

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
the Application of)	
)	
Virtual Geosatellite, LLC	)	IBFS No. SAT-LOA -19990108-00007
	)	IBFS No. SAT-AMD-20020916-00173
For Authority to Launch and Operate	)	IBFS No. SAT-AMD-20041222-00227
a Global Fixed-Satellite Service System	)	IBFS No. SAT-AMD-20051118-00242
Employing Non-Geostationary Satellites in)	
Sub-Geosynchronous Elliptical Orbits	)	Call Sign S2366

ORDER AND AUTHORIZATION

Adopted: December 21, 2006

Released: December 21, 2006

By the Acting Chief, International Bureau:

I. INTRODUCTION

1. By this Order, we grant Virtual Geosatellite, LLC (Virtual Geo) authority to construct a satellite system of highly-elliptical, non-geostationary satellite orbit (NGSO) fixed-satellite service (FSS) satellites to operate in C- and Ku-band frequencies. Specifically, we authorize Virtual Geo to construct 18 NGSO FSS satellites capable of operating service links, infrastructure and relay links, and telemetry, tracking, and command links in the 5925-6725 MHz, 12.75-13.25 GHz, and 13.8-14.5 GHz uplink frequency bands (Earth-to-space), and the 3700-4200 MHz, and 10.7-12.7 GHz downlink frequency bands (space-to-Earth). Upon Virtual Geo meeting certain orbital debris requirements, this authorization will allow Virtual Geo to offer a range of data, voice, and video broadband fixed satellite services to businesses and consumers around the globe, and will promote competition and investment in broadband services.

2. We do not, however, authorize Virtual Geo to launch or operate its NGSO satellites because we have unresolved concerns about its plans for orbital debris mitigation. Nevertheless, we address issues relating to Virtual Geo's proposed NGSO FSS operations in this Order so that we will be in a position to act expeditiously when it files a modification application satisfying our orbital debris concerns, and requesting authority to launch and operate the system.

II. BACKGROUND

A. Processing Round

3. In 1997, SkyBridge L.L.C. (SkyBridge) filed the first application for a non-geostationary satellite orbit fixed-satellite system in Ku-band frequencies. In response, the Satellite Policy Branch established a January 8, 1999 cut-off date for filing competing NGSO FSS system applications.¹ A total

¹ International Bureau Satellite Policy Branch Information: Cut-Off Established for Additional Applications and Letters of Intent in the 12.75-13.25 Ghz, 13.75-14.5 Ghz, 17.3-17.8 Ghz and 10.7-12.7 Ghz Frequency Bands, *Public Notice*, Report No. SPB-141, released November 2, 1998 (*Ku-band Cut-Off Notice*). The filing cut-off was for NGSO FSS applications in the 10.7-12.7, 12.75-13.25, 13.75-14.5, and 17.3-17.8 GHz frequency bands. The
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of six entities, including SkyBridge and Virtual Geo, filed applications to launch and operate seven NGSO FSS systems.² Three applicants have since withdrawn their applications, and the Commission dismissed a fourth application as defective.³ The International Bureau issued SkyBridge a Ku-band NGSO FSS license in July 2005, but SkyBridge declined the authorization.⁴

B. Service Rules Proceeding

4. Contemporaneously with its review of the Ku-band NGSO FSS applications, the Commission opened a rulemaking proceeding to consider co-frequency operation of NGSO FSS systems with geostationary satellite orbit (GSO) systems and terrestrial systems already operating in those frequencies.⁵ In late 2000, the Commission adopted rules for inter-service sharing between multiple satellite services and terrestrial services in shared Ku-band frequencies.⁶ These rules are based on an international consensus on GSO/NGSO sharing developed through study groups of the International Telecommunication Union (ITU). The ITU study groups concluded that a combination of single-entry equivalent power flux-density downlink (EPPF_{down}) limits and aggregate EPPF_{down} limits for NGSO FSS operations adequately protects GSO FSS operations, thereby defining the level of acceptable interference from an NGSO FSS system into a GSO FSS system.⁷ The Commission determined that it would require U.S.-licensed NGSO FSS systems to comply with each type of limit, although it acknowledged that it had not yet adopted a method for verifying compliance with the aggregate EPPF_{down} limit.

5. In 2002, the Commission adopted service rules that permit multiple NGSO FSS systems to operate in the Ku-band.⁸ The Commission also later refined the rules for sharing between GSO systems

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Commission subsequently decided not to allocate the 17.3-17.8 GHz band to NGSO FSS. For purposes of this Order and Authorization, the term "Ku-band" consists of the 10.7-12.7, 12.75-13.25, and 13.75-14.5 GHz frequency bands.

² In addition to the Virtual Geo and SkyBridge applications, applications were filed by: Denali Telecom, LLC; Hughes Communications Inc. (an application for 22 medium-Earth orbit satellites); Hughes Communications Inc. (a separate application for 70 low-Earth orbit satellites); Teledesic, L.L.C.; and The Boeing Company.

³ Denali Telecom, L.L.C. See Satellite Policy Branch Information: Actions Taken, *Public Notice*, Report No. SAT-00231, DA 04-2436 (released July 30, 2004).

⁴ Application of SkyBridge L.L.C. for Authority to Launch and Operate a Global Network of Low-Earth Orbit Communications Satellites Providing Broadband Services in the Fixed-Satellite Service, *Order and Authorization*, 20 FCC Rcd 12389, (Int'l Bur. 2005). SkyBridge surrendered the license on August 17, 2005. See Satellite Policy Branch Information, Actions Taken, *Public Notice*, Report No. SAT-00314, DA 05-2327 (released August 19, 2005).

⁵ Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band Frequency Range, *Notice of Proposed Rulemaking*, 14 FCC Rcd 1131 (1998) (*Ku-band Sharing Proceeding*).

⁶ Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band Frequency Range, *First Report and Order and Further Notice of Proposed Rulemaking*, 16 FCC Rcd 4096 (2000) (*First Report and Order*).

⁷ *First Report and Order*, 16 FCC Rcd at 4128 ¶ 72.

⁸ 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*, 17 FCC Rcd 7841 (2002) (*Ku-band NGSO FSS Service Rules Order*).

and the proposed NGSO FSS systems in Ku-band frequencies, and revised several requirements for the validation EPFD demonstration.⁹

C. Virtual Geo Application

6. Virtual Geo seeks authority to launch and operate an FSS system with a constellation of 15 highly-elliptical orbit (HEO) NGSO satellites and three in-orbit spare satellites.¹⁰ Virtual Geo's Application seeks authority to operate with user links in the 14.0-14.5 GHz band (Earth-to-space) and the 11.2-12.7 GHz band (space-to-Earth).¹¹ Virtual Geo's Application seeks authority for gateway links in the 12.75-13.25 GHz, 13.8-14.0 GHz, and 5925-6725 MHz bands (Earth-to-space) and the 10.7-11.2 GHz and 3700-4200 MHz bands (space-to-Earth).¹² Virtual Geo's proposed system will be composed of three sub-constellations containing five satellites each, with two of the sub-constellations tracking the Earth's northern hemisphere and the third tracking the southern hemisphere. The satellites in each sub-constellation will actively communicate with earth stations only when they are in that portion of their orbital arc that is at a latitude greater than 45 degrees away from the equator in the respective operating hemisphere. Three spare satellites, one per sub-constellation, will also be placed in the respective sub-constellations to provide for rapid replacement of any failing satellite. No comments were filed on the Virtual Geo application, and no party petitioned to deny the application.

III. DISCUSSION

A. Processing Framework

7. When Virtual Geo filed its initial application, it was included in a processing round -- a licensing procedure by which the Commission grouped applications proposing operations in a particular frequency band and processed them together. Under this process, if an application was deemed acceptable for filing, the Bureau released a public notice announcing a "cut off" date for other interested parties to file applications to be considered concurrently. In 2003, the Commission revised the space station licensing process and adopted a "first come, first served" procedure for GSO-like applications, and a modified processing round approach for NGSO applications, which enables the Commission to act on applications with greater efficiency.¹³ However, the Commission decided not to apply the new processing rules to certain applications pending at that time, such as those in the Ku-band NGSO processing round. This is because the Commission was in the process of considering sharing rules for Ku-band NGSO licensees, and completing that rulemaking proceeding would lead to the best-suited licensing method for

⁹ Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band Frequency Range, *Third Memorandum Opinion and Order*, 18 FCC Rcd 2307 (2003) (*Third Order*).

¹⁰ Virtual Geosatellite, LLC, Application, IBFS No. SAT-LOA-19990108-00007 (Virtual Geo Application). As described in this Order, the Virtual Geo Application has subsequently been amended three times: an amendment to conform its application to the service rules, IBFS No. SAT-AMD-20020916-00173 (2002 Conforming Amendment); and two amendments to address orbital debris issues, IBFS No. SAT-AMD-20041222-00227 (2004 Amendment), and IBFS No. SAT-AMD-20051118-00242 (2005 Amendment). In its 2002 Conforming Amendment, Virtual Geo deleted its initial request to operate in the 17.3-17.8 GHz frequency band, in accord with the service rules order.

¹¹ Virtual Geo Application at iii.

¹² *Id.*

¹³ Amendment of Commission's Space Station Licensing Rules and Policies, Mitigation of Orbital Debris, *First Report and Order and Further Notice of Proposed Rulemaking in IB Docket No. 02-34, and First Report and Order in IB Docket No. 02-54*, 18 FCC Rcd 10760 (2003) (*First Space Station Licensing Reform Order*).

those Ku-band NGSO applications without delaying grant of the licenses.¹⁴ Therefore, we continue to process Virtual Geo's application as part of the Ku-band NGSO FSS processing round.

8. All applicants requesting authority to launch and operate satellite space stations must present information sufficient to establish their legal and technical qualifications to hold a Commission license.¹⁵ The regulations set forth in Part 25 of the Commission's rules govern FSS applicants and licensees, including this application for NGSO FSS in the Ku-band frequencies. We have reviewed Virtual Geo's satellite application and associated amendments. Nothing in the record suggests that Virtual Geo is not legally qualified to provide its proposed service. Moreover, we find that Virtual Geo's proposed facilities and operations, as conditioned in this *Order*, below, will comply with all applicable rules, regulations, and policies. Thus, we conclude that grant of this application will serve the public interest, convenience and necessity.

B. Technical Qualifications

9. When NGSO FSS systems in this service are operational, they will share the Ku-band spectrum with each other under the "avoidance of in-line interference events" technique adopted by the Commission in the *Ku-band NGSO FSS Service Rules Order*.¹⁶ At the same time, Virtual Geo and other Ku-band NGSO FSS licensees will share already heavily-used Ku-band spectrum with GSO space station operators and with terrestrial users pursuant to the sharing mechanisms adopted in the *First Report and Order*.¹⁷ We discuss in this section the technical characteristics of Virtual Geo's proposed system, its sharing requirements within the Ku-band NGSO FSS service, and each of the required sharing constraints with GSO FSS and terrestrial incumbent services in the respective sub-bands in which Virtual Geo's NGSO FSS system will operate.

