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April 5, 2002

VIA ELECTRONIC FILING

William F. Caton
Acting Secretary
Federal Communications Commission
445 12 Street S.W.
Washington D.C. 20054

Re: Additional Technical Analysis of The Boeing Company
IB Docket No. 01-185
ET Docket No. 95-18

Dear Mr. Caton:

In response to a public notice issued by the Commission,[1] on March 22, 2002, The Boeing Company ("Boeing") filed Further Comments in the above referenced proceeding addressing the technical issues involved in the provision of an Ancillary Terrestrial Component ("ATC") by mobile satellite service ("MSS") licensees in the 2 GHz MSS band.[2] In its Further Comments, Boeing indicated its intent to file shortly on an *ex parte* basis an additional technical analysis of the potential interference issues implicated by proposals for ATC and other terrestrial uses of the 2 GHz MSS band.[3] Boeing, through its attorneys, provides as an attachment to this letter Boeing's additional technical analysis.

As indicated in the analysis, the Commission should not authorize any severed terrestrial use of either the uplink or downlink portions of the 2 GHz MSS band. Any severed terrestrial services that attempt to operate co-frequency in spectrum assigned now, or in the future to Boeing's 2 GHz MSS network would result in harmful interference to Boeing's aeronautical communication services. As the

[1] *See* Public Notice, *Commission Staff Invites Technical Comment on the Certain Proposals to Permit Flexibility in the Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-band, and the 1.6/2.4 GHz Band*, DA 02-554 (March 6, 2002) ("*Public Notice*").

[2] *See Further Comments of The Boeing Company*, IB Docket No. 01-185, ET Docket No. 95-18 (March 22, 2002).

[3] *See id.* at 2.

analysis shows, such operations would not be feasible due to the very large separation distances that would be required between terminals of the two services.

Boeing supports proposals to permit ATC in 2 GHz MSS uplink spectrum that is outside the spectrum assigned for Boeing's network, subject to limited restrictions that are discussed in Boeing's further technical analysis. Boeing also does not oppose proposals to permit ATC in 2 GHz MSS downlink spectrum that is outside of Boeing's spectrum assignment as long as the Commission adopts appropriate interference limits for such operations. The specific limits that would be necessary in order to permit ATC operations in the 2 GHz MSS downlink band are indicated in Boeing's further technical analysis. Boeing is also continuing to study the issue in order to determine whether alternate or additional measures may be appropriate.

Recognizing the feasibility of ATC services, the Commission should promptly authorize 2 GHz MSS licensees to provide ATC as an integrated part of their services to consumers. At the same time, the Commission should not authorize any severed terrestrial use of the 2 GHz MSS band. If the Commission does consider authorizing severed terrestrial services, the Commission should first grant Boeing its original request to use at least 8 MHz of paired 2 GHz MSS spectrum, which Boeing demonstrated is required to provide its aeronautical communication services to the aviation industry.

Sincerely,

David A. Nall

Enclosure

Further Technical Analysis of The Boeing Company

April 5, 2002

1. Issues

There are a number of issues that should be considered when assessing the potential operation of terrestrial mobile services in the 2 GHz MSS spectrum allocation. The first is the operation of a severed terrestrial mobile service operating co-frequency in the Boeing frequency assignment. In the following analysis, Boeing shows that a severed terrestrial service operating co-frequency in Boeing's frequency assignment is impossible due to the very large separation distances that would be required between terrestrial user terminals ("UT") and base stations and Boeing's 2 GHz MSS receivers in order to avoid harmful interference to Boeing's system.

The second issue is the operation of an ancillary terrestrial component ("ATC"), or other terrestrial mobile service, in a frequency band that is adjacent to the Boeing assignment. Boeing supports proposals to permit ATC in 2 GHz MSS uplink spectrum that is outside the spectrum assigned for Boeing's network subject to limited restrictions. Boeing also does not oppose proposals to permit ATC in 2 GHz MSS downlink spectrum that is outside the spectrum assigned for Boeing's network if the Commission adopts appropriate interference limits for such operations.

2. Summary

Co-frequency sharing between a severed terrestrial mobile service and Boeing's 2 GHz MSS network will result in harmful interference to both systems. As a result, the Commission should not permit any severed terrestrial networks to operate co-frequency in the spectrum assigned now or in the future to Boeing for the operation of its 2 GHz MSS network.

Boeing supports proposals to permit ATC in 2 GHz MSS uplink spectrum that is outside the spectrum used for Boeing's aeronautical services subject to limited conditions:

1. Regulatory restrictions should be placed on the areal EIRP density resulting from the terrestrial mobile service, and
2. The Commission must not impose any additional out of band ("OOB") emission limitations on 2 GHz MSS networks.

Boeing also does not oppose proposals to permit ATC in 2 GHz MSS downlink spectrum that is outside the spectrum assigned for Boeing's network. If such operations are authorized, it is important for the Commission to adopt the following restrictions:

1. The Commission should adopt OOB emission limits for terrestrial base-stations and UTs operating in the MSS downlink band.

