at most, impact Inmarsat-4 satellite receivers by an additional 0.7% ΔT/T, for a total of 1.4%. *ATC Order*, Appendix C2 § 2.1.1. MSV is asking the Commission for a reasonable ATC growth that conforms to the internationally-accepted (ITU-sanctioned) 6% ΔT/T noise impact. The total increase in co-channel terrestrial frequency reuse that MSV is requesting (inclusive of its US-wide and non-US-wide ATC) is clear from the following expression:

$$\textbf{(X reuse/6\%) = (1,725 reuse/0.7\%)} \rightarrow \textbf{X = 14,785 reuse}$$

or, equivalently, from

$$\textbf{(X reuse/6\%) = (3,450 reuse/1.4\%)} \rightarrow \textbf{X = 14,785 reuse}$$

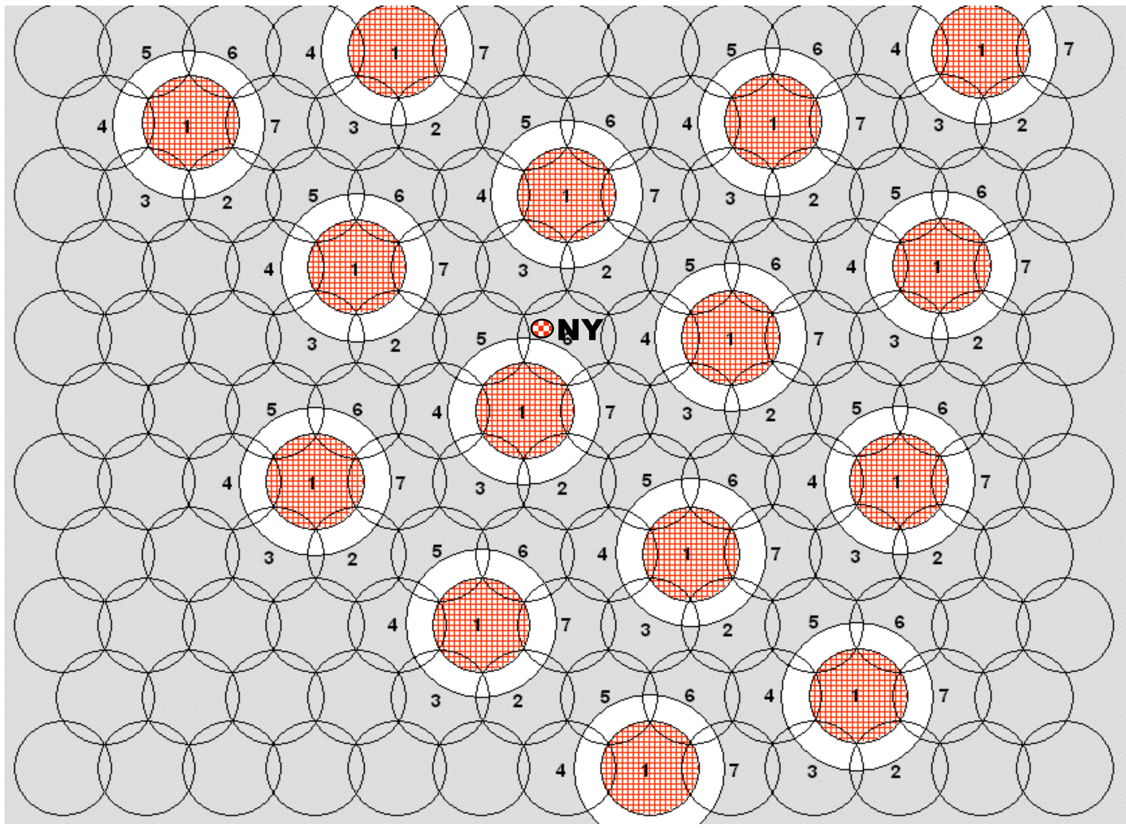
It is seen from the above that the total increase in ATC co-channel frequency reuse that MSV is requesting is **(14,785/3,450) ≈ 4.3** not 17-fold as Inmarsat claims.

1.2 The Intra-System Impact of a Larger ATC.

Inmarsat expresses concern that allowing MSV to increase co-channel frequency reuse will impact MSV's satellite system by more than 6% ΔT/T. *Inmarsat Opposition*, Annex § 2.2. Such concerns are unfounded. MSV has developed a satellite receiver processor capable of maintaining the ATC's intra-system impact to 6% ΔT/T, or less, even as the ATC doubles or quadruples in size beyond the level that the Commission has currently authorized. The following paragraphs explain the operation of this receiver processor and provide results illustrating its performance.

In reference to Figure 1, an illustrative seven cell frequency reuse pattern is shown that enables the space segment to use and reuse the frequencies that are available to the system over the geographic areas defined by the multitude of satellite cells. Figure 1 also illustrates the location of an ATC. This ATC, labeled as "NY" for New York ATC, is outside of satellite cell 1 and its exclusion region, and may thus reuse all the frequencies of satellite cell 1. Similarly, the NY ATC can reuse all frequencies that are used by satellite cells 2, 4 and 7.

