Exhibit C to Form 312

PART I: Demonstration of Compliance with Validation EPFD Limits

The following demonstration is provided pursuant to Sections 25.146(a) and 25.146(h)(3) of the Commission's Rules, which require a technical showing demonstrating that the proposed NGSO FSS system will not exceed the validation equivalent power flux-density ("EPFD") limits ($EPFD_{down}$ and $EPFD_{up}$) in Sections 25.208(g),(k), and (l) (the "Validation Limits").

As indicated below, much of the data for this showing is contained on two CD ROMs (the "SkyBridge CD ROMs") – labeled "SkyBridge Demonstration of Compliance with Validation EPFD Limits, September 16, 2002" and "SkyBridge Validation Software Executable Code, September 16, 2002"– which are being submitted to the Commission via hand-delivery in conjunction with this Amendment.

§ 25.146(a)(1) $EPFD_{down}$

§ 25.146(a)(1)(i) Downlink PFD Masks

The SkyBridge CD ROMs contain a set of power flux-density ("PFD") masks, on the surface of the Earth, for each space station in the NGSO FSS system, generated in accordance with ITU-R Recommendation BO.1503. As required by Section 25.146(a)(1)(i), these masks "encompass the power flux-density radiated by the space station regardless of the satellite transmitter power resource allocation and traffic/beam switching strategy that are used at different periods of a NGSO FSS system life." They are provided in a form that can be assessed by the computer program being provided pursuant to Section 25.146(a)(1)(iii).

§ 25.146(a)(1)(ii) Assumptions Used in Generating the PFD Masks

The assumptions and conditions used in generating the PFD masks (and computing the $EPFD_{down}$ results) are those contained in ITU-Recommendation BO.1503, and are included in the SkyBridge CD ROMs. No other assumptions are required.

§ 25.146(a)(1)(iii) Software

As the Commission knows, the ITU intends to develop and test a software tool to be used for its determination of compliance with the Validation Limits. This software is not yet available. However, the ITU software is not needed in order to demonstrate compliance with the Validation Limits. Indeed, the terms of Section 25.146(a)(1)(iii) contemplate that applicants may employ their own software, so long as

the software is based on the specification contained in ITU-R Recommendation BO.1503. This is what SkyBridge has done.

An executable version of the software used by SkyBridge for the single-entry $EPFD_{down}$ validation computation is contained on the SkyBridge CD ROMs. The software has two components – the first is used to generate the PFD masks from the input data, and the second is used to compute the EPFD levels from the PFD masks and orbital parameters of the system. This software is in full accordance with ITU-R Recommendation BO.1503 in all respects.

The source code for this software, which was developed for SkyBridge by a commercial software vendor, contains highly proprietary information. SkyBridge is not permitted, by the terms of its agreement with this vendor, to publicly disclose the source code. SkyBridge has therefore submitted the source code separately to the Commission, along with a request for confidential treatment pursuant to Section 552(b)(4) of the U.S. Code, and Sections 0.457(d) and 0.459 of the Commission's Rules.[1] In addition, in Exhibit B, SkyBridge requests a waiver of the requirement that each applicant provide the source code for its software, in the event that the Commission finds the submission in any way deficient.

§ 25.146(a)(1)(iv) Input Parameters to Software

The necessary input parameters for the execution of the software identified above are contained on the SkyBridge CD ROMs.

§ 25.146(a)(1)(v) Results

Using the above-cited PFD masks and input parameters, the worst case test point for the SkyBridge system for each of the $EPFD_{down}$ Validation Limits was computed using the software indicated above. The results are included on the SkyBridge CD ROMs. The results demonstrate that the SkyBridge system fully meets the $EPFD_{down}$ Validation Limits according to the compliance methodology developed by the ITU.

