preserved by System 1, System 2 and Orbcomm in the 148-148.855 MHz band for exclusive use by System 3 and the S80-1 system.[86]

59. The operations of System 1, System 2 and Orbcomm in the spectrum to be occupied by System 3 will likely reduce System 3's link margin[87] but not its capacity.[88] Our calculations demonstrate that if System 3 is the only system in the 148-148.855 MHz band, its link margin will be approximately 5 dB. When both System 3 and S80-1 are operating in the 148-148.855 MHz band, System 3's link margin will decline from approximately 5 dB to 2.5 dB. When S80-1 and System 1 and System 2 are operating in the band, System 3's link margin will be approximately 1.5 dB.[89] Thus, System 3's link margin is unlikely to be reduced further with Orbcomm operating in this band.

60. The expected reduction of System 3's link margin is tolerable as evidenced by E-Sat's agreement to operate as System 3 in this spectrum.[90] In the Little LEO Order, we stated that system capacity may have to be decreased over time.[91] Consequently, System 3 will be required to accept such a link margin reduction caused by the operations of System 1, System 2 and Orbcomm. Furthermore, the results of our analysis are supported by an analysis performed by GE-Starsys before it withdrew from the second processing round. That analysis demonstrated that by avoiding System 3's center frequencies and placing multiple narrow-band FDMA or TDMA carriers at the edges of System 3's spectrum band the impact to

---

[86] Id.

[87] Link margin is the excess power with which a system is designed. The excess power helps the system to overcome the unforeseen losses in power of a signal during its transmission. For example, a user terminal may be designed to transmit a signal at 15 dB and the space station designed to receive that signal at 10 dB. Therefore, the uplink in the system is designed with a link margin of 5 dB which allows the space station to receive a signal from the user terminal even if the power of the signal is reduced by 5 dB, due to unforeseen propagation phenomena, by the time it reaches the space station.

[88] We based our analysis on a draft new recommendation submitted by GE-Starsys to the ITU-R Working Party 8D, "Methodology for Evaluating Interference From Narrow-Band Mobile-Satellite Networks to Spread-Spectrum Direct-Sequence Mobile-Satellite Networks Operating with Space Stations in Low-Earth Orbit at Frequencies Below 1 GHz." GE-Starsys has requested that we use this paper to analyze the effect on GE-Starsys of new entrants into the band. See Comments of GE-Starsys at 20. We assumed that the GE-Starsys and the S80-1 CDMA systems are operating with twelve simultaneous users.

[89] Although both System 1 and System 2 will operate in the same spectrum as System 3, our analysis of interference is based on assigning FDMA to the 148.0-148.25 MHz and 148.75-148.855 MHz portions of System 3's frequency band. TDMA and FDMA systems operate in channels. Thus, a channel can only be occupied by one system, either System 1, System 2, or Orbcomm, at a time.

[90] See Joint Proposal.

[91] Little LEO Order ¶ 20.

System 3 is minimized.[92] Thus, we conclude that it is desirable to operate three second round FDMA or TDMA systems at the band edges of System 3's uplink band. In order to obtain international recognition for this use, System 1, System 2 and Orbcomm will be required to be coordinated with the S80-1 system. As is general policy, the Commission will undertake the coordination of System 1's, System 2's and Orbcomm's operations in this band.

ii. Sharing with Orbcomm (148.905-149.81 MHz band)

61. The operation of System 1 and System 2 in the 148.905-149.81 MHz band will not significantly affect the system capacity of or cause harmful interference to Orbcomm's authorized system. System 1 and System 2 will share the 148.905-149.81 MHz portion of the band with Orbcomm. We anticipate that Orbcomm will operate in accordance with DCAAS/FDMA transmission techniques to minimize interference among its system, System 1 and System 2.

62. System 1 and System 2 can operate in this band without causing harmful interference into the Orbcomm system. In contrast, LEO One proposes operating two new systems in the spectrum in which Orbcomm is authorized.[93] However, we are concerned about the impact that operating such additional systems in the spectrum will have on Orbcomm's capacity. Orbcomm's capacity will be affected if Orbcomm does not have a sufficient number of open channels on which to operate. In their comments, Orbcomm expresses concern that with the addition of NVNG systems to the 148.905-149.90 MHz band, there may not be a sufficient number of unoccupied channels, particularly at peak times.[94] Orbcomm suggests use of both the lower and upper portions of the 148-149.90 MHz band and use of the spectrum allocated at WRC-95.[95] Second round applicants have agreed that Orbcomm can operate in both the lower and upper parts of this band so this should provide Orbcomm with a sufficient number of open channels on which to operate.[96]

63. In addition, because Orbcomm's system is designed to operate in accordance with DCAAS and FDMA transmission techniques, it can search for open channels using the available spectrum most efficiently.[97] As Orbcomm recognizes, by employing DCAAS and FDMA transmission techniques, System 1 and System 2 can also use the spectrum efficiently

[92] See Comments of GE-Starsys at 20

[93] Comments of LEO One at 33.

[94] See Comments of Orbcomm at 42.

[95] Id.

[96] See Joint Proposal.

[97] See Orbcomm Authorization ¶ 5.

and avoid causing harmful interference into Orbcomm's uplink transmissions by detecting open channels on which to transmit.[98] In order to accommodate System 1 and System 2, Orbcomm, a first round licensee, has agreed that it will no longer have exclusive spectrum in the 148.955-149.81 MHz portion of the frequency band.[99] Use of DCAAS techniques by Orbcomm, System 1 and System 2 also increases the likelihood that the systems will be able to access a sufficient number of unoccupied channels without significantly diminishing Orbcomm's capacity.

64. Orbcomm will have access to sufficient open channels and will not exclusively bear the burden of accommodating the new systems in the band since System 1, System 2 and Orbcomm will also operate in spectrum assigned to System 3. The increased amount of uplink spectrum assigned to System 1, System 2 and Orbcomm and each system's ability to use DCAAS ensures access to a sufficient number of unoccupied channels for these systems. Orbcomm will continue to operate in the 149.81-149.9 MHz band with only VITA, as authorized in the first processing round.

iii. Sharing the 149.95-150.05 MHz band

65. We will authorize System 1 to use the 149.95-150 MHz portion and System 2 to use the 150-150.05 MHz portion of the band, respectively for feeder links.[100] As discussed, Orbcomm will continue to operate its feeder links in the 149.585-149.635 MHz band, however, if System 2 relocates its feeder uplinks to another frequency band in the future, Orbcomm shall relocate its feeder uplinks into the 150-150.05 MHz band. Applicants generally sought 50 kHz or less of spectrum for their feeder links, and we have no reason to believe that more spectrum is necessary for feeder link use.[101] Based on the requests of existing licensees and applicants, we believe that 50 kHz of spectrum will be sufficient for feeder uplink operations. Given that land-based gateways will be the primary users of feeder link spectrum, the 149.90-150.05 MHz band is best used for feeder links because it is

[98] Comments of Orbcomm at 41.

[99] See Joint Proposal.

[100] The United States and France agreed, at an April 1996 bilateral meeting, that the 149.9-149.95 MHz band would be reserved for use by the French S80-1 system. Nonetheless, there is a need for System 1 and System 2 to coordinate the use of this 50 kHz of spectrum with France since the French S80-1 system has priority over System 1 and System 2 in the ITU coordination process.