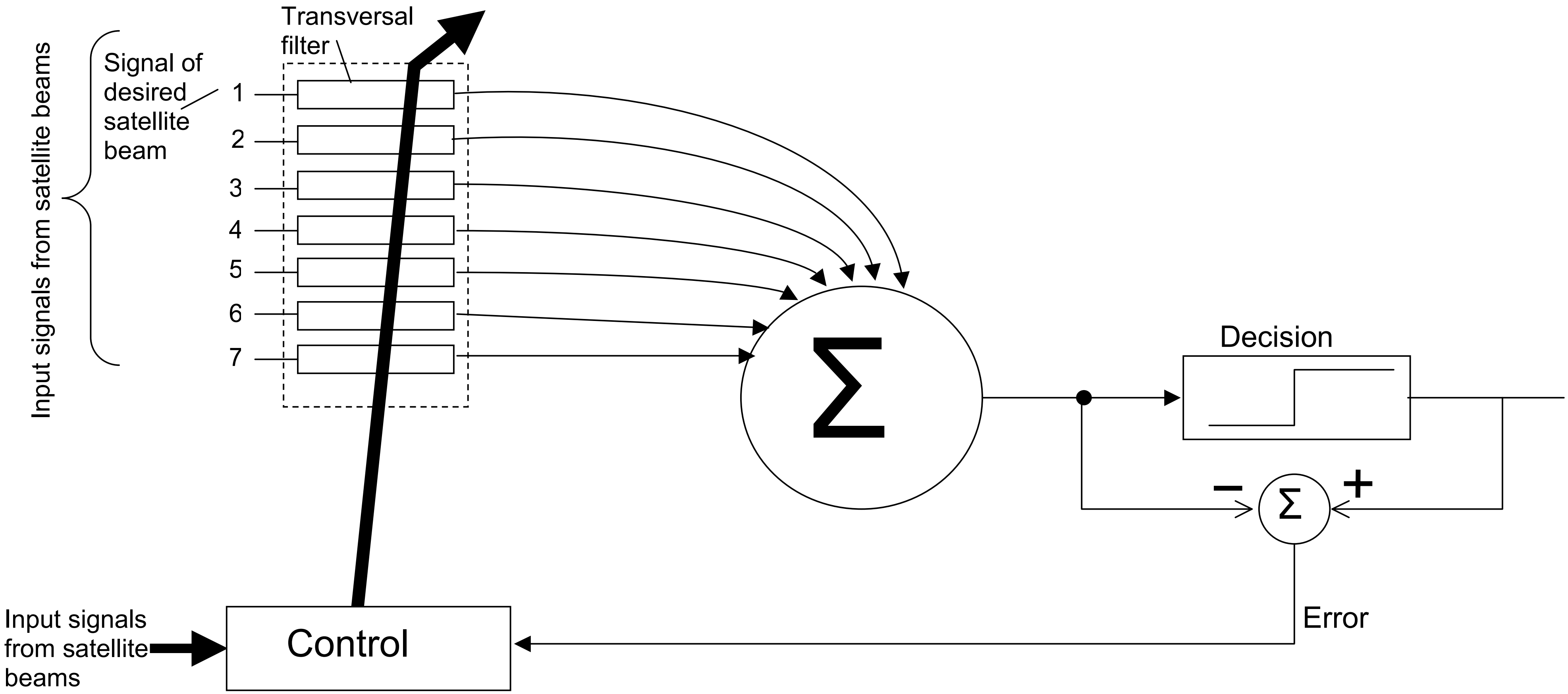
Figure 1: Illustrative Frequency Reuse between Space Segment and ATC



As the Commission concluded in the *ATC Order*, if the antenna discrimination of satellite cells 1, 2, 4, and 7 is at least 10 dB over the geographic area spanned by the ATC, and the co-channel reuse of the ATC is limited to 173-fold, then the $\Delta T/T$ impact to the co-channel receivers of satellite cells 1, 2, 4, and 7 will be limited to 6%. Does self-interference increase if at least one of the above two criteria is violated? The answer is no, provided the satellite receivers of satellite cells 1, 2, 4, and 7 are equipped with adaptive interference cancellation signal processing means.

The principles of interference cancellation are certainly not new; they have been known for decades and have been applied to numerous commercial and military wireless communications systems. Figure 2 illustrates key elements of the receiver architecture of an interference canceller. The receiver shown is configured for canceling the ATC-induced interference on a co-channel receiver of satellite cell 1 (*see* Figure 1). In accordance with the block diagram of Figure 2, the signals that are intercepted by the "desired" satellite cell (cell 1) and by the neighboring satellite cells, over the frequency span of the desired signal, are transported to the satellite gateway where they are linearly combined via fractionally-spaced transversal filters to form an optimum decision variable in accordance with a Least Squared-Error criterion.

