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Marlene H. Dortch
Secretary
Federal Communications Commission
The Portals
445 Twelfth Street, S.W.
Washington, DC 20554

Re: ***Ex Parte Presentation***:
IB Docket No. 01-185;
Motient Services Inc. and Mobile Satellite Ventures Subsidiary LLC
File No. SAT-ASG-20010302-00017 et al.;
TMI Communications and Company, Limited Partnership
File No. SES-ASG-20010116-00099 et al.

Dear Ms. Dortch:

Enclosed on behalf of Inmarsat Ventures plc is a paper entitled "MSV is Unable to Operate ATC Without Using Additional Spectrum Beyond That Used for Its MSS System."

An original and five copies are enclosed.

Respectfully submitted,

John P. Janka

Enclosure
cc (w/ encl.):
Rick Engelman
Breck Blalock
Trey Hanbury
Paul Locke

No. of Copies rec'd 0+5
List ABCDE

MSV is Unable to Operate ATC Without Using Additional Spectrum Beyond That Used for Its MSS System

Inmarsat Ventures plc

May 21, 2002

IB Docket No. 01-185

1 Introduction

One of the fundamental claims made by MSV regarding its ATC proposal is that the terrestrial component will simply re-use spectrum that is simultaneously in use by its MSS (Mobile Satellite Service) system. This paper demonstrates that this claim by MSV is false. We demonstrate here that, even assuming MSV's claimed isolation value of only 10 dB, there will be significant geographic areas throughout the overall MSV coverage area where the terrestrial component of the proposed MSV system will have no existing MSS spectrum assignment available in which to operate. In fact, if a realistic assumption about the necessary isolation is made, we show that MSV will have no ATC spectrum anywhere in the USA. Therefore, in order for MSV to be able to operate the kind of ancillary terrestrial service it proposes, additional L-band spectrum will be required above and beyond that coordinated internationally for the MSV satellite system.

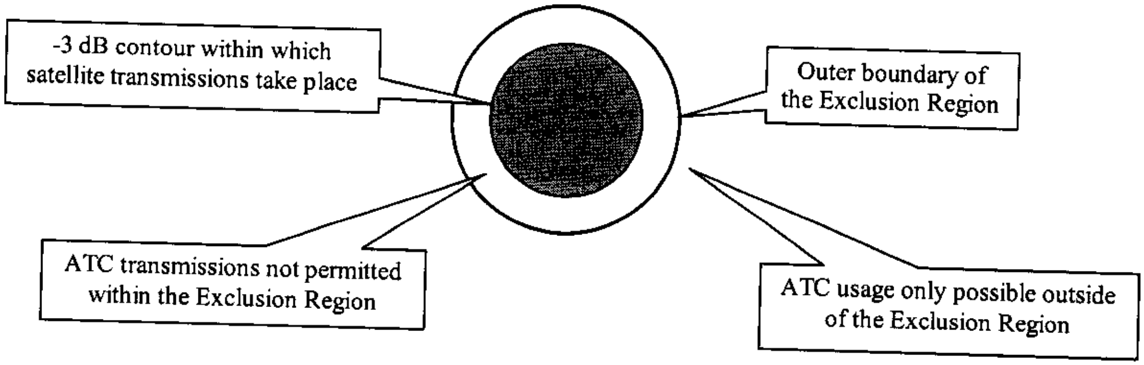
2 Relevant Information Provided by MSV

MSV has repeatedly mentioned in its various ATC related pleadings that it requires an antenna isolation of 10 dB to protect against interference into its MSS satellite uplinks from its own terrestrial ATC operations. As explained in detail in a number of Inmarsat papers, Inmarsat disagrees with this assertion. Inmarsat calculations show that the interference MSV would receive from its ATC system would be more than 100 times greater than that assumed by MSV.[1] With the levels of self-interference calculated by Inmarsat, MSV would need much more than 10 dB antenna isolation to protect its satellite receiver against interference from its ATC system, and hence the ATC system would be completely unable to reuse MSV satellite frequencies anywhere within the MSV service area.

Nevertheless, if we use the MSV assumption that only 10 dB antenna isolation would be sufficient, this means that MSV's terrestrial transmissions must take place outside the –10 dB receive gain contour of its co-frequency satellite beams (the "exclusion region") to avoid harmful self-interference, as shown in Figure 1 below. However, in its earlier pleadings MSV did not define exactly, in physical terms related to the size of the satellite beam, the boundary of this exclusion region. Rather it suggested that the exclusion region was sufficiently small that it would not prohibit essential use of the MSS uplink spectrum by the terrestrial component.