1. System Design

10. As amended, the Virtual Geo system is comprised of 15 active satellites in fifteen separate orbital planes, one satellite per plane, and three spare satellites in "parking" orbits.¹⁸ The fifteen satellites' orbits are synchronized to provide continuous coverage of specific desired land masses on the surface of the Earth while the satellites transit the active operating arc of their highly-elliptical orbits. The apogee of the orbits is at the northernmost (or southernmost, for the southern hemispheric orbits) extent of the satellites' transit. Each satellite requires eight hours to complete one orbital revolution. The satellites begin active communications with earth stations as each revolution in a satellite's orbit toward apogee exceeds 45 degrees in latitude from the equator, providing angular separation from the GSO satellite belt. Virtual Geo satellites communicate with earth stations through the orbital apogee, at 26,630 kilometers, and as the satellites return toward perigee, until they approach 45 degrees from the equator on descent.¹⁹

11. The Virtual Geo satellites' highly-elliptical orbits are designed to maximize the time the satellites spend in transit through the "active arc." The satellites are active for four hours and 47 minutes of each eight-hour orbit. As the Earth rotates under the Virtual Geo satellites' orbits, each Virtual Geo satellite will transit ground tracks in three different land masses on Earth in the 24 hours of each day.

¹⁴ *First Space Station Licensing Reform Order*, 18 FCC Rcd at 10866-67.

¹⁵ See 47 U.S.C. § 301.

¹⁶ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7850 ¶ 27.

¹⁷ *First Report and Order*, 16 FCC Rcd 4096.

¹⁸ Virtual Geo Application at 11.

¹⁹ Virtual Geo Application at 14.

Viewed from the Earth, continuous coverage in each desired ground track requires five satellites, because each satellite covers the ground track for approximately 4.8 hours of each day. Virtual Geo therefore groups its constellation of 15 satellites into three groups of five satellites, two groups that cover six ground tracks in the northern hemisphere, and one group covering three ground tracks in the southern hemisphere. The three spare satellites are positioned to be available to replace any individual satellite in one of the three groups.²⁰

12. A key feature of the Virtual Geo space stations is the operation of phased array antennas. The Virtual Geo satellite space stations will create user and gateway antenna beams with actively steered phased array antennas designed and operated so as to maintain a given beam on a service area within the ground track on the Earth at all times during a space station's transit of its active arc. Phased array antennas minimize the number of space station beam handoffs needed to maintain service to earth stations. Individual space station beams will have a nominal beamwidth of 2.25 degrees, and 38 dBi of peak gain on boresight.²¹

13. Space station beams will connect to gateway terminal earth stations and user terminal earth stations that also use phased array receiver antennas capable of tracking "rising" and "setting" Virtual Geo satellites by following the space stations' beacons. The user terminal earth stations will be approximately 45 centimeters in diameter. They will be equipped with variable uplink power to ensure a complete link without using more power than necessary, while compensating for rain fade and variation in distance between user terminals and the Virtual Geo satellites. Software built into the user earth stations will enable a terminal to predict a Virtual Geo satellite orbit track and then lock onto the satellite by means of its downlink beacon signal.²² Once a communications link is established, tracking capability is also supported by distributing ephemeris data for the entire Virtual Geo constellation from a gateway through a satellite link to user terminal earth stations.²³

14. Gateway terminal earth stations will consist of two conventional large tracking earth station antennas at least 5 meters in diameter.²⁴ The gateway terminals will be capable of performing all the satellite tracking functions necessary to support the user terminals. The gateways will also operate variable uplink power control to overcome rain fade and distance variations. The gateway terminals will be fully interconnected via land lines to three Virtual Geo regional network control centers (two in the northern hemisphere and one in the southern hemisphere) and a single spacecraft operations control center. The spacecraft operations control center will be connected via land lines to telemetry, tracking & command (TT&C) earth stations.²⁵

2. Intra-Service Sharing with Other NGSO FSS Systems

15. In the *Ku-band NGSO FSS Service Rules Order*, the Commission adopted an "avoidance of in-line interference events" spectrum sharing method as the basis of spectrum sharing between and among NGSO FSS service operators.²⁶ The Commission adopted an Earth-surface based (topocentric) angular separation standard to define an in-line interference event, based on a 10-degree-avoidance angle between

²⁰ Virtual Geo Application at 17.

²¹ 2004 Amendment, Annex 2 at 3.

²² Virtual Geo Application at 84.

²³ Virtual Geo Application at 32.

²⁴ Virtual Geo Application at 85.

²⁵ Virtual Geo Application at 87.

²⁶ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7850 ¶ 27.

satellites of different networks. When satellites of different networks reach positions at which the topocentric angle between them is less than 10 degrees, as measured from an earth station where their transmissions might coincide, the satellite operators must undertake some means of avoiding the potential in-line interference event. The Commission permitted system operators to undertake in advance a coordination agreement in which they agree on a method to avoid in-line interference events between themselves.²⁷ If for any reason operators do not agree on another avoidance strategy, the default sharing mechanism is that the NGSO FSS Ku-band frequencies are split equally according to their chosen home base spectrum for the duration of the in-line interference event.²⁸ By filing its 2002 Conforming Amendment, Virtual Geo indicated its ability to operate under this Ku-band NGSO FSS service rule. Virtual Geo's satellites must maintain the ability to avoid in-line interference events with other NGSO FSS licensees in the Ku-band, by means of the default, spectrum-splitting technique.

3. Inter-Service Sharing with Other Users in Ku-band Spectrum

16. The Commission adopted technical sharing criteria to allow co-frequency NGSO FSS and FS operations in the Ku-band, consisting of power flux density (PFD) limits, consistent with decisions taken at WRC-2000.²⁹ The Commission also adopted technical sharing criteria to allow NGSO FSS and GSO FSS co-frequency operations, consisting of equivalent power flux density (EPFD) downlink limits, likewise consistent with WRC-2000 decisions.³⁰

17. Section 25.146(e) of the Commission's rules provides that NGSO FSS systems shall not claim protection from GSO FSS and Broadcast Satellite Service (BSS) networks operating in accordance with Commission rules.³¹ Thus NGSO FSS systems must operate in Ku-band frequencies on a non-harmful interference basis toward GSO FSS systems. The Commission adopted a number of EPFD limits on Ku-band NGSO FSS operations to protect incumbent Ku-band services from harmful interference by the new Ku-band NGSO FSS systems.

18. Specifically, the Commission adopted EPFD_{down} limits for emissions from all satellites in an NGSO FSS system. The limits contain three elements: (1) "validation" EPFD_{down} limits, including more stringent validation EPFD_{down} limits for specific sizes of antennas located at high latitudes; (2) "operational" EPFD_{down} limits, which protect against synchronization loss in GSO FSS earth stations between 3 and 18 meters in diameter; and (3) "additional operational" EPFD_{down} limits for 3 meter and 10 meter GSO FSS earth stations.³² Individual NGSO FSS systems must meet each of these limits, which, collectively, comprise the "single-entry EPFD_{down} limits."³³ In addition to the single-entry EPFD_{down} limits, the Commission adopted aggregate validation EPFD_{down} limits, which limit the cumulative level of

²⁷ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7857 ¶ 54.

²⁸ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7857 ¶ 53.

²⁹ *First Report and Order*, 16 FCC Rcd at 4116 ¶ 39. Power flux-density (PFD) is a measure of the amount of energy emitted by a transmitter that is present over a unit area at the Earth's surface or at the satellite, and is a critical factor in determining whether satellite systems can successfully share spectrum with other services or satellite systems. *Id.* at 4140 ¶ 106. The Commission adopted revised terminology used by international working groups, referring to "EPFD_{down}" for power limits applicable to NGSO FSS space stations within an NGSO FSS system and EPFD_{up} for power limits applicable to NGSO FSS Earth stations within an NGSO FSS system or GSO BSS and FSS systems. *Id.* See also 47 C.F.R. § 25.208(b).

³⁰ *First Report and Order*, 16 FCC Rcd at 4128 ¶ 72.

³¹ 47 C.F.R. § 25.146(e).

³² *First Report and Order*, 16 FCC Rcd at 4130 ¶¶ 78-80.

³³ *First Report and Order*, 16 FCC Rcd at 4128 ¶ 74.

interference from all co-frequency NGSO FSS systems into GSO FSS networks.³⁴ The Commission's rules require that each NGSO FSS applicant demonstrate, prior to licensing, that it meets the single-entry validation EPFD limits by using a software simulation developed in accordance with an ITU software specification. Further, as a condition of each Ku-band NGSO FSS license, the licensee must file an annual certification that the system continues to meet the EPFD limits.

19. Further protection of incumbent GSO FSS operations in the Ku-band is afforded by the operational EPFD limits, and additional operational EPFD limits.³⁵ Virtual Geo must demonstrate that it meets these operational and additional operational limits after licensing, but prior to its system being placed into service.³⁶ And, finally, the Commission adopted a limit to aggregate EPFD, which is the cumulative level of interference into GSO FSS systems from all co-frequency NGSO FSS systems, although the method for verifying compliance with this limit has not yet been determined.³⁷

20. In addition, the Commission required coordination between NGSO FSS operators and radio astronomy service receivers in the 10.6-10.7 GHz band,³⁸ and coordination to protect GSO FSS networks in this band using sensitive receiving earth stations with very large antennas.³⁹ The *First Report and Order* revised footnotes to the Table of Frequency Allocations to state that NGSO FSS systems shall not claim protection from GSO systems operating in accordance with the ITU Radio Regulations and that NGSO FSS systems shall operate in such a way that any unacceptable interference that may occur during their operations shall be rapidly eliminated.⁴⁰

a. Demonstration of Single-Entry Validation EPFD Limits

21. The Commission's rules require that each NGSO FSS applicant demonstrate, prior to licensing, that it meets the single-entry validation EPFD limits by using a software simulation developed in accordance with an ITU software specification. The Commission requires that applicants provide the results of the computer program in a cumulative probability distribution function of EPFD_{down}.⁴¹ For the validation EPFD_{up} limits, the Commission's rules require a comparable cumulative probability distribution function of EPFD_{up}.⁴² The purpose of the validation EPFD limits is to provide a fixed outer limit on the amount of power that NGSO FSS systems can be designed to emit.⁴³

22. The ITU Joint Task Group 4-9-11 (JTG) developed a software requirement for a computer simulation to demonstrate that an NGSO FSS system can meet the required EPFD limits. In order for the computer simulation to work on all types of NGSO FSS constellations (including, for example, both low

³⁴ *First Report and Order*, 16 FCC Rcd at 4140 ¶ 106.

³⁵ *First Report and Order*, 16 FCC Rcd at 4136 ¶ 96 (incorporating EPFD limits codified at 47 C.F.R. §§ 25.208(i) and 25.208(j)).

³⁶ *First Report and Order*, 16 FCC Rcd at 4136 ¶ 96. See also 47 C.F.R. §§ 25.146(b); section III.B.2, *infra*.

³⁷ *First Report and Order*, 16 FCC Rcd at 4140 ¶¶ 106-107. Ku-band NGSO FSS licensees must certify to the Commission that they will meet the aggregate limits set forth at 47 C.F.R. §25.208(h).