Figure 2: Illustrative Interference Canceller Architecture



1.3 Numerical Results.

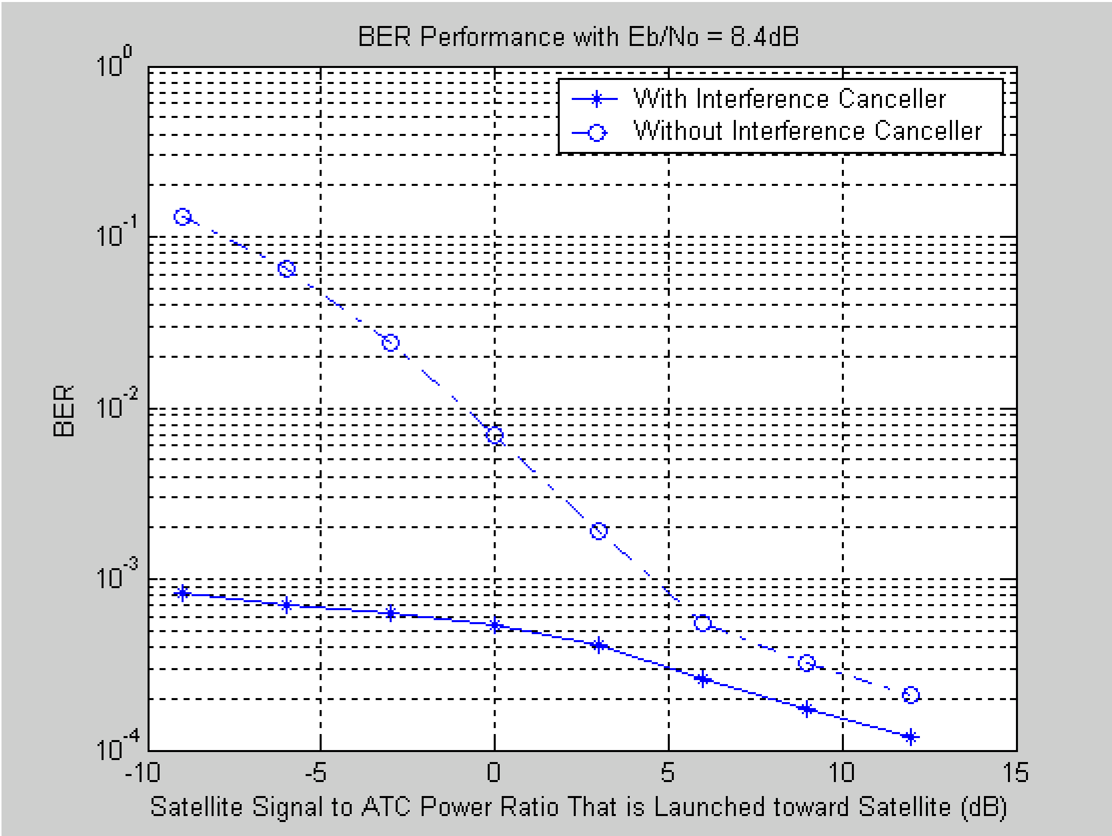
The performance of a satellite receiver equipped with the interference canceller of Figure 2 has been evaluated by Monte Carlo computer simulation. The Bit Error-Rate (BER) curves presented below summarize the results. For simplicity and without loss of generality, the computer simulation modeled the desired satellite signal as uncoded BPSK, and placed the desired satellite terminal at the center of the desired satellite beam (cell 1). The interference signal of the NY ATC was modeled as zero mean Gaussian-distributed to reflect the relatively large number of co-channel emissions of an ATC. In the curves below the satellite receiver BER is plotted (for a fixed $E_b/N_0 = 8.4$ dB) as a function of the ratio of desire signal to aggregate ATC signal power that is launched towards the satellite after all ATC-related signal attenuating factors, such as that due to power control, have been accounted for.

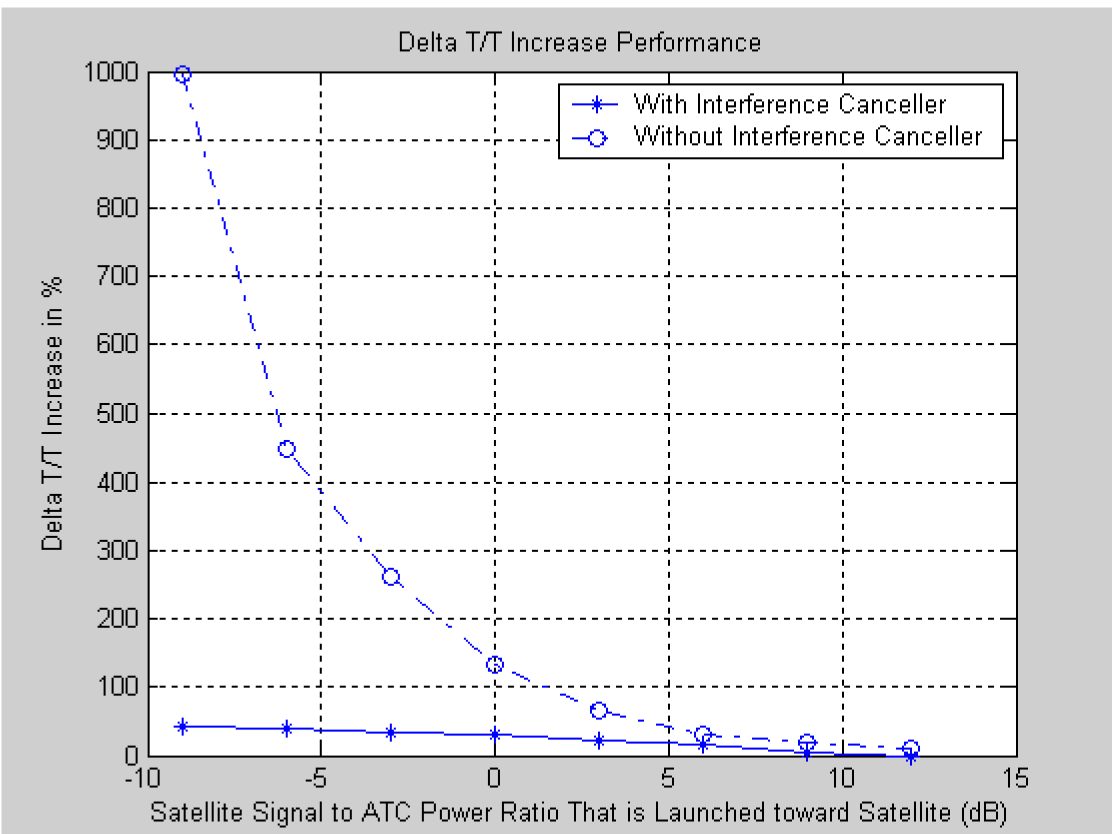
In the computer simulation, the contours of Figure 1, denoting the "3 dB down" level of the satellite cells, are assigned a normalized diameter of 1. The center of the NY ATC is placed at 0.75 units away from the center of satellite cell 1. As already stated, satellite cell 1 contains the desired satellite terminal at its center. The desired satellite terminal signal level is calibrated so that in the absence of the NY ATC the satellite receiver is operating at an E_b/N_0 of 8.4 dB, producing a BER of 1×10^{-4} (theoretical performance for uncoded BPSK). In accordance with the Commission's analysis, a 173-fold co-channel reuse by the ATC in the vicinity of a co-channel satellite cell is the maximum allowed to maintain the intra-system interference impact to no more than 6% ΔT/T. MSV's computer simulation results demonstrate that the satellite receiver that is equipped with interference cancellation allows the local 173-fold reuse of the ATC (in the vicinity of a co-channel satellite cell) to grow by approximately a factor of four without impacting a neighboring co-channel satellite cell by more than 6% ΔT/T.