1 Inmarsat *ex parte* presentation to FCC, February 21, 2002.

Figure 1 – MSV "Exclusion Region"



From our review of its pleadings, we believe that MSV has recently defined more accurately the exclusion region related to this requirement for 10 dB isolation.[2] In that *ex parte* submission it defines the width of the exclusion region that is outside of the satellite beam as follows: "*Each white ring exclusion region has a width of approximately1/3 to ½ of a cell radius*".[3] Unfortunately such a definition is still rather vague, and our analysis shows that, even taking the upper bound of the range stated by MSV (i.e., ½ of a cell radius), it is insufficient to take account of practical satellite antenna design and other system requirements of the proposed ATC system. The fact of the matter is that the exclusion region is much larger than MSV has stated and this results in significant geographic gaps in the MSV system where no existing MSS spectrum is available for the ATC system.

3 <u>Realistic Analysis Approach to Determining the Size of the Exclusion Region</u>

MSV provides no details about its assumptions used in determining the actual size of the exclusion region. From its March 28 *ex parte* we are left to understand that the boundary of this region is related to an <u>average</u> discrimination of 10 dB. We believe that the use of average is inappropriate and that the boundary should in fact be the *effective* –10 dB gain contour of the satellite beam, and not the average. The reason for this is that the MSV terrestrial transmitters will, according to MSV, be concentrated in the metropolitan areas and not spread uniformly across the USA. The use of <u>average</u> for the antenna discrimination would only be appropriate if the terrestrial interferers were distributed uniformly across the sidelobes of the beam. If a significant metropolitan area were located at the –10 dB contour (or just outside to be consistent with MSV's stated requirements) then the dominant interference will be received by the MSV satellite at an antenna gain of approximately –10 dB. Therefore in this analysis we will use the *effective* –10 dB gain contour as the boundary of the exclusion region. The meaning of "*effective*" in this context is explained further below.

The next step in determining the size of the exclusion region is to determine the satellite antenna pointing error. It would appear that MSV has not taken this into account in determining the size

2 See MSV *ex parte* submission dated March 28, 2002, entitled "Monitoring and Control of Ancillary Terrestrial Emissions by MSV's Space Segment".

3 See text immediately following Figure 5 of MSV's March 28, 2002 *ex parte.*

of the exclusion region, but it is essential that this effect is included in a realistic system analysis of the proposed MSV ATC system.

Satellite pointing error is not normally such a crucial parameter for a system intended to provide only MSS services. In such an MSS-only case the movement of users between the satellite beams is catered for by "beam hand-off", regardless of whether such movement is caused by the mobile users changing their position or the satellite antenna changing its pointing direction, as would be normal with any satellite antenna.[4] However, when the pointing direction of the satellite antenna affects the interference received from a terrestrial system, such as the proposed ATC, then the pointing errors of the satellite antenna must be fully taken into account. In other words it is necessary to consider the –10 dB threshold interference gain contour with the satellite antenna pointing error added. The –10 dB gain contour with satellite pointing error added is defined here as being the "*effective*" –10 dB gain contour, as referred to in the paragraph above.

Typical satellite pointing error is in the region of ±0.15° or probably greater for the type of very large reflector antenna proposed by MSV for its next-generation satellite. In the analysis presented below we have included a pointing error of ±0.15° in the –10 dB gain contours which we believe is conservative. We note that this error is larger than MSV claims it will achieve with its proposed new generation satellite, which is a roll error of 0.04° and a pitch error of 0.05°.[5] Such high antenna pointing accuracy as claimed by MSV could only be achieved using closed-loop RF sensing techniques, and even then it would only be achieved at or close to the ground beacon site. There will be inherent distortions of the 12 meter unfurlable antenna reflector, which would likely vary over time due to the thermal changes in the antenna caused by changing sun illumination, and these will inevitably mean that the effective antenna pointing error is much larger than MSV claims for the vast majority of the service area of the MSV satellite.

4 Analysis Results for the Size of the Exclusion Region

4.1 Assuming 10 dB Isolation as Claimed by MSV

Figure 2 below shows the results obtained when the *effective* –10 dB gain contours define the exclusion region in the MSV system. These contours have been derived based on the following assumptions:

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4 Large satellite antenna reflectors, as proposed for next-generation MSS satellites such as Inmarsat's and MSV's, present particularly difficult challenges in terms of pointing error, because their parabolic profile is susceptible to distortions caused by thermal effects, spacecraft station-keeping perturbances, and just their inherent imperfect surface accuracy that results from them having to be unfurled once the spacecraft is in orbit. The beam distortions and beam pointing errors are even worse for beams further away from the geometric boresight of the antenna because of "scan-loss" effects (see further discussion of this in Section 6.1).