³⁸ *First Report and Order*, 16 FCC Rcd at 4191 ¶ 256; see also 47 C.F.R. §2.106 Footnote US355.

³⁹ *First Report and Order*, 16 FCC Rcd at 4142 ¶ 112; see also 47 C.F.R. §25.146(f).

⁴⁰ *First Report and Order*, 16 FCC Rcd at 4128 ¶ 73; see also 47 C.F.R. §2.106 Footnotes 5.441 and 5.484A.

⁴¹ 47 C.F.R. § 25.146(a)(1)(v).

⁴² 47 C.F.R. § 25.146(a)(2)(v).

⁴³ *First Report and Order*, 16 FCC Rcd at 4130.

Earth orbit and highly elliptical orbit systems such as that proposed by Virtual Geo) and in order to take into account the fact that operational parameters of NGSO FSS systems change frequently, the software used for the simulation employs worst case scenario parameters, not actual operating parameters. The ITU JTG software specification thereby simulates an "outer envelope" of acceptable interference by any NGSO FSS system.

23. For an EPFD_{down} demonstration, the software will compute power flux-density masks representing the power from each satellite in an NGSO FSS constellation at worst-case power levels and beam configurations. EPFD statistics will then be computed by simulating the movement of the satellites in the constellation and adding the power flux-density radiated by the NGSO satellites at the input of a GSO FSS receiver at each time step. The software will then compute the worst case power level from the NGSO FSS system as a whole into any GSO location anywhere in the world. The resulting worst-case power level can then be compared with, and must be lower than, the validation EPFD limits specified in the Commission's rules.

24. Likewise, for an EPFD_{up} demonstration, the software will compute power flux-density masks representing the power from Earth stations in an NGSO FSS system at worst-case power levels and beam configurations. EPFD statistics will then be computed by adding the power flux-density radiated by the Earth stations at the input of a GSO satellite receiver for each time step. The software will then compute the worst case power level from the NGSO FSS system as a whole into any GSO FSS satellite location. The resulting worst-case power level will be compared with, and must be lower than, the validation EPFD_{up} limits specified in the Commission's rules.

25. Virtual Geo provided the required computer program, developed in accordance with the specifications stipulated in the ITU-R Recommendation BO.1503, or S.1503, for the single-entry EPFD validation computation, including both the source code and the executable file.⁴⁴ Virtual Geo did not, however, provide the results of the computer program in a cumulative probability distribution function of EPFD_{down} and in a comparable cumulative probability distribution function of EPFD_{up}. Virtual Geo contends that EPFD compliance is difficult to demonstrate only for NGSO FSS systems that employ circular low-Earth orbits; not those that employ highly elliptical orbits. This, Virtual Geo asserts, is due in part to the fact that HEO systems use satellites with active arcs that are widely separated from the geostationary orbit. Virtual Geo surmises that the complex computer algorithms contemplated by the ITU studies and Commission's Rules are really meant for systems that employ circular low-Earth orbits in order to ensure the EPFD levels established for the protection of geostationary networks are met. For HEO systems, Virtual Geo claims a "straight-forward" analytical approach, which shows the maximum EPFD_{down} and EPFD_{up} levels produced by its proposed system, are lower than the most stringent EPFD limits given in both Section 25.208 of the Commission's Rules,⁴⁵ and Article 22 of the ITU Radio Regulations, should be sufficient to demonstrate compliance with the EPFD limits.

26. In the EPFD_{down} computations, the Virtual Geo satellite is portrayed as capable of producing 28 spot beams, each serving user terminals and each configured in a 1-in-4 frequency re-use pattern, over a service area. Beams serving gateway terminals are not analyzed as they produce a much lower EPFD than user terminals. In Virtual Geo's model, each spot beam has a maximum antenna gain of 38 dBi and an antenna pattern that corresponds to Recommendation ITU-R S.1528. The maximum PFD at the surface of the Earth in the center of the beam over the operational orbital arc of the satellite is -141 dBW/m²/40 kHz. Virtual Geo's system-aggregate PFD at the center of a given beam will include contributions from all other co-frequency beams, of which there are seven. Virtual Geo's system-

⁴⁴ 2004 Amendment at Annex 2.

⁴⁵ 47 C.F.R. § 25.208.

aggregate PFD produced at the center of any of the spot beams will be the combination of these seven beams and will be a maximum of $-140.37 \text{ dBW/m}^2/40 \text{ kHz}$. Calculations based on this methodology showed worst-case single-entry EPFD_{down} values for protection of various FSS earth stations were between -178.95 to $-206.27 \text{ dBW/m}^2/40 \text{ kHz}$; a minimum of 2.25 dB margin with respect to the most stringent EPFD_{down} limits in Section 25.208(g) of the Commission's rules. As for the protection of the various BSS earth stations, the worst-case single-entry EPFD_{down} values were between -174.67 and $-196.65 \text{ dBW/m}^2/40 \text{ kHz}$; a minimum of 2.75 dB margin with respect to the most stringent EPFD_{down} limits in Section 25.208(l) of the rules.

27. In the EPFD_{up} computations, Virtual Geo has 28 equivalent fully occupied uplink user beams in the Virtual Geo system operating in the same 1-in-4 frequency re-use pattern; with only one earth station transmitting in a given uplink beam at a time. This allows for up to seven co-frequency, co-polar uplinks within the service area of a given Virtual Geo satellite. Based on this information, calculations, which had been done on a representative set of earth station locations, showed the worst-case single-entry EPFD_{up} values for protection of earth stations were between -166.85 to $-171.61 \text{ dBW/m}^2/40 \text{ kHz}$; a minimum of 6.85 dB margin with respect to the most stringent EPFD_{up} limits in Section 25.208(k) of the rules.

28. After reviewing Virtual Geo's analytical approach, supporting assumptions, and computer software, we have sufficient evidence to conclude the proposed Virtual Geo system will operate within the EPFD_{down} and EPFD_{up} levels required by our rules. Therefore, Commission review of the submission finds Virtual Geo to be in compliance with Section 25.146(a) of the Commission Rules.

b. Downlink Bands

29. We now address inter-service sharing issues in each portion of the uplink and downlink Ku-frequency bands in which Virtual Geo proposes to operate its system.

(i) 10.7 - 11.7 GHz

30. Virtual Geo proposes to use the 10.7-11.2 GHz band for downlinks to gateway earth stations, and the 11.2-11.7 GHz band for downlinks to user terminals.⁴⁶ Before 2000, the Commission allocated the 10.7-11.7 GHz band on a co-primary basis to terrestrial fixed service (FS) and GSO FSS downlinks for international systems only,⁴⁷ but in the *First Report and Order*, the Commission decided to permit NGSO FSS gateway earth stations to provide space-to-Earth transmissions (downlinks) in this band, subject to EPFD limits.⁴⁸

31. In addition to EPFD limits, the Commission considered other limitations on deployment of NGSO FSS gateway stations in this frequency band. Because the Commission found that deployment of NGSO FSS service links in some Ku-frequency bands could hinder future co-frequency terrestrial service deployment in those bands, including the 10.7-11.7 GHz band, it limited NGSO FSS use of this band to gateway earth stations.⁴⁹ Gateway earth stations do not originate or terminate traffic, but interconnect multiple non-collocated user earth stations operating in frequency bands other than designated gateway bands, through a satellite to other primary networks, such as the public switched telephone network and

⁴⁶ Virtual Geo Application at 27.

⁴⁷ See 47 C.F.R. § 2.106 of the Commission's Rules, note NG104. Internationally, the ITU also allocates the band on a co-primary basis to mobile services, excepting aeronautical mobile.

⁴⁸ *First Report and Order*, 16 FCC Rcd at 4099 ¶ 2, 4128 ¶ 72.

⁴⁹ *First Report and Order*, 16 FCC Rcd at 4110 ¶ 23, 4111 ¶ 29.

the Internet.⁵⁰ In the Ku-band, NGSO FSS earth station gateways are limited to providing NGSO FSS backbone support.⁵¹ Although they are not prohibited from connecting to all private networks, they cannot offer a gateway earth station connection for the exclusive use of any single customer.⁵² Further, the Commission found that to protect incumbent services' use of the bands, it would limit NGSO FSS gateway earth station deployment in specified geographic areas that would protect incumbent services' use of the bands.⁵³ The Commission is currently evaluating how best to implement this geographic limitation.⁵⁴ We will require Virtual Geo and any other NGSO FSS licensees in the Ku-band to meet any rules adopted in that gateway earth station deployment proceeding.

32. Virtual Geo proposes to use the upper half of this band, 11.2-11.7 GHz, for user terminal downlink communications. This is not consistent with the use limitations of this band,⁵⁵ which restrict use to downlink communications to gateway terminals. Therefore we deny Virtual Geo's non-conforming request. Instead, we grant Virtual Geo authority to use the spectrum segment, but only in conformance with the restrictions on the band. In the lower half of the band, however, Virtual Geo's proposal to provide gateway terminal downlinks to its gateway stations is consistent with the restrictions on the frequency band, and is therefore granted.⁵⁶ Thus, Virtual Geo is authorized to operate gateway terminal downlinks to gateway earth stations in the 10.7-11.7 GHz frequency band, subject to the applicable EPFD limits.⁵⁷ We found in section III.B.3.a, above, that Virtual Geo demonstrated its ability to meet the single-entry validation EPFD limits applicable to this band. We condition its authorization in this band on demonstrating its ability to meet the operational and additional operational EPFD_{down} limits, no later than 90 days prior to commencing service to the public,⁵⁸ and on its certification that it can meet the aggregate EPFD_{down} limits.⁵⁹

33. Domestically, footnote US355 is applicable.⁶⁰ This footnote requires that in the band 10.7-11.2 GHz non-geostationary satellite orbit licensees in the fixed-satellite service (space-to-Earth), prior to

⁵⁰ *First Report and Order*, 16 FCC Rcd at 4111 ¶ 29.

⁵¹ *Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-band*, Second Memorandum Opinion and Order, 18 FCC Rcd 2324, 2335 ¶ 25 (2003) (*Second MO&O*).

⁵² *Second MO&O*, 18 FCC Rcd at 2332 ¶ 20.

⁵³ *First Report and Order*, 16 FCC Rcd at 4126 ¶ 66.

⁵⁴ *Amendment of Parts 25, 74, 78 and 101 of the Rules regarding Coordination between the Non-Geostationary and Geostationary Satellite Orbit Fixed-Satellite Service and Fixed, Broadcast Auxiliary and Cable Television Relay Services in the 7 GHz, 10 GHz and 13 GHz Frequency Bands*, Notice of Proposed Rulemaking, FCC 03-318, ET Docket No. 03-254 (released Dec. 23, 2003) (*NGSO FSS, BAS and CARS Coordination NPRM*).

⁵⁵ Virtual Geo Application at 27-31.

⁵⁶ Virtual Geo Application at 29, 31.

⁵⁷ 47 C.F.R. § 25.208(g).

⁵⁸ 47 C.F.R. § 25.208(i), (j); § 25.146(a).