The plots of "ΔT/T Increase Performance" that are shown below have been generated using the relationship

$$\Delta T/T\% = 100[10^{\{(8.4 - X)/10\}} - 1]$$

in which X denotes the "equivalent" E_b/N_0 receiver operating point as estimated by the computer simulation (the computer simulation first derives the BER of the receiver and then, using the ideal uncoded BPSK curve, maps the derived BER to an equivalent E_b/N_0 value).


BER Performance with Eb/No = 8.4dB
With Interference Canceller
Without Interference Canceller
BER
Satellite Signal to ATC Power Ratio That is Launched toward Satellite (dB)


Delta T/T Increase Performance
With Interference Canceller
Without Interference Canceller
Delta T/T Increase in %
Satellite Signal to ATC Power Ratio That is Launched toward Satellite (dB)

2. THE HALF-RATE VOCODER

Inmarsat has misunderstood MSV's demonstration that an interference reduction factor of 3.5 dB applies to half-rate vocoders. *MSV Petition*, Appendix B. Contrary to Inmarsat's assertion MSV does not invoke any power control argument in conjunction with the use of a half-rate vocoder. Power control and the use of a specific vocoder are independent of each other. MSV's demonstration is very simple: The return-link interference potential depends on the peak (maximum) EIRP of the ATC terminal as is clearly seen from Table 2.1.1.C of the *ATC Order*, Appendix C2 (third row). As this parameter changes, so does the interference potential (dB for dB). The use of a half-rate vocoder and a half-rate channel over the upper-most 3.5 dB range of a terminal's EIRP **effectively** changes this parameter. The constraint of having to use a half-rate vocoder and a half-rate channel every time the Power Amplifier (PA) output of a terminal exceeds -3.5 dBW, limits the **effective** peak EIRP of the terminal to -3.5 dBW. This is true because even though the terminal's PA can still deliver more than -3.5 dBW (up to 0 dBW) when operating in half-rate mode, it does so every other frame. The relevant question for the interference analysis is not what percentage of terminals at any given time are using the half-rate vocoder and the half-rate channel, but rather what is the **effective** peak EIRP of the ATC terminals. In accordance with the half-rate vocoder constraint, the **effective** peak terminal EIRP is limited to -3.5 dBW. That is, subject to the half-rate vocoder and half-rate channel constraint the terminal becomes **equivalent** to one that is always operating with a full-rate vocoder and a full-rate channel but with a PA output that is limited to -3.5 dBW.

When a terminal that is using a full-rate vocoder and a full-rate channel is commanded to switch-over to a half-rate vocoder and a half-rate channel, that terminal will, from an **equivalent** maximum EIRP standpoint (which is what is relevant to the interference analysis) reduce its level by 3.5 dB. The first 3 dB comes from the fact that a terminal in half-rate mode transmits half as often as a terminal in full-rate mode (the terminal stays silent every other frame because transmission on every other frame suffices to transport the reduced information rate of the half-rate vocoder). The remaining 0.5 dB comes from the fact that the information rate of GSM's half-rate vocoder is 4.75 kbps whereas the information rate of the full-rate GSM vocoder is approximately 13 kbps. The less-than-half rate of the half-rate vocoder (relative to the rate of the full-rate vocoder) allows for more than one dB of additional power reduction ($10\log\{6.5/4.75\} \approx 1.36$ dB). We have conservatively assumed only 0.5 dB. This additional (1.36 dB) power reduction, over-and-above all other interference reduction benefits accounted by the Commission, will not be used to extend the range of an ATC cell since the ATC cell radius is also determined (and will thus be constrained) by the base station's emissions which will always be at full rate. Furthermore, for a terminal that is operating within a cluster of ATC base stations (as will typically be the case in an urban environment) extending the range of a base station is meaningless since a next (adjacent) base station is there to pick-up the load.[1]

[1] At the edges of an ATC coverage area, MSV has already explained how the ATC will not serve terminals that are beyond the engineered (18 dB in-building penetration margin) service footprint of the ATC. *MSV Opposition* at 4-5 and Appendix A.

3. THE OVERLOAD THRESHOLD OF INMARSAT MOBILE EARTH TERMINALS ("METS")

MSV has demonstrated previously that the Commission adopted an unreasonably conservative overload threshold of -60 dBm for Inmarsat land-mobile and maritime METs. *MSV Petition*, Appendix C. MSV has procured and tested a total of nine Inmarsat land-mobile and maritime METs including the models used by the US Coast Guard and the most popular land-mobile models made by NERA and Thrane & Thrane. *MSV Petition*, Appendix C; *MSV ATC Reply Comments*, IB Docket No. 01-185 (November 13, 2001), Technical Appendix 12-15. None of these METs has demonstrated an overload threshold of less than -45 dBm. In response, Inmarsat continues to critique MSV's testing and claims that its METs are far more susceptible to overload. As MSV has explained in response, Inmarsat has failed to demonstrate that its METs overload at a level less than -45 dBm. *MSV Opposition*, Appendix B. In the unlikely event that there are some low volume Inmarsat MET models that do overload at a level less than -45 dBm, these METs are clearly not being manufactured consistent with best industry practices as demonstrated by the popular models made by NERA and Thrane & Thrane that MSV has evaluated.[2] The METs used with MSV's system, for example, typically suffer overload at an interfering signal level of -30 dBm. This threshold is consistent with other mobile satellite receivers as well as terrestrial wireless terminals. Inmarsat has offered no explanation for why the METs used on its system are unusually susceptible to overload compared to other mobile satellite terminals.