5 See MSV's Application, Appendix A, Table 1-1.

1. MSV beam size (-3 dB) consistent in size and cross-over point with those proposed by Motient.[6,7] These –3 dB gain contours are shown by the smaller thin lined circles in Figure 2.

2. –10 dB gain contours calculated assuming a Gaussian beam roll-off. This is consistent with the ITU Recommendations concerning satellite antenna gain roll-off.[8] These *effective* –10 dB gain contours are shown by the larger thick-lined circles in Figure 2.

3. Satellite antenna pointing error of ±0.15° in all directions, as explained in Section 3 above.

Figure 2 shows a set of seven MSV beams so that the exclusion regions from all six beams surrounding the central beam can be seen. Note that the larger *effective* -10 dB contours from the surrounding beams extend well into the central –3 dB satellite beam contour. Within each of these six exclusion regions the satellite frequency used by the beams associated with each exclusion region cannot be used by the terrestrial system. Note that there is a (shaded) near-hexagonal region (which we term the "no-MSS spectrum region") in the center of the central beam which is overlapped by all six of the exclusion regions from the six surrounding beams. Inside this "no-MSS spectrum region" none of the frequencies used by the six surrounding satellite beams can be used. Similarly, the frequencies used by the central satellite beam cannot be used, and so no MSS spectrum is available in this region. For MSV to offer terrestrial service in this "no-MSS spectrum region" it would have to use additional MSS spectrum not hitherto used by the MSV satellite system, and this would be in violation of the principles of the international coordination agreement embodied in the Mexico MOU. Note that such a "no-MSS spectrum region" will exist in all of the MSV beams that have significant numbers of surrounding beams, which means essentially that this problem will be repeated across the entire coverage area of the MSV satellite. For an illustration of this, see Figure 3.

6 *Mobile Satellite Ventures Subsidiary LLC Application for Assignment and Modification of Licenses and for Authority to Launch and Operate a Next-Generation Mobile Satellite System, et al.*, File No. SAT-ASG-20010302-00017, et al. (filed March 1, 2001) (the "*Application*"), Appendix A, Section 1.4, pp. 5-10.

7 See MSV *ex parte* submission dated March 28, 2002, entitled "Monitoring and Control of Ancillary Terrestrial Emissions by MSV's Space Segment", Figure 5.

8 Ref. IRU-R Recommendation S.672-3 entitled "Satellite Antenna Pattern for Use as a Design Objective in the Fixed Satellite Service Employing Geostationary Satellites".

Figure 2 - MSV Exclusion Region Circles calculated by Inmarsat (assuming effective –10 dB contour defines Exclusion Region)