⁵⁹ 47 C.F.R. § 25.208(h).

⁶⁰ Footnote US355 (47 C.F.R. § 2.106) reads as follows:

In the band 10.7-11.7 GHz, non-geostationary satellite orbit licensees in the fixed-satellite service (space-to-Earth), prior to commencing operations, shall coordinate with the following radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz:

(continued....)

commencing operations, shall coordinate with the specified radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities operating in the band 10.6-10.7 GHz.

(ii) **11.7 - 12.2 GHz**

34. Virtual Geo proposes to operate user terminals downlinks in the 11.7-12.2 GHz (space-to-Earth) frequency band.⁶¹ The 11.7-12.2 GHz band was previously allocated on a primary basis for FSS downlinks, and the Commission did not have any specific GSO/NGSO sharing provisions in this band. In the *First Report and Order*, the Commission allowed the NGSO FSS to share the band with the GSO FSS on a co-primary basis by adopting the same EPFD_{down} limits for NGSO FSS service downlinks in the band that it adopted for NGSO FSS gateway downlinks in the 10.7-11.7 GHz. Since the same EPFD limits apply to downlinks to gateway earth stations and to user terminal earth stations, either type of earth station may be operated in this band. Virtual Geo is authorized to operate user terminals in the 11.7-12.2 GHz band, subject to the controlling EPFD limits.⁶² We found in section III.B.3.a, above, that Virtual Geo demonstrated its ability to meet the single-entry validation EPFD limits applicable to this band. We condition its authorization in this band on demonstrating its ability to meet the operational and additional operational EPFD_{down} limits, no later than 90 days prior to commencing service to the public,⁶³ and on its certification that it can meet the aggregate EPFD_{down} limits.⁶⁴

(iii) **12.2 - 12.7 GHz**

35. Virtual Geo proposes to operate downlinks to user terminal earth stations in the 12.2-12.7 GHz frequency band.⁶⁵ The 12.2-12.7 GHz band is allocated on a primary basis to the BSS for use by direct broadcast service systems, and NGSO operators in this band cannot claim protection from those

(...continued from previous page)

Observatory	West Longitude	North Latitude	Elevation
Arecibo Observatory.....	.....66° 45' 11"	....18° 20' 46"	.....496 m
Green Bank Telescope (GBT).....	.....79° 50' 24"	....38° 25' 59"	.....825 m
Very Large Array (VLA).....	.....107° 37' 04"	....34° 04' 44"	.....2126 m
Very Long Baseline Array (VLBA) Stations:			
Brewster, WA.....	.....119° 40' 55"	....48° 07' 53"	.....255 m
Fort Davis, TX.....	.....103° 56' 39"	....30° 38' 06"	.....1615 m
Hancock, NH.....	.....71° 59' 12"	....42° 56' 01"	.....309 m
Kitt Peak, AZ.....	.....111° 36' 42"	....31° 57' 22"	.....1916 m
Los Alamos, NM.....	.....106° 14' 42"	....35° 46' 30"	.....1967 m
Mauna Kea, HI.....	.....155° 27' 29"	....19° 48' 16"	.....3720 m
North Liberty, IA.....	.....91° 34' 26"	....41° 46' 17"	.....241 m
Owens Valley, CA.....	.....118° 16' 34"	....37° 13' 54"	.....1207 m
Pie Town, NM.....	.....108° 07' 07"	....34° 18' 04"	.....2371 m
St. Croix, VI.....	.....64° 35' 03"	....17° 45' 31"	.....16 m

⁶¹ Virtual Geo Application at 27, 28, 31.

⁶² 47 C.F.R. § 25.208(g).

⁶³ 47 C.F.R. § 25.208(i), (j); § 25.146(a).

⁶⁴ 47 C.F.R. § 25.208(h).

⁶⁵ Virtual Geo Application at 27, 28, 31.

BSS operations.⁶⁶ In the *First Report and Order*, the Commission further allocated the 12.2-12.7 GHz band to NGSO FSS service downlinks, sharing with BSS operations on a co-primary basis under technical operating parameters, consisting of EPFD limits.⁶⁷ In order to allow NGSO FSS sharing with BSS, the Commission adopted single entry and aggregate EPFD_{down} limits for NGSO FSS operations.⁶⁸ The Commission also permitted the terrestrial multichannel video distribution and data service (MVDDS) to operate in this band on a co-primary basis to NGSO FSS and on a non-harmful interference basis to incumbent BSS,⁶⁹ and specified low-angle PFD limits from NGSO FSS systems into MVDDS receivers.⁷⁰

36. In light of Virtual Geo's demonstration of ability to meet validation EPFD_{down} limits in this band,⁷¹ we grant Virtual Geo authority to operate downlinks to user terminal earth stations in this band, conditioned on its certification that it can meet the applicable aggregate EPFD_{down} limits to protect BSS earth stations.⁷²

c. Uplink Bands

(i) 12.75 - 13.25 GHz

37. Virtual Geo proposes to use the entire 12.75-13.25 GHz frequency band for its NGSO FSS uplinks from gateway terminal earth stations.⁷³ The Commission permits NGSO FSS gateway uplink earth stations to operate in most of the 12.75-13.25 GHz band on a co-primary basis with incumbent operators.⁷⁴ The incumbent broadcast auxiliary service (BAS) and cable television relay service (CARS) operators are entitled to interference protection from NGSO FSS gateway uplinks, although new coordination procedures among these services need to be developed, and some form of geographic protection area must be developed for locating NGSO FSS gateway earth stations.⁷⁵ Virtual Geo's operations in this band will be subject to any coordination procedures and geographic restrictions adopted in the future.

38. In addition to sharing this band with BAS and CARS, NGSO FSS licensees must coordinate with GSO FSS operators using the band.⁷⁶ The Commission adopted EPFD_{up} limits at the geostationary satellite orbit, regardless of whether the NGSO FSS system transmission emanates from a gateway or

⁶⁶ See 47 C.F.R. § 2.106 Footnotes 5.484A and 5.487A. The band also has a primary allocation for the terrestrial fixed service, although FS systems licensed in the band after September 9, 1983 must operate on a non-harmful interference basis to the BSS.

⁶⁷ *First Report and Order*, 16 FCC Rcd at 4162 ¶ 176.

⁶⁸ *First Report and Order*, 16 FCC Rcd at 4162 ¶ 174; 47 C.F.R. §§ 25.208(l) and (m).

⁶⁹ *First Report and Order*, 16 FCC Rcd at 4182 ¶ 224. See also 47 C.F.R. § 25.139 (NGSO FSS information sharing with MVDDS licensees).

⁷⁰ 47 C.F.R. § 25.208(o).

⁷¹ See Section III.B.3.a of this *Order*, above, meeting the requirements of 47 C.F.R. § 25.146(a), by establishing ability to meet the single entry limits of 47 C.F.R. § 25.208(l).

⁷² 47 C.F.R. § 25.208(m).

⁷³ Virtual Geo Application at 27, 29, 31.

⁷⁴ *First Report and Order*, 16 FCC Rcd at 4146 ¶ 122.

⁷⁵ See *NGSO FSS, BAS and CARS Coordination NPRM*, FCC 03-318.

⁷⁶ See 47 C.F.R. § 2.106 Footnote 5.441.

from a user earth station facility.⁷⁷ These limits are single-entry EPFD_{up} limits adopted at WRC-2000 and adopted in the Ku-band NGSO FSS service rules.⁷⁸

39. The Commission permits NGSO FSS gateway earth stations in the 12.75-13.15 GHz band and the 13.2125-13.25 GHz bands. The Commission limits NGSO FSS use of the 13.15-13.2125 to protect remote backup operations throughout the United States for incumbent BAS and CARS.⁷⁹ NGSO FSS uplink operations in the 13.15-13.2125 GHz band are limited to areas of the country outside a 50 km radius of the top 100 television markets.⁸⁰

40. We have reviewed the EPFD_{up} calculations provided by Virtual Geo and find that they comply with our EPFD limits.⁸¹ Virtual Geo is authorized to provide gateway terminal uplinks from earth stations from 12.75-13.15 GHz and from 13.2125-13.25 GHz. In the frequency band from 13.15-13.2125 GHz, Virtual Geo may operate gateway terminal uplinks only from gateway earth stations located outside a 50 km radius of the top 100 television markets.

(ii) 13.8 - 14.0 GHz

41. Virtual Geo proposes to use the 13.8-14.0 GHz frequency band for its NGSO FSS gateway terminal uplinks, a request consistent with the service rules for the Ku-band NGSO FSS.⁸² To facilitate NGSO FSS sharing with GSO FSS operations, the Commission adopted the same EPFD_{up} limits for the 13.75-14.0 GHz band that it adopted for the 12.75-13.25 GHz and 14.0-14.5 GHz bands.⁸³ The Commission also found that technical requirements it adopted in those bands are adequate to permit NGSO FSS gateway uplink spectrum sharing with incumbent operations.⁸⁴

42. The 13.75-14.0 GHz band has been allocated domestically and internationally to the fixed-satellite service, subject to restrictions embodied in footnotes to the domestic and international tables of allocations. The 13.75-14.0 GHz band is shared on a primary basis with the Government radiolocation service and with the forward space-to-space and space-to-Earth links of the National Aeronautics and Space Administration (NASA) Tracking and Data Relay Satellite System (TDRSS) in the space research service. Consequently, earth stations in the United States and its possessions (US&P) operating with the Virtual Geo satellite system will require coordination through the National Telecommunications and Information Administration (NTIA) Interdepartment Radio Advisory Committee's (IRAC) Frequency

⁷⁷ *First Report and Order*, 16 FCC Rcd at 4149 ¶ 131.

⁷⁸ See 47 C.F.R. § 25.208(k).

⁷⁹ *First Report and Order*, 16 FCC Rcd at 4147 ¶ 126.

⁸⁰ *Second MO&O*, 18 FCC Rcd at 2328 ¶ 11.

⁸¹ See Section III.B.3.a of this *Order*, above, meeting the requirements of 47 C.F.R. § 25.146(a), by establishing ability to meet the single entry limits of 47 C.F.R. § 25.208(k).

⁸² Virtual Geo Application at 27, 29, 31.

⁸³ *First Report and Order*, 16 FCC Rcd at 4155 ¶ 147. See 47 C.F.R. § 25.208(k); see also 47 C.F.R. § 2.106 Footnote 5.484A.

⁸⁴ *First Report and Order*, 16 FCC Rcd at 4155 ¶ 146.

Assignment Subcommittee (FAS).⁸⁵ We have received a letter from the NTIA requesting that we identify this requirement in any grant of authority to operate a satellite in the 13.75-14.0 GHz band.⁸⁶

43. Domestically, footnotes US337, US356, and US357 are applicable.⁸⁷ These footnotes place certain restrictions on FSS operations to protect government operations in the band, including manned space flight.⁸⁸ Internationally, footnotes 5.502 and 5.503 to the International Telecommunication Union (ITU) Radio Regulations place certain similar restrictions on FSS operations.⁸⁹ For NGSO networks, there are no fundamental differences between the domestic and international footnotes, in that they require a minimum earth station diameter of 4.5 meters.