2. The Commission should also adopt mandatory minimum separation distance requirements for terrestrial base stations in order to ensure that such stations are not placed near the aircraft operational areas of airport facilities, where they could cause harmful interference to Boeing's aeronautical communication services.

3. Measures should also be taken to ensure that the transmit power from nearby terrestrial base stations and terrestrials UTs that are operating in the MSS downlink band do not cause saturation of the Boeing receiver front end. Boeing is continuing to investigate potential means to alleviate the saturation problem, but Boeing has not yet identified an acceptable solution.

3. Boeing Opposes any Proposal to Permit Severed Terrestrial Service Co-Frequency with Boeing's 2 GHz MSS Spectrum Assignments

One of the major differences between proposals for severed terrestrial mobile use of the 2 GHz MSS band and proposals for ATC is that a possibility exists that severed terrestrial mobile systems could attempt to operate co-frequency in the Boeing spectrum assignment. The first portion of this analysis considers the possibility of co-frequency operations of severed terrestrial mobile services in spectrum assigned now, or in the future, for Boeing's MSS services.

An independent terrestrial service operating co-frequency in the Boeing downlink assignment would cause significant interference to Boeing's system. As a result, such operations would make the Boeing system inoperable. In the past the Commission has ruled that ubiquitously deployed terrestrial mobile systems were not able to share spectrum co-frequency with ubiquitously deployed MSS systems. Table 1 shows a calculation of the separation distance required for a terrestrial mobile UT operating co-frequency in the Boeing MSS downlink spectrum assignment. The simple analysis given in Table 1 assumes a line-of-sight transmission path to a Boeing receiver that is affixed to an aircraft on the ground.

As indicated, the required separation distance according to this calculation is 240.161 kilometers. Table 1 indicates that any terrestrial mobile UT that is in the vicinity of a Boeing receive terminal would cause significant interference to the Boeing system. Table 2 shows the required separation distance between a terrestrial mobile UT on the ground and an aircraft in flight at 40,000 feet. This results in a terrestrial mobile UT that is less than 4 degrees below the aircraft horizon. The normal pitch and roll of an aircraft during standard maneuvers would result in the terrestrial mobile UT being above the relative horizontal of the aircraft at times. Therefore, no adjustment has been made in Table 2 in the gain of the Boeing terminal antenna.

These calculations address solely the case of an independent terrestrial mobile UT operating co-frequency with the Boeing network. A significantly greater interference problem would result if the Commission were to authorize the operation of severed terrestrial base stations within the Boeing 2 GHz MSS spectrum assignment.

Table 1: Calculation of Required Separation Distance between Boeing Receiver on the Ground and a Severed Terrestrial UT Operating Co-frequency in Boeing Downlink Band.

Frequency	GHz	2.185
Noise temp (Boeing terminal)	K	200
No (Boeing terminal)	dBW/Hz	-205.59
Interference criteria, Io/No	dB	-12.22
Allowed Io	dBW/Hz	-217.81
Transmit EIRP (terrestrial mobile)[1]	dBW	-10.00
Transmit bandwidth	MHz	1.25
Transmit power density	dBW/Hz	-70.97
Antenna gain (Terrestrial UT)	dB	0.00
Antenna gain (Boeing terminal)	dB	0.00
Propagation loss (LOS)	dB	146.84
Required Range	Km	240.161

Table 2: Calculation of Required Separation Distance between Airborne Boeing Transmitter and Severed Terrestrial UT Operating Co-frequency in Boeing Uplink Band.

Frequency	GHz	2.185
Noise temp (Boeing terminal)	K	200
No (Boeing terminal)	dBW/Hz	-205.59
Interference criteria, Io/No	dB	-12.22
Allowed Io	dBW/Hz	-217.81
Transmit EIRP (terrestrial mobile)	dBW	-10.00
Transmit bandwidth	MHz	1.25
Transmit power density	dBW/Hz	-70.97
Antenna gain (Terrestrial UT)	dB	0.00
Antenna gain (Boeing terminal)	dB	0.00
Propagation loss (LOS)	dB	146.84
Range	Km	240.161
Aircraft altitude	Ft	40000
Elevation angle	Degrees	-3.98
Required separation distance	Km	239.852

[1] Lacking detailed information on the parameters of any proposed independent terrestrial mobile system operating in the 2 GHz MSS downlink band, Boeing used the parameters of the proposed ICO ATC service as an example system.

As indicated in Tables 1 and 2, a severed terrestrial UT operating within Boeing's assigned spectrum would cause significant interference to Boeing's terminals and should not be permitted to operate in MSS downlink frequencies assigned now, or in the future for Boeing's 2 GHz MSS network.