[101] See Comments of GE-Starsys at 12; Comments of Final Analysis at 16. After filing their comments, the second round applicants (excluding LEO One) indicated to the Commission that some applicants could operate their systems with less than 50 kHz of spectrum for feeder uplinks in the 148-150.05 MHz uplink band. See Memorandum to Ruth Milkman from CTA, E-SAT, Final Analysis, GE-Starsys, Orbcomm and VITA, dated April 11, 1997.

allocated worldwide and useable only for land MSS, not aeronautical or maritime MSS.[102] We agree with the commenters that sharing feeder uplinks among multiple Little LEO systems in the band would result in harmful interference to existing users and disrupt their ability to use feeder link spectrum continuously.[103]

66. The 149.90-150.05 MHz band is restricted to land MSS use, not maritime or aeronautical MSS, and we believe the Russian satellite system, TSYKADA, is currently providing RNSS in the band. The 149.90-150.05 MHz band is also subject to ITU Radio Regulation S5.220 which provides that land MSS shall not constrain the development and use of the RNSS service in the same band.[104] Therefore, System 1 and System 2 are required to coordinate the use of this band with RNSS systems worldwide. We do not have substantial information concerning the RNSS systems that are currently or will be operating in the 149.90-150.05 MHz band. As is general policy, the Commission will undertake coordination of commercial satellite systems operating in this band.

b. Downlink Band for Systems 1, 2 and VITA (400.15-401 MHz)

67. In the 400.15-401 MHz downlink band, System 1 shall operate in the 400.15-400.505 MHz and 400.645-401 MHz portions of the band. In the future, the DoD expects to operate its DMSP system in the 400.15-400.505 MHz and 400.645-401 MHz portion of the band and System 1 shall time-share this spectrum with the DoD DMSP system. DoD opposes time-sharing with more than one Little LEO system operating in the 400.15-401 MHz downlink band because of the increased risk of unacceptable interference into its DMSP system and due to the absence of international acceptance of the time-sharing methodology.[105] In order to avoid interference and any capacity loss to the DoD system, System 1 must time-share the band with DoD by employing frequency hopping or other time-sharing techniques.

68. DoD is expected to merge its DMSP system with NOAA's meteorological satellite ("MetSat") system . Beginning in 1998, NOAA will be responsible for "on orbit" operations of the DMSP system, and NOAA will assume all command and control functions for the DMSP system by 2007. Our use of the terms "NOAA" and "DoD" in this Report and Order incorporates the separate systems operated by NOAA and DoD as well as the system resulting from NOAA's responsibility for DoD's "on orbit" operations.

---

[102] See 47 C.F.R. § 2.106. In the Table of Frequency Allocations the 149-150.05 MHz frequency band is internationally and domestically allocated to land MSS on a co-primary basis. Land mobile-satellite service is a MSS in which mobile earth stations are located on land.

[103] See Comments of Final Analysis at 17. Orbcomm believes that sharing feeder uplinks is not possible. See Comments of Orbcomm at 41.

[104] ITU Radio Regulation S5.220 MOD (WRC-95).

[105] See NTIA Letters and DoD correspondence cited therein.

69. Time-sharing will require System 1's satellites to avoid transmitting into the region on the Earth's surface into which the DoD satellites are then transmitting (the "protection area"). DoD plans to operate a satellite system worldwide that could consist of up to five satellites in the 400.15-400.505 MHz and the 400.645-401 MHz bands. VITA, System 2, and S80-1 will operate in the center portions of the 400.15-401 MHz band.[106] System 1 will operate in the 400.15-400.505 and 400.645-401 MHz parts of the band and must coordinate with and avoid causing harmful interference to DoD's use of these frequency bands.

70. As stated in the Notice, we estimate that when DoD's five satellite system is operational a user in Washington, D.C. will have access to the system no more than 15.5 percent of the time, or approximately 4 hours per day.[107] Under a time-sharing scheme, a large portion of the remaining 84.5 percent of the time, or approximately 20 hours per day, System 1 could operate in the DoD frequencies.

71. If System 1 were to employ frequency hopping, for example, the time that System 1 would be available to its customers would increase. Under a frequency hopping scheme, when a DoD satellite is using the 400.15-400.505 MHz band to transmit to a particular region, System 1 would cease transmitting to that region and would switch to the 400.645-401 MHz sub-band, not being used by DoD, before continuing its transmissions to that region. We recognize that not all second round applicants may be capable of employing the frequency hopping technique. Therefore, we will not mandate that System 1 use frequency hopping. However, we do believe that frequency hopping uses the limited amount of spectrum most efficiently, and we encourage second round applicants to incorporate this technique into their system design.

72. We do not assign specific feeder links in the 400.15-401 MHz downlink band to System 1. We will allow System 1 and DoD to retain the flexibility to coordinate feeder link spectrum. Because of the requirement for System 1 to time-share with DoD the use of channels in this band, System 1 will not be able to have a single dedicated feeder link channel in the 400.15-401 MHz band. However, if System 1 employs both time-sharing and frequency hopping techniques, we expect that it will be able to access enough spectrum to transmit feeder link information on a relatively continuous basis.

73. Given the significant national security interests involved, we emphasize that System 1's operations in the 400.15-401 MHz band must avoid causing harmful interference into the DoD system worldwide. To protect the DoD system, if System 1 is causing unacceptable interference to the DoD system, the Commission will require that System 1 immediately terminate its interfering operations, wherever located, and the Commission will not hesitate to

[106] See Negotiated Rulemaking Report. The United States and France also agreed that the French S80-1 system would operate in the 400.5517-400.5983 MHz band.

[107] The 15.5 percent is calculated using an elevation angle of 0 degrees.

impose sanctions on System 1, including monetary forfeitures and license revocations, if appropriate. If NTIA notifies the Commission that DoD is receiving unacceptable interference from System 1, we will require that System 1 terminate its interfering operations immediately unless it demonstrates to our satisfaction, and that of NTIA, that it is not responsible for causing harmful interference into the DoD system. If System 1 operates in the 400.15-401 MHz band, System 1 assumes the risk of any liability or damage that it and its directors, officers, employees, affiliates, agents and subcontractors may incur or suffer in connection with an interruption of its NVNG MSS service, in whole or in part, arising from or relating to its compliance or noncompliance with this condition.

74. Also in the 400.15-401 MHz downlink band, we will assign the 400.505-400.5517 MHz and 400.5983-400.645 MHz portions of the band to System 2. DoD is not authorized to operate in these portions of the band. System 2 will be required to time-share the 400.505-400.5517 MHz band with VITA, an existing authorized user. System 2 will also operate in the 400.5983-400.645 MHz band on a time-shared basis with VITA's satellite applied for in the second processing round if VITA's satellite is authorized by the Commission. As discussed, GE-Starsys has returned its first round authorization to the Commission, including use of this spectrum, and the Commission will use the 400.5983-400.645 MHz portion of that spectrum to accommodate System 2 and VITA.[108] In the event that System 2's authorization to operate in the 400.505-400.5517 MHz and/or 400.5983-400.645 MHz bands is returned to the Commission, terminated by the Commission, or System 2 notifies the Commission that it is discontinuing use of this spectrum, upon written request to the Commission, System 1 will be permitted to operate in either or both of these bands outside of a processing round to the same extent and under the same conditions that System 2 was permitted to operate in the bands. The S80-1 system is coordinated to operate in the adjacent spectrum, the 400.5517-400.5983 MHz band. Because of this coordination, this spectrum is not available for assignment to System 2 in this second processing round. However, upon System 2's written request, we shall initiate a communication to the Government of France requesting permission for System 2 to operate in the 400.5517-400.5983 MHz band until the time the S80-1 system commences operations in this spectrum. If System 2's authorization to operate in the 400.5517-400.5983 MHz band is returned to the Commission, terminated by the Commission, or System 2 notifies the Commission that it is discontinuing use of this spectrum, upon written request to the Commission, System 1 will be permitted to operate in this band outside of a processing round, subject to the same conditions imposed upon System 2, to the extent and under the same conditions that System 2 was permitted to operate in this spectrum. As is general policy, the Commission will undertake coordination of commercial satellite system operations in this band.