Regarding the overload threshold measurements that MSV has already placed on the record, Inmarsat claims that MSV has inappropriately used an IF reference point to measure the -1 dB compression point of Inmarsat METs instead of appropriately using the RF output of the receiver's front end. *Inmarsat Opposition*, Annex § 3. This is not true. Given that MSV took both input <u>and</u> output measurements at RF, there is no basis for Inmarsat's claim that MSV's reference point was at IF. MSV's measurements of the overload threshold of Inmarsat METs entailed subjecting the receiver front-end to a calibrated out-of-channel RF interference while measuring the RF power level at the output of the terminal's RF front-end (after the terminal's LNA stage). MSV invites Commission staff to visit MSV's laboratories to witness MSV's measurement methodology and results.

Inmarsat argues that its GAN terminal is the most susceptible to interference of all Inmarsat terminals because of its wide receive-filter bandwidth. *Inmarsat Opposition*, Annex § 4. MSV has already demonstrated that Inmarsat's claims regarding the susceptibility of the GAN terminal to overload are wrong. *MSV Opposition*, Appendix B. In addition, a wide receive-filter bandwidth does not necessitate a high susceptibility to overload. The overload threshold of a terminal is determined by the terminal's LNA circuitry and not by the receiver filter bandwidth. There is no reason why the GAN terminal cannot be manufactured to meet at least an overload threshold of -45 dBm, which MSV has demonstrated is the overload threshold for the most susceptible Inmarsat MET.

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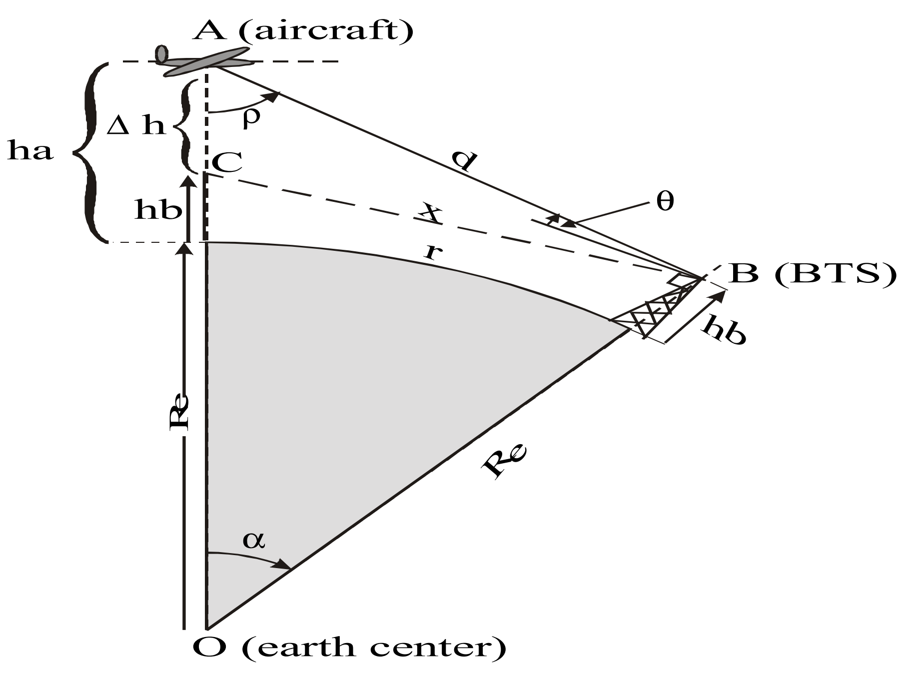
[2] It is unlikely that such METs would be able to provide reliable service from a populous area even if no ATC base stations were present.

4. ANALYSIS OF RF ISOLATION BETWEEN AN AIRBORNE SATELLITE MET AND MSV'S ATC BASE STATIONS

In MSV's Petition for Partial Reconsideration of the *ATC Order*, MSV demonstrated that L-band ATC base stations can operate with 10 dB higher emissions over elevation angles from 55° to 145° and with 8 dB higher emissions over elevation angles from 30° to 55° without causing an increase of more than 0.03 dB of potential interference to airborne satellite terminals. *MSV Petition*, Appendix D. The following provides a further mathematical support for MSV's conclusions.

In the *ATC Order*, the Commission presented results of a Monte Carlo simulation for evaluating the RF isolation to an Inmarsat airborne receiver at 1000 feet from an ensemble of 1000 ATC base stations randomly distributed within a circular area of radius 81.908 km (line-of-sight limit from 1000 ft. altitude). *See ATC Order*, Appendix C2 § 2.2.3. MSV subsequently performed its own calculation of the aggregate RF isolation for the same random base station distribution modeled by the Commission. However, rather than performing a Monte Carlo simulation, MSV's analytical approach used computer numerical integration to calculate the expected value of isolation for a single randomly placed base station. Then, assuming that the base station locations are independent random variables (consistent with the Commission's simulation), the expected value of isolation for the total distribution of 1000 base stations is simply 30 dB plus the expected value of isolation (in dB) from a single base station. This technical Appendix explains the geometric calculations and numerical integration method used in MSV's analysis.

Fig. 1: Geometric Model



Referring to Fig. 1, the following parameter definitions are used subsequently in this analysis:

- **r** = horizontal separation between aircraft and BTS as measured on the earth's surface. The value of **r** can vary from 0m (BTS directly beneath aircraft) to 81.91 km (LOS limit).
- **hb** = BTS antenna height (30 m).
- **ha** = aircraft altitude (304.7 m).
- **Re** = radius of the earth (6378.1 km).

Given these parameters, we wish to solve for the following:

- **d** = line-of-sight distance between aircraft and BTS antenna.
- θ = elevation angle from BTS antenna to aircraft, relative to horizontal.
- ρ = elevation angle from aircraft antenna to BTS, relative to nadir.