4. Boeing Believes that ATC is Feasible in the 2 GHz MSS Band Subject to Restrictions.

4.1 Boeing Supports ATC Operations in the MSS Uplink Band Subject to Limited Restrictions.

The Commission should authorize the operation of ATC services in the 2 GHz MSS uplink band outside of the spectrum assignments used for Boeing's aeronautical communication services. In authorizing ATC in the uplink band, Boeing urges the Commission to adopt two restrictions. First, a regulatory limit should be imposed on the areal EIRP density of the terrestrial mobile service. The areal EIRP density is the effective aggregate EIRP over a given area of the Earth that the uplink receiver on a satellite would experience. Second, contrary to the apparent suggestion of proponents of severed terrestrial services, no additional constraints should be placed on the OOB emissions of GHz MSS networks in an attempt to reduce OOB interference into terrestrial mobile operations.[2]

4.1.1 Interference Criteria

The first step in assessing the potential for interference from ATC services into MSS networks is to establish interference criteria. Boeing believes that the appropriate criteria for an MSS network that includes ATC is that the combined interference from the terrestrial component and the satellite component of the network should not be permitted to create interference that exceeds a 6 % increase in $\Delta T/T$ for 2 GHz MSS networks operating in adjacent bands. The 6 % limited is a commonly accepted standard for assessing interference between satellite networks.

Boeing has not completed its analysis of how the interference budget should be split between the MSS component and the ATC component. In order to calculate an appropriate limit on areal ERIP density, however, Boeing assumes herein that half of the 6 % $\Delta T/T$ interference criterion has been allocated to the terrestrial component.

Boeing is also still analyzing other factors that must be taken into account when determining an appropriate areal EIRP density limit, such as the anticipated network configuration of MSS systems that include an ATC component. For purposes of this analysis, however, Table 3 provides a sample calculation of the areal EIRP density limit that may be required to protect Boeing's 2 GHz MSS network from the operations of

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[2] *See, e.g., Flexibility for Delivery of Communications By MSS Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band; Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service*, IB Docket No. 01-185, ET Docket No. 95-18, *Ex Parte* Letter of Verizon Wireless, Inc. at 2-3 (Mar. 22, 2002).

terrestrial mobile systems in adjacent portions of the 2 GHz MSS uplink band. Once more information is known about the technical parameters of MSS/ATC networks, Boeing will be in a position to determine whether its proposed areal EIRP density limits will need adjustment.

Table 3: Example Areal EIRP Density Limit

Frequency	GHz	2.005
Noise temperature (Boeing satellite receiver)	K	405
Noise density	dW/Hz	-202.53
Interference criteria (Io/No)	dB	-15.23
Allowed Io	dBW/Hz	-217.75
Range	Km	20187
Propagation loss	dB	-184.58
Polarization isolation	dB	-1.46
Antenna gain (Boeing satellite receive antenna)	dbi	34.8
Transmit EIRP density	dBW/Hz	-66.51
Beamwidth (3dB)	Degrees	3.359
Earth coverage area (edge of coverage beam)	km2	8.31E+06
Areal EIRP density	dBW/Hz-km2	-135.71
Maximum areal EIRP density	**dBW/4 kHz-40k km2**	**-53.67**

4.2 Boeing Does Not Oppose ATC Operations in the 2 GHz MSS Downlink Band as long as the Commission Adopts Adequate Interference Limits to Protect Boeing's Network.

Although Boeing does not oppose the provision of ATC in the 2 GHz MSS downlink band, Boeing has concerns about the interference that could result to Boeing's 2 GHz MSS network. Boeing's first concern is that OOB emissions from terrestrial mobile UTs or base stations operating in adjacent frequency bands could interfere with Boeing's services. Boeing's second concern is the possibility that saturation of Boeing's terminals could occur due to transmit power levels from nearby terrestrial mobile UTs and base stations. It is possible to address these concerns by limiting ATC OOB emissions and maintaining minimum separation between Boeing terminals and ATC UTs and base stations.

4.2.1 OOB Emission Limits

Prior to authorizing ATC to operate in portions of the 2 GHz MSS downlink band, the Commission should impose a limit on the OOB emissions from terrestrial transmitters in order to protect Boeing's receivers operating in adjacent frequency assignments. Imposing OOB emission limits would be especially important in the event that ATC operators design their systems to operate in the downlink duplex sharing mode. Such an arrangement would place both ATC UTs and ATC base stations in the 2 GHz MSS downlink band operating in a half-duplex mode, increasing further the potential for harmful interference into 2 GHz MSS networks.

In order to define an OOB emissions mask, criteria must be developed on the acceptable level of interference that can be imposed on 2 GHz MSS networks. Utilizing an appropriate interference criteria and separation distances, a suitable OOB emissions mask can be developed.