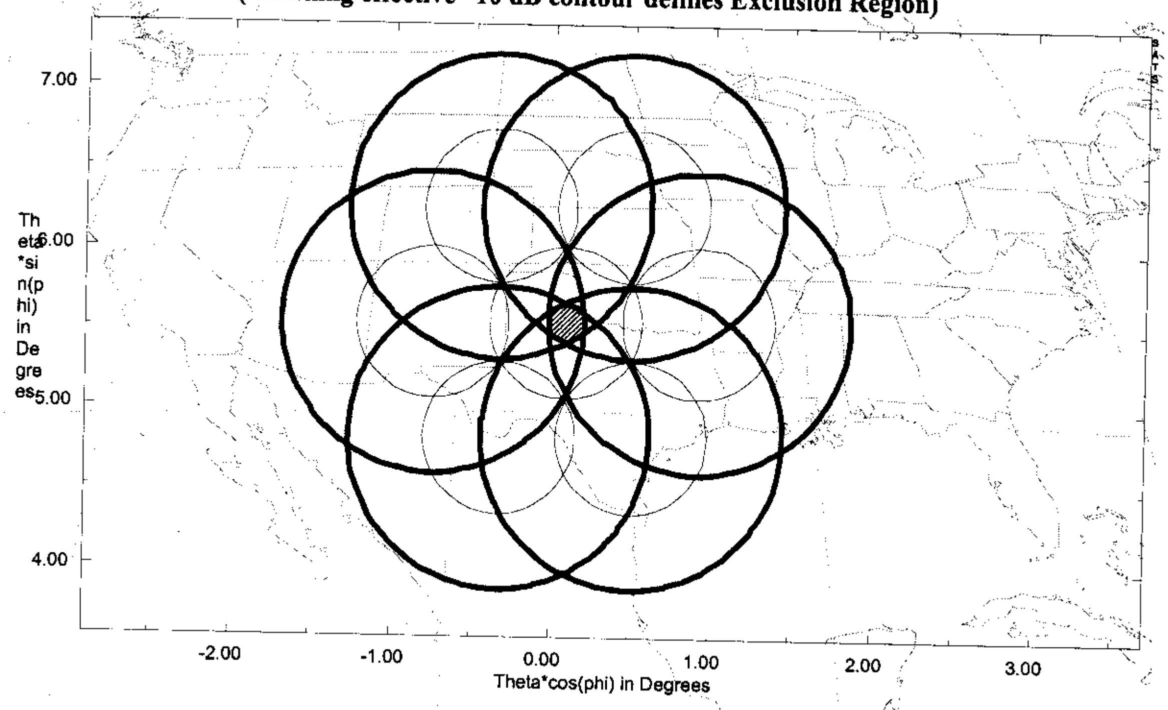
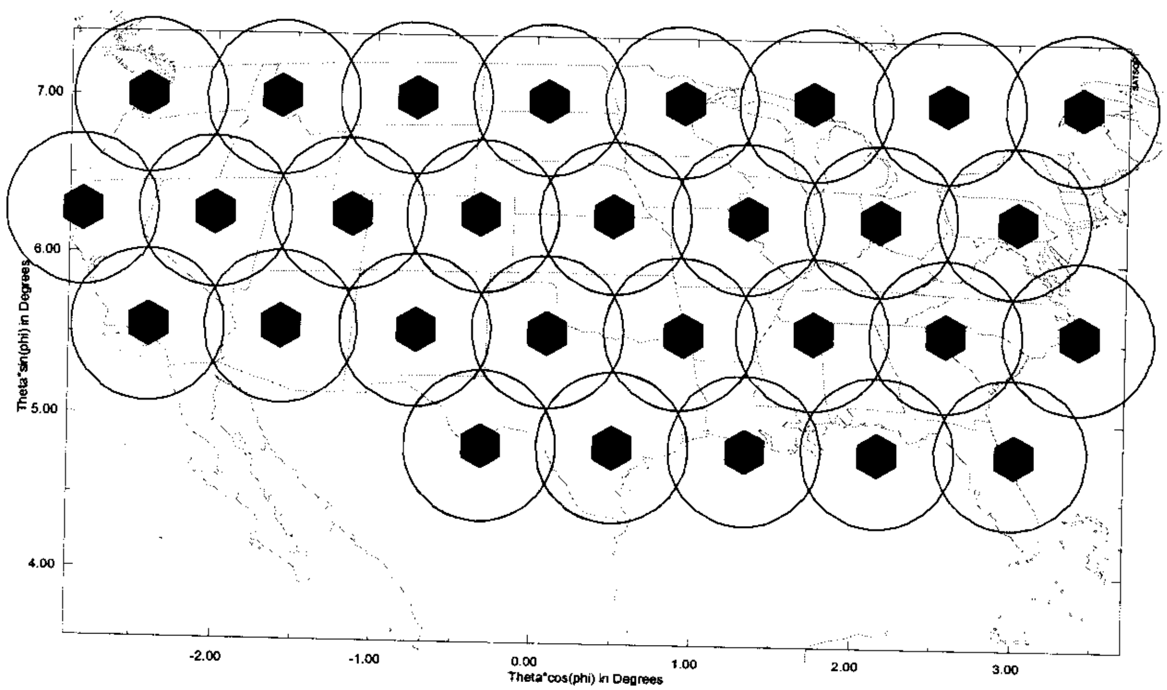


Figure 3 - Overall effect of the "No-MSS Regions" Across the USA (assuming effective –10 dB contour defines Exclusion Region)