44. ITU Radio Regulation footnote 5.503A, which has since been eliminated, mandated that, prior to January 1, 2000, earth stations operating in this band could not cause interference to spaceborne precipitation radars operating in the 13.793-13.805 GHz frequency band.⁹⁰ We have received a letter from NTIA noting that NASA operates a Tropical Rainfall Measuring Mission (TRMM) satellite system radar in the 13.793-13.805 GHz frequency band.⁹¹ NTIA states that, because TRMM provides valuable services, with a broad range of international users, the Commission and other operators in the band should cooperate in reducing interference to the TRMM radar.⁹² NTIA requests that FSS earth stations operating in the 13.793-13.805 GHz frequency band and located south of 39° N. and east of 110° W. operate with emission levels below -150 dBW/600 kHz at the TRMM space station receiver. Because TRMM operations in this band have not been protected since January 2000, we will urge, but not require,

⁸⁵ See Amendment of Parts 2, 25, and 90 of the Commission's Rules to Allocate the 13.75-14.0 GHz band to the Fixed-Satellite Service, *Report and Order*, 11 FCC Rcd 11951, 11960-61 (¶ 20) (1996).

⁸⁶ See Letter from William Hatch, Acting Associate Administrator, Office of Spectrum Management, NTIA, to Roderick Porter, Acting Chief, International Bureau, FCC (dated May 11, 1999).

⁸⁷ Footnote US337 requires that earth stations operating in the 13.75-13.8 GHz band be coordinated through NTIA's IRAC FAS to minimize interference to the forward space-to-space link of the NASA TDRSS. 47 C.F.R. § 2.106 US337.

⁸⁸ Footnote US356 restricts minimum antenna size to 4.5 meters for earth stations operating in the 13.75-14.0 GHz band and indicates a minimum equivalent isotropically radiated power (EIRP). Footnote US357 limits FSS earth station EIRP spectral density in the 13.77-13.78 GHz band until those geostationary space stations in the space research service for which advance publication information was received by the ITU prior to 31 January 1992 cease to operate in this band.

⁸⁹ Footnote 5.502 to the ITU Radio Regulations establishes minimum antenna diameters for earth stations of geostationary and non-geostationary satellite networks, and places certain restrictions on either the minimum EIRP or the power flux-density (PFD) levels produced by earth stations operating in the 13.75-14.0 GHz band. Footnote 5.503 limits FSS earth station EIRP spectral density in the 13.770-13.780 GHz band for earth stations in the FSS operating with geostationary-orbit space stations, until those geostationary space stations in the space research service for which advance publication information was received by the ITU prior to 31 January 1992 cease to operate in this band.

⁹⁰ Footnote 5.503A was suppressed at WRC-03. It stated that: "Until 1 January 2000, stations in the fixed-satellite service shall not cause harmful interference to non-geostationary space stations in the space research and Earth exploration-satellite services. Additionally, when planning earth stations in the fixed-satellite service to be brought into service between 1 January 2000 and 1 January 2001, in order to accommodate the needs of spaceborne precipitation radars operating in the band 13.793-13.805 GHz, advantage should be taken of the consultation process and the information given in Recommendation ITU-R SA.1071."

⁹¹ See Letter from Frederick R. Wentland, Acting Associate Administrator, Office of Spectrum Management, NTIA, to Don Abelson, Chief, International Bureau, FCC (dated Feb. 28, 2002).

⁹² *Id.*

operators of earth stations accessing the Virtual Geo satellite system in the 13.8 - 14.0 GHz band to cooperate with NASA to facilitate continued operation of the TRMM satellite.⁹³

45. Virtual Geo seeks gateway terminal uplink authority in the 13.8-14.0 GHz band.⁹⁴ Virtual Geo has provided the Commission the appropriate EPFD_{up} calculations as required under 47 C.F.R. § 25.146(a) and, upon review of those calculations, we find that it is in compliance.⁹⁵ Thus, we authorize Virtual Geo to operate gateway terminal uplinks in the 13.8-14.0 GHz frequency band.

(iii) **14.0 - 14.5 GHz**

46. Virtual Geo proposes to use the 14.0-14.5 GHz frequency band for NGSO FSS service uplinks from user terminal earth stations.⁹⁶ The 14.0-14.5 GHz band contains the same EPFD_{up} limits as those applicable to the 12.75-13.25 GHz band.⁹⁷ These limits are designed to protect GSO FSS satellites from NGSO FSS user terminal uplink operations. Virtual Geo has provided the Commission with a demonstration that it will meet the appropriate EPFD_{up} limits required by the rules.⁹⁸ Virtual Geo is authorized to operate uplinks from end user terminal earth stations in the 14.0-14.5 GHz frequency band.

47. We recognize, however, that user terminals could interfere with NASA's Tracking and Data Relay Satellite System (TDRSS) in Guam and New Mexico. NASA's TDRSS earth station facilities are located on Guam (latitude: 13° 36' 55" N, longitude: 144° 51' 22" E) and at White Sands, New Mexico (latitude: 32° 20' 59" N, longitude: 106° 36' 31" W; and latitude: 32° 32' 40" N, longitude: 106° 36' 48" W). These stations receive downlinked data at low elevation angles from TDRSS geostationary satellites operating pursuant to the secondary space research service allocation at 14.0-14.2 GHz. Further, NASA plans to establish another TDRSS receive facility on the east coast of the United States within two to three years. Any Virtual Geo user terminals located in the vicinity of these TDRSS earth station facilities could cause interference to the TDRSS operations. Because TDRSS supports critical national assets, including the International Space Station and NASA's Space Shuttle, NTIA has requested the Commission and non-Federal entities cooperate in avoiding interference to TDRSS operations.⁹⁹ NTIA requests that NGSO FSS earth stations in the 14.0-14.2 GHz frequency band not be located within line of sight of TDRSS earth station facilities, or that the parties discuss possible methods of protecting this limited number of TDRSS earth stations. Accordingly, we will urge operators of earth stations accessing the Virtual Geo satellite system in the 14.0-14.2 GHz band to cooperate with NASA, upon request, to facilitate continued operation of the TDRSS satellite network.

⁹³ NTIA also notes that none of the other space-based radar operations previously covered by footnote 5.503A will seek continued cooperation in this respect.

⁹⁴ Virtual Geo states that it does not propose use of the 13.75-13.8 GHz band, in an effort to avoid interference with NASA's Tracking and Data Relay Satellite System operations. Virtual Geo Application at 77.

⁹⁵ See Section III.B.3.a of this *Order*, above, meeting the requirements of 47 C.F.R. § 25.146(a), by establishing ability to meet the single entry limits of 47 C.F.R. § 25.208(k).

⁹⁶ Virtual Geo Application at 27, 31.

⁹⁷ *First Report and Order*, 16 FCC Rcd at 4149 ¶ 131, 4183 ¶ 231. See 47 C.F.R. § 25.208(k); see also 47 C.F.R. § 2.106 Footnote 5.484A.

⁹⁸ See Section III.B.3.a of this *Order*, above, meeting the requirements of 47 C.F.R. § 25.146(a), by establishing ability to meet the single entry limits of 47 C.F.R. § 25.208(k).

⁹⁹ See Letter from Frederick R. Wentland, Acting Associate Administrator, Office of Spectrum Management, NTIA, to Don Abelson, Chief, International Bureau, FCC (dated March 9, 2005).

4. C-Band Operations

a. Processing Framework

48. Virtual Geo proposes to operate gateway terminal uplinks and downlinks in the conventional and extended C-band frequencies.¹⁰⁰ Virtual Geo also proposes to perform TT&C functions at the edges of the conventional C-band frequencies, with TT&C uplinks at 5926 MHz and 6424 MHz, and with TT&C downlinks at 3701 and 4199 MHz.¹⁰¹

49. In adopting the *First Space Station Licensing Reform Order* in 2003, the Commission stated that the revised application processing procedures would apply to pending applications, except where the Commission had already started a processing round, and found that applying the revised processing procedure to these applications would not be likely to expedite action on them.¹⁰² As noted, this was the case with the Ku-band NGSO FSS processing round. Thus we will consider the C-band portion of Virtual Geo's application under the processing framework established in the *First Space Station Licensing Reform Order*. The Commission has no service rules establishing criteria for sharing between GSO and NGSO satellite systems in the C-band frequencies. The Commission announced in the *First Space Station Licensing Reform Order* that, in these cases, it would not consider NGSO applications after it has granted GSO applications in that band.¹⁰³ Because the C-band is heavily used by GSO systems, the Commission can consider only additional GSO applications.¹⁰⁴ This is because we will not grant an application if it is technically incompatible with previously licensed systems. Absent specific sharing criteria, NGSOs are generally incompatible with GSO operations in the same band. In this case, however, we find that Virtual Geo's operations are compatible. For the reasons discussed below, we grant Virtual Geo waiver of the Commission's rules to permit its proposed C-band operations.

b. Gateway Terminal Links

50. Virtual Geo proposes to operate gateway terminal uplinks in the 5925-6725 MHz band,¹⁰⁵ spanning the conventional and extended C-band frequencies.¹⁰⁶ Virtual Geo asserts that its proposed NGSO FSS systems can share C-band spectrum under the ITU's existing FSS allocation in that band, and in accordance with Radio Regulation S22.2.¹⁰⁷ In the United States, most of the requested C-band spectrum is allocated to the Fixed Service (FS) and FSS on a co-primary basis,¹⁰⁸ although a portion (6425-6525 MHz) is allocated to FSS and Mobile Service (MS) on a co-primary basis.

¹⁰⁰ For purposes of this Order, the term "conventional C-band" denotes the 3700-4200 MHz frequency band with respect to downlinks, and the 5925-6425 MHz frequency band with respect to uplinks. The term "extended C-band" denotes the 6425-6725 MHz with respect to uplinks.

¹⁰¹ Virtual Geo Application at 34.

¹⁰² *First Space Station Licensing Reform Order*, 18 FCC Rcd at 10865-66 ¶ 280.

¹⁰³ 47 C.F.R. § 25.156(d)(5).

¹⁰⁴ *First Space Station Licensing Reform Order*, 18 FCC Rcd at 10786 ¶ 58.

¹⁰⁵ Virtual Geo Application at 29.

¹⁰⁶ Virtual Geo Application at 29.

¹⁰⁷ Virtual Geo Application at 26.

¹⁰⁸ 47 C.F.R. § 2.106.

