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International Bureau Seeks Comment on	)	Report No. SPB-196
Proposal to Permit Reducing Orbital Spacings	)	
Between U.S. Direct Broadcast Satellites	)	DA 03-3903

ERRATA

Pegasus Development Corporation hereby submits this errata to correct errors contained in the Technical Appendix submitted with its Comments in this proceeding.[1] Attached as Exhibit A is a complete, corrected copy of the Technical Appendix.

Specifically, Pegasus replaces paragraphs six and seven of section 4.2, page A-4 of the Technical Appendix as follows:

> If the interference from all Tweeners results in an adjacent satellite C/I = 25.66 dB, then the CNR, using the above parameters, is reduced from 9.17 to 9.07 dB, a 0.1 dB degradation (the allowance for rain in this link is 3.7 dB). This corresponds to a single Tweener PFD of -135.0 dBW/m^2/MHz. Thus the Tweener eirp is reduced by 11.4 dB, corresponding to an increase in the size of the subscriber earth station from 45 to 167 centimeters.
>
> If the interference from all Tweeners results in an adjacent satellite C/I = 17 dB, then the CNR is reduced from 9.17 to 8.5 dB, a 0.67 dB degradation (the allowance for rain in this link is 3.7 dB). This corresponds to a PFD limitation, for the above example, of -126.3 dBW/m^2/MHz. Thus, the Tweener eirp is reduced by 2.7 dB, corresponding to an increase in the size of the subscriber earth station from 45 centimeters to 61 centimeters.
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> Improved Tweener signal coding or more coding can improve these results.

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[1] *See* Public Notice, DA 03-3903 (December 16, 2003).

Respectfully submitted,

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Exhibit A

Technical Appendix

INTRODUCTION AND SUMMARY. Pegasus believes that "Tweener" Broadcast-Satellite Service ("BSS") satellites may be interlaced at 4.5 degree spacing with existing BSS satellites, the latter operating in accordance with the Region 2 BSS Plan. Based on principles established for the Fixed-Satellite Service ("FSS") satellites, which operate with 2 degree spacing, it is possible to establish a PFD limitation and subscriber antenna characteristic that will prevent unacceptable interference between a Tweener satellite and BSS satellites operating according to the Plan. Eventually, the Commission should establish a "long-term" BSS PFD limitation (which will result in a small increase in the eirp of all future BSS satellites) enabling all satellites to operate with 4.5 degree spacing without harmful interference. Once all BSS satellites are capable of operating in a 4.5° environment, all Tweener PFD limitations can be lifted.

1.0 REGION 2 BSS PLAN. Region 2 BSS operates with 9 degree spacing, for space systems with overlapping coverage, according to the parameters given in Appendices 30 & 30A of the ITU Radio Regulations. For administrations such as the United States, Canada or Mexico, which have large geographic expanses, the spot and elliptical beams described in the Plan have been replaced by highly contoured wide area beams such as CONUS shaped beams which provide higher gain for regions having higher rain rates. Satellites with spot beams, providing local-into-local service, also are in service. The orbital station assignments and frequency plan of the Region 2 BSS Plan are strictly adhered to.

In Region 2, small, unobtrusive 45 centimeter single beam antennas and slightly larger multibeam antennas have contributed to the success of BSS and are used by millions of households. The QPSK modulation and coding now in use by these receivers cannot easily be changed.

There are two general issues addressed herein, at the request of the Commission. The first issue is the ultimate capability of the BSS to support reduced orbital spacing, maintaining as much as possible the design and operational flexibility inherent in the existing BSS. For this issue, the FCC's goals and rules in establishing 2 degree spacing for the C, Ku and Ka band FSS can be compared with BSS with reduced orbital spacing. It is apparent that, in order to operate between existing BSS satellites, a Tweener satellite must operate with reduced PFD levels. The second issue is what can be done in the long term towards reduced orbital spacing with all BSS satellite systems meeting the same technical characteristics. These two approaches, consisting of both interim and long term solutions, can lead to a substantial increase in the orbital capacity of BSS, perhaps doubling it.

