ATTACHMENT A
Technical Exhibit

A.1 SCOPE AND PURPOSE

This Attachment provides the Federal Communications Commission ("Commission") with the technical characteristics of the HNS 95W satellite. This attachment contains the information required by 47 C.F.R. §25.114 and other relevant sections of the FCC's Part 25 rules.

A.2 GENERAL DESCRIPTION

The HNS 95W satellite will replace Spaceway 3, which is currently located at the nominal 95° W.L. orbital location. Specifically, HNS 95W will operate at the 95.2° W.L. orbital location and will provide high-speed broadband fixed-satellite service using a number of segments in both the Ka-band and Q/V-band.[1]

With respect to the Ka-band payload, the following chart shows the different segments to be built in the satellite and the intended use of each segment.

Frequencies	Direction	Use	Coverage
18.3 - 18.6 GHz	space-to-Earth	User terminals	North, Central and South America
18.6 - 18.8 GHz	space-to-Earth	User terminals	North, Central and South America
18.8 - 19.3 GHz	space-to-Earth	User terminals	North,[2] Central and South America
19.7 - 20.2 GHz	space-to-Earth	User terminals	North, Central and South America
27.5 - 28.0 GHz	Earth-to-space	Gateways	North, Central and South America
28.1 - 28.6 GHz	Earth-to-space	Gateways	North, Central and South America
29.3 - 29.5 GHz	Earth-to-space	User terminals	North, Central and South America
29.5 - 29.9 GHz	Earth-to-space	User terminals	North, Central and South America

Table 2-1. Ka-band Frequencies.

The international and U.S. allocations for the frequency bands listed in the table above are as follows:[3]

[1] Hughes has been unable to enter the correct orbital location in the Schedule S form, as a result of an apparent glitch in the system. As a result, the Schedule S form incorrectly states that the HNS 95W satellite will be located at the 95.0º W.L., rather than the 95.2° W.L., orbital location.

[2] Hughes does not propose to provide service to the United States in the 18.8-19.3 GHz band.

[3] 47 C.F.R. §§ 2.106, 25.202(a)(1).

Band (GHz)	ITU Region 2 Allocation	U.S. Allocation
18.3-18.6	FIXED FSS (space-to-Earth) - 18.1-18.4 for GSO BSS FL (Earth-to-space) MOBILE	**Federal:** FSS (space-to-Earth) **non-Federal:** FSS (space-to-Earth)
18.6-18.8	FIXED FSS (space-to-Earth) MOBILE (Except aeronautical mobile) EESS (passive) SRS (passive)	**Federal:** FSS (space-to-Earth) **non-Federal:** FSS (space-to-Earth)
18.8–19.3	FIXED FSS (space-to-earth) MOBILE	**Federal:** FSS (space-to-Earth) **non-Federal:** FSS (space-to-Earth) - limited to NGSO FSS
19.7–20.2	FSS (space-to-earth) MSS (space-to-earth)	**Federal:** FSS (space-to-Earth) **non-Federal:** FSS (space-to-Earth) MSS (space-to-Earth)
27.5–28.0	FIXED FSS (Earth-to-space) MOBILE	**Federal:** None **non-Federal:** FIXED FSS (Earth-to-space) - secondary to UMFUS MOBILE
28.1–28.5	FIXED FSS (Earth-to-space) MOBILE	**Federal:** None **non-Federal:** FIXED FSS (Earth-to-space) - secondary to UMFUS in 28.1-28.35 GHz MOBILE
28.5-28.6	FIXED FSS (Earth-to-space) MOBILE	**Federal:** None **non-Federal:** FSS (Earth-to-space) MOBILE
29.3–29.5	FSS (Earth-to-space) MOBILE FIXED	**Federal:** None **non-Federal:** FIXED FSS (Earth-to-space) MOBILE
29.5–29.9	FSS (Earth-to-space) MSS (Earth-to-space)	**Federal:** None **non-Federal:** FSS (Earth-to-space) MSS (Earth-to-space)

Table 2-2. Ka-band Frequency Allocations.

In the Ka-band frequencies, the Commission's rules permit FSS operations in the 18.3-18.8 GHz, 19.7-20.2 GHz, 27.5-28.0 GHz, 28.1-28.6 GHz, 29.3-29.9 GHz band, and Hughes' operations will comply with all applicable requirements.[4] HNS 95W operations in the United States in the 27.5-28.0 and 28.1-28.35 GHz bands (Earth-to-space) will be on a secondary basis to terrestrial operations in that band, *i.e.*, the Upper Microwave Flexible Use Service ("UMFUS").[5]

Hughes is requesting waiver of the U.S. Table of Frequency Allocations to operate in the 18.8-19.3 GHz band on a co-primary basis for GSO FSS service links to user terminals operating outside of the United States but within the satellite coverage area (*e.g.*, Central and South America and the Caribbean).[6]

Uplink transmissions in the 27.5 -28.0 GHz and 28.1-28.6 GHz bands (Earth-to-space) will only be made by gateway stations; no blanket-licensed user terminals will use the bands.[7] User terminals will uplink only in the 29.3-29.90 GHz band (Earth-to-space).