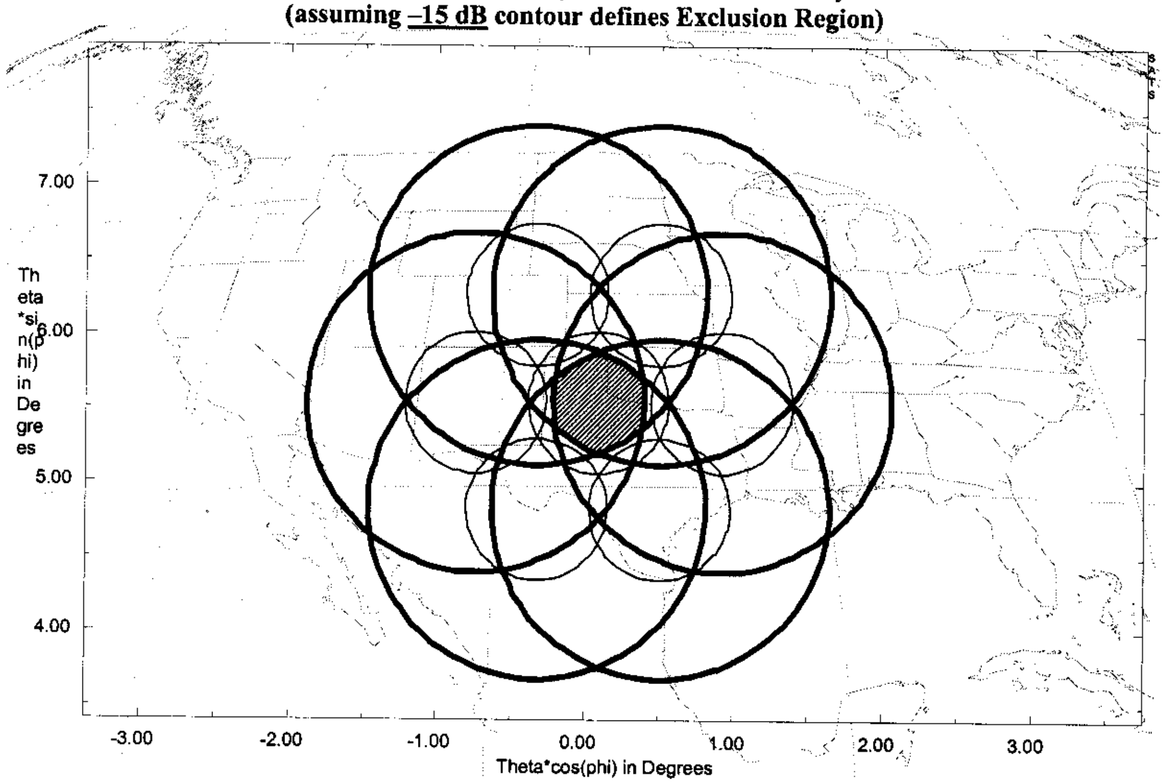


4.2 Assuming Higher Values of Isolation to Protect MSV from Harmful Self-Interference

As mentioned in Section 2 above, the antenna isolation actually required by MSV to protect its satellite receiver against interference from ATC is actually greater than the 10 dB assumed by MSV. Inmarsat's analyses conclude that more than 30 dB isolation could be required.[9] Assuming a higher value of isolation is required, the Exclusion Regions will be larger, as demonstrated in this sub-section.

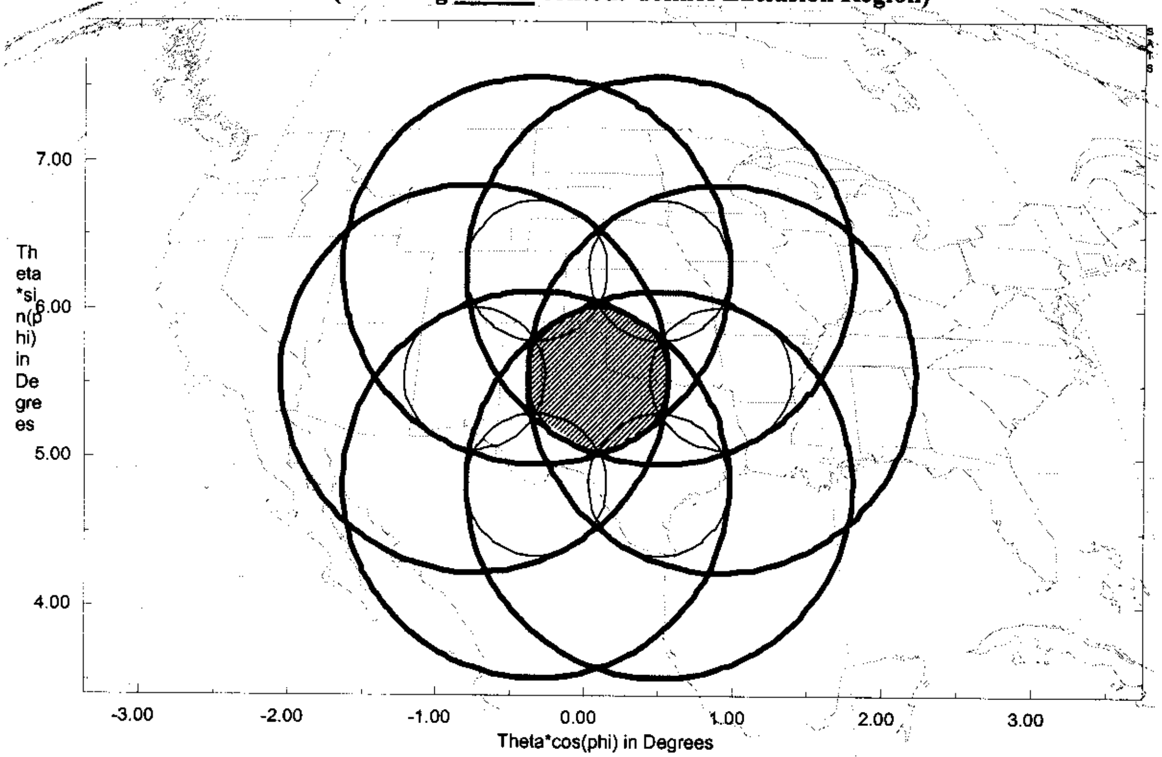
We have performed the same analysis given in Section 4.1 above for alternative values of antenna isolation. The results show that, even if only 20 dB isolation is required, then the entire MSV service area becomes a "no-MSS spectrum" region. Even if only 15 dB isolation is required, the "no-MSS spectrum" regions have grown so significantly as to cover more than 50% of the service area. These results are shown in Figures 4 and 5 below.