75. VITA may operate one satellite applied for in the second processing round in the 400.5983-400.645 MHz band on a time-shared basis with System 2 if the Commission

[108] See, supra, ¶ 10.

authorizes the VITA satellite in the second processing round.[109] Prior to launch of VITA's second round satellite, System 2 will have primary use of the 400.5983-400.645 MHz band. The spectrum assigned to VITA in our spectrum sharing plan approximates the amount of downlink spectrum relinquished by VITA to the S80-1 system in prior coordination negotiations and when this spectrum is added to VITA's existing authorization in the 400.505-400.5517 MHz band will approximate the amount of uplink spectrum VITA is currently authorized to operate in.[110]

c. Downlink Band (137-138 MHz)

76. In the 137-138 MHz downlink band, System 1 will operate in the 137-137.025 MHz band. Due to the concerns about Little LEO user terminal emissions causing interference to civil and military aeronautical safety and navigational communications expressed in the Negotiated Rulemaking Report, this 25 kHz of spectrum is most useful for gateway feeder links, not service downlinks.[111] System 1 will be required to coordinate its use of this 25 kHz of spectrum with the S80-1 system. In the event that System 1's authorization to operate in the 137-137.025 MHz band is returned to the Commission, terminated by the Commission, or System 1 notifies the Commission that it is discontinuing use of this spectrum, upon written request to the Commission, System 2 will be permitted to operate in this band outside of a processing round to the same extent and under the same conditions that System 1 was permitted to operate in the band.

77. In order to avoid interference to and any capacity loss by the NOAA MetSat system, System 2 will be required to time-share the 137.025-137.175 MHz and 137.825-138 MHz bands (the "NOAA bands")[112] and the 137.333-137.367 MHz, 137.475-137.525 MHz,

[109] VITA states that it would consider time-sharing this spectrum with a newly-authorized second round licensee. See VITA Letter. Because VITA has applied to operate one satellite in the 400.15-401 MHz band, VITA appears well-suited to operate in this spectrum.

[110] See VITA Letter. VITA's use of the 400.5983-400.645 MHz band would provide it with approximately 90 kHz of downlink spectrum which would match its 90 kHz of uplink spectrum currently authorized in the 149.81-149.9 MHz band.

[111] See Negotiated Rulemaking Report ¶ 10.

[112] System 2's operations in the NOAA bands must be on a secondary basis to existing authorized users. See ITU Radio Regulations Article S5, Frequency Allocations. The Code of Federal Regulations indicates that the NOAA bands are allocated to mobile-satellite service on a primary basis. See 47 C.F.R. § 2.106, Table of Allocations. This is a misprint in the Code of Federal Regulations. Mobile-satellite service in the NOAA bands is also allocated domestically on a secondary basis.

137.595-137.645 MHz, 137.753-137.787 MHz bands (the "NOAA channels")[113] with NOAA in a manner consistent with NOAA's implementation of the NOAA bands and the NOAA channels.[114] NOAA opposes time-sharing with more than one Little LEO system because insufficient technical studies have been conducted to provide assurance that such time-sharing will not cause harmful interference into the NOAA system.[115] System 2 shall also operate in the 137.367-137.4125 MHz band adjacent to one of the NOAA channels and will time-share the 137.375-137.4125 MHz portion of this band, subject to coordination with the Russian METEOR system.[116] Because System 2 will be sharing the 137-138 MHz band with several other systems, System 2's use of this band must be coordinated with System 3 consistent with the arrangement between GE-Starsys and NOAA, with the S80-1 system and with Orbcomm with respect to sharing adjacent channels.

78. Two CDMA systems, System 3 and the S80-1 system, in addition to Orbcomm and the Russian METEOR system, are also expected to operate in the 137-138 MHz band. System 3 will also operate in the 137.0725-137.9275 MHz portion of this band. System 3 will be required to coordinate its system and avoid causing harmful interference to all existing users of the 137-138 MHz band.

79. Orbcomm is currently operating in the 137-138 MHz band in the spectrum adjacent to the NOAA channels. Subject to the Commission's approval of Orbcomm's pending modification request, Orbcomm shall operate in the 137.175-137.3275 MHz, 137.4225-137.4725 MHz, 137.535-137.585 MHz, 137.65-137.75 MHz and 137.7875-137.8125 MHz bands not being used by NOAA or System 2. Orbcomm shall time-share the 137.275-137.325 MHz band, subject to coordination with the Russian METEOR system. Orbcomm shall coordinate its use of this spectrum with adjacent channels belonging to System 3 and other existing users in these bands. As is general policy, the Commission will undertake any coordination of this band with foreign administrations for all United States licensed commercial operators in this band.

---

[113] The NOAA channels are based on emission bandwidth and do not include the spectrum required to account for the effects of Doppler shift. As a result, the spectrum assigned to System 2 in the 137-138 MHz band has a wider bandwidth than the NOAA channels reflected in the U.S. Table of Frequency Allocation.

[114] Ongoing studies in the ITU - Radiocommunication Sector ("ITU-R") indicate that sharing between mobile-satellite service downlinks and MetSats at 137-138 MHz can be accomplished by using co-frequency avoidance (frequency hopping) in the same geographic area. See "Modification to Attachment 21; Report of the Fifth Meeting of ITU-R Working Party 8D" (Geneva 13-22 March 1996) § 4.1.1.1.5.

[115] See NTIA Letters and correspondence cited therein from NOAA. See also NOAA Letter dated April 21, 1997, to NTIA.

[116] We understand that the Russian METEOR system will be transitioning its MetSat system to the NOAA bands in the medium term. When the Russian METEOR system vacates these bands, the System 2 and Orbcomm will no longer be required to time-share this spectrum with the Russian METEOR system.

80. NOAA has an agreement with the European Meteorological Satellite Organization ("Eumetsat") for the operation of a polar orbiting meteorological satellite in conjunction with NOAA's system in the NOAA bands. The Eumetsat system may begin operations as early as 2003. Our use of the term NOAA in this Report and Order incorporates any operations resulting from the agreement with Eumetsat.

i. Channels for Orbcomm

81. In the Notice, we stated that NOAA and Orbcomm had been coordinating Orbcomm's use of the 137-138 MHz band to prevent causing harmful interference into the NOAA system and that Orbcomm might have to migrate its operations from the 137.1850-137.2375 MHz sub-bands to two of the NOAA channels, specifically the 137.333-137.367 MHz and the 137.753-137.787 MHz channels.[117] We understand that Orbcomm and NOAA will be able to coordinate any interference to the NOAA system caused by Orbcomm and that Orbcomm will not be required to move its operations in the 137.1850-137.2375 MHz sub-band to the NOAA channels. This should also address the commenters' opposition to Orbcomm's migration to the NOAA channels.[118]

ii. Time-Sharing with NOAA

82. System 2 will be required to time-share both the NOAA channels and the NOAA bands consistent with NOAA's implementation of the NOAA channels and the NOAA bands. As discussed in the Notice, NOAA will continue operating its existing polar satellite MetSat system in the NOAA channels until the satellites become inoperable.[119] Between 2006 and 2009, NOAA plans to commence MetSat operations in the NOAA bands.[120] During this period, we expect NOAA to vacate two of the NOAA channels, the 137.485-137.515 MHz and 137.605-137.635 MHz bands (the "NOAA APT channels"). NOAA, however, has expressed a continuing need for transmission of data using the 137.333-137.367 MHz and 137.753-137.787 MHz frequencies in the NOAA channels (the "NOAA TIP channels") until approximately the year 2012, when service in the NOAA TIP channels will no longer be

[117] Notice ¶ 53.

[118] See Comments of GE-Starsys at 19; Reply Comments of CTA at 12; Comments of LEO One at 48.