Regarding the Q/V-band payload, the following chart shows the different segments to be built in the satellite and the intended use of each segment.

Frequencies	Direction	Use	Coverage
40.0 - 40.5 GHz	space-to-Earth	Gateways	North, Central and South America
40.5 - 42.0 GHz	space-to-Earth	Gateways	North, Central and South America
47.2 - 50.2 GHz	Earth-to-space	Gateways	North, Central and South America
50.4 - 51.4 GHz	Earth-to-space	Gateways	North, Central and South America

Table 2-3. Q/V-band Frequencies.

The international and U.S. allocation for the frequency bands listed in the table above are as follows:

[4] 47 C.F.R. §§ 2.102(a), 2.106, 25.202. 50.40–51.40 GHz is not identified as available for non-Federal use for FSS in 47 C.F.R. §25.202(a), and Hughes has requested a waiver of this rule to the extent necessary. *See* Narrative, Section III.A.2.

[5] 47 C.F.R. § 25.136.

[6] *See* Narrative, Section III.A.1. Although Hughes does not plan on operating in the 18.8-19.3 GHz band in the United States, the company will accept the imposition of a condition that any such operations will be on an unprotected, non-harmful interference basis.

[7] *See supra* Table 2-1.

Band (GHz)	ITU Region 2 Allocation	U.S. Allocation
40.0–40.5	FIXED MOBILE FSS (space-to-Earth) MSS (space-to-Earth) EESS (Earth-to-space) SPACE RESEARCH (Earth-to-space)	**Federal:** MSS (space-to-Earth) EESS (Earth-to-space) SPACE RESEARCH (Earth-to-space) FSS (space-to-Earth) **non-Federal:** FSS (space-to-Earth) MSS (space-to-Earth)
40.5–42.0	FSS (space-to-Earth) FIXED BROADCASTING BSS	**Federal:** FSS (space-to-Earth) in 40.5-41 GHz only **non-Federal:** BSS BROADCASTING FSS (space-to-Earth) MOBILE (only 41-42 GHz) FIXED (only 41-42 GHz)
47.2–50.2	FIXED FSS (Earth-to-space) MOBILE	**Federal (in 48.2–50.2 GHz only):** FIXED FSS (Earth-to-space) MOBILE **non-Federal:** FIXED FSS (Earth-to-space) MOBILE
50.4–51.4	FIXED FSS (Earth-to-space) MOBILE	**Federal:** FIXED FSS (Earth-to-Space) MOBILE MSS (Earth-to-Space) **non-Federal:** FIXED FSS (Earth-to-Space) MOBILE MSS (Earth-to-Space)

Table 2-4. Q/V-band Frequency Allocations.

Under the international and U.S. table of allocations, the Q/V-band frequencies in Table 2-4 above are allocated on a co-primary basis for FSS.[8] The HNS 95W satellite will meet all

[8] As discussed in the narrative exhibit, Hughes requests waiver of 47 C.F.R. § 25.202(a), to the extent necessary, to operate in the 50.4-51.4 GHz band (Earth-to-space). *See* Narrative, Section III.A.2.

Commission regulations regarding operations in these bands.[9] Further, the HNS 95W satellite will comply with the default service rules given that the Commission has not adopted service rules in portions of these bands, as discussed in section A.19 below.

The HNS 95W satellite system is designed to provide connectivity between large earth stations designated as gateways and user terminals. The satellite will provide, in the aggregate, approximately 2.5 times as much bandwidth from gateway to user terminals as from user terminals to gateway station. The ground segment will initially consist of 18 gateways,[10] which will provide 2 GHz capacity per uplink in the Ka-band frequencies, and 8 GHz per uplink in the Q/V-band frequencies, for a total of 180 GHz of forward bandwidth. In the return direction, the aggregation of all user terminals uplinks will be downlinked to each gateway in 4 GHz of Q-band bandwidth, for a total of 72 GHz bandwidth of return bandwidth.[11]

For both the Ka-band and Q/V-band frequencies, the satellite uses both left and right hand circular polarization (LHCP and RHCP) together with beam separation to achieve full frequency re-use at acceptable levels of co- and cross-polarized intra-system interference.[12]

The satellite utilizes a bent-pipe architecture with asymmetric forward (gateway-to-subscriber) and return (subscriber-to-gateway) links as described above. Forward links consist of a single TDM 500 MHz wide carrier, while the return links use MF-TDMA with a variety of bandwidths/data rates employed. The network uses adaptive coding and modulation to combat rain fades. That is, the modulation type, amount of coding and/or user data rate is dynamically varied to meet the link requirements during rain events.

A.3 SPACE STATION TRANSMIT AND RECEIVE CAPABILITY

A.3.1 Ka-band Frequencies

The HNS 95W satellite beam coverage, for both transmit and receive, will initially consist of 18 gateway beams and 286 user beams that will provide service to the Americas.[13]

A.3.2 Q/V-band Frequencies

The HNS 95W satellite Q/V-band beam coverage, for both transmit and receive, will initially consist of 18 gateway beams.