Figure 4 - MSV Exclusion Region Circles calculated by Inmarsat (assuming __-15 dB__ contour defines Exclusion Region)



9 For example, see Inmarsat *ex parte* presentation to FCC, February 21, 2002.

Figure 5 - MSV Exclusion Region Circles calculated by Inmarsat
(assuming -20 dB contour defines Exclusion Region)



5 Comparison of the Inmarsat-calculated Exclusion Region Size with MSV's Suggested Size (assuming 10 dB isolation)

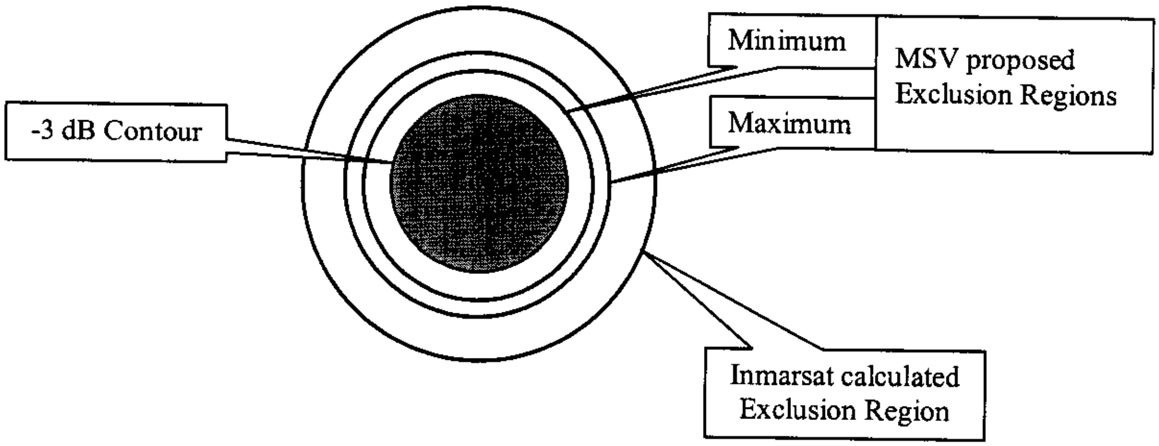
The width of the exclusion regions shown in Figure 2 above (i.e., the distance between the *effective* -10 dB contour and the –3 dB contour) is exactly equal to the radius of the –3 dB contour. This contrasts with the range suggested by MSV which is only from one third to one half of the radius of the –3 dB contour.

There are even greater differences in the size of the exclusion region, when considered as an area, according to the Inmarsat analysis and the MSV suggestion.[10] In this case the value from the above Inmarsat analysis is between 2.4 times (relative to the MSV value of one half) and 3.9 times (relative to the MSV value of one third) greater than the area proposed by MSV.

A scale diagram showing the Inmarsat versus the MSV exclusion region sizes is shown in Figure 6 below.

[10] The exclusion region area is the difference between the area of the *effective* -10 dB contour and the area of the –3 dB contour.