4.2.1.1 Interference Criteria

As indicated above, appropriate criteria for assessing ATC interference into 2 GHz MSS networks would be an increase in $\Delta T/T$ of no more than 6 % resulting from the combination of the MSS and the ATC component of an adjacent network. As in the previous analysis, half of the interference budget, or a 3 % increase in $\Delta T/T$, has been allocated to the ATC component of the combined network for purposes of this analysis.

4.2.1.2 Separation Distance

In addition to establishing an interference criterion, a separation distance must be determined in order to consider the level of interference that will be evaluated. The separation distance needs to be based on practical considerations of the likely minimum distance between users of the two services, both of which involve mobile terminals.

A significant percentage of Boeing's terminals will be affixed to commercial aircraft, which function for large periods of time at airports. It can be anticipated that handheld ATC UTs will be in significant use at airports, just as cellular telephones are today. It is not uncommon to see cell phone users in the terminal building at a height equal to or even above the top of an airplane fuselage. A cell phone user standing in the terminal building near a window has an excellent interference geometry to the Boeing user terminal antenna. Another common situation is the cell phone user walking down the jet-way, or walking across the field and up a boarding ladder to the airplane while talking on a cell phone.

In light of the potential proximity between ATC UTs and Boeing receivers, Boeing believes that a separation distance must be established that accurately reflects these interference conditions. For purposes of this analysis, Boeing has used a separation distance of five meters. Further investigation would be necessary to confirm this figure.

Unlike user terminals, the separation distance for ATC base stations can be controlled by the Commission through the adoption of mandatory minimum separation distances restrictions. In the absence of mandatory separation distances, service providers may seek to install ATC base station antennas directly on airport terminal buildings that are too close to aircraft operational areas. Through the use of mandatory separation distance requirements, however, the distance between ATC base stations and aircraft operational areas at airport facilities can be controlled, thus enabling the adoption of less restrictive OOB limits.

4.2.2 Calculation of OOB Emission Limits

Figure 1 shows the OOB emission limits that would be required as a function of the minimum separation distance between an ATC UT and Boeing's receivers. Using this information, Table 4 shows the OOB emission limit that would be necessary for ATC UTs assuming a minimum separation distance of five meters. The OOB emission limit has been calculated based on interference from a single UT transmitter. The value has then been reduced by 3 dB to account for the aggregate interference from multiple ATC UTs. Of course, the 3 dB adjustment for aggregate interference is dependent in part on the separation distance that is employed in the analysis.

Figure 1: OOB Emission Limits for an ATC UT vs. Minimum Separation Distance between ATC UT and Boeing Receiver on the Ground

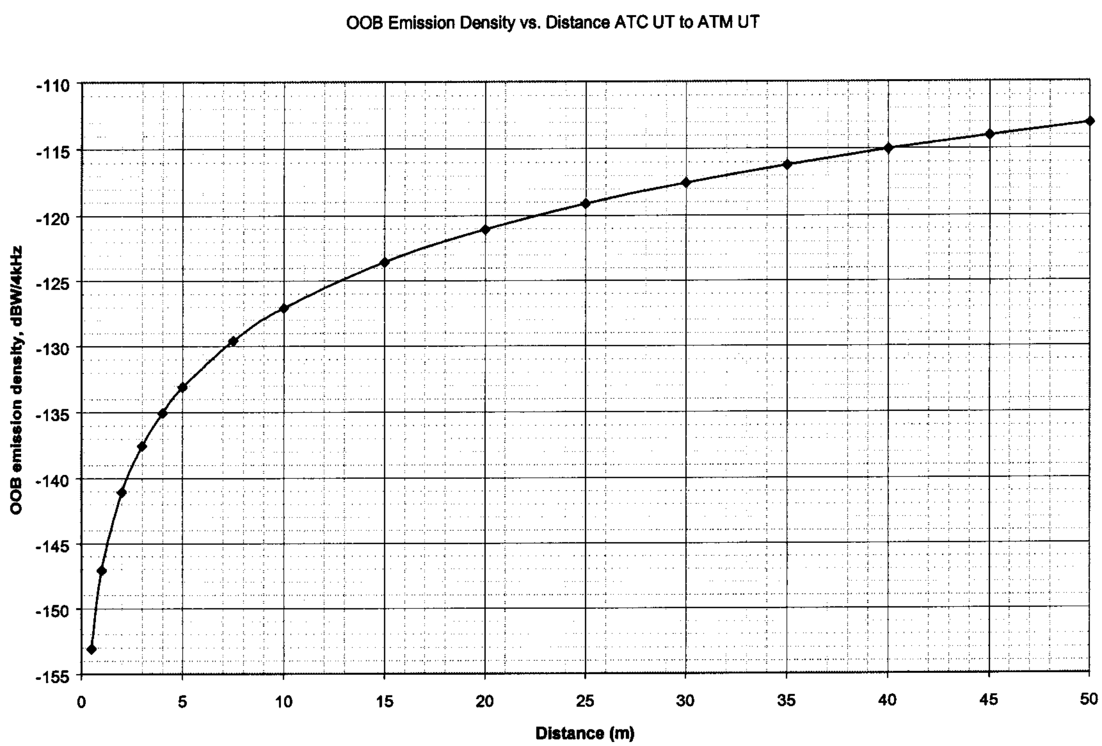

Table 4: OOB Emission Limit for a Terrestrial UT at Five Meters[3]