The Commission's Rules require additional results, not required or contemplated by the ITU software specification contained in ITU-R Recommendation BO-1503. As SkyBridge has demonstrated, these requirements are therefore ambiguous in their interpretation. Moreover, even if an interpretation is assumed by an applicant, the software was not designed to perform the requested computations, making the required showings impractical. SkyBridge has filed a Petition for Reconsideration of these rules (the "SkyBridge Petition for Reconsideration"), which remains pending.[2] In Exhibit B, SkyBridge requests waivers of these rules.

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1 5 U.S.C. § 552(b)(4); 47 C.F.R. § 0.457(d); 47 C.F.R. § 0.459.

2 *See* Petition for Reconsideration, SkyBridge L.L.C., ET Docket 98-206, RM-9147, RM-9245, March 19, 2001 (the "SkyBridge Petition for Reconsideration"). *See also*

In particular, Section 25.146(a)(1)(v) requires results indicating the $EPFD_{down}$ for the worst 3 test points in the United States, and the $EPFD_{down}$ for the worst 3 test points on each continent, except Antarctica, outside of the U.S. As SkyBridge explained in its Petition for Reconsideration, ITU-R Recommendation BO-1503 does not contain a definition for the "worst three test points" in terms of EPFD statistics, which are represented by curves specifying maximum power levels for any given percentage of time.[3] Following lengthy technical discussions, the ITU-R study groups reached an agreement on a definition of the single "worst-case" configuration (in terms of GSO location and pointing direction), anywhere in the world, at which the compliance test should be performed. The Commission's rule is therefore indefinite, and open to multiple interpretations.

Moreover, as a result of the ITU working group decision to determine only the worst-case location worldwide, the software specification contains a procedure only for determining that location.[4] The software specification cannot be readily used to determine the worst-case location over any sub-territority, or the second and third worst-cases either worldwide or over any sub-territory. In order to determine the three worst case test points over the U.S., for example, an applicant would have to use the software to compute the $EPFD_{down}$ *at every geographical location in the United States* in order to determine the three worst-case points.[5] Computing $EPFD_{down}$ at a single location currently takes SkyBridge many hours of computation time. The density of test points needed to pinpoint accurately the worst-case points leads to computations that would take months. Moreover, the lack of a standard procedure for this computation (such as the density of points that must be examined) leaves any results open to dispute. For the above reasons, SkyBridge requested reconsideration of these requirements.

Nevertheless, in an effort to provide additional information to the Commission of the type sought by its rules, SkyBridge provides, on the SkyBridge CD ROMs, results for 11 additional points throughout the world. These results correspond to locations that were determined during testing of the software to be among the worst-case locations for the SkyBridge system. However, because these points were located based on a relatively small sampling of locations world-wide (about 150, due to the lengthy run-time of the software for each point), SkyBridge can make no claim that it has captured the second and third worst-cases worldwide, or in any sub-territory. The information is provided solely for illustration purposes.

It must be noted that with the software and input parameters contained on the SkyBridge CD ROMs, any other interested party may perform the kinds of

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Ex Parte Presentation of SkyBridge, ET Docket No. 98-206, June 18, 2002 (the "SkyBridge *Ex Parte*").

3 SkyBridge Petition for Reconsideration at 30-31; *see also* SkyBridge *Ex Parte* at 14-15.

4 *See* SkyBridge *Ex Parte* at 15-16.

5 *See* SkyBridge *Ex Parte* at 16.

computations made by SkyBridge for this Amendment. This could include samplings over given sub-territories, or computations for specific geographical points of interest. SkyBridge would be pleased to assist any such party, and the Commission in particular, in making such computations.

§ 25.146(a)(2) $EPFD_{up}$

§ 25.146(a)(2)(i) Uplink EIRP Masks

The SkyBridge CD ROMs contain a set of NGSO FSS earth station maximum equivalent isotropically radiated power ("EIRP") masks as a function of the off-axis angle generated by a NGSO FSS earth station, generated in accordance with ITU-R Recommendation BO.1503. As required by Section 25.146(a)(2)(i), these masks "encompass what would be radiated regardless of the earth station transmitter power resource allocation and traffic/beam switching strategy are used at different periods of a NGSO FSS system life." These masks are provided in a form that can be assessed by the computer program being provided pursuant to § 25.146(a)(2)(iii).