To facilitate the solution, we define a new point C located directly beneath the aircraft at a height **hb** above the earth. Next construct line x as the straight-line distance between points B and C as shown in Fig. 1. The solution then proceeds as follows:

$$\text{Geocentric angle } \alpha \text{ (radians)} = \mathbf{r} / \mathbf{Re} \qquad (1)$$

Using the symmetry of triangle OBC, we have:

$$x = 2(\mathbf{Re} + \mathbf{hb}) \sin(\alpha/2) \qquad (2)$$

$$\text{Angle(OCB)} = \text{Angle(OBC)} = (\pi - \alpha)/2 \qquad (3)$$

Then: $\text{Angle(ACB)} = \pi - \text{Angle(OCB)} = (\pi + \alpha)/2 \qquad (4)$

Applying Law of Cosines to triangle ACB:

$$\mathbf{d} = \{x^2 + \Delta\mathbf{h}^2 - 2x\Delta\mathbf{h} \cos[(\pi + \alpha)/2]\}^{1/2} \qquad (5)$$

where:

$$\Delta\mathbf{h} = \mathbf{ha} - \mathbf{hb} \qquad (6)$$

Recognizing that $\cos[(\pi + \alpha)/2] = -\sin(\alpha/2)$, then (5) reduces to:

$$\mathbf{d} = \{x^2 + \Delta\mathbf{h}^2 + 2x\Delta\mathbf{h} \sin(\alpha/2)\}^{1/2} \qquad (7)$$

Applying the Law of Sines to triangle ACB, it can be shown that:

$$\text{Angle(ABC)} = \sin^{-1}[(\Delta\mathbf{h}/\mathbf{d})\cos(\alpha/2)] \qquad (8)$$

Then:

$$\theta = \text{Angle(ABC)} + \text{Angle(OBC)} - \pi/2 \qquad (9)$$

Substituting (3) and (8) into (9) yields an expression for the aircraft elevation angle θ as viewed from the BTS antenna (relative to horizontal):

$$\theta = \sin^{-1}[(\mathbf{\Delta h}/\mathbf{d})\cos(\alpha/2)] - \alpha/2 \qquad (10)$$

However, it is more useful to reference the aircraft elevation angle with respect to the BTS antenna bore site, since this includes the effect of the antenna down-tilt angle. Let ϕ be defined as the elevation angle to the aircraft relative to the BTS antenna bore site (where the bore site direction provides the maximum antenna gain). Then:

$$\phi = \sin^{-1}[(\mathbf{\Delta h}/\mathbf{d})\cos(\alpha/2)] - \alpha/2 + \textbf{Down-tilt} \qquad (11)$$

where **Down-tilt** is the BTS antenna down-tilt angle. For MSV's analysis, **Down-tilt** = 5^o.

Finally, the elevation angle ρ of the BTS as viewed from the aircraft (relative to nadir) is given by:

$$\rho = \pi/2 - \sin^{-1}[(\mathbf{\Delta h}/\mathbf{d})\cos(\alpha/2)] - \alpha/2 \qquad (12)$$

Calculation of RF Isolation for a Given Separation Distance:
Let I(**r**) be the RF isolation between the airborne Inmarsat receiver and a single BTS separated by a distance **r** measured on the ground as shown in Fig. 1. Then I(**r**) can be expressed as:

$$I(\mathbf{r})\ (\text{dB}) = FSL(\mathbf{d}) + Gbs(\phi) + Gac(\rho) + Lf(\rho) \qquad (13)$$

where:

FSL(**d**) = Free Space Loss; $FSL(\mathbf{d}) = 20 \log[\lambda/(4\pi\mathbf{d})]$; λ = wavelength (.194 m).

Gbs(ϕ) = BTS antenna side lobe discrimination toward the aircraft, relative to the peak bore site gain. MSV's analysis considered two different BTS antenna discrimination models, one reflecting the discrimination limits set forth in the *ATC Order* (identical to the model used in the Commission's simulation), and a second representing the discrimination limits proposed in MSV's *Petition* dated July 7, 2003. Both Gbs(ϕ) models are described in detail in this Appendix.

Gac(ρ) = airborne Inmarsat antenna gain toward the BTS. Both MSV's analysis and the Commission's simulation model assumed that Gac(ρ) = 0 dBi for all elevation angles ρ.

Lf(ρ) = shielding attenuation of the aircraft fuselage at BTS elevation angle ρ below the aircraft. For the Commission's model, Lf(ρ) = 0 dB for all angles ρ since no fuselage shielding was assumed. MSV's model considered this case as well as a second case where the shielding attenuation Lf(ρ) = -10 dB for BTS elevation angles up to 30^o below the horizon (i.e., $\rho \leq 60^o$), and 0 dB attenuation for $\rho > 60^o$.

We note that each of the variables **d**, **ϕ**, and **ρ** in (13) can be expressed as a function of the ground separation distance **r** and constants **ha**, **hb**, and **Re**, as derived in (1) through (12) above.