[119] See Notice ¶ 52. The bandwidth identified for each NOAA channel is the emission bandwidth and does not take into account the Doppler frequency shift or the frequency tolerance. Use of the NOAA channels by Little LEO systems is secondary to Government satellite operations until January 1, 2000. Commencing January 1, 2000, Government and non-Government users of the NOAA channels will be on a co-primary basis. See Footnote US318 of the Table of Frequency Allocations, 47 C.F.R. Section 2.106.

[120] Id.

supported by MetSat satellites.[121] Thus, System 2 will have time-shared use of the four NOAA channels until between 2006 and 2009 --- when NOAA vacates the NOAA APT channels. After such time, System 2 will no longer be required to time-share the NOAA APT channels with NOAA but will continue time-sharing the NOAA TIP channels with NOAA until approximately 2012 --- when NOAA ceases service in the NOAA TIP channels. After approximately 2012, System 2 will have no longer be required to time-share the NOAA channels and will operate in this spectrum along with other primary allocated services.

83. The NOAA bands are allocated on a secondary basis to MSS.[122] Thus, MSS operations in the NOAA bands shall not cause harmful interference to NOAA MetSat systems nor can they claim protection from unacceptable interference received from NOAA MetSat systems operating in the NOAA bands. Our understanding is that NOAA intends to implement a three satellite MetSat system in the NOAA bands between 2003 and 2006. However, Eumetsat may implement its system as early as 2003. Therefore, System 2's use of the NOAA bands must be on a secondary time-shared basis with the Eumetsat system, future NOAA or other MetSat satellites.

84. Time-sharing offers an efficient means of using the NOAA channels and the NOAA bands. Because the NOAA system is currently operating two satellites in the NOAA channels, we anticipate that the MetSat users could access the NOAA system between 7.6 and 18.4 percent of the time.[123] We also anticipate that System 2 can use a large portion of the remaining time for the provision of Little LEO services. If NOAA implements a three satellite system in the NOAA bands, we calculate that System 2 initially will be able to use the NOAA bands for a large portion of the 84.5 percent of the time that it is available.[124] As

---

[121] See Letter dated May 7, 1997, from Richard D. Parlow, Associate Administrator, Spectrum Management, United States Department of Commerce National Telecommunications and Information Administration, to Peter Cowhey, Chief, International Bureau, Federal Communications Commission, Ref. IB Docket 96-220, enclosing correspondence from NOAA. The specific dates when NOAA intends to vacate the NOAA APT channels and the NOAA TIP channels are not known with certainty. Thus, the launch dates provided by NOAA to the Commission are for planning purposes only and are subject to change.

[122] See, supra, note 112.

[123] This calculation is based on the operation of two satellites by NOAA with an earth station having an elevation angle towards the satellite of zero degrees and for a user located in the Washington, D.C. area. Currently, NOAA's two satellites are phased in their orbital planes and each utilizes two of the four channels to provide meteorological satellite service. As previously stated, the availability of the satellite to the user is, in part, a function of the location of the user. For example, NOAA's two satellites will be available to its users located at latitudes of 0, 30, and 60 degrees for 7.6, 9.2 and 18.4 percent of the time, respectively.

[124] This calculation is based on the operation of three satellites by NOAA with an elevation angle of 0 degrees. The availability of the NOAA system to its users will increase if NOAA increases the number of satellites in its system. This in turn will diminish the availability of the Little LEO system to its users. As previously stated, the Little LEO licensee will need to coordinate its system with other users of the NOAA bands.

additional MetSat systems become operational in the NOAA bands, the time available for System 2 to use the NOAA bands will decrease. If System 2 were to employ frequency hopping in combination with time-sharing, its ability to access vacant frequencies in the NOAA channels and the NOAA bands would increase significantly. Frequency hopping would detect those frequencies in the NOAA channels and the NOAA bands in use and would switch System 2's transmissions to a frequency not being used by NOAA. Again, because not all second round applicants may be capable of employing this technique, we will not mandate the use of frequency hopping. However, frequency hopping uses the limited amount of spectrum most efficiently and we encourage second round systems to incorporate it into their system design.

85. Our spectrum sharing plan enables System 3 to operate a spread-spectrum CDMA system across the entire 137-138 MHz band. As GE-Starsys commented, operation of System 2 in the NOAA channels could severely increase the unacceptable interference to a CDMA system operating in the band in the same geographic areas.[125] Thus, when operating in NOAA channels close to System 3's 137.5 MHz centerline frequency, System 2 will likely have to reduce its power to avoid causing harmful interference into System 3's CDMA system operating in the band.[126] In light of the potential for harmful interference to System 3, prior to commencing operation, System 2 will be required to complete frequency coordination of its downlink operations with System 3 in the 137-138 MHz downlink band.

86. We will not assign specific feeder link spectrum in the 137-138 MHz downlink band. We will allow System 2 the flexibility to coordinate such spectrum with NOAA, Orbcomm, System 3 and the other users of the band. For the reasons previously discussed, Little LEO systems typically require continuous use of 50 kHz of feeder link spectrum. Due to the scarcity of spectrum in the band, System 2 may initially have to time-share its feeder links with NOAA. Once NOAA vacates the NOAA channels, System 2 will have continuous use of the NOAA channels, which should reduce the interference into System 3's system.

87. We recognize that there are numerous satellite systems operating or scheduled to operate in the 137-138 MHz band. NOAA's migration of its MetSat operations from the NOAA APT channels to the NOAA bands between 2006 and 2009 and from the NOAA TIP channels to the NOAA bands by approximately 2012 --- when service in the NOAA TIP channels is no longer supported by the MetSat satellites --- will relieve congestion in this band freeing spectrum for use by System 2. Thus, we conclude that one additional Little LEO system can time-share with NOAA in the NOAA channels and the NOAA bands in the 137-138 MHz downlink band through the use of time-sharing and frequency hopping techniques.

---

[125] See Comments of GE-Starsys at 19.

[126] See id. at 19-20.

88. Given the significant national interests involved, we emphasize that System 2's operations in the 137-138 MHz band must avoid causing harmful interference into the NOAA system worldwide. To protect the NOAA system, if System 2 is causing unacceptable interference to the NOAA system, the Commission will require that System 2 immediately terminate its interfering operations, wherever located, and we will not hesitate to impose sanctions on a licensee, including monetary forfeitures and license revocations, if appropriate. If NTIA notifies the Commission that NOAA is receiving unacceptable interference from System 2, we will require System 2 to terminate its interfering operations immediately unless it demonstrates to our satisfaction, and that of NTIA, that it is not responsible for causing harmful interference into the NOAA system. System 2 assumes the risk of any liability or damage that it and its directors, officers, employees, affiliates, agents and subcontractors may incur or suffer in connection with an interruption of its NVNG MSS service, in whole or in part, arising from or relating to its compliance or noncompliance with this condition.

89. GE-Starsys's return of its first round authorization makes the 137.0725-137.9275 MHz spectrum available to a system with similar transmission characteristics. We conclude that use of this returned spectrum in the Little LEO second application processing round is in the public interest. We assign this spectrum to System 3.[127] System 3 will be required to be a CDMA system in order to avoid causing harmful interference into NOAA's system, Orbcomm's system and the other authorized users in the band and to comply with NOAA's requirement that it will time-share with only one narrow-band Little LEO system in the NOAA channels and NOAA bands.[128]

90. As discussed, Section 309(j)(6)(E) of the Communications Act of 1934, as amended,[129] provides that the Commission has an obligation in the public interest to use engineering solutions, negotiation, threshold qualifications, service regulations, and other means in order to avoid mutual exclusivity in application and licensing proceedings.[130] Without use of the spectrum returned to the Commission by GE-Starsys, the available spectrum is insufficient to accommodate the remaining Little LEO second processing round applicants. The second round applicants have relied upon the use of this spectrum in developing their mutually agreed upon spectrum sharing plan submitted to the Commission.[131] Accordingly, we find that use of this spectrum in the second processing round is in the public interest because it permits the licensing of all qualified second round applicants on an

[127] Our spectrum sharing plan also assigns the 400.5983-400.645 MHz band, a small portion of GE-Starsys's returned spectrum, to System 2.