Frequency	GHz	2.185
Noise temp (Boeing terminal)	K	200
Noise density, No (Boeing terminal)	dBW/Hz	-205.59
Interference criteria, Io/No	dB	-15.2
Allowed Io	dBW/Hz	-220.82
Transmit EIRP	dBW	-10.00
Transmit bandwidth	MHz	1.25

[3] The methodologies used by Boeing to calculate anticipated propagation loss, polarization isolation and antenna gain are described in Annex A.

Transmit power density	dBW/Hz	-70.97
Separation range	M	5.00
Propagation loss	dB	-53.21
Polarization isolation	dB	-1.46
Antenna gain (Boeing terminal)	dB	0.00
Received power density	dBW/Hz	-125.64
Required OOB suppression	dB	95.18
Required OOB emissions level (single interferer)	dBW/4 kHz	-130.13
Aggregate interference factor	dB	-3
Required OOB emissions limit (single interferer)	**dBW/4 kHz**	**-133.13**

Figure 2 shows the OOB emission limits that would be required as a function of the minimum separation distance between an ATC base station and Boeing's 2 GHz MSS receivers. As indicated previously, the separation distance could be largely controlled by the Commission through the adoption of mandatory minimum separation distances in order to ensure that ATC base stations are not placed near the aircraft operational areas of airport facilities. Table 5 shows the OOB emission limit that would be necessary for an ATC base station assuming a minimum separation distance of 200 meters. Boeing believes that if a separation distance is employed that is significantly greater than 200 meters, then additional investigation may be necessary in order to ensure that ATC base stations do not interfere with Boeing terminals affixed to aircraft that are landing or taking off from airports.

The following analysis has been done assuming interference from a single terrestrial base station transmitter. Boeing has not completed a detailed analysis of the aggregate interference that would result due to multiple transmitters. In an attempt to anticipate the aggregate interference from multiple terrestrial base stations, the OOB emission limit that has been calculated for a single interfering transmitter has been reduced by 3 dB. This adjustment for aggregate interference is dependent in part on the separation distance that is used in the analysis.

Figure 2: OOB Emission Limits for an ATC Base Station vs. Minimum Separation Distance between ATC Base Station and Boeing Receiver on the Ground.