Numerical Integration Solution for the Expected Value of Isolation:
Having derived the expression in (13) for RF isolation I(**r**) given a ground separation **r** between the BTS and aircraft, we now wish to determine the expected value of I(**r**) over all possible BTS locations within view of the aircraft. The BTS is assumed to be located with equal likelihood anywhere within a circular region bounded by radius R = 81.91 km (LOS limit for an aircraft at 1000' altitude) whose center is directly beneath the aircraft. Then the expected value of I(**r**) over all values of **r**, denoted **E**{I}, is given by:

$$\mathbf{E}\{I\} = \int_{\mathbf{r}=0}^{R} I(\mathbf{r}) f_r(\mathbf{r})\, d\mathbf{r} \qquad (14)$$

where I(**r**) is given in (13) (converted to linear units), and $f_r(\mathbf{r})$ is the probability density function of the random variable **r**. Since **r** represents the random distance from the center of a circle bounded by radius R, then it can be shown that the probability density of **r** is:

$$f_r(\mathbf{r}) = \frac{2\mathbf{r}}{R^2} \qquad (15)$$

Substituting (15) into (14) yields:

$$\mathbf{E}\{I\} = (2/R^2) \int_{\mathbf{r}=0}^{R} \mathbf{r}\, I(\mathbf{r})\, d\mathbf{r} \qquad (16)$$

While the integral in (16) is not readily solved in closed form, it can be approximated very closely by using numerical integration on a computer. A standard spreadsheet program was used to implement MSV's numerical integration method. The derivation of the numerical integration solution is described below:

We begin by dividing the integral in (16) into N contiguous integral segments denoted F(n), with each segment spanning a radial distance δ. The values of N and δ are chosen such that:

$$N\delta = R \qquad (17)$$

For MSV's analysis, the values selected for δ and N were 10m and 8191, respectively. Then the expression in (16) becomes:

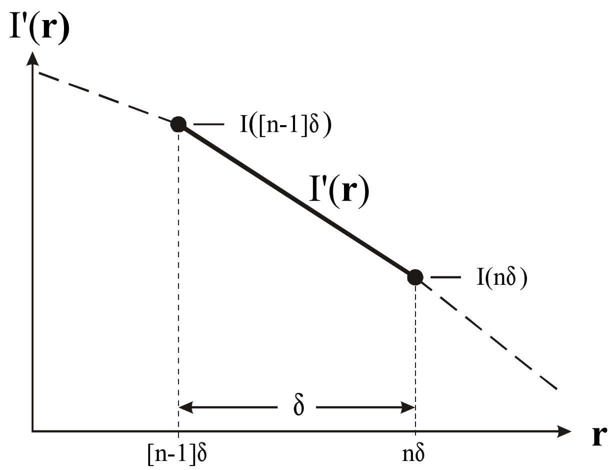
$$\mathbf{E}\{I\} = 2/(N^2\delta^2) \sum_{n=1}^{N} F(n) \qquad (18)$$

where:

$$F(n) = \int_{\mathbf{r}=(n-1)\delta}^{n\delta} \mathbf{r}\, I(\mathbf{r})\, d\mathbf{r} \qquad (19)$$

Next, the function I(**r**) is replaced with a piecewise-linear approximation denoted by I'(**r**). Within each integral segment F(n), the function I'(**r**) is represented by a straight line connecting the two segment end-points, as illustrated in Fig. 2:

Fig. 2: Piecewise-Linear Approximation for Isolation Function I(r)



Within each integral segment F(n), I'(**r**) is given by the following straight-line equation:

$$I'(\mathbf{r}) = \frac{[I(n\delta) - I([n-1]\delta)]}{\delta}\,\mathbf{r} + \{[1 - n]\, I(n\delta) + n\, I([n-1]\delta)\},\quad [n-1]\delta \le \mathbf{r} \le n\delta \quad (20)$$

Substituting (20) into (19), integrating, and combining like-terms yields the following approximate solution for F(n) as a function of I'(**r**):

$$F(n) \approx \int_{\mathbf{r}=(n-1)\delta}^{n\delta} \mathbf{r}\, I'(\mathbf{r})\, d\mathbf{r} = (\delta^2/2)\ \{[n - ⅓]\, I(n\delta) + [n - ⅔]\, I([n-1]\delta)\} \quad (21)$$

Substituting (21) into (18) yields:

$$\mathbf{E}\{I\} \approx (1/N^2) \sum_{n=1}^{N} \{[n - ⅓]\, I(n\delta) + [n - ⅔]\, I([n-1]\delta)\} \quad (22)$$

Combining like-terms of I(n) in (22) leads to the final numerical integration expression for the expected value of RF isolation for a single randomly placed BTS:

$$\mathbf{E}\{I\} \approx (1/N^2)\ \left\{ I(0)/3 + [N - ⅓]\, I(R) + 2\sum_{n=1}^{N-1} n\, I(n\delta) \right\} \quad (23)$$

where I(**r**) is defined by (13), converted from dB to linear units.

Since the random locations of the 1000 base stations are assumed to be statistically independent, it follows that the expected value of the aggregate isolation factor for 1000 base stations is just 1000 times **E**{I} for a single BTS given in (23) above. This completes the analytical derivation of the RF isolation factor for 1000 randomly placed ATC base stations.

Base Station Antenna Discrimination Models: The following antenna discrimination models were used in MSV's analytical calculation of ATC base station isolation toward an airborne Inmarsat receiver:

Model #1: Reflects BTS antenna discrimination limits in accordance with *ATC Order*. This model is identical to the one used by the Commission in its Monte Carlo simulation and conforms to the antenna discrimination mask set forth in the *ATC Order*

Antenna Discrimination Gbs(ϕ) Relative to Peak (Bore Site) Gain (dB)	**Range of Elevation Angle ϕ Above the Bore Site (degrees)**
$-12 * \phi^2 / 46.090521$	$0^o \le \phi < 4^o$
$(4 - \phi) * 2.5 - 4.166$	$4^o \le \phi < 13.5^o$
-28	$13.5^o \le \phi < 29^o$
-35	$29^o \le \phi < 56^o$
-40	$56^o \le \phi < 145^o$
$-40 + 14 * (\phi - 145) / 35$	$145^o \le \phi \le 180^o$

ATC Base Station Antenna Discrimination Mask as Set Forth in *ATC Order*
(Corresponding to Model 1 above)