[128] See Second NTIA Letter.

[129] 47 U.S.C. § 309(j)(6)(E).

[130] Id.; see also Big LEO Order ¶ 71.

[131] See Joint Proposal.

expedited basis and avoids mutual exclusivity among applicants. More Little LEO licensees will promote competition in the Little LEO service markets, create incentives for rapid service delivery and innovation among Little LEO licensees and is likely to result in reasonably priced Little LEO services for consumers. These are the primary goals of this second application processing round proceeding.

91. Other parties with an interest in operating in the spectrum returned by GE-Starsys have been on notice that all spectrum in these frequency bands was being considered for assignment of Little LEO licenses since the time we issued our Public Notice announcing the commencement of the second application processing round and no later than our subsequent Notice.[132] At those times it was foreseeable that an existing Little LEO licensee, such a GE-Starsys, could return its spectrum to the Commission for reassignment in the second application processing round. Thus, public notice was given of our proposed use of this spectrum for Little LEO service in the second application processing round.

d. Time-Sharing with VITA, DoD and NOAA

92. In the Notice, we proposed that Little LEO systems time-share spectrum with DoD, NOAA and VITA. Time-sharing effectively allows System 1 to share the 400.15-401 MHz band with DoD and System 2 to share the 137-138 MHz band with NOAA while ensuring that neither the DoD nor NOAA systems experience unacceptable interference from the transmissions of System 1 and System 2, respectively. VITA is currently authorized to operate in the 400.505-400.5517 portion of the 400.15-401 MHz band and will operate in the 400.5983-400.645 MHz band under our spectrum sharing plan. In order to avoid causing harmful interference and any capacity loss to the VITA system, a System 2 licensee must time-share this spectrum with VITA by employing frequency hopping or other time-sharing techniques. We anticipate that with one satellite in operation, a user at the equator will be able to "see" the VITA satellite for approximately 3.7 percent of the time.[133] Therefore, when a VITA satellite is not visible, a System 2 licensee will have access to the VITA frequencies for a large portion of the 96 percent of the time that it is available, or approximately 23 hours per day.

93. Time-sharing requires that the satellites of System 1 and System 2 not transmit into the regions beneath the DoD or NOAA satellites, the "protection areas," on the same frequency being used by the DoD or NOAA satellites. Likewise, System 2 time-sharing the 400.505-400.5517 MHz and 400.5983-400.645 MHz bands with VITA will not transmit into the VITA protection areas on the same frequency being used by the VITA satellite. As the DoD, NOAA and VITA satellites progress along their orbits, their protection areas will move

[132] See, supra, notes 12 and 17.

[133] This calculation is based on a VITA satellite operating at an elevation angle of 0 degrees, an altitude of 800 km, and an orbital inclination of 99 degrees.

across the surface of the Earth beneath them. The satellites of System 1 and System 2 must track these moving protection areas worldwide and, if they enter a protection area, System 1 and System 2 must cease their satellite transmissions or transmit on a frequency different from the frequencies being used by the DoD, NOAA or VITA satellites in the protection area.

94. In order to avoid transmitting into the protection areas of the DoD, NOAA and VITA satellites, the satellites of System 1 and System 2 must know the precise location of each DoD, NOAA and VITA satellite in its orbit at any given time. System 1 and System 2 must obtain ephemeris data and use an elevation angle of five degrees in the 400.15-401 MHz band and the NOAA channels and zero degrees in the NOAA bands to calculate the protection area of the DoD, NOAA and VITA satellites.[134] To facilitate frequency-hopping, System 1 and System 2 must know the frequency on which DoD, NOAA and VITA satellites are transmitting at any given time.[135]

95. In general, none of the commenters oppose the concept of time-sharing with another satellite system. Both DoD and NOAA, however, oppose time-sharing in their respective downlink bands with multiple Little LEO systems.[136] Although CTA supports the protection area concept, it suggests that sharing may be able to occur with DoD and NOAA on a coordination basis without strictly implementing a time-sharing scheme.[137] Given the important national security and government operational interests involved, we believe it is necessary to establish a specific sharing scheme to protect the DoD and NOAA systems from harmful interference caused by Little LEO systems authorized to operate in the same frequency bands.

96. As stated in the Notice, the operators of System 1 and System 2 must designate and identify a point of contact accessible 24 hours per day, seven days per week, authorized

---

[134] Ephemeris data are technical parameters calculated for a particular satellite that mathematically represent the location of the satellite in its orbit at any given time. The elevation angle is the angular height of the satellite above the horizon as viewed from a point on the Earth. As used herein, for example, the elevation angle is the upward angle, as measured from a DoD earth station on the Earth, to a passing DoD satellite. If the passing NOAA satellite is at the horizon, the elevation angle is 0 degrees. If the NOAA satellite is directly overhead the elevation angle is 90 degrees. The elevation angle is used in calculating the size of the protection area on the earth into which the DoD, VITA, or NOAA satellite is transmitting.

[135] The DoD system will frequency hop (that is change frequencies) among its operational satellites. Therefore, if a Little LEO licensee knows the frequency on which a DoD satellite is operating, the Little LEO licensee would be able to transmit into the DOD satellite protection area on a different frequency and avoid causing interference to DoD ground terminals in the protection area. Interference will occur to DoD ground terminals if both DoD and the Little LEO licensee satellites are transmitting into the protection area on the same frequency at the same time.

[136] See, supra, ¶ 52.

[137] Comments of CTA at 24-25.

to resolve or address in an expeditious manner anomalies or reports of interference while time-sharing with DoD, NOAA or VITA.

97. The following discussion addresses specific time-sharing and operational requirements as they pertain to DoD and NOAA. However, we remind System 2 that time-sharing techniques are required to avoid causing harmful interference to the VITA system in the 400.15-401 MHz downlink band. Although we will not mandate specific time-sharing requirements with regard to VITA, we expect that System 2 will obtain ephemeris data from VITA regularly and use an elevation angle of five degrees in computing the protection area for VITA's satellites. By not mandating these requirements, we afford VITA and System 2 the flexibility necessary to establish procedures appropriate for the operators of commercial systems.

i. Transfer of Precision Data

98. In the Notice, we proposed that the Little LEO systems obtain information from DoD and NOAA on a weekly basis or as often as necessary to avoid causing harmful interference to the DoD and NOAA systems.[138] The gravitational forces of the Sun and Moon, the non-spherical nature of the Earth, and the atmospheric drag affect the location of a satellite in its orbit, thereby slightly altering the relevant ephemeris data over time. Consequently, ephemeris data pertaining to DoD, NOAA and VITA satellites must be uploaded to Little LEO satellites frequently to prevent them from accumulating erroneous ephemeris data that could result in the identification of incorrect protection areas. Therefore, System 1 must periodically obtain ephemeris data from DoD and System 2 must obtain such data from NOAA and VITA.

99. Commenters generally support the electronic transferral of ephemeris data on a weekly basis.[139] LEO One points out that a weekly transfer of this data should ensure sufficient accuracy for the operators of System 1 and System 2 to avoid DoD and NOAA protection areas and that orbit propagators can adequately project ephemeris data seven to 10 days forward.[140] Accordingly, we will require System 1 and System 2 to obtain ephemeris data from DoD and NOAA on at least a weekly basis in order to update their satellite constellations unless the parties agree upon some other time interval.

100. Because an electronic transfer can occur quickly and accurately, an electronic transfer of data may be the most efficient means of transferring ephemeris data. LEO One notes that the information can be transferred by Internet as well as a direct modem to modem

[138] Notice ¶ 59.