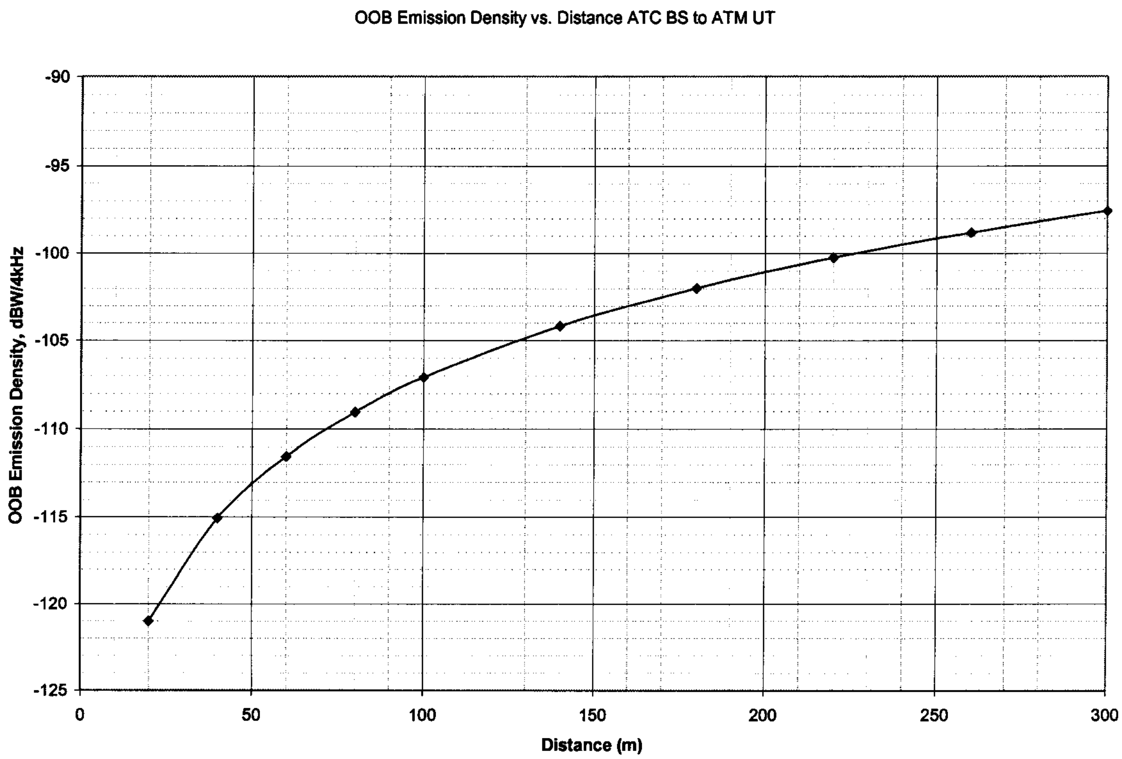

Table 5: OOB Emission Limits for a Terrestrial Base Station at 200 Meters

Frequency	GHz	2.185
Noise temp (Boeing terminal)	K	200
Noise density, No (Boeing terminal)	dBW/Hz	-205.59
Interference criteria, Io/No	dB	-15.2
Allowed Io	dBW/Hz	-220.82
Transmit EIRP	dBW	27.00
Transmit bandwidth	MHz	1.25
Transmit power density	dBW/Hz	-33.97
Separation range	M	200.00
Propagation loss	dB	-85.25
Polarization isolation	dB	-1.46
Antenna gain (Boeing terminal)	dB	0.00
Received power density	dBW/Hz	-120.68
Required OOB suppression	dB	100.14
Required OOB emissions level (single interferer)	dBW/4 kHz	-98.09
Aggregate interference factor	dB	-3
Required OOB emissions limit (multiple interferers)	**dBW/4 kHz**	**-101.09**

4.2.3 Receiver Saturation

Boeing is also concerned about ATC UT or base station transmitters saturating the front end of Boeing's receivers in an adjacent band. The Boeing user terminal receiver needs to be able to tune across the entire available 2 GHz downlink band. The Commission's rules require that Boeing's transceivers must be able to tune across at least 70% of the U.S. 2 GHz MSS allocation.[4] This capability is necessary because 2 GHz MSS licensees have not yet been assigned specific spectrum for their initial operations in the 2 GHz band, and it may be several years before they receive specific assignments for expansion spectrum. Furthermore, portions of the expansion spectrum may not be immediately adjacent to Boeing's initial spectrum assignment. 2 GHz MSS terminals also must be capable of tuning across the band in order to operate in different spectrum segments in different regions of the world (which will be necessary in order to achieve global spectrum coordination). This capability will be particularly important for Boeing's network in order to permit Boeing to place common equipment on aircraft that are used for international flights.

The following analysis shows the required separation distance to avoid saturation of the Boeing receivers. Figure 3 shows the required separation for an ATC UT as a function of Boeing receiver saturation threshold. Table 6 shows the calculation of required separation using a Boeing receiver saturation threshold of –80 dBW, which is the saturation threshold of the receiver as it is currently designed. Boeing is exploring the possibility of making modifications to its receivers. The saturation level of –80 dBW shown in Table 6, however, is the level required for an equivalent Aircraft Earth-Station (AES) receiver at L-band pursuant to standards published by RTCA Inc.

[4] *See* 47 C.F.R. § 25.143(b)(2)(ii) (2001).

Figure 3: Required ATC UT Separation Distance from Boeing Receiver vs. Boeing Receiver Saturation Threshold

