Federal Communications Commission
Washington, D.C. 20554

August 16, 2016

Bruce A. Olcott
Jones Day
51 Louisiana Ave., NW
Washington D.C. 20001

Re: The Boeing Company
IBFS File No.: SAT-LOA-20160622-00058
Call Sign: S2966

Dear Mr. Olcott:

On June 22, 2016, The Boeing Company (Boeing) filed the above-captioned application for authority to launch and operate a non-geostationary orbit (NGSO) fixed-satellite service system. To aid the Commission's evaluation of the application, please provide the following additional information:

1. Section 25.114(c)(4)(vi) of the Commission's rules requires that the applicant provide predicted space station antenna gain contour(s) for each transmit and receive antenna beam, based on the applicable beam characteristics described in paragraphs (B)-(D) of Section 25.114(c)(4)(vi).[1] These diagrams are to be provided as file attachments to the FCC Form 312, Schedule S.[2] Accordingly, please provide a separate beam diagram file for each such transmit and receive beam, consistent with the applicable requirements specified in Section 25.114(c)(4)(vi)(B)-(D), and as discussed in the questions below.

2. Section 25.114(c)(4)(vi)(B) of the Commission's rules further requires that for space stations in non-geostationary orbits, that the applicant specify for each unique orbital plane, the predicted antenna gain contour(s) for each transmit and receive antenna beam for one space station if all space stations are identical in the constellation.[3] If individual space stations in the constellation have different antenna beam configurations, the applicant must specify the predicted antenna gain contours for each transmit and receive beam for each space station type and orbit or orbital plane requested.[4] It is not clear from Boeing's application whether all space stations in the constellation are identical or whether different antenna beam configurations are proposed for individual satellites. Accordingly, please provide the appropriate set of beam diagrams for the system architecture that Boeing intends, and clarify the following:

    - The five example beams discussed in the narrative section beginning on p. 7 of Boeing's application are described as "illustrating the typical beam contours in an example coverage area".[5] Please explain whether additional beam configurations are possible, whether the

[1] 47 CFR § 25.114(c)(4)(vi).

[2] *See* 47 CFR § 25.114(c).

[3] 47 CFR § 25.114(c)(4)(vi)(B).

[4] *Id.*

[5] The Boeing Company, IBFS File No. SAT-LOA-20160622-00058, Application at 7-17 (Boeing Application).

beams are all identical on each satellite, and specify how many beams are possible for each satellite.

- Two example beam widths are presented, *i.e.*, typical spot beams for the smallest diameters (approximately 8-11 km) and a larger-diameter beam (approximately 21 km).[6] Do these beam diameters represent the only two possibilities? Are even larger or smaller diameter beams planned? To what extent might the satellite's beams be otherwise shaped?

3. Section 25.114(c)(4)(vi)(C) of the Commission's rules requires that applicants proposing space stations with shapeable antenna beams specify the contours, as defined in 25.114(c)(4)(vi)(B), for the transmitting beam configuration that results in the highest equivalent isotropically radiated power (e.i.r.p.) density for the beams listed in 25.114(c)(4)(ii) and for the receiving beam configuration with the smallest gain-to-temperature ratio (G/T) and the highest required saturation power flux density for the beams listed in 25.114 (c)(4)(v).[7] If the shapeable beams are also steerable, 25.114 (c)(4)(vi)(C) requires that the applicant include the contours that would result from moving the beam peak around the limit of the effective beam peak area and the 0 dB relative antenna gain isoline.[8] The proposed maximum coverage area must be clearly specified.[9] It is not clear from the examples provided in Boeing's application to what extent the beams it proposes may be considered to be shapeable.[10] Please clarify to what extent this provision may be applicable to Boeing's satellites and provide the appropriate beam diagram information. In particular, please verify that the information provided represents the worst-case EIRP density in the case of the transmitting beams and the worst case G/T for the receiving beams.

4. If necessary, please provide an amended FCC Form 312, Schedule S to correct any information in Schedule S Tables S7 through S10 that may be required as a result of changes to the antenna beam contour information provided.[11]

5. Please clarify whether the example beams provided at 36.5° off-nadir represent the extremes of pointing and explain over what range the beams may be steered.[12]

6. Please explain how many simultaneous beams might cover a single cell on the ground and whether this might occur from the same satellite and/or from multiple satellites.[13]

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[6] *Id.* at 7.