Figure 6 - Comparison of Exclusion Region Sizes



6 Other Factors Affecting Exclusion Region Size

The analysis presented here does not take into account other factors that will further increase the size of the exclusion regions in different parts of the service area. These are discussed in the following sub-sections:

6.1 Beam Scan-Aberration Effects

The simple circular beam shapes considered here (and also as shown by MSV) are correct only for beams that are generated close to the geometrical boresight of the satellite antenna. For beams that are further away from the boresight (such as towards the edge of CONUS which happens to be where the largest populations exist) the beam contours are not truly circular and become distorted.[11,12] The distortion is greater for the lower level contours so, for example, the –10 dB contour will be more distorted than the –3 dB contour. Therefore the exclusion regions, assuming that they are related to the –10 dB contours as proposed by MSV, will be larger than those calculated in Section 4.1 above. The –15 dB and –20 dB contours would be even more distorted.

To illustrate this effect we have analyzed the performance of a typical MSV satellite antenna in this respect, and the results are shown in Figure 7. The boresight of the antenna (indicated by a circle with a cross centered in it) has been located in east Texas, approximately in the center of the overall service area of the proposed MSV satellite, in order to minimize the scan-aberration

11 This effect is usually referred to as "beam scan-aberration". The effect also causes the peak gains of the beams to be lower when the beams are located ("scanned") further away from the boresight, and hence the effect is also sometimes referred to as "scan loss".

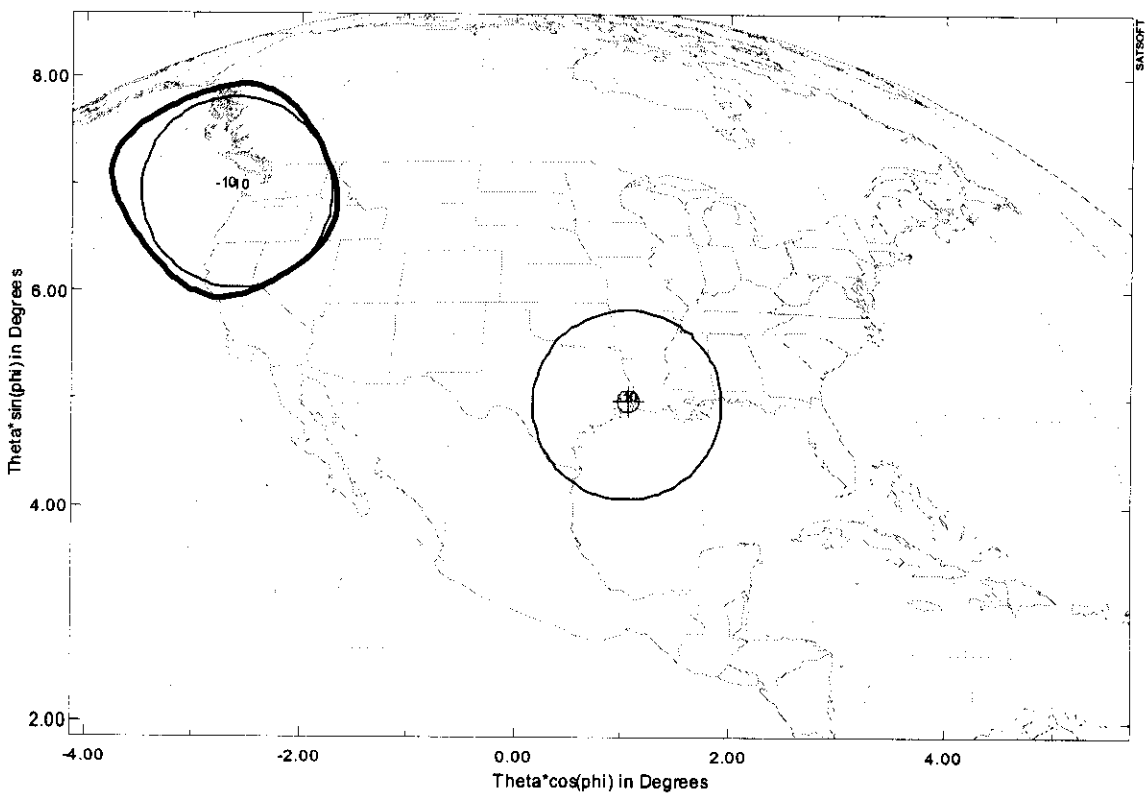
12 The scan-aberration effect is totally separate from the effect often noticed when circular beams are plotted on a flat Earth projection and they appear to be distorted ellipses. This latter effect is not a true distortion of the beam, but rather a feature of the way the beam is plotted on the Earth. In order not to confuse these two effects all beam plots shown in this document are as viewed from the satellite, and therefore the Earth-projection effect is not relevant or apparent.

effects at the extreme edges of the service area.[13] The beam being investigated here is the one approximately centered on Seattle, WA. The *effective* -10 dB contour for this beam, shown with the thicker line, is the one that includes the scan-aberration effect. To better see the enlargement and distortion of this contour produced by the scan-aberration effect we also show an ideal *effective* –10 dB contour that would be generated at or near the boresight. This latter "ideal" contour is shown in the correct position over the boresight, as well as repeated over Seattle so that its size and shape can be compared with the actual beam that exhibits the scan-aberration effect.

