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November 10, 2004

By Hand

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th St., S.W.
Washington, DC 20554

Re: Orbital Debris Mitigation; SkyBridge L.L.C., Application for Authority to Launch and Operate the SkyBridge Satellite System – File Nos. SAT-LOA-19970228-00021; SAT-AMD-19970703-00058; SAT-AMD-19980630-00056; SAT-AMD-19990108-00004; SAT-AMD-20020917-00167; SAT-AMD-20040719-00135; Call Sign S2241.

Dear Ms. Dortch:

This letter is written on behalf of SkyBridge L.L.C. ("SkyBridge"), in response to a letter from Thomas Tycz to the undersigned, dated October 1, 2004 (the "FCC Letter").[1] The FCC Letter requested that SkyBridge provide certain additional details on its orbital debris mitigation plan for the SkyBridge satellite system. SkyBridge provides the requested information below.

The Commission requested a statement as to whether SkyBridge has assessed and limited the probability of its satellites becoming a source of debris by collision with large debris or other functioning satellites. As noted in its application, SkyBridge has every economic incentive to ensure the robustness of its spacecraft

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[1] Letter from Thomas S. Tycz, Chief, Satellite Division, to Jeffrey Olson, File Nos. SAT-LOA-19970228-00021; SAT-AMD-19970703-00058; SAT-AMD-19980630-00056; SAT-AMD-19990108-00004; SAT-AMD-20020917-00167; SAT-AMD-20040719-00135, dated October 1, 2004. *See also* Letter from Jeffrey H. Olson to Marlene H. Dortch, Secretary, dated October 14, 2004, File Nos. SAT-LOA-19970228-00021, *et al.*; Letter from Jeffrey H. Olson to Marlene H. Dortch, Secretary, dated October 21, 2004, File Nos. SAT-LOA-19970228-00021, *et al.*

design to prevent loss of valuable assets.[2] SkyBridge has assessed the risk of collision and the design of the satellites to ensure that the risks of collision with debris or operating satellites do not pose an unreasonable risk to the physical integrity and operation of its satellites. Furthermore, as discussed below, SkyBridge plans to implement an active monitoring regime that examines the trajectories of other satellites and objects on an ongoing basis, so that, in the event of a collision threat, emergency maneuvers can be employed to avoid that potential collision. In addition to protecting the SkyBridge investment, such measures will also help limit the probability that its satellites will become a source of debris.

SkyBridge knows of no other NGSO system operating satellites sufficiently close (taking into account apogee, perigee, inclination, RAAN and stationkeeping tolerance) to the SkyBridge orbit (1469.3 km) to pose a systematic threat of collision due to overlapping orbital volumes. Nor is SkyBridge aware of any such proposed NGSO system that is: (1) licensed by the Commission or any other administration; (2) the subject of a pending application before the Commission; or (3) the subject of an ITU filing and progressing toward implementation. If such a system were to be implemented, SkyBridge would, of course, coordinate its physical operations with the operator of such system to avoid any potential collision.

Further, in the event of a satellite or other object passing through or near the orbit of any SkyBridge satellite, the monitoring procedures noted above will enable SkyBridge to avoid a collision. This system works as follows: Two Line Element (TLE) data from the NORAD system is obtained twice per week, and propagated one week in advance to predict possible collision scenarios. Whenever a satellite or other object is predicted to come closer than 1.5 km from a protected satellite, an alarm is generated, so that the potentially affected SkyBridge satellite can be maneuvered out of harm's way as necessary. Such small maneuvers will not adversely affect the operational mission of SkyBridge or other systems. It should be noted that this approach currently is employed by the French Centre National d'Études Spatiales (CNES) with regard to the Spot satellites.

The Commission also requested clarification regarding the tolerance, during operational life of the satellites, to which certain orbital parameters will be maintained. These tolerances are summarized in the following table:

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[2] *See* SAT-AMD-20020917-00167, Exhibit C at 8.

Orbital Parameter[3]	**Tolerance**
Apogee	Δa = 20 m, where a is the semi-major axis[4] $\Delta e = 2 \times 10^{-5}$, where e is eccentricity
Perigee	Δa = 20 m, where a is the semi-major axis $\Delta e = 2 \times 10^{-5}$, where e is eccentricity
Inclination	$\Delta i = 1.5 \times 10^{-4}$ deg., where i is inclination
Right ascension of the ascending node (RAAN)	$\Delta\Omega = 1.5 \times 10^{-2}$ deg., where Ω is RAAN
Satellite phasing	$\Delta\alpha$ = 0.1 deg., where α, the phasing, is the true anomaly difference between two adjacent satellites on two adjacent planes[5]

In practice, α is the parameter that experiences the greatest variation. When the stationkeeping constraint is nearing violation, α is corrected by a maneuver modifying the semi-major axis "a".

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[3] *See* SAT-AMD-19990108-00004, at A-15-17 for details on the SkyBridge constellation orbital parameters.

[4] The apogee and perigee altitudes (h_a and h_p, respectively) can be converted to semi-major axis and eccentricity (a and e, respectively), and vice versa, via the formulas:

$$a = (R_a + R_p)/2 = (h_a + h_p)/2 + R_e$$
$$e = (R_a - R_p)/(R_a + R_p) = (h_a - h_p)/(h_a + h_p + 2R_e)$$

where:

R_e = earth radius = 6378.14 km
R_a = apogee radius = $R_e + h_a$
R_p = perigee radius = $R_e + h_p$

In the case of the SkyBridge constellation, $h_a = h_p$ =1469.3 km; a = 7847.44 km; and $e = 8 \times 10^{-4}$ (the eccentricity is never exactly zero in a real orbital system due to the earth's ellipticity).

[5] The tolerance is the same for both phasing (true anomaly difference between two satellites on the same plane (same RAAN)) and relative phasing (true anomaly difference between two adjacent satellites on two adjacent planes (different RAAN)). The phasing and relative phasing for the SkyBridge constellation are 90° and 67.5° respectively.

As the Commission noted, SkyBridge has previously indicated that SkyBridge will maintain stationkeeping to within 0.1°.[6] This tolerance refers essentially to the tolerance for $\Delta\alpha$, the source of the greatest variation, as noted in the table above. More precisely, it refers to the condition $\sqrt{(\Delta\alpha + \Delta\Omega\cos i)^2 + \Delta i^2 + (\Delta\Omega \sin i)^2} < 0.1\,\text{deg}$, where $\Delta\alpha = \Delta\alpha_o + 2\,\Delta e$, and $\Delta\alpha_o$ is the mean and long term periodic evolution of the true anomaly, and $2\,\Delta e$ is the short maximal amplitude of the periodic term evolution of the true anomaly coming from the eccentricity evolution. However, as noted above, in practice the term $\Delta\alpha$ dominates the equation, and leads to the need for orbital correction.

If there are any questions regarding this matter, please contact the undersigned.

Respectfully submitted,

Jeffrey H. Olson
Diane C. Gaylor

Attorneys for SkyBridge L.L.C.

cc: Thomas Tycz
Sankar Persaud
Karl Kensinger

[6] *See* SAT-AMD-20020917-00167, Exhibit C at 8.