[139] See Comments of LEO One at 49; Comments of Final Analysis at Exhibit 2, p. 8.

[140] See Comments of LEO One at 49-50.

telephone link. Voice transfer is also feasible. In order to prevent spoofing, a digital signature and algorithm can be used to verify the message authenticity.[141] We do not know what mode of transfer of ephemeris data is most appropriate for DoD and NOAA. Therefore, we will allow DoD, NOAA, System 1 and System 2, the flexibility to determine the most appropriate means for transferring ephemeris data.

ii. Elevation Angle

101. In the Notice, we proposed using a zero degree elevation angle to calculate the protection areas for NOAA and DoD satellites in part based on a DoD requirement to operate at low elevation angles in the future when new systems are deployed. However, the applicants comment that establishing a protection area with less than a five degree elevation angle is beyond the functional requirements and performance limitations of MetSat systems.[142] We generally agree with the commenters and, therefore, we will require System 1 to use an elevation angle of five degrees when calculating the protection areas of the DoD system in the 400.15-401 MHz band and System 2 to use an elevation angle of five degrees when calculating the protection areas of the NOAA system in the NOAA channels, provided, that System 1 and System 2 will cease their transmissions prior to their respective service area, based on an elevation angle of zero degrees, overlapping a DoD or NOAA protection area. Because NVNG MSS providers are required to operate on a non-interference basis to the MetSat service in the NOAA bands, we will require that System 2 use an elevation angle of zero degrees, or less if reasonably necessary, for calculating the NOAA protection area in the NOAA bands, provided, that System 2 shall cease its transmissions prior to its service area, based on an elevation angle of zero degrees, overlapping a NOAA protection area.

102. LEO One points out that as a result of signal degradation due to atmospheric refraction and multipath fading at low elevation angles, any data received by a MetSat user located below an elevation angle of five degrees would be too flawed to be of value.[143] Further support for a five degree elevation angle can be found in a NOAA-OPQ study on the MetSat spacecraft planned for operations in the NOAA bands. The report states that user terminals operating below a five degree minimum elevation angle will not be able to receive the minimum required effective isotropic radiation power from the NOAA satellite.[144] In addition, the performance and interference criteria adopted internationally for MetSat services

[141] Id. at 50.

[142] See, e.g., Comments of CTA at 26.

[143] Comments of LEO One at 55. See also ITU-R Recommendations SA.1025 and SA.1026.

[144] See NOAA-OPQ study report on spacecraft transmission systems operating in the NOAA Low Resolution Picture Television bands (NOAA bands). The effective isotropic radiation power level in the baseline design is just sufficient to enable a low-gain antenna user to achieve a bit error rate of 10E-6 at five degrees if forward-error correction is employed, albeit with no residual margin.

specify elevation angles of five degrees or higher.[145] Because the information received by a user at a zero degree elevation angle is likely to be less accurate, there generally are no functional requirements for a user to receive data from a MetSat at elevation angles below five degrees.[146] Moreover, a requirement to protect a MetSat footprint below a five degree elevation angle will unnecessarily decrease the availability of System 1 and System 2 to users by as much as 10 percent.

103. System 1 and System 2 will use an elevation angle of five degrees when computing the protection areas of DoD satellites in the 400.15-401 MHz band and NOAA satellites in the NOAA channels, respectively. We have found no support domestically or internationally for the premise that information transmitted from a satellite to an earth terminal at an elevation angle below five degrees is sufficiently accurate for commercial or governmental use. Notwithstanding the preceding sentence, System 2 will use an elevation angle of zero degrees, or less if reasonably necessary, in the NOAA bands to protect MetSat receiving stations from receiving unnecessary interference from System 2.

iii. Orbital Propagator Algorithms

104. In the Notice, we proposed requiring Little LEO systems to provide a description of the orbital propagator algorithm they expect to use with their system and stated that we might specify use of a particular orbital propagator algorithm.[147] Little LEO systems will use an orbital propagator algorithm to calculate the location, and hence, the protection area of a satellite at any given time. Based on the comments and our analysis, we will not specify a particular orbital propagator algorithm to be used by System 1 and System 2, but we will require that System 1 and System 2 use an orbital propagator algorithm with an accuracy equal to or greater than the NORAD propagator used by NOAA.

105. LEO One commented that an orbital propagator algorithm with a higher accuracy than NORAD should be specified.[148] LEO One notes that the advantage of using an orbital propagator algorithm more accurate than NORAD is that the satellite orbit can be projected more accurately, and thus, for a longer period of time. We agree that Little LEO systems can achieve an appropriately high level of accuracy with different orbital propagator algorithms. Therefore, we will require that each second round licensee use an orbital propagator algorithm with an accuracy equal to or greater than the NORAD propagator used by NOAA. We also

[145] See ITU-R Recommendations SA.1025 and SA.1026.

[146] Comments of LEO One at 53 and Appendices D and E.

[147] Notice ¶ 71.

[148] See Comments of LEO One at 56.

expect System 1 and System 2 operators to work with DoD and NOAA in selecting an appropriate orbital propagator algorithm.

iv. System 1: Frequency Reset in Response to DoD Frequency Changes

106. In the Notice, we stated that operational or logistical circumstances may require DoD to alternate the frequency on which its satellites operate from the 400.15-400.505 MHz band to the 400.645-401 MHz band, and vice versa, and to inform its user terminals worldwide of the frequency change in less than 90 minutes.[149] In order to avoid causing harmful interference to a DoD user terminal, we proposed in the Notice that a Little LEO system planning to frequency hop in the 400.15-401 MHz band must be capable of implementing DoD imposed frequency changes within 90 minutes.[150] LEO One and Final Analysis comment that they cannot meet a 90 minute frequency change requirement for all of their satellites without adding more ground command stations outside the United States.[151] Based on the comments and our technical analysis, initially we will require System 1 to be able to change the frequency on which the satellites in its constellation are operating within 125 minutes of receiving notification from DoD of a frequency change in the 400.15-401 MHz downlink band. Thereafter, as System 1 builds additional gateway earth stations around the world, these additional gateway earth stations should enable System 1 to decrease the time needed to implement a DoD frequency change. System 1 shall notify the Commission promptly of such licensee's capability to implement a frequency change in less than 125 minutes and shall use its best efforts to decrease to 90 minutes the time needed to change the frequency on which the satellites in its constellation are operating after receiving notification from DoD of a frequency change in the 400.15-401 MHz uplink band.

107. From time to time DoD changes the frequencies used by its satellite systems for national security and other reasons. Unacceptable interference to a DoD user terminal will occur if a Little LEO satellite transmits into a DoD protection area on the same frequency a DoD satellite is using to transmit into the DoD protection area. A Little LEO satellite can avoid causing harmful interference into a DoD user terminal by not transmitting into a DoD protection area or by transmitting into the DoD protection area on a different frequency than that being used by a DoD satellite. If the Little LEO system satellite chooses to transmit into a protection area, it must know the frequency on which the DoD satellites are operating and be able to change the frequency on which it is operating whenever the DoD satellite changes its frequency.

---

[149] Notice ¶¶ 72-73.

[150] Id.

[151] See Comments of LEO One at 56; Comments of Final Analysis at 24.

108. Due to the design of the Little LEO systems, we estimate that all of the second round applicants would be capable of resetting their satellite and user terminal frequencies within 125 minutes. The orbital period[152] for each of the proposed second processing round systems is approximately 104 minutes for LEO One; 111 minutes for E-Sat; and 105 minutes for Final Analysis. LEO One commented that an additional 10-15 minutes is needed to generate and transmit command streams to the appropriate command stations for uplinking to its satellites.[153] Thus, adding the maximum orbital period of the Little LEO systems (111 minutes) to the time required to generate and distribute command streams to the satellites (10-15 minutes) indicates that a frequency change could be implemented by System 1 in approximately 125 minutes.