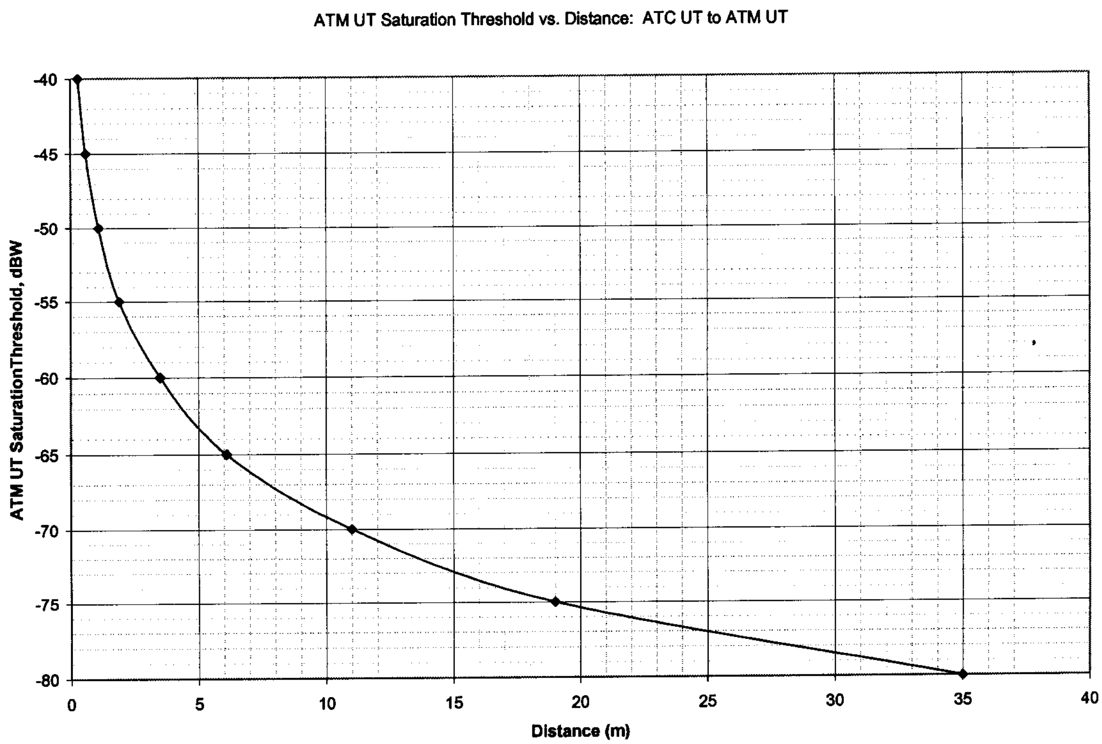

Table 6: Required Separation Distance from Terrestrial User Terminal for a Boeing Receiver With a Saturation Threshold of –80 dBW.

Frequency	GHz	2.185
Terrestrial UT transmit power	dBW	-10.00
ATM saturation threshold	dBW	-80.00
Polarization isolation	dB	-1.46
Antenna gain (Boeing terminal)	dB	0.00
Required path loss	dB	70.00
Required range	**Km**	**0.035**

Figure 4 shows the required separation for an ATC base station as a function of Boeing receiver saturation threshold. Table 7 shows the calculation of required separation using a Boeing receiver saturation threshold of –80 dBW, which is the saturation threshold of the receiver as it is currently designed. As indicated above, Boeing is exploring the possibility of making modifications to its receivers.

Figure 4: Required ATC Base Station Separation Distance from Boeing Receiver vs. Boeing Receiver Saturation Threshold

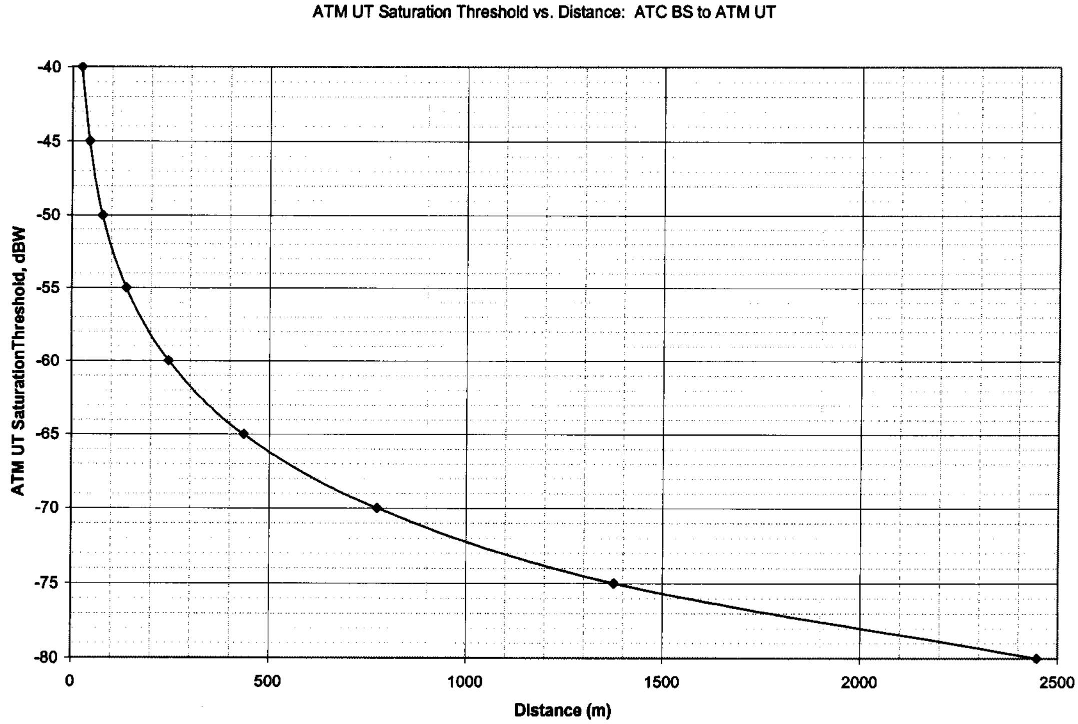

Table 7: Separation Distance from Terrestrial Base Station for a Boeing Receiver With a Saturation Threshold of –80 dBW.