2.0 MODIFICATION OF REGION 2 BSS PLAN. A modified BSS Plan should include an interim phase wherein Tweener satellites are constrained by particular PFD limitations so that adjacent BSS satellites operating according to the current Plan do not receive unacceptable adjacent satellite interference. A subscriber antenna characteristic also is required. However, all new BSS satellites would be required to meet a new BSS PFD for operations in a 4.5 degree environment. Older satellites would be allowed to expire according to their design. Once all BSS satellites are capable of operating in a 4.5 degree environment, any PFD limitation on a Tweener satellite reached through coordination or otherwise can be lifted.

3.0 TECHNICAL CHARACTERISTICS OF ORBITAL SPACING. Some guidance can be obtained by considering FSS experience in the Ka band, compared to what might be obtainable in reducing BSS orbital spacing. First, the adjacent satellite interference in the Ka band FSS with 2 degree spacing is compared to adjacent satellite interference in the Ku band BSS with 4.5 degree and then 3 degree spacing.

3.1 KA BAND FSS WITH 2 DEGREE SPACING. A 66 centimeter antenna, typical for this service, has a gain of 40.6 dBi and a beamwidth of 1.65 degrees at 19.3 GHz. These antennas are required to comply with Part 25.209, however at 2 degree spacing, the mainlobe gain is higher than the sidelobe characteristic of Part 25.209. The resulting C/I, from satellites spaced +/- 2, 4, 6 and 8 degrees away is 15.06 dB, assuming all satellites have the same eirp density performance over CONUS. If the desirable satellite and the adjacent satellites use spot beam antennas an allowance must be made for the case where an adjacent satellite has a beam peak where the desired satellite has a beam minimum (from either a spot beam or CONUS beam). This is controlled with a limiting PFD. *See* 47 C.F.R. § 25.209. In any case, the interfering signals are limited by the PFD specified in Part 25.138. Consequently, FSS satellites making use of conventional technology, such as QPSK and rate 3/4 or 1/2 encoding, or equivalent, must provide more power to overcome the effects of adjacent satellite interference while meeting performance objectives including the 2 degree spacing requirement.

3.2 KU BAND BSS WITH 4.5 DEGREE SPACING. A 45 centimeter antenna, typical for this service, has a gain of 33.5 dBi and a beamwidth of 3.75 degrees at 12.45 GHz. These antennas are not required to comply with Part 25.209, however, close to the mainlobe the Part 25.209 characteristic is met.[1] In any event, at 4.5 degree spacing, the mainlobe gain is higher than the sidelobe characteristic of Part 25.209. Part 25.209 characteristic may be used close in to the sidelobes for orbital spacings between 9 and 18 degrees. The resulting C/I, from satellites spaced +/- 4.5, 9.0 and 13.5 degrees away is 13.8 dB assuming all satellites have the same eirp density performance over CONUS. The C/I value of 13.8 dB is only 1.2 dB lower than the C/I calculated above for the Ka Band FSS with 2 degree spacing, suggesting that 4.5 degree spacing is realizable for the BSS. In the Ka band FSS, additional spacecraft power is needed to overcome the C/I resulting from 2 degree spacing. Similarly, the BSS spacecraft power must be increased to overcome the increased interference caused by 4.5 degree spacing.

Existing BSS satellites do not have the power to completely overcome the added interference caused by the 4.5 degree spacing. All new BSS satellites, however, should be designed to meet these requirements. Thus, Pegasus suggests that ultimately the BSS rules in a 4.5 degree environment would provide for the operation of satellites with uniform performance constraints.

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[1] *See* MITRE Report, Docket No. 98-206, "The Analysis of Potential MVDDS Interference to DBS in the 12.2-12.7 GHz band," Figure 4-8, at page 4-7 (April 2001).

3.3 KU BAND BSS WITH 3 DEGREE SPACING. This analysis follows the analysis described in the previous paragraph for a 4.5 degree orbital spacing and 45 centimeter antenna. At 3 degree spacing, the mainlobe gain is higher than the sidelobe characteristic of Part 25.209. The resulting C/I, from satellites spaced +/-3, 6, 9 and 12 degrees away is 4.5 dB assuming all satellites have the same eirp density performance. This C/I is too low for modulations and coding presently contemplated for the service, that is, for threshhold CNRs around 4 to 5 dB. Thus, it is believed that 3 degree spacing, even for new satellites, when all existing satellites have been retired, cannot result in a workable service, unless there is an unanticipated breakthrough in technology.