109. We fully support protection of the DoD system and we recognize that System 1 may be able to reduce its frequency change implementation time by designing its system to locate additional gateway earth stations outside of the United States. LEO One's system does not envision locating any gateway earth stations outside of the United States and Final Analysis indicates that meeting a 90 minute reset requirement would require additional operations team support and construction of up to six additional gateway earth stations thereby increasing the cost of its system.[154] Keeping such stations properly staffed and trained may be difficult in light of a gateway earth station's infrequent operations. More importantly, this would require System 1 to provide the access codes to its satellites to more parties in foreign countries. Because access to these codes allows control of the command functions of the satellite, including the ephemeris data relating to DoD satellites, it is prudent that they be guarded carefully. However, if System 1 adds gateway earth stations outside of North and South America, it shall use its best efforts to decrease to 90 minutes the time required to change the frequency on which the satellites in its constellation are operating in the 400.15-401 MHz uplink band after receiving notification from DoD of a frequency change. System 1 shall notify NTIA and the Commission promptly of any decrease in the time required for such licensee to change the frequency on which the satellites in its constellation are operating in the 400.15-401 MHz uplink band.

110. In order for System 1 to achieve frequency reset within 125 minutes, gateway earth stations will be required to be established outside of the United States. We believe that minimizing the number of gateway earth stations worldwide by establishing a "north-south fence" offers the best means of effectively implementing a DoD imposed frequency change. The "north-south fence" would require System 1 to locate command stations in North and South America. This would minimize the number of gateway earth stations outside of the

[152] The orbital period of a satellite system is the time required for the satellite to complete one Earth-revolution in its orbit.

[153] See Comments of LEO One at Appendix E, p. 29.

[154] Id.; Comments of Final Analysis at 24-25.

United States and the additional costs of system design and enable System 1 to achieve frequency reset within 125 minutes. In support of the "north-south fence" proposal, LEO One contends that after approximately 55 minutes, more than half of the satellites in a constellation will have received a command to switch frequencies.[155] And, after 104 minutes all satellites have been commanded to new frequencies.[156]

111. In order to ensure Little LEO systems can implement a frequency change, we proposed in the Notice that at DoD's instruction, the Little LEO system operator be required to test, up to four times a year, the ability of its system to implement a DoD frequency change.[157] In response, commenters stated that this requirement is excessive and unnecessary.[158] We agree with the commenters that requiring a test or demonstration four times a year is excessive. System 1 operating on a frequency hopping basis will implement DoD frequency changes in the course of its operations and any problems would be readily apparent to both DoD and System 1. Once System 1 successfully demonstrates to DoD that its system is able to implement DoD frequency changes, however, we will require System 1 to demonstrate its capability to implement the DoD frequency change only once per year thereafter at the instruction of DoD. LEO One also requests that the demonstrations occur during off-peak hours.[159] We find that this is a reasonable request and will achieve the same objectives of ensuring that System 1 can frequency hop without interfering with DoD's system. It will also ensure that System 1 will be able to serve its customers without interruptions in its service. Therefore, such demonstrations shall be conducted during off-peak hours as determined by the operator of System 1. System 1 must coordinate with DoD in establishing a plan for such a demonstration. In the event that System 1 fails to demonstrate to DoD that it is capable of implementing a DoD frequency change in accordance with a demonstration plan established by DoD and the operator of System 1, upon our receipt of a written notification from NTIA describing such failure, we shall impose additional conditions or requirements on System 1's authorization as may be necessary to protect DoD operations in the 400.15-401 MHz downlink band until we are notified by NTIA that System 1 has successfully demonstrated its ability to implement a DoD frequency change. We delegate authority to the International Bureau to impose such conditions or requirements in System 1's authorization and to take all steps necessary to enforce these conditions and requirements.

v. 72 Hour Reset Signal

[155] Comments of LEO One at Appendix E, p. 34.

[156] Id.

[157] Notice ¶ 75.

[158] Id.

[159] Comments of LEO One at 55.

112. Also in the Notice, we proposed requiring a Little LEO satellite to automatically cease transmissions in the 137-138 MHz and 400.15 -401 MHz bands if the satellite does not receive a valid reset signal from a Little LEO gateway station within 48 hours.[160] The rationale for this requirement is to ensure that each Little LEO satellite is functioning properly and to avoid causing harmful interference into the DoD or NOAA satellite systems in the event of a satellite malfunction. Commenters found this requirement to be unnecessary and disruptive.[161] For example, Final Analysis indicated that it already had several layers of protection against a failed-on condition, including, but not limited to, on-board computers that cease all transmitter (and other) operations when a satellite experiences a low-voltage condition. LEO One comments that there is no need for a 48 hour reset signal because the probability of any satellite in its constellation becoming a rogue interferer is less than 5×10^{-8} in five years.

113. In order for time-sharing to work properly, the DoD and NOAA systems must be protected from harmful interference caused by transmissions from a malfunctioning satellite in the System 1 or System 2 constellations. However, we agree with the commenters that the 48 hour reset signal requirement may be unduly burdensome and that the proposed requirement should be relaxed. Accordingly, we will require that System 1 and System 2 be designed so that their satellites have a turn-off switch that automatically turns off the satellite and ceases satellite transmissions if after 72 consecutive hours no reset signal is received and verified by the satellite. Each licensed satellite in their constellations shall be capable of instantaneous shutdown on any sub-band upon command from System 1's or System 2's , as the case may be, gateway earth station. We encourage satellite system designers to incorporate other appropriate fail-safe measures into the satellite system design, for example, on-board computers that cease all transmitter (and other) operations when a satellite experiences a low-voltage condition.

3. Operation of a CDMA System

114. In the Notice, we concluded that sufficient spectrum exists to license additional Little LEO systems in the second processing round if such systems use, among other things, appropriate transmission techniques.[162] The sharing plan agreed to by Orbcomm, GE-Starsys and VITA in the first processing round also concluded that additional systems could be accommodated by using CDMA and FDMA transmission techniques.[163] In the second processing round, E-Sat proposes a CDMA system asserting that it would operate

---

[160] Notice ¶ 63.

[161] See, e.g., Comments of Final Analysis at Exhibit 2, p. 8; Comments of LEO One at 51; Comments of CTA at 26.

[162] Notice ¶ 41.

[163] See Negotiated Rulemaking Report at 8-9.

transparently and not cause harmful interference to other systems in the uplink and downlink bands.[164] Both CTA and GE-Starsys agree that a CDMA system could be accommodated in the bands, subject to successful coordination with existing users.[165] In addition, the second round applicants have included E-Sat's CDMA system as System 3 in their spectrum sharing plan filed with the Commission.[166] Particularly in light of GE-Starsys's return of its authorized spectrum in the 148-150.05 MHz, 400.15-401 MHz and 137-138 MHz frequency bands to the Commission, we agree with the commenters that a CDMA system similar to the GE-Starsys system can be accommodated in the vacated GE-Starsys spectrum. Accordingly, System 3 in our spectrum sharing plan adopted in this Report and Order can be a CDMA system.

4. Industry Spectrum Sharing Plans

115. Initially LEO One proposed the A/B plan in which LEO One, CTA, E-Sat and Final Analysis share the limited uplink and downlink spectrum (the "LEO One Proposal")[167] and six of the eight original second processing round applicants jointly proposed a different plan, the X/Y plan, in which they would share the uplink and downlink spectrum among their proposed systems (the "Six-Party Proposal").[168] After review of these two proposals, we find that it is not technically feasible to accommodate more than two new Little LEO systems in the available uplink and downlink spectrum without causing degradation to the DoD, NOAA and existing Little LEO licensees' systems operations. Moreover, these proposals were unacceptable because they would require DoD and/or NOAA to time-share with multiple Little LEO licensees, which DoD and NOAA have rejected. The spectrum sharing plan proposed by the second round applicants in the Joint Proposal[169] effectively supersedes the

---

[164] Comments of E-Sat at 1.