[9] *See* 47 C.F.R. §§ 25.114(c)(8); 25.208 (c), (e), (q), (s) and (u); ITU RR Article 21; *see also infra* Section A.16 (discussing sharing in the 40.0-42.2 GHz); Section A.17 (discussing sharing in the 50.4-51.4 GHz band).

[10] Hughes expects to increase the number of gateway earth stations by up to approximately 4 to 7.

[11] *See infra* Section A.5; 47 C.F.R. § 25.114(c)(4)(i), (13).

[12] *See* 47 C.F.R. § 25.114(c)(4)(i), (13).

[13] *See supra* Table 2-1.

A.3.3 Antenna gain contours for typical beams and service area

As required by 47 C.F.R. §25.114(c)(4)(vii) the predicted antenna gain contours for typical transmit and receive antenna beams are provided in GXT format in the corresponding Schedule S.

The gain contours are identical for all user and gateway beams within their respective type. The table below lists the typical beams for which the predicted gain contours are provided.

No.	Beam	Tx/Rx	Frequencies	Polarization
1	UR1L	Rx	29300-29900 MHz	LHCP
2	UR1R	Rx	29300-29900 MHz	RHCP
3	UR3L	Rx	29300-29900 MHz	LHCP
4	UR3R	Rx	29300-29900 MHz	RHCP
5	UR5L	Rx	29300-29900 MHz	LHCP
6	UR5R	Rx	29300-29900 MHz	RHCP
7	UT1L	Tx	18300-19300 MHz	LHCP
8	UT1R	Tx	18300-19300 MHz	RHCP
9	UT3L	Tx	18300-19300 MHz	LHCP
10	UT3R	Tx	18300-19300 MHz	RHCP
11	UT5L	Tx	18300-19300 MHz	LHCP
12	UT5R	Tx	18300-19300 MHz	RHCP
13	VT1L	Tx	19700-20200 MHz	LHCP
14	VT1R	Tx	19700-20200 MHz	RHCP
15	VT3L	Tx	19700-20200 MHz	LHCP
16	VT3R	Tx	19700-20200 MHz	RHCP
17	VT5L	Tx	19700-20200 MHz	LHCP
18	VT5R	Tx	19700-20200 MHz	RHCP
19	GR1L	Rx	27500-28000 MHz	LHCP
20	GR1R	Rx	27500-28000 MHz	RHCP
21	GR2L	Rx	28100-28600 MHz	LHCP
22	GR2R	Rx	28100-28600 MHz	RHCP
23	GR4L	Rx	47200-50200 MHz	LHCP
24	GR4R	Rx	47200-50200 MHz	RHCP
25	GR6L	Rx	50400-51400 MHz	LHCP
26	GR6R	Rx	50400-51400 MHz	RHCP
27	GT1L	Tx	40000-42000 MHz	LHCP
28	GT1R	Tx	40000-42000 MHz	RHCP

Table 3-1. List of gain contours for typical beams.

For all beams, a single isoline map showing the service area is provided in GXT format and the map is shown in Figure 3-1 below.

Figure 3-1. Single isoline map of service area.

A.4 FREQUENCY AND POLARIZATION PLAN

The HNS 95W satellite Ka-band and Q/V-band frequency plan is provided in Figures 4-1 and 4-2 below.

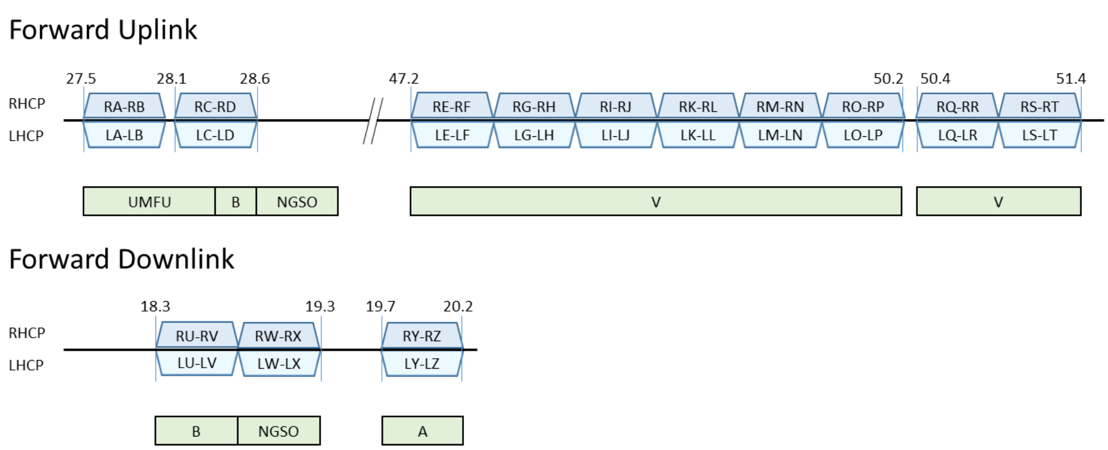

Figure 4-1. Frequency plan for the forward link.

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