§ 25.146(a)(2)(ii) Assumptions Used in Generating the EIRP Masks

The assumptions and conditions used in generating the EIRP masks (and computing the $EPFD_{up}$ results) are those contained in ITU-Recommendation BO.1503, and are included on the SkyBridge CD ROMs. No other assumptions are required.

§ 25.146(a)(2)(iii) Software

An executable version of the software used by SkyBridge for the single-entry $EPFD_{up}$ validation computation is contained on the SkyBridge CD ROMs. The software has two components – the first is used to generate the EIRP masks from the input data, and the second is used to compute the $EPFD_{up}$ levels from the EIRP masks and orbital parameters of the system. This software is in full accordance with ITU-R Recommendation BO.1503 in all respects.

As discussed above, the source code for this software contains highly proprietary information, and SkyBridge has submitted the source code separately, along for a request for confidential treatment. In addition, in Exhibit B, SkyBridge requests a waiver of the requirement that each applicant provide the source code for its software, in the event that the Commission finds the submission in any way deficient.

§ 25.146(a)(2)(iv) Input Parameters to Software

The necessary input parameters for the execution of the computer program are contained on the SkyBridge CD ROMs.

§ 25.146(a)(1)(v) Results

Using the above-cited EIRP masks and input parameters, the worst case test point for the SkyBridge system for the $EPFD_{up}$ Validation Limits was computed using the software indicated above. The results are included on the SkyBridge CD ROMs. The results demonstrate that the SkyBridge system fully meets the $EPFD_{up}$ Validation Limits according to the compliance methodology developed by the ITU.

As in the case of the $EPFD_{down}$ limits, the Commission's Rules require additional results, not contemplated by the ITU software specification contained in ITU-R Recommendation BO-1503. The pending SkyBridge Petition for Reconsideration also seeks reconsideration of these rules. In Exhibit B, SkyBridge requests waivers of these requirements.

In particular, the Commission's Rules require $EPFD_{up}$ for every longitudinal location on the GSO orbit at every two-degree spacing that is visible to the U.S. for domestic service, and $EPFD_{up}$ for every longitudinal location on the GSO orbit at every three-degree spacing for service outside the U.S. As SkyBridge explained in its Petition for Reconsideration, ITU-R Recommendation BO-1503 does not contain a definition for the "worst-case" at specific points along the arc.[6] It is not clear how the definition should be extended to cover these cases (including, for example, what satellite coverage should be considered), and therefore the rule is open to multiple interpretations.

Moreover, as a result of the ITU working group decision to determine only the worst-case $EPFD_{up}$ for any orbital location, the software specification contains a procedure only for determining that location. The software specification cannot be readily used to determine the worst-case result for any particular orbital location. In order to determine the worst case test point for a particular orbital location, an applicant would have to use the software to compute the $EPFD_{up}$ for every location on earth to which a satellite at that location might point.[7] Computing $EPFD_{up}$ at a single location currently takes SkyBridge over a day of computation time. The density of test points needed to pinpoint accurately the worst-case points leads to computations that would take months. Moreover, the lack of a standard procedure for this computation (such as the density of points on the ground that must be examined) leaves any results open to dispute. For the above reasons, SkyBridge requested reconsideration of these requirements.

As discussed above, with the software and input parameters contained on the SkyBridge CD ROMs, any other interested party may perform $EPFD_{up}$ computations for particular configurations of interest. SkyBridge would be pleased to assist any such party, and the Commission in particular, in making such computations.

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6 SkyBridge Petition for Reconsideration at 30.

7 *See* SkyBridge *Ex Parte* at 17.