3.4 EFFECT OF SATELLITE DRIFT AND SUBSCRIBER ANTENNA MISALIGNMENT. For satellites operating with significant rain margins, these effects on overall performance are virtually negligible and are neglected herein. For example, if an adjacent satellite drifts toward the desirable satellite, the satellite spacing decreases and adjacent satellite interference increases, slightly reducing the rain margin. When the adjacent satellite drifts in the opposite direction the satellite spacing increases and adjacent satellite interference decreases, slightly increasing the rain margin. The overall effect is a negligible decrease in rain margins. The same effect is true for subscriber antenna misalignment, if the misalignment errors are random.

4.0 TWEENER SATELLITES.

4.1 TWEENER SATELLITE IMPLEMENTATION. Tweener satellites that cause no unacceptable interference should be permitted to co-exist between existing BSS satellites. Interference from Tweener satellites can be decreased by implementation of PFD limitations. Such restrictions will be temporary, effective until all BSS space stations can operate at the reduced orbital spacing. A Tweener satellite may be launched as soon as the Region 2 Plan is modified for that satellite. Tweener satellites may continue in use until replaced by satellites meeting the new rules for 4.5 degree spacing and may continue in service even beyond that point. The earliest implementation of reduced orbital spacing with the final rules will occur only when all present BSS space systems, designed to meet the existing BSS rules, have expired.

4.2 EMISSION LIMITATIONS. The eirp of any Tweener satellite to be implemented in the near term must be limited so as not to cause unacceptable interference to the existing BSS satellites, including those BSS satellites of other administrations. Such a limitation could be in the form of a PFD limitation, similar to that specified for the Ka band FSS. *See* 47 C.F.R. § 25.138. The purpose of this section is to recommend how such a limit would be derived, and to give an example, based on a limited set of parameters.

Adjacent satellite interference without Tweeners may be estimated using, as appropriate, the mainlobe characteristic or the antenna characteristic given in Part 25.209, for the sidelobe characteristic near the boresight. Considering satellites at +/-9 degrees and +/-18 degrees from a BSS satellite, the interference due only to the 45 cm subscriber antenna is estimated to be a C/I = 24.9 dB. The interfering satellite's eirp may vary over CONUS relative to the interfered-with satellite, reducing this to a C/I of 22.9 dB or even less.

Tweener satellites spaced +/-4.5 degrees from the interfered-with satellite cause additional interference; the interference to a BSS satellite from identical Tweener satellites spaced 4.5 degrees is substantially higher because, at 4.5 degrees, the interference is received on the mainlobe of the 45 cm antenna. In this case, the C/I caused by Tweeners at +/-4.5 degrees and +/-13.5 degrees is 14.1 dB. Thus, the Tweener satellite eirp needs to be reduced significantly in order not to cause unacceptable interference.

An example can be derived from the BSS application of DirecTV, submitted to the Commission in March, 1999, leading to a licensing order released August 2, 1999. *See* SAT-LOA-19990331-00035 (March 3, 1999).. The effect of adjacent satellite interference from Tweeners is strongly influenced by the individual link assumptions made by the BSS operator regarding such entries as uplink CNR, crosspol and adjacent satellite interference based on 9 degree spacing and many other assumptions. How to deal with this variability can be addressed on a case-by-case basis. The example DirecTV link to Chicago, is presented in Table A-11, page 15 of the application, and is partially repeated here:

Eirp, downlink, dBW	52.7
Rain Loss	3.7 dB (attenuation + sky noise)
Downlink CNR, dB	10.1
CNR, uplink, dB	27.7
Crosspol Interference, dB	18.2
Adjacent Satellite Interference, dB	21.8
Total C/N+I, dB	9.17*

* A 1.1 dB margin is included, presumably for contingencies, a C/N+I = 9.1 dB is listed in the text.

The PFD for Chicago, based on the eirp of 52.7 dBW and 24 MHz bandwidth, is calculated to be -123.59 dBW/m^2/MHz.

If the interference from all Tweeners results in an adjacent satellite C/I = 25.66 dB, then the CNR, using the above parameters, is reduced from 9.17 to 9.07 dB, a 0.1 dB degradation (the allowance for rain in this link is 3.7 dB). This corresponds to a single Tweener PFD of -135.0 dBW/m^2/MHz. Thus the Tweener eirp is reduced by 11.4 dB, corresponding to an increase in the size of the subscriber earth station from 45 to 167 centimeters.