Angle from Direction of Maximum Gain, in Vertical Plane, Above Antenna (Degrees)	Antenna Discrimination Pattern (dB)
0 ……………………………………	Gmax
5………………..……………….	Not to Exceed Gmax -5
10………………………………	Not to Exceed Gmax -19
15 to 30………………………….	Not to Exceed Gmax -27
30 to 55…………………………..	Not to Exceed Gmax -35
55 to 145 ………………………	Not to Exceed Gmax -40
145 to 180……………………….	Not to Exceed Gmax -26

****

Model #2: This model reflects the BTS antenna discrimination limits corresponding to the MSV-proposed antenna mask limits (*see* MSV's *Petition*, dated July 7, 2003, Appendix D, Table 2)

Antenna Discrimination Gbs(ϕ) Relative to Peak (Bore Site) Gain (dB)	Range of Elevation Angle ϕ Above the Bore Site (degrees)
$-12 * \phi^2 / 46.090521$	$0^o \leq \phi < 4^o$
$(4 - \phi) * 2.5 - 4.166$	$4^o \leq \phi < 13.1^o$
-27	$13.1^o \leq \phi < 55^o$
-30	$55^o \leq \phi < 145^o$
$-30 + 4 * (\phi - 145) / 35$	$145^o \leq \phi \leq 180^o$

ATC Base Station Antenna Discrimination Mask Corresponding to Model #2

Angle from Direction of Maximum Gain, in Vertical Plane, Above Antenna (Degrees)	Antenna Discrimination Pattern (dB)
0 ………………………………….	Gmax
5………………..……………….	Not to Exceed Gmax -5
10………………………………	Not to Exceed Gmax -19
15 to 55………………………….	Not to Exceed Gmax -27
55 to 145 ………………………	Not to Exceed Gmax -30
145 to 180……………………….	Not to Exceed Gmax -26

****

Similarities between the Commission's and MSV's Results and the two Models: The Table below summarizes the results of MSV's analytical calculations of the isolation factor for 1000 base stations using the base station antenna discrimination values of Models 1 and 2 above, and compares these results to the Commission's simulation (Monte Carlo) result:

Numerical results comparison[3] - Commission's analysis vs. MSV's.

Case	Solution Method	BTS Antenna Discrimination	Receive Antenna Gain -30° to -90°	Calculated Isolation Factor for 1000 Base Stations
A	Monte-Carlo simulation (FCC)	Per Table 1	0 dBi	-105.1 dB
B	Analysis (MSV)	Per Table 1	0 dBi	**-105.37 dB**
C	Analysis (MSV)	Per Table 2	-10 dBi	**-105.36 dB**
D	Analysis (MSV)	Per Table 2	0 dBi	**-105.35 dB**

Case A above shows the Commission's Monte Carlo simulation result presented in the *ATC Order*, using base station antenna discrimination values modeled after the mask defined in Model 1. The simulation conservatively assumes an Inmarsat AMS(R)S receiver antenna gain of 0 dBi at elevation angles below the aircraft.

Case B shows the results of MSV's analytical solution using the same assumptions for both base station antenna discrimination and AMS(R)S receiver antenna gain that the Commission used in its simulation. This case was performed to verify that the two solution methods produced equivalent results. Comparing the isolation values from Case A and Case B reveals that the Commission's Monte Carlo simulation value and MSV's result are in excellent agreement (only 0.27 dB difference).

In Case C, the analysis was repeated substituting the base station antenna discrimination changes proposed in Model 2, and assuming an additional AMS(R)S receiver antenna isolation factor of 10 dB for elevation angles from -30 to -90 degrees below the aircraft. The results show that the isolation (including the effect of the 10 dB AMS(R)S antenna discrimination over the range from -30º to -90º) is essentially unchanged from Case B, confirming that the proposed changes to the discrimination limits in Table 2 have no practical effect on the base station isolation factor.

In Case D, the analysis was repeated using the proposed discrimination mask in Model 2, but in this case the airborne AMS(R)S receiver antenna gain toward the ATC base stations was set to 0 dBi, consistent with the Commission's assumption. The results show only 0.02 dB reduction in the base station isolation factor compared to Case C which assumed 10 dB of AMS(R)S antenna isolation below the aircraft. Case D demonstrates that the specific aircraft isolation at elevation

[3]This Table as originally presented in MSV's *Petition* displays results that differ by about 0.4 dB from the results above. This was due to an error in a numerical integration routine that has since been corrected. With this correction, the Commission's results and those of MSV's are in better agreement.

angles between -30° and -90° does not strongly influence the base station isolation factor. This is because the geographic area contained within the circle defined by a -30° elevation arc from an aircraft altitude of 1000 feet is very small compared to the entire surface area viewed by the aircraft. Thus, a randomly-distributed group of ATC base stations that is within the viewing area of the aircraft will contribute a very small proportion of total interference power at elevation angles from the aircraft below -30°.

Conclusion: MSV has demonstrated that the ATC base station antenna mask, as specified by the Commission in the *ATC Order*, is unnecessarily over-specified and can thus be relaxed, as proposed by MSV, with no practical impact to AMS(R)S operations. MSV's sensitivity analysis has shown that 10 dB of pattern relaxation from 55° to 145° and 8 dB relaxation from 30° to 55° degrades the base station isolation factor less than 0.03 dB.

TECHNICAL CERTIFICATION

I, Dr. Peter D. Karabinis, Vice President & Chief Technical Officer of Mobile Satellite Ventures Subsidiary LLC ("MSV"), certify under penalty of perjury that:

I am the technically qualified person with overall responsibility for preparation of the technical information contained in the foregoing "Reply." The information contained in the "Reply" is true and correct to the best of my belief.

/s/Dr. Peter D. Karabinis
Dr. Peter D. Karabinis
Vice President & Chief Technical Officer

September 2, 2003

CERTIFICATE OF SERVICE

I, David Konczal of the law firm of Shaw Pittman LLP, hereby certify that on this 2nd day of September 2003, served a true copy of the foregoing "Reply" by first class United States mail, postage prepaid, upon the following:

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