PART II: Additional Technical Information Required by Commission's Rules

§ 25.146(h)(1) and (2) Geographic Coverage

As demonstrated in SkyBridge's January 8, 1999 Amendment, the constellation parameters of the SkyBridge system permit continuous service to users between the ± 72° latitudes, assuming a gateway is appropriately located to take advantage of this capability.[8]

The northernmost point of the United States is Point Barrow, Alaska, at a latitude of 71.3° North. Therefore, the SkyBridge system is capable of providing FSS service on a continuous basis throughout the fifty states, Puerto Rico and the U.S. Virgin Islands. It is also capable of providing service to all locations as far north as 70 deg. latitude and as far south as 55 deg. latitude for at least 75 percent of every 24-hour period. The SkyBridge system therefore complies with Section 25.146 (h)(1) and (2).

§ 25.146(h)(3) Information on System Modeling

Section 25.146(h)(3) requires submission of "sufficient information on the NGSO FSS system characteristics to properly model the system in computer sharing simulations," including, at a minimum:

- hand-over and switching strategies
- satellite beam patterns
- satellite antenna patterns
- earth station antenna patterns

The above parameters are inputs to the validation software discussed in Part I of this Exhibit C. In particular, the hand-over and switching strategy used by SkyBridge in its computations corresponds to that specified by ITU-R Recommendation BO.1503, which assumes use of the worst-case beam configuration at all times.[9] The satellite beam and

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[8] *See* SkyBridge Amendment, January 8, 1999, File No. SAT-AMD-1999-0108-00004, at A-17-18 and Figure IV-8.

[9] As discussed in comments of SkyBridge in relevant proceedings, *see, e.g.,* Comments of SkyBridge, IB Docket No. 01-96, July 6, 2001, at 27, the hand-over and switching strategies employed by an operating system change with time as traffic patterns evolve, and contain highly-proprietary information related to the commercial service being provided. Therefore, the specific beam configurations that will be used at any given time cannot be provided for purely practical reasons, and should not be required to be publicly disclosed for reasons of confidentiality. For this reason, Recommendation ITU-R BO.1503 employs assumes worst-case switching, *i.e.*, it

antenna patterns are contained on the SkyBridge CD ROMs. The earth station antenna patterns are inputs to the software and are also discussed in the SkyBridge Application filings.[10]

Section 25.146(h)(3) also requires explanation of the "switching protocols" used to avoid transmission to the GSO arc. As SkyBridge explained in its original Application, the SkyBridge system employs a "non-operating zone" to protect the GSO arc. This zone spans ±10° on either side of the GSO arc as seen by any earth station in the gateway cell. The approach of a satellite toward the non-operating zone of any earth station with which the satellite is in communication is one of the triggers for switching traffic to another satellite (other triggers include the existence of another satellite with a better elevation angle, and local environmental blockage), and one of the techniques employed by the system for complying with the $EPFD_{down}$ and $EPFD_{up}$ limits applicable to NGSO FSS systems.[11]

Section 25.146(h)(3) requires submission of the orbital parameters contained in Section A.3 of Annex 1 to Resolution 46. These are input parameters to the validation software discussed in Part I of this Exhibit C, and are contained on the SkyBridge CD ROMs.

Finally, Section 25.146(h)(3) requires "a sufficient technical showing that the proposed non-geostationary satellite orbit system meets the power-flux density limits contained in Section 25.208, as applicable." Such a showing is contained in Part I of this Exhibit C, with respect to the Validation Limits. Demonstration of compliance with limits contained in Section 25.208 other than the Validation Limits (i.e., the "operational limits," the "additional operational limits," and the "aggregate limits") is not required at the application stage, according to the explicit terms of Section 25.146(b).[12]

§ 25.146(h)(4) Orbital Debris Mitigation

Section 25.146(h)(4) requires a demonstration of the strategies that will be used to mitigate orbital debris, including a casualty risk assessment if planned post-mission disposal involves atmospheric re-entry of the spacecraft.

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employs that configuration of beams that leads to the worst-case result at any given time.

10 *See* SkyBridge Amendment, July 3, 1997, File No. 89-SAT-AMEND-97, at 7.