Comparing the two *effective* -10 dB contours (thin line and thick line) over Seattle shows clearly that the scan-aberration effect will considerably enlarge the Exclusion Region in areas away from the boresight.

It should be noted that the scan-aberration effects are directly related to the geometry of the satellite antenna, in particular the F/D ratio (F = Focal length of the satellite reflector; D = Diameter of the satellite reflector). The smaller the F/D ratio the worse the scan-aberration effects. The results shown in Figure 5 are for an F/D of 1.0. In practice it is likely that the MSV satellite antenna, which will use a very large 12 meter unfurlable reflector, will need to have a relatively short focal length in order to accommodate the antenna and realizably sized feed horns on the spacecraft platform. In this case, with a shorter focal length, the F/D ratio could well be shorter than 1.0, and the scan-aberration effects could be worse than is shown in Figure 5.

Figure 7 - Enlargement and Distortion of Exclusion Regions Due to Beam Scan-Aberration Effects



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13 See MSV Application, Appendix A, Section 1.4, Figure 1-2.

6.2 Non-Uniform Traffic Loading

Although the analysis presented above does not necessarily assume even traffic loading of all seven satellite beams, there are some additional problems that would be caused when the MSV satellite has very non-uniform traffic loading. In such a case where one or several of the satellite beams might be using a large proportion of the available MSS spectrum ("high MSS use beams"), then the available spectrum for the proposed terrestrial system will be severely limited, not just in those "high MSS use beams", but also in large parts of the neighboring beams. Inmarsat believes that this could be a severely limiting factor in the usefulness of the ATC in large portions of the MSV satellite service area.

7 Conclusions

In this paper we have challenged MSV's claim that its proposed ATC system can re-use MSS satellite spectrum used by the MSV satellite. The conclusions, based upon a thorough analysis that contrasts with the absence of any such analysis on MSV's part, fully demonstrate that large parts, if not all, of the MSV ATC service area will have no free spectrum available to it. This will mean that MSV will be obliged to request additional spectrum during the international ITU coordination process just in order to satisfy its proposed terrestrial system, and this will be in violation of international treaty obligations on the USA.

Specifically, the analysis presented here has shown the following:

1. MSV has apparently ignored the quite considerable satellite antenna pointing error that will exist over large parts of the service area, even assuming the satellite uses closed-loop RF sensing for antenna pointing control. When a reasonable satellite antenna pointing error of ±0.15° is taken into account, the effective exclusion regions are enlarged. Even assuming that exclusion regions based on the –10 dB contour is sufficient to protect MSV from harmful self-interference, the resulting aggregate exclusion regions create significant geographic regions where no MSS spectrum is available for the proposed ATC system, and these regions will be repeated across the USA.[14]

2. The exclusion region based on the *effective* –10 dB contour calculated by Inmarsat and referred to in 1 above is between 1.33 and 1.5 times greater in width than MSV asserts is the case. When considered as an area the exclusion region calculated by Inmarsat is between 2.4 and 3.9 times greater than MSV states.

3. Inmarsat's analysis is based on an idealized satellite beam that does not exhibit scan-aberration effects. These real-life effects will further enlarge and distort the exclusion regions. Such effects will be most noticeable at locations in CONUS further away from the geometric boresight of the MSV satellite antenna, which is likely to be the highly

[14] As noted earlier in this paper, Inmarsat does not believe that 10 dB is sufficient isolation to allow MSV's satellite system to be protected from harmful self-interference.

populated east and west coasts of the USA. This effect will further increase the size of the exclusion regions in key parts of the MSV service area and exacerbate the lack of MSS spectrum.

4. If realistic self-interference isolation values are assumed then the exclusion regions are considerably larger. Isolation of only 15 dB results in approximately 50% of the area of the USA being denied ATC spectrum, and an isolation value of 20 dB denies MSS spectrum from all of the USA. These isolation values are not excessive, and are still far short of what Inmarsat believes is necessary for the MSV satellite system to function correctly, as has previously been shown by Inmarsat.

5. Other real-life effects of non-uniform traffic loading in the MSV satellite system will further impact the spectrum available to the proposed MSV ATC system.

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