If the interference from all Tweeners results in an adjacent satellite C/I = 17 dB, then the CNR is reduced from 9.17 to 8.5 dB, a 0.67 dB degradation (the allowance for rain in this link is 3.7 dB). This corresponds to a PFD limitation, for the above example, of -126.3 dBW/m^2/MHz. Thus, the Tweener eirp is reduced by 2.7 dB, corresponding to an increase in the size of the subscriber earth station from 45 centimeters to 61 centimeters.

Improved Tweener signal coding or more coding can improve these results.

Differences in eirp performance over CONUS also need to be taken into account. Different modulations and improved coding may be used by a Tweener system (since it is new and can use the latest technology) to reduce its subscriber antenna size.

The Tweener satellite operates in an interference environment which is similar to that of the adjacent BSS satellites. The eirp of each Tweener satellite is limited, to a smaller or larger extent, depending on the link parameter selection made by the Tweener and interfered-with BSS satellite operators and by the rain margin degradation deemed to be acceptable. For example, the interference for the DirecTV satellite is largely affected by the crosspol isolation stated by DirecTV which is only 18.2 dB; if this were larger (better) the allowable Tweener satellite eirp could be increased. In any case, the selection of a PFD limitation for a particular Tweener satellite must consider all of the adjacent BSS satellites now in operation or under construction, including those of other administrations. Differences in point to point eirp also must be taken into consideration.

4.3 BSS PERFORMANCE WITH 4.5 DEGREE SPACING. Ultimately, for a final BSS with 4.5 degree spacing, the satellite eirp, using the satellite parameters given in the previous section, must be increased by 0.7 dB, or 17%, in order to achieve the same performance characteristic (3.7 dB total rain margin and CNR = 9.17 dB) as current BSS satellites. The corresponding adjacent satellite C/I is 13.7 dB, which is obtained by considering neighboring BSS satellites out to +/-18 degrees and considering that the adjacent satellites have similar eirp distribution over CONUS. Thus, it appears that the spacecraft power and cost penalties will be relatively small, compared to the benefits of approximately doubling the total amount of BSS spectrum available. The precise world-wide increase in BSS spectrum is uncertain, because the BSS Plan is complex, deals with overlapping and non-overlapping coverages and partial and full spectrum allocations.

4.4 INTERFERENCE TO OTHER REGION 2 ADMINISTRATIONS. The use of 4.5 degree spacing raises significant additional issues dealing with other administrations. Consistent with current ITU regulations, any new operations must be coordinated with these other administrations.

4.5 OTHER INTERFERENCE. The existing BSS also must accommodate interference caused by potential NGSO and MVDDS systems.

5.0 NEW TECHNOLOGY AND MITIGATION TECHNIQUES. The FCC has requested comments on the use of technology that might influence future satellite orbital spacing. In the past, the FCC, where possible, has refrained from imposing specific technology on operators other than emission limitations and similar rules, in order to encourage new services and the use of new and different technologies. Other than the establishment of PFD limitations and subscriber antenna characteristics, which are not technology specific, the Commission should continue to follow that practice. Following is a discussion of the utility of certain technologies and mitigation techniques relevant to this proceeding.

5.1 COORDINATION OF POWER LEVELS AND FREQUENCIES. It has been suggested by Echostar that administrations of adjacent satellites coordinate the power levels and frequencies delivered to a given area on the ground in order to reduce adjacent satellite interference. For example, if the two satellites had identical antenna coverage patterns and power, then no allowance need be made for eirp differences; only the subscriber antenna characteristics would determine adjacent satellite interference. This would require a high degree of coordination.

5.2 SATELLITE ANTENNA BEAM SHAPING AND POWER ROLL-OFF. Since DBS subscribers are national and intermixed (subscribers of one operator are neighbors to the subscribers of another operator) the same approximate performance must be delivered to each subscriber on a national basis. Other than putting different weights on providing service to subscribers in different rain regions, and small differences in the performance of CONUS beam antennas manufactured by the various manufacturers, there does not appear to be much to gain from this approach. This also involves the Commission in design details that are better left to the operators.