Frequency	GHz	2.185
Terrestrial base station transmit power	dBW	27.00
ATM saturation threshold	dBW	-80.00
Polarization isolation	dB	-1.46
Antenna gain (Boeing terminal)	dB	0
Required path loss	dB	105.54
Required range	**Km**	**2.068**

Boeing has not been able to identify measures that can be taken by ATC providers to resolve the saturation problem, except to reduce the transmit power of the terrestrial service. Measures that Boeing might employ in order to make its receivers less susceptible to front end saturation would appear to result in degraded performance for users and increases in costs for the terminals. Boeing is continuing to investigate whether it would be feasible to develop an alternative design for its terminals that might lessen the interference problem without degrading excessively the performance of Boeing's network and also without increasing unacceptably the cost and weight of its terminals. Thus far, Boeing has not yet identified an acceptable solution. Boeing has developed an internal plan, however, to analyze the problem on an ongoing basis.

One approach that is under consideration is to design a new Boeing receiver with a higher dynamic range that could tolerate a greater power overload at the front end. Boeing is continuing to investigate this option, but will not have an answer for several months. Boeing is concerned, however, that it would likely be difficult to increase the dynamic range of the receiver sufficiently to achieve the levels that would be necessary to prevent saturation of the RF front end for close proximity operation with ATC UTs or base stations. If such an approach does prove to be feasible, it would likely have an impact on both the performance and cost of the Boeing receiver. Boeing is continuing to investigate this option.

Another approach under consideration would be to place a filter at the front end of the Boeing receiver in order to reduce the power from a terrestrial mobile service operating in an adjacent frequency. Such a filter would have to be tunable, so that Boeing's terminals could operate in different spectrum segments in different regions of the world. After some initial investigation, Boeing has been unable to locate an existing filter that could meet Boeing's requirements.

The filters that Boeing has been able to identify have insertion losses of about 1.5 to 2.0 dB. This would materially increase the noise figure of the receiver and would require more transmit power from the spacecraft, potentially at increased cost. Additionally, the tunable filters that Boeing has identified tend to be large (on the order of 10 x 5 x 3 inches) and consume about 50 Watts. This would result in a significant cost and performance burden for each Boeing terminal, particularly with respect to their use in general aviation aircraft. In any event, as indicated above, the filters that Boeing has identified thus far do not provide adequate performance to keep the saturation problem from occurring.

ANNEX A

Interference Analysis Factors

Boeing's interference analysis includes the following assumptions.

Power Control Loss Factor. A power control loss factor is commonly used when investigating the aggregate interference that would result from a large number of UTs. The idea behind the power control loss factor is that not all transmitters will be operating at peak power all the time, and therefore, in the aggregate, the transmit power is less than the power if all the transmitters were operating at their peak. The Boeing analysis considers potential interference from a single mobile transmitter and no power control loss factor is included. Additional analysis is needed to determine the appropriate power control loss factor for a small number of terrestrial mobile transmitters whose aggregate interference potential would be greater than that of a single mobile transmitter.

Voice Activity Loss Factor. The voice activity loss factor is much the same as the power control loss factor. A CDMA system typically reduces its transmit power when the user is not talking. This reduces the total multiple-access interference in a CDMA cell and allows the CDMA system to accommodate a larger number of users. This is only effective if there are a relatively large number of users that are being considered. In the case of a single user, one must consider the maximum transmit power of the terminal. Boeing also excluded a voice activity loss factor because ATC networks may be used for data communications.

Polarization Isolation. Terrestrial mobile systems use vertical polarization, while the Boeing system uses circular polarization. Boeing accounted for this difference in polarization by employing a polarization loss factor of 1.4 dB in its interference analysis. This is the commonly accepted polarization isolation that is utilized in interference calculations involving linear and circular polarized systems.[5]

The polarization isolation between two systems is dependent on the axial ratios of the transmit and receive antennas, and also the relative orientation of the antennas. With respect to a terrestrial mobile UT antenna, the relative orientation of the antenna depends on how it is held. Whenever a UT is held horizontally, the UT transmits a horizontally polarized signal relative to the horizon. Although the orientation of a terrestrial base station antenna can be determined with better certainly, the axial ratio of the base station is not perfectly linear and the axial ratio of the interfered with circular polarization antenna is not pure.

Antenna Gain. In Boeing's analysis, an antenna gain toward the horizon of 0-dBi has been used. This is a nominal value that Boeing believes is justified based on the possible antenna types and mounting configurations that are likely to be employed.

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[5] *See* ITU Radio Regulations, Appendix S8

The Boeing user terminal antenna is designed so that, when mounted on an aircraft, it can communicate with a satellite at elevation angles down to 5 degrees, even during the normal pitch and roll maneuvers of the aircraft. In order to meet this requirement, Boeing's user terminal antennas must provide a reasonable gain at angles of greater than 90 degrees from boresight. In addition, the actual radiation pattern that will result from a Boeing antenna will depend on the type of aircraft that is used. Different aircraft are likely to require different antennas. The radiation pattern of an antenna mounted to the tail of a small aircraft will likely produce a different radiation pattern than an antenna mounted flush on the top of a 747 fuselage.