51. Virtual Geo requests a waiver of the Commission's allocation rules, to the extent necessary, to permit it to use the requested C-band frequency segments.¹⁰⁹ Section 1.3 of the Commission's rules authorizes the Commission to waive its rules for "good cause shown."¹¹⁰ Waiver is appropriate only if special circumstances warrant a deviation from the general rule, and such deviation would better serve the public interest than would strict adherence to the general rule.¹¹¹ Generally, the Commission may grant a waiver of its rules in a particular case only if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.¹¹² In considering requests for non-conforming spectrum uses, the Commission has indicated that it would generally grant such waivers "when there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the non-conforming operator accepts any interference from authorized services."¹¹³

52. We find that the Virtual Geo's waiver request, as conditioned, will not undermine the purposes of the Commission rules being waived.¹¹⁴ The purpose of both these rules is to prevent harmful interference to licensees operating in compliance with the Commission's rules. Virtual Geo's request meets the criteria generally required for non-conforming spectrum use, because the design of its system permits it to operate in a manner that will not cause interference into FS, MS or GSO FSS systems already operating on a co-primary basis in that band.¹¹⁵ Generally, Virtual Geo selected the orbital parameters of its system to ensure that the active Virtual Geo satellites operate only at high elevation angles as viewed from Virtual Geo earth stations.¹¹⁶ These high elevation angles allow sharing with FS antennas, while an angular separation of greater than 40 degrees from the equator also allows for geographical separation from the GSO FSS orbit.¹¹⁷ For these reasons, we find that waiver of the Commission's satellite application processing rules in Section 25.156(d)(5) is warranted. In light of these facts, we grant waiver to allow Virtual Geo authority to operate in the requested C-band frequency segments on an unprotected, non-harmful interference basis relative to the FS, MS and GSO FSS services.

¹⁰⁹ Virtual Geo Application at Exhibit 1.

¹¹⁰ See Section 1.3 of the Commission's rules, 47 C.F.R. §1.3. See also *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969) (*WAIT Radio*); *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1166 (D.C. Cir. 1990) (*Northeast Cellular*).

¹¹¹ *Northeast Cellular*, 897 F.2d at 1166.

¹¹² *WAIT Radio*, 418 F.2d at 1157.

¹¹³ Fugro-Chance, Inc., Application for Blanket Authority For Blanket Authority to Construct and Operate a Private Network of Receive-Only Mobile Earth Stations, *Order and Authorization*, 10 FCC Rcd 2860 ¶ 2 (1995) (authorizing non-conforming mobile-satellite service in the C-band). See also *Motorola Satellite Communications, Inc., Application for Modification of License, Order and Authorization*, 11 FCC Rcd 13952, 13956 ¶ 11 (1996) (authorizing service to fixed terminals in bands allocated to the mobile-satellite service).

¹¹⁴ 47 C.F.R. §§ 2.102(a), 25.156(d)(5).

¹¹⁵ Space stations operating in primary services are protected against interference from stations of secondary services. Stations operating in the secondary service cannot cause harmful interference to or claim protection from harmful interference from stations of a primary service. Co-primary services have equal rights to operate in particular frequencies. 47 C.F.R. §§ 2.104(d) and 2.105(c). In bands designated for exclusive use, nonconforming services may only be provided on a non-harmful interference basis to any licensed service provided in accordance with the Table of Allocations, and may not claim interference protection from other authorized services. See *Echostar LLC Petition for Reconsideration, Memorandum Opinion and Order*, DA 06-865, ¶ 2 n.3 (Int'l Bur. released April 14, 2006).

¹¹⁶ Virtual Geo Application at 73.

¹¹⁷ Virtual Geo Application at 57.

53. Virtual Geo shall not cause harmful interference to, nor claim protection from, authorized FS, MS, and GSO FSS stations in C-band frequencies that are presently assigned, or that may be assigned in the future. As a condition of this authorization, we require Virtual Geo to inform its customers, in writing, of the potential for interference from FS, MS, and GSO FSS operations. In addition, Virtual Geo may not cause harmful interference to or claim protection from any other non-conforming services previously authorized¹¹⁸ on a non-harmful interference basis.¹¹⁹ In addition, Virtual Geo must certify in each annual report that its C-band operations are within the bounds of the power flux-density limits adopted by the ITU for NGSO operations in the conventional and extended C-bands.¹²⁰ We require Virtual Geo to comply with the ITU EPFD limits, as the Commission has required licensees to meet applicable ITU requirements before it adopts frequency-band-specific service rules.¹²¹ Further, Virtual Geo will be required to comply with any service-band-specific service rules that the Commission may adopt in the future for NGSO operations in C-band frequencies.

c. Telemetry, Tracking and Command

54. Under the Commission's rules, TT&C operations may be provided at the edges of the frequency bands in which the particular satellite will be providing service.¹²² Virtual Geo proposes to perform TT&C functions at the edges of the conventional C-band frequencies, with TT&C uplinks at 5926 MHz and 6424 MHz, and with TT&C downlinks at 3701 and 4199 MHz.¹²³ Because we permitted, under waiver, Virtual Geo's operation of gateway terminal uplinks and downlinks in C-band frequencies, we will also permit TT&C operations in the C-band, subject to the same conditions to protect other C-band operations. Thus, Virtual Geo must operate TT&C in the requested C-band frequency segments on an unprotected, non-harmful interference basis relative to the FS, MS and GSO FSS services. Virtual Geo shall not cause harmful interference to, nor claim protection from, authorized FS, MS, and GSO FSS stations in C-band frequencies that are presently assigned, or that may be assigned in the future. In addition, Virtual Geo may not cause harmful interference to or claim protection from any other non-conforming services previously authorized¹²⁴ on a non-harmful interference basis.¹²⁵

¹¹⁸ Sirius Satellite Radio, Inc. for Minor Modification of License to Construct, Launch and Operate a Non-Geostationary Satellite Digital Audio Radio Service System, *Order and Authorization*, 16 FCC Rcd 5419, 5429 ¶¶ 31-33 (Int'l Bur. 2001) (*Sirius Order*).

¹¹⁹ See contactMEO Communications, LLC, Application for Authority to Launch and Operate a Non-Geostationary Orbit Fixed-Satellite System in the Ka-band Frequencies, *Order and Authorization*, 21 FCC Rcd 4035 ¶1 n. 3 (Int'l Bur. 2006) (*contactMEO Order*).

¹²⁰ The ITU has also adopted power flux-density (PFD) limits designed to allow GSO FSS and NGSO FSS satellite systems to share spectrum in the conventional and extended C-bands. At the 2003 World Radiocommunications Conference (WRC-03), the ITU adopted power flux-density limits for NGSO FSS systems in the 3400-4200 MHz frequency band under Article 21.16 (Table 21-4), as well as equivalent power flux-density limits for NGSO FSS systems in the 3700-4200 MHz downlink band and in the 5925-6725 MHz uplink band under Article 22.5C (Tables 22-1E and 22-2).

¹²¹ *First Space Station Licensing Reform Order*, 18 FCC Rcd at 10784 ¶ 52, 10808 ¶ 120.

¹²² 47 C.F.R. § 25.202(g).

¹²³ Virtual Geo Application at 34.

¹²⁴ *Sirius Order*, 16 FCC Rcd at 5429 ¶¶ 31-33.

¹²⁵ See *contactMEO Order*, ¶1 n. 3.

5. Inter-Satellite Links

55. Virtual Geo proposes to use inter-satellite links (ISLs) achieved through line of sight connectivity during the active arc of its satellites' orbits.¹²⁶ Virtual Geo proposes the use of optical ISLs, although it does not propose any specific frequencies. Under these circumstances, no further action is necessary at this time. Virtual Geo may reapply for ISL authority as a modification to this license if and when it chooses specific ISL frequencies.

6. Coverage Requirement

56. In the *Ku-band NGSO FSS Service Rules Order*, the Commission required that NGSO FSS systems in the Ku-band to be capable of providing service on a continuous basis throughout the fifty states, Puerto Rico, and the United States Virgin Islands.¹²⁷ These systems must also be capable of serving locations as far north as 70 degrees latitude and as far south as 55 degrees latitude for at least 75 percent of every 24-hour period.¹²⁸ The Virtual Geo constellation meets these requirements, because it is designed to provide full time coverage with elevation angles always above 5 degrees to all points on the Earth.¹²⁹

7. Conclusion

57. Based on the foregoing review of Virtual Geo's amended application for authority to operate an NGSO FSS satellite system in the Ku-band, we find that Virtual Geo is technically qualified to operate its planned system as conditioned below.

C. License Conditions

1. Operational and Additional Operational EPFD_{down} Limits Demonstration

58. NGSO FSS systems operating in the Ku-band must also meet single-entry operational and additional operational EPFD_{down} limits in order to protect 3 and 10 meter GSO FSS earth station antennas from unacceptable interference.¹³⁰ Operational emissions from NGSO FSS space stations cannot exceed the operational EPFD_{down} limits¹³¹ or the additional operational EPFD_{down} limits¹³² at any point on the Earth's surface. NGSO FSS licensees must demonstrate that they meet these operational and additional operational limits, at selected GSO earth station locations, prior to commencing commercial service.¹³³ The Commission recognized that the tools required to make this demonstration may not be available to NGSO FSS licensees before they receive their space station authorizations from the Commission. In particular, certain NGSO FSS licensees will need to make use of more accurate system information (e.g., actual measured NGSO FSS satellite antenna performance, expected satellite/earth station resource allocation scheme, spacecraft antenna switching algorithm) that has not yet been finalized at the space

¹²⁶ Virtual Geo Application at 34.

¹²⁷ 47 C.F.R. § 25.146(i)(1).

¹²⁸ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7860 ¶ 64; 47 C.F.R. § 25.146(i)(2).

¹²⁹ 2002 Conforming Amendment at Exhibit No. 4, p. 2.

¹³⁰ 47 C.F.R. § 25.208(i)(j); *First Report and Order*, 16 FCC Rcd at 4134 ¶ 90.

¹³¹ 47 C.F.R. § 25.208(j).

¹³² 47 C.F.R. § 25.208(i).

¹³³ *First Report and Order*, 16 FCC Rcd at 4134 ¶ 96; *see also*, *Third Order*, 18 FCC Rcd at 2313 ¶ 24.

station licensing stage.¹³⁴ The Commission therefore did not require this demonstration prior to licensing, but stated that authority to operate the space station segment will be conditioned on the NGSO FSS licensee submitting to the Commission 90 days prior to the initiation of service, a demonstration that its system is expected to meet the operational and additional operational limits.¹³⁵

59. Not later than 90 days prior to its initiation of service to the public, Virtual Geo must submit to the Commission a comprehensive technical showing demonstrating that its system is not expected to operate in excess of the operational EPFD_{down} limits and the additional operational EPFD_{down} limits and coordinate with GSO FSS networks using sensitive receiving earth stations with very large antennas.¹³⁶

2. Bond Requirement

60. In its *First Space Station Reform Order*, the Commission eliminated the financial qualifications requirements then in place and replaced them with a bond requirement.¹³⁷ The bond requirement is intended to ensure that licensees are financially able and committed to implementing their licensed systems in a timely manner. Under this requirement, any entity awarded a satellite license for an NGSO system must execute a performance bond in the amount of \$5 million, payable to the U.S. Treasury, within 30 days of the date of the license grant.¹³⁸ The bond is payable upon failure to meet any of the implementation milestones included in every license, where adequate justification for extending that milestone is not provided. Licensees may reduce the amount of the bond owed upon meeting each milestone.

61. Thus, Virtual Geo must execute a \$5 million performance bond payable to the United States Treasury within 30 days of release of this license as a condition of its license.¹³⁹ Should it fail to do so, its license will be null and void.