5.3 INTERFERENCE CANCELLATION. If the subscriber antenna also illuminates the adjacent satellites with separate receive beams, the adjacent satellite interference may be subtracted from the desired signal (containing the desired signal plus the interference) the interference can be largely canceled, reducing adjacent satellite interference. Signal cancellation is a well known technique and many examples may be cited in the industry and literature for a number of different applications. Interference reduction comes at the expense of two additional feeds which will increase the antenna cost and further complicate the antenna design and installation. Whether such a technique is suitable for a consumer service is best left to the judgment of the satellite operators.

5.4 BETTER SUBSCRIBER ANTENNA CHARACTERISTICS. It was described above that 2 degree spacing in the FSS with 66 cm antennas and 4.5 degree spacing in the BSS with 45 cm antennas resulted in interception of the adjacent satellites by the main beam of the subscriber antennas. Thus, improved sidelobe characteristics would not be beneficial to the interference received from the adjacent satellites, however, the interference from satellites farther removed also is important. The characteristic described in Part 25.209 might be used for BSS antennas in the vicinity of the boresight, however, the existing designs have backlobes that exceed this characteristic.

Elevation and topographic satellite separation vary with geographic locations around the country and with orbital location relative to the user. While these effects are significant, FSS in the C band, Ku band and Ka band seem to cope well with these variabilities. To date, the BSS also seems to cope with these variabilities so that these variabilities do not seem important enough to impose regulatory limits.

Present subscriber antennas were designed for 9 degree spacing. At 4.5 degree spacing the mainlobe illuminates the adjacent satellite. Increasing the antenna size to 51 centimeters (to achieve $29\text{-}25\text{Log}\theta$ at 4.5 degrees) can increase adjacent satellite isolation by 4 dB. The decision to increase subscriber antenna size to improve isolation is best left to the judgment of each individual operator.

5.5 POLARIZATION AND FREQUENCY OFFSET. If both polarizations are used at an orbital station, then cross polarization cannot be used to increase adjacent satellite isolation. With regard to transponder frequency offsets, the Region 2 transponder frequency assignments in the 12.2-12.7 GHz band can be modified into two plans, one offset by +7.29 MHz and the other offset by -7.29 MHz. Consequently, adjacent satellites would be offset half a channel. The resulting improvement in isolation is not large, approximately 1 dB, because digital signal levels are relatively flat over a bandwidth. But 1 dB can be significant for the ultimate service based on 4.5 degree spacing due to the low values of adjacent satellite interference, C/I, that would be obtained in this scenario. This plan could be made part of the long-term plan to move to 4.5 degree spacing.

Long-term modifications to the Region 2 BSS Plan might also include changing the transponder frequency assignments in the old Plan to a simple spectral assignment as is done in C, Ku and Ka band FSS systems, leaving the transponder channel bandwidth and channel spacing up to the operator. For example, an operator might choose a bandwidth of 36 MHz or even a bandwidth of 250 MHz, thereby eliminating the FDMA format. In the latter case, the interstitial advantage would vanish.

5.6 OTHER MODULATIONS AND CODING. Satellites in the BSS make use of efficient QPSK and Rate 3/4 coding. The coding reduces the data rate but also reduces the threshold CNR which is advantageous in an interference environment. New turbo codes and other codes, used in conjunction with QPSK or 8PSK or other modulations, may have advantages particularly for new BSS or Tweener systems.

5.7 OPERATIONAL COMPLEXITY. Operational complexity can be increased if primary allocations can be made to uplinks instead of shared feederlinks and if orbital assignments, particularly to Tweeners, can be made to operators/administrators who intend to implement space systems.

Technical Certification

I, John Kiesling, Consulting Engineer for Pegasus Development Corporation, hereby certify under penalty of perjury that:

> I am the technically qualified person responsible for preparation of the engineering information contained in the Comments and Technical Appendix, that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted in the Comments and Technical Appendix, and that it is complete and accurate to the best of my knowledge.

John Kiesling

February 11, 2004

Certificate of Service

I, Renee Williams, a secretary with the law firm of Shaw Pittman LLP, hereby certify that copies of the foregoing "**Errata**" were served via courier or Federal Express on this 11th day of February, 2004, to the following:

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