11 *See* SkyBridge Application, February 28, 1997, File No. 48-SAT-P/LA-97, at 24-27, 68-70

12 With respect to the "aggregate limits," *see also* The Establishment of Policies and Service Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band, *Report and Order and Further Notice of Proposed Rulemaking*, IB Docket No. 01-96 (FCC 02-123, Apr. 26, 2002), ¶¶ 92-98.

The following discussion is based upon the U.S. Government guidelines (the "Government Standard Practices") applied to U.S. Government missions, which SkyBridge intends to follow.[13] In the Government Standard Practices, four separate scenarios in which orbital debris may be created are identified. SkyBridge discusses how it plans to address each of those scenarios below.

Control of Orbital Debris Released During Mission Operations

As is typically the case with communications payloads, it is anticipated that operation of the spacecraft will require no purposeful release of debris, in the absence of accidental explosions or collisions.

Minimizing Debris Generated by Accidental Explosions

To minimize the risk of accidental explosions during mission operations, failure mode analysis, or the equivalent, will be performed on the final spacecraft design to identify failures modes that could credibly lead to an explosion, and to take steps (design or operational) to limit the probability of explosion.

To minimize the risk of accidental explosions at the end of the life of each satellite, all on-board sources of energy will be depleted once the satellite has reached its storage or reentry orbit (see below).

Selection of a Safe Flight Profile and Operational Configuration

SkyBridge will plan launch, orbital maneuvers, and operational orbits, and maintain stationkeeping to within 0.1°, which will limit the probability of collision with known large objects during the spacecraft lifetime.

The SkyBridge satellites will be assessed by their designer/manufacturer in order to limit the probability that a collision with a small object in space could lead to debris. In particular, spacecraft shielding, placement of components, and use of redundant systems, will be considered, as appropriate, in order to protect the spacecraft, and reduce the probability that a collision could lead to loss of spacecraft control that would prevent proper disposal. It should be noted that SkyBridge has every economic incentive to ensure the robustness of its spacecraft design to prevent loss of valuable assets.

Post-Mission Disposal of Spacecraft

The method for disposal of the SkyBridge satellites at the end of their operational lives has not been definitely determined. Most likely, disposal will involve

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[13] *See* In the Matter of Mitigation of Orbital Debris, *Notice of Proposed Rulemaking*, IB Docket No. 02-54, (FCC 02-80, rel. March 18, 2002) (the "Orbital Debris *NPRM*"), Appendix A.

atmospheric reentry, which is one of the disposal options identified in the Government Standard Practices appropriate for LEO satellites. In this case, the structure will be either directly de-orbited for atmospheric reentry, or placed in a decaying orbit, which will lead to eventual atmospheric reentry. The Commission has identified atmospheric reentry as one of the most effective methods for ensuring that the spacecraft will not, through collision, become a source of a large number of orbital debris in the future.[14]

SkyBridge will fully assess the safety concerns associated with atmospheric reentry before any such maneuver, and take whatever steps, in satellite design and in reenty protocols, are feasible to reduce the probability that portions of the spacecraft may survive reentry and reach the surface of the earth. In particular, SkyBridge will ensure that the results of its casualty assessment are well within all applicable rules and guidelines.

It is possible that a storage orbit could be used for some or all of the SkyBridge satellites. In that event, SkyBridge will maneuver its satellites so as to reduce risk that any satellite will be placed near any operational orbit. Once the satellites have reached the disposal orbit, all on-board energy sources will be depleted, in accordance with the Government Standard Practices.

SkyBridge will take steps to ensure that the on-board fuel of its spacecraft does not drop below that required to reliably execute planned end-of-life maneuvers.

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[14] Orbital Debris *NPRM*, ¶ 52.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

I hereby declare under penalty of perjury that I am a technically qualified person responsible for preparation of the engineering information contained in this Amendment, that I am familiar with Part 25 of the Commission's Rules, and that I have either prepared or reviewed the engineering information submitted in this Amendment, and that it is complete and accurate to the best of my knowledge and belief.

By: _____

Didier Casasoprana
Director, regulatory and special projects
SKYBRIDGE L.L.C.

September 16, 2002