3. Milestone Schedule

62. Consistent with the Commission's decisions in the *Ku-band NGSO FSS Service Rules Order*¹⁴⁰ and the *First Space Station Reform Order*,¹⁴¹ Virtual Geo must enter into a non-contingent satellite manufacturing contract for its system within 12 months of this authorization, complete critical design review within two years of authorization, begin physical construction of all satellites in the system within two and a half years of this authorization, and complete construction and launch of the first two satellites in its system within three and a half years of grant. The entire Virtual Geo system must be launched and operational within six years of this authorization. In addition, Virtual Geo must file a

¹³⁴ *First Report and Order*, 16 FCC Rcd at 4136-37 ¶ 97.

¹³⁵ *Id.*

¹³⁶ 47 C.F.R. §§ 25.146(b), 25.146(f), and 25.146(g).

¹³⁷ *Amendment Of The Commission's Space Station Licensing Rules And Policies*, First Report and Order and Further Notice of Proposed Rulemaking in IB Docket No. 02-34, and First Report and Order in IB Docket No. 02-54, 18 FCC Rcd 10760, 10825 ¶ 167 (2003) (*First Space Station Reform Order*).

¹³⁸ *Amendment of the Commission's Space Station Licensing Rules and Policies*, First Order on Reconsideration and Fifth Report and Order, 19 FCC Rcd 12637 (2004).

¹³⁹ 47 C.F.R. § 25.165.

¹⁴⁰ *Ku-band NGSO FSS Service Rules Order*, 17 FCC Rcd at 7864 ¶ 75.

¹⁴¹ *First Space Station Reform Order*, 18 FCC Rcd at 10828 ¶ 177.

certification with the Commission within ten days following each of the milestones dates specified.¹⁴² Failure to meet a milestone will render this license null and void without further Commission action.

4. International Coordination

63. We will follow the applicable advance-publication, coordination, due diligence, and notification procedures set forth in the ITU Radio Regulations in coordinating Virtual Geo's satellites with other affected administrations. No protection from interference caused by radio stations authorized by other administrations is guaranteed unless coordination procedures are timely completed or, with respect to individual administrations, by successfully completing coordination agreements. In order to do so, we require that Virtual Geo provide the Commission with the international coordination information specified in our rules within 90 days of the release date of this Order.¹⁴³ Virtual Geo will be responsible for all cost recovery fees associated with any ITU filings on behalf of its system.

5. Orbital Debris Showings

64. Section 25.114(d)(14) of the Commission's rules requires applicants for space station authorizations to submit a description of the design and operational strategies that they will use to mitigate orbital debris, including a statement detailing post-mission disposal plans for space stations at the end of their operating life.¹⁴⁴ This information addresses four specific elements of orbital debris mitigation: 1) spacecraft hardware and design; 2) minimizing accidental explosions; 3) safe flight profiles; and 4) post-mission disposal. Virtual Geo submitted an amendment addressing each of these elements for its NGSO satellites.¹⁴⁵

65. In its orbital debris mitigation plan, Virtual Geo represents that it intends to incorporate vehicle design and operational techniques to minimize orbital debris.¹⁴⁶ Virtual Geo states that no debris is planned to be released during the course of normal operation and that the spacecraft will use redundant control, sensor, thruster subsystems, and shielding to minimize the probability of the spacecraft becoming a source of debris from small objects or meteoroids.¹⁴⁷ Virtual Geo also states that it has taken, and will continue to take, measures to minimize the probability of its spacecraft becoming a source of debris resulting from accidental explosion.¹⁴⁸

66. Virtual Geo states that it has evaluated and limited the probability of its satellites creating a source of debris as a result of collision with large objects and with satellites of other known and relevant NGSO constellations (those operating within the same altitude regime as Virtual Geo).¹⁴⁹ Virtual Geo identified a number of NGSO constellations within its operating envelope. Virtual Geo states that the probability of collision with these constellations is much smaller than the probability cited by NASA

¹⁴² See 47 C.F.R. § 25.146(k).

¹⁴³ See 47 C.F.R. § 25.111(b).

¹⁴⁴ 47 C.F.R. §§ 25.114(d)(14).

¹⁴⁵ In September 2002 Virtual Geo submitted an orbital debris mitigation plan which was superseded by its amendment filed December 2004 in response to the Commission letter dated November 10, 2004 (letter from Thomas S. Tycz, Chief, Satellite Division, to David Castiel, President and Manager of Virtual Geosatellite, LLC). In December 2005, Virtual Geo further amended the orbital debris mitigation plan submitted in December 2004.

¹⁴⁶ 2005 Amendment.

¹⁴⁷ 2005 Amendment at 1.

¹⁴⁸ 2005 Amendment at 2.

¹⁴⁹ 2005 Amendment at 2.

guidelines for collision with large objects.¹⁵⁰ Virtual Geo also states that it will maintain watch on all satellites in intersecting orbits for any impending near approach, and will implement drift maneuvers to ensure safe passage when warranted.¹⁵¹ We note, however, that as a general matter, although the risk of collision between the satellites is extremely low, the Commission has indicated that in cases in which orbital parameters for proposed satellite systems are similar to those of other operating systems, such that the two systems may have an increased risk of physical collision, further review may be warranted.¹⁵²

67. At end of mission, Virtual Geo plans to de-orbit its highly-elliptical orbit satellites through controlled re-entry by using a series of maneuver burns.¹⁵³ Virtual Geo states that the de-orbit process will be designed to assure that the satellite is stable and under control throughout the process.¹⁵⁴ Virtual Geo has identified an open area in the southern Pacific Ocean as the projected geographic region of the debris field.¹⁵⁵ Virtual Geo also states that authorities for shipping lanes and airline routes in the area of the debris field will be notified of the event.¹⁵⁶

68. This case is one of the first in which we have addressed a system's plans to dispose of satellites using controlled atmospheric reentry at end-of-life. According to Virtual Geo, its system is still in the design process. Given the stage of development for its highly-elliptical orbit NGSO constellation, Virtual Geo's application does not provide more detailed information concerning end-of-life operations, such as detailed operational plans, methods for coordination with relevant government agencies, and insurance arrangements. We believe that a more detailed review of these issues is warranted as system design progresses, and prior to authorization of launch and operating authority. Until such a review can be completed, we are not in a position to conclude that either the disposal of Virtual Geo's satellites, or the launch that would necessitate disposal, are in the public interest. Accordingly, we will require Virtual Geo to file, no later than 30 days following completion of the Critical Design Review milestone for its NGSO satellites, an application to modify its license to specify its end-of-life operations. This application should provide detailed information concerning all aspects of the proposed disposal plan. Because the United States is potentially strictly liable for any damage caused on the surface of the Earth by re-entering Virtual Geo satellites, we would anticipate that such a plan would involve insurance policies listing the United States as an additional insured party.¹⁵⁷ Authority to launch and operate the satellites will be granted if the information submitted demonstrates that Virtual Geo's end-of-life disposal plans are in the public interest.

¹⁵⁰ NASA guideline states that when the probability of collision with large objects is on the order of or less than 0.001, the intent of the guideline has been met. See NASA Safety Standard, Guidelines and assessment Procedures for Limiting Orbital Debris, NSS 1740.14, August 1995.

¹⁵¹ 2005 Amendment at 4.

¹⁵² See e.g., *Orbital Debris Order*, 19 FCC Rcd at 11588.

¹⁵³ 2005 Amendment at 4.

¹⁵⁴ 2005 Amendment at 5.

¹⁵⁵ 2005 Amendment at 9-10.

¹⁵⁶ 2005 Amendment at 6.

¹⁵⁷ *Mitigation of Orbital Debris, Second Report and Order*, 19 FCC Rcd 11567, 11613 ¶¶ 109-110 (2004). See also Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Article VII (entered into force October 10, 1967); Convention on International Liability for Damage Caused by Space Objects, Article II (entered into force September 1, 1972).

6. Reporting Requirements

69. Virtual Geo must follow the Part 25 reporting requirements for FSS systems, including an annual report describing the status of satellite construction and anticipated launch dates, and a detailed description of the use made of each transponder on each of the in-orbit satellites.¹⁵⁸ Beginning in the first year following launch of the first two space stations in its system, Virtual Geo must file a report on June 30 of each year, containing information current as of May 31 of that year.

70. In its annual report, Virtual Geo must also annually certify that its system continues to operate within required EPFD limits.¹⁵⁹ Since Commission Rules parallel ITU-R Recommendation BO.1503, any revisions to the ITU Recommendation or associated ITU-R publications must be incorporated into the software program used to demonstrate Virtual Geo's continued ability to meet all applicable EPFD limits. A revision of ITU-R Recommendation S.1503 was approved by ITU Study Group 4 in October 2004.¹⁶⁰ Finally, the Commission may request, at any time, additional information concerning the EPFD levels and related technical showings.¹⁶¹

7. Ephemeris Data Requirements

71. The Commission has noted that GSO FSS operators must have the information necessary to locate satellites in each NGSO FSS constellation at any given time.¹⁶² The avoidance of in-line interference events method for co-frequency sharing operations among NGSO FSS systems in the Ku-band likewise requires updated ephemeris data. The Commission therefore adopted a requirement that Ku-band NGSO FSS licensees publish their satellites' orbital elements in the North American Aerospace Defense Command 2-line element format on an Internet web site maintained by the licensee.¹⁶³ Once operational, Virtual Geo must meet this requirement, and its 2-line element data must be updated once every three days.

8. Replacement Satellites and In-Orbit Spare Satellites

72. After its NGSO FSS system is fully operational, if Virtual Geo develops a need to replace any space station in its system, it must certify to the Commission, at least thirty days prior to the launch of any replacement, that the space station it intends to launch is technically identical to the space stations being replaced.¹⁶⁴ In addition, Virtual Geo must certify that no replacement space station or in-orbit spare launch will cause Virtual Geo to exceed the total number of operating space stations specified in this authorization.¹⁶⁵

¹⁵⁸ See 47 C.F.R. §§ 25.146(l), and 25.210(l).

¹⁵⁹ 47 C.F.R. § 25.146(c).

¹⁶⁰ The ITU-BR is currently unable to examine NGSO FSS systems subject to the validation EPFD limits due to the lack of approved software to perform these validations.

¹⁶¹ 47 C.F.R. § 25.146(d).

¹⁶² *First Report and Order*, 16 FCC Rcd at 4138 ¶ 102.

¹⁶³ *Id.*; see 47 C.F.R. § 25.271(e).

¹⁶⁴ 47 C.F.R. § 25.146(m).

¹⁶⁵ 47 C.F.R. § 25.146(n).

IV. CONCLUSION

73. Upon review of Virtual Geo's application, as amended, we find that Virtual Geo is qualified to be a Commission licensee, and that grant of this application will serve the public interest, convenience, and necessity.