[165] See Reply Comments of CTA at 9; Reply Comments of GE-Starsys at 6.

[166] See Joint Proposal at 2. 6.

[167] See Comments of LEO One at 32. The LEO One Proposal provides that all four new second round applicants share the 148-150.05 MHz uplink band; that LEO One time-share the 400.15-401 MHz downlink band with existing users; and that CTA, E-Sat and Final Analysis time-share the 137-138 MHz downlink band with existing users.

[168] See Memorandum To Ruth Milkman, Deputy Chief, International Bureau, From CTA Commercial Systems, Inc., E-Sat, Inc., Final Analysis Communications Services, Inc., GE-Starsys Global Positioning, Inc., Orbital Communications Corp. and Volunteers in Technical Assistance, dated April 11, 1997. The Six-Party Proposal includes all of the second round applicants except LEO One. All parties to the proposal would share the 148-150.05 MHz uplink band; the 400.15-401 MHz downlink band would be shared between the two second round systems' service links; and the 137-138 MHz downlink band would be shared between the two second round systems' feeder links and all of the other parties.

[169] See Joint Proposal.

LEO One Proposal and the Six-Party Proposal previously submitted by the second round applicants. We agree with the second round applicants that the spectrum sharing plan they propose in the Joint Proposal is a technically workable band plan. Consequently, that plan forms the basis for the spectrum sharing plan that we adopt in this Report and Order.

5. Virtual Constellation

116. Consistent with comments and our statements in the Notice,[170] we would likely sanction an agreement by all parties to share the spectrum but will not mandate that applicants participate in such a sharing arrangement.[171] Therefore, we will not mandate that the parties participate in a "Virtual Constellation" system as proposed by Final Analysis.

117. A Virtual Constellation system involves licensing all applicants to operate over the entire available spectrum, with each applicant operating a small number of technically compatible satellites. Although the satellites would be independently owned and operated, there would be some joint operations to facilitate spectrum sharing.

118. Commenters do not support our requiring a Virtual Constellation system. CTA argues that compelling companies with different goals and interests to join together in using the same facilities to provide Little LEO service would result in either outright system failure or a system compromised to the point of marginality.[172] LEO One argues that a Virtual Constellation system would have limited channel capacity and no assurance of obtaining additional spectrum.[173] As Final Analysis notes, mandating a Virtual Constellation system should be an act of last resort.[174] We agree and find that to mandate a Virtual Constellation system given the technical constraints of the spectrum available to second processing round applicants would be imprudent.

6. Set-Aside for Humanitarian Uses

119. SatelLife, Inc. ("SatelLife"), in its comments, requests that we adopt a rule requiring Little LEO licensees to set aside a portion of their capacity for humanitarian uses.[175]

---

[170] Notice ¶ 44.

[171] See id.

[172] Comments of CTA at 23.

[173] Comments of LEO One at 42-43.

[174] Comments of Final Analysis at 28.

[175] Comments of SatelLife.

Although the Commission applauds the humanitarian work done by SatelLife, we decline to adopt such a rule.

120. SatelLife has an experimental authorization and is operating a satellite in the same frequencies authorized for use by Orbcomm, VITA and System 2: 149.81-149.9 MHz and 400.505-400.5517 MHz bands. SatelLife is an international not-for-profit organization which uses a LEO satellite and computer network to provide low-cost, health-related communication and information services in the developing world. In the Notice, we proposed to license a new system to use the VITA bands, and consistent with the terms of its authorization, stated that SatelLife would have to terminate its experimental operations in the VITA bands prior to the launch of any satellite by a second round licensee authorized to use the band.[176] Under the Rules we adopt in this Report and Order, VITA will share its downlink spectrum with System 2 and continue to share its uplink spectrum with Orbcomm under its first round authorization. Therefore, it will be necessary for SatelLife to vacate the spectrum when VITA or System 2 launches an authorized Little LEO satellite.[177]

121. SatelLife argues that the Commission has established a set-aside for the Direct Broadcast Service, and therefore, should do so for the Little LEO service.[178] We disagree.[179]

C. No Mutual Exclusivity

122. In the Notice we proposed to conduct auctions to select a System licensee if there are mutually exclusive applications for these licenses.[180] The spectrum sharing plan that we adopt in this Report and Order avoids mutual exclusivity among the applicants. Therefore, it will not be necessary to conduct auctions to select a licensee from among mutually exclusive applications.

D. Unauthorized and Interfering Transmissions

---

[176] See Notice at 16, n.35; See also SatelLife Experimental Radio Station Construction Permit and License. Call sign KS2XDT. File No. 4892-EX-PL-95 (effective September 20, 1995). VITA has informed us that its satellite successfully was launched on September 23. 1997.

[177] We expect that SatelLife will begin transitioning its existing customers off of these experimental frequencies in a timely fashion in recognition of the assignment of this spectrum to Orbcomm, VITA and System 2 under the spectrum sharing plan adopted in this Report and Order and in anticipation of the grant of licenses to these systems to operate in this spectrum.

[178] See Comments of SatelLife at 8-12.

[179] See also Reply Comments of LEO One at 50 - 52; Reply Comments of Orbcomm at 26 - 27 (arguing that the Commission lacks the legal authority to impose a set-aside in the Little LEO service).

[180] See Notice ¶ 82.

123. In the Notice, we requested comments regarding ways to prevent Little LEO user terminals from making unauthorized transmissions and the costs of such methods.[181] One way to prevent unauthorized transmissions is to require that Little LEO systems be able to determine the location of a user terminal to ensure that the transmission is not originating from an unauthorized location. Commenters generally oppose this requirement because it would result in significant additional cost. In light of this assessment, we do not require the first or second round Little LEO licensees to outfit their systems with position determination equipment. However, we continue to be concerned that users may operate mobile earth terminals in countries in which they are unauthorized violating the country's sovereign rights and possibly causing interference to authorized users of the spectrum. Unauthorized transmissions are a particularly difficult problem because Little LEO user terminals are expected to be small, inexpensive and easily transportable. Because Little LEO satellites in orbit will be capable of seeing numerous countries around the globe, users may knowingly or unknowingly operate their user terminals in a country where proper authorization has not been obtained.

124. The vast majority of commenters argue that in the Little LEO service, Doppler and global positioning system ("GPS") are not viable position determination solutions for the problem of unauthorized transmissions. They argue that equipping Little LEO systems with position determination equipment would diminish their competitive advantage of providing low cost service. In particular, commenters argue that adding position determination devices to the user terminals would double their cost[182] and require larger terminals and additional battery power.[183] Commenters also argue that the use of Doppler will require the addition of extensive software capability to the systems and multiple messages to determine the position of the transmission. Conducting position determination for every transmission would consume a significant portion of each message and reduce a system's capacity for actually carrying messages.[184] Orbcomm notes that both GPS and Doppler determinations have notable time delays and limited accuracy.[185] Specifically, Orbcomm states that Doppler shift calculations are accurate generally to about 600 to 1,000 meters and will take seven to 10 minutes to calculate the first fix while GPS takes two to seven minutes from a cold start and accuracy is limited to 100 meters.[186]

---

[181] Id. ¶ 101.

[182] Comments of CTA at 34.

[183] Comments of GE-Starsys at 27; Comments of Orbcomm at 55. Comments of LEO One at 66-69.

[184] Comments of GE-Starsys at 28; Comments of Orbcomm at 56.

[185] Comments of Orbcomm at 55.

[186] Id. at 56.