[7] 47 CFR § 25.114(c)(4)(vi)(C).

[8] *Id.*

[9] *Id.*

[10] Section 25.103 of the Commission's rules defines a "shapeable antenna beam" as a "satellite transmit or receive antenna beam, the gain pattern of which can be modified at any time without physically repositioning a satellite antenna reflector." 47 CFR § 25.103.

[11] *See* The Boeing Company, IBFS File No. SAT-LOA-20160622-00058, Schedule S, items S7-S10.

[12] *See* Boeing Application at 7.

[13] *See id.* at 7-17.

7. Section 25.114(d)(14) of the Commission's rules further requires that the applicant provide a description of the design and operational strategies that will be used to mitigate orbital debris.[14] Please provide the following additional information and clarifications with respect to orbital debris mitigation to enable the Commission evaluate whether grant of the application is in the public interest:

   - In the orbital debris analysis on p. 34 of its Application, Boeing estimates that each satellite would need to perform 1.6 collision avoidance maneuvers per vehicle-year.[15] Please clarify what assumptions were included in this analysis, and in particular whether the satellite constellation proposed by WorldVu Satellites Limited (WorldVu) was taken into consideration. If not, please provide an estimate of the number of maneuvers that would be required taking into account the WorldVu constellation. For purposes of the analysis, and as a simplifying assumption, please assume that the WorldVu constellation will not undertake collision avoidance maneuvers as a result of conjunctions with the proposed Boeing satellites.

   - Boeing states further that it would work with WorldVu to develop an analysis of the potential risk of collision.[16] Please describe what contact with WorldVu has been made to date and what approaches to coordination have been discussed.

   - Please describe any steps Boeing, either individually or jointly with WorldVu, has taken to analyze the level of data-sharing that would be required between the two operators, such as through analyzing likely requirements for ephemeris refresh rates and time frames for coordination of planned maneuvers.

   - Please provide information, as described in 25.114(d)(iii), regarding the accuracy to which the NGSO space station orbital parameters will be maintained, including apogee, perigee, inclination, orbital altitude, and right ascension of the ascending node(s).[17]

   - Please discuss whether alternative orbital altitudes might be considered for the constellation, and clarify whether an alternative altitude or altitudes would materially affect Boeing's ability to provide service.

   - On p. 35 of the Application, Boeing states that its standard design practices would provide sufficient redundancy to ensure a high reliability of successful deorbit for all satellites.[18] Please state whether Boeing will meet the reliability metric of 90 percent as described in the technical standards developed by NASA,[19] and specify how high Boeing's deorbit reliability

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[14] 47 CFR § 25.114(d)(14).

[15] Boeing Application at 34.

[16] *Id.*

[17] 47 CFR § 25.114(d)(14)(iii).

[18] Boeing Application at 35.

[19] *See* NASA Technical Standard, Process for Limiting Orbital Debris, NASA-STD-8719.14A (with Change 1) (May 25, 2012), http://www.hq.nasa.gov/office/codeq/doctree/871914.pdf (*NASA Standard*).

value is anticipated to be. Please clarify how many satellites will not be expected to achieve successful atmospheric reentry in five years following the end of the spacecraft mission, based on reliability targets.

- Boeing further states that the probability of collision for the vehicle during the disposal process was determined to be less than $1.3x10^{-4}$, as calculated using the NASA Debris Assessment Software (DAS).[20] Please clarify whether this was an individual probability per spacecraft, or if it was calculated for the constellation as a whole. Please provide details as to the input assumptions that were used to run the NASA DAS.

- Please calculate the collision risk for any satellites that fail during any other phases of operations, including: immediately at orbital insertion; during transit to or from the mission orbit (using representative or worst case assumptions); and on-orbit (at each of the three orbital altitudes specified in the application). .

- With regard to the risk for human casualties from disposal by atmospheric reentry, on p. 35 of the Application, Boeing states that it performed a preliminary assessment using the NASA DAS to determine that the risk of human casualties would be less than 1 in 10,000.[21] Please provide that assessment. Further, please provide an aggregate risk value for the constellation as a whole based on that assessment.

To facilitate the Commission's timely evaluation of Boeing's application, we ask that you provide the requested information no later than September 16, 2016.

Sincerely,

Jose Albuquerque

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International Bureau

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[20] Boeing Application at 35.

[21] *Id.*