V. ORDERING CLAUSES

74. Accordingly, IT IS ORDERED that, pursuant to Section 309(a) of the Communications Act, as amended, 47 U.S.C. § 309(a), the application of Virtual Geosatellite, LLC, IBFS File Nos. SAT-LOA-19990108-00007, SAT-AMD-20020916-00173, SAT-AMD-20041222-00227, and SAT-AMD-20051118-00242, IS GRANTED, and Virtual Geosatellite LLC IS AUTHORIZED to construct a system of 15 active satellites in 15 orbital planes, and three spare satellites in parking orbits, designed to operate in the 5925-6725 MHz, 12.75-13.25 GHz, and 13.8-14.5 GHz bands for its uplinks (Earth-to-space) and in the 3700-4200 MHz, and 10.7-12.7 GHz bands for its downlinks (space-to-Earth), in accordance with the terms, conditions, and technical specifications set forth in its amended application, so far as is permitted in this *Order and Authorization*.

75. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC's requests for waiver of the United States Table of Frequency Allocations, 47 C.F.R. § 2.106, in order to provide non-geostationary satellite orbit fixed-satellite service in the 3700-4200 MHz and 5925-6725 MHz bands IS GRANTED, conditioned as set forth in this *Order and Authorization*.

76. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC SHALL OPERATE its system in the 3700-4200 MHz and 5925-6725 MHz bands on a non-harmful interference basis relative to fixed stations, mobile service stations, and geostationary satellite orbit fixed-satellite service stations, and, as such, Virtual Geosatellite, LLC may not cause harmful interference to, or claim protection from, fixed stations, mobile service stations, and geostationary satellite orbit fixed-satellite service stations in the 3700-4200 MHz and 5925-6725 MHz bands that have either already been assigned, or to which frequencies may be assigned at a later date. In addition, the non-conforming Virtual Geosatellite, LLC operations at 3700-4200 MHz and 5925-6725 MHz shall not cause harmful interference to, nor claim interference protection from, any non-conforming services previously authorized in those bands on a non-harmful interference basis.

77. IT IS FURTHER ORDERED, that Virtual Geosatellite, LLC shall operate its non-geostationary satellite orbit fixed-satellite service satellites in the 3700-4200 MHz, 5925-6725 MHz, 10.7-12.7 GHz, 12.75-13.25 GHz, and 13.8-14.5 GHz bands consistent with the power flux density requirements of 47 C.F.R. § 25.208, ITU Article 21.16 (Table 21-4), and ITU Article 22 (Tables 22-1A, 22-1D, 22-1E, 22-2, 22-3, 22-4A, 22-4A1, and 22-4C).

78. IT IS FURTHER ORDERED that Virtual Geosatellite LLC is required to inform its customers, in writing, of the potential for interference from fixed stations, mobile service stations, and geostationary satellite orbit fixed-satellite service stations operating in the 3700-4200 MHz and 5925-6725 MHz bands.

79. IT IS FURTHER ORDERED, that Virtual Geosatellite LLC's request for waiver of the United States Table of Frequency Allocations, 47 C.F.R. § 2.106, to conduct telemetry, tracking and command operations in the 3701 and 4199 MHz (downlink) center frequencies and 5926 and 6424 MHz (uplink) center frequencies IS GRANTED. Virtual Geosatellite LLC IS AUTHORIZED, on a non-harmful interference basis to U.S.-licensed geostationary satellite orbit fixed-satellite service operations, to conduct telemetry, tracking and command, and on a non-harmful interference basis to any non-conforming services previously authorized in these bands, to conduct telemetry, tracking and command

operations in the 3701 and 4199 MHz (downlink) center frequencies and 5926 and 6424 MHz (uplink) center frequencies.

80. IT IS FURTHER ORDERED, that within 30 days of the date of this grant, by January 20, 2007, Virtual Geosatellite, LLC must file a certification that it will meet the aggregate EPFD_{down} limits that protect GSO FSS networks and BSS networks.

81. IT IS FURTHER ORDERED, that not later than 90 days prior to its initiation of service to the public, Virtual Geosatellite LLC must submit to the Commission a comprehensive technical showing demonstrating that its system is not expected to operate in excess of the operational EPFD_{down} limits and the additional operational EPFD_{down} limits and coordinate with GSO FSS networks using sensitive receiving earth stations with very large antennas.

82. IT IS FURTHER ORDERED, that not later than 90 days prior to its initiation of service to the public, Virtual Geosatellite LLC must submit to the Commission a technical showing that its system is capable of meeting the power flux-density limits into operational multichannel video distribution and data service receivers.

83. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC shall file a report on June 30 of each year certifying that the system continues to operate within bounds of the power masks generated in its single entry validation EPFD demonstration.

84. IT IS FURTHER ORDERED that in the band 10.7-12.7 GHz Virtual Geosatellite, LLC shall complete coordination with GSO FSS networks using sensitive receiving earth stations with very large antennas prior to its initiation of service to the public.

85. IT IS FURTHER ORDERED that in the band 10.7-11.7 GHz, Virtual Geosatellite, LLC satellites, prior to commencing operations, shall be coordinated with the radio astronomy observatories to achieve a mutually acceptable agreement regarding the protection of the radio telescope facilities listed in footnote US355 to the Table of Frequency Allocations, 47 C.F.R. § 2.106.

86. IT IS FURTHER ORDERED that in the 13.8-14.0 GHz band, all earth stations in the United States and its Possessions are required to coordinate through NTIA's Interdepartment Radio Advisory Committee's Frequency Assignment Subcommittee, in accordance with footnote US337 to the Table of Frequency Allocations, 47 C.F.R. § 2.106.

87. IT IS FURTHER ORDERED that operation of the Virtual Geosatellite, LLC satellite network in the 13.8-14.0 GHz band shall be in accordance with footnotes US356 and US357 to 47 C.F.R. § 2.106 in the United States and its Possessions, and with footnotes 5.502 and 5.503 to the ITU Radio Regulations outside of the United States and its Possessions.

88. IT IS FURTHER ORDERED that operators of earth stations accessing the Virtual Geosatellite, LLC satellites in the 13.8 - 14.0 GHz band are urged to cooperate voluntarily with NASA in order to facilitate continued operation of the Tropical Rainfall Measuring Mission satellite.

89. IT IS FURTHER ORDERED that in the 14.0-14.2 GHz band, Virtual Geosatellite, LLC is urged to cooperate voluntarily with NASA, upon request by NASA, in order to facilitate the protection of the Tracking and Data Relay Satellite System earth stations.

90. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC, in accordance with 47 C.F.R. § 25.111(b), shall prepare the necessary information, as may be required, for submission to the ITU to initiate and complete the advance publication, international coordination, due diligence, and notification process of this satellite system, in accordance with the ITU Radio Regulations, within 90 days of the

release date of this *Order and Authorization*. Virtual Geosatellite, LLC shall be held responsible for all cost recovery fees associated with these ITU filings. No protection from interference caused by radio stations authorized by other administrations is guaranteed unless coordination and notification procedures are timely completed or, with respect to individual administrations, by successfully completing coordination agreements. Any radio station authorization for which coordination has not been completed may be subject to additional terms and conditions as required to effect coordination of the frequency assignments of other administrations.

91. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC shall avoid in-line interference events with any other non-geostationary satellite orbit fixed satellite system operating in the Ku-band frequencies. An "in-line interference event" is defined as the interference associated with an occurrence of any physical alignment of space stations of two or more satellite networks with an operating earth station of one of these networks in such a way that the angular separation between operational links of the two networks is less than 10 degrees as measured at the earth station.

If no agreed coordination exists between Virtual Geosatellite, LLC and one or more other satellite networks, then the bands will be divided among the affected satellite networks involved in an in-line interference event in accordance with the following procedure:

- (1) Each of n (number of) satellite networks involved in a particular in-line interference event shall select $1/n$ of the assigned spectrum available in each frequency band for its home base spectrum. The selection order for each satellite network shall be determined by and be in accordance with the date that the first space station in each satellite network is launched and operating;
- (2) The affected space station(s) of the respective satellite networks shall only operate in the selected ($1/n$) spectrum associated with its satellite network, its home base spectrum, for the duration of the in-line interference event;
- (3) All affected space station(s) may resume operations throughout the assigned frequency bands once the angular separation between the affected space stations in the in-line interference event is again greater than 10 degrees.

Any coordination procedure agreed among the affected operating satellite networks, which allows operations of the satellite networks when each network's respective space stations are within the 10 degrees avoidance angle associated with an in-line interference event, shall supersede the default procedure. Coordination may be effected using information relating to the space stations and the parameters of one or more typical earth stations. All parties are required to coordinate in good faith.

92. IT IS FURTHER ORDERED that Virtual Geosatellite LLC shall maintain an electronic web site bulletin board to list the satellite ephemeris data, for each satellite in the NGSO Ku-band constellation, using the North American Aerospace Defense Command (NORAD) two-line orbital element format. The orbital elements shall be updated at least once every three days.

93. IT IS FURTHER ORDERED that this authorization shall become NULL and VOID with no further action required on the Commission's part in the event that Virtual Geosatellite, LLC's space stations are not constructed, launched and placed into operation in accordance with the technical parameters and terms and conditions of the authorization by the following dates:

Milestone	Deadline
Enter Non-contingent Satellite Manufacturing Contract	December 21, 2007
Complete Critical Design Review	December 21, 2008
Begin Physical Construction of All Satellites	June 21, 2009
Complete Construction and Launch First Two Satellites in System	June 21, 2010
Certify Entire System Operational	December 21, 2012

Virtual Geosatellite, LLC must file a performance bond with the Commission in the amount of \$5 million, pursuant to the procedures set forth in Public Notice, DA 03-2602, 18 FCC Rcd 16283 (2003), within 30 days of the date of this grant, by January 20, 2007.

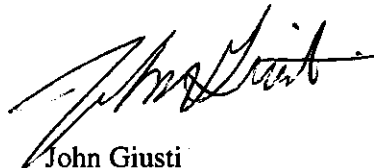
94. IT IS FURTHER ORDERED that Virtual Geosatellite LLC must submit, prior to January 20, 2009, an application to modify its authorization for construction specifying its end-of-life operations for its NGSO FSS satellites. Upon grant of that application, Virtual Geosatellite LLC will be authorized to operate its NGSO FSS satellites as specified in this Order. Coordination with all Federal FSS systems and other operational NGSO FSS licensees must be completed prior to launch of Virtual Geosatellite, LLC's first NGSO FSS satellite.

95. IT IS FURTHER ORDERED that the license term for the Virtual Geosatellite, LLC satellite system, Call Sign S2366, is 15 years, commencing on the date that Virtual Geosatellite, LLC certifies to the Commission that its initial space station has been successfully placed into orbit and that the operations of its satellite fully conforms to the terms and conditions of this space station system authorization.

96. IT IS FURTHER ORDERED that Virtual Geosatellite, LLC is granted 30 days from the date of the release of this *Order and Authorization* to decline this authorization as conditioned. Failure to respond within that period will constitute formal acceptance of the authorization as conditioned.

97. This *Order and Authorization* is issued pursuant to Section 0.261 of the Commission's rules on delegated authority, 47 C.F.R. § 0.261, and is effective upon release.

FEDERAL COMMUNICATIONS COMMISSION



John Giusti
Acting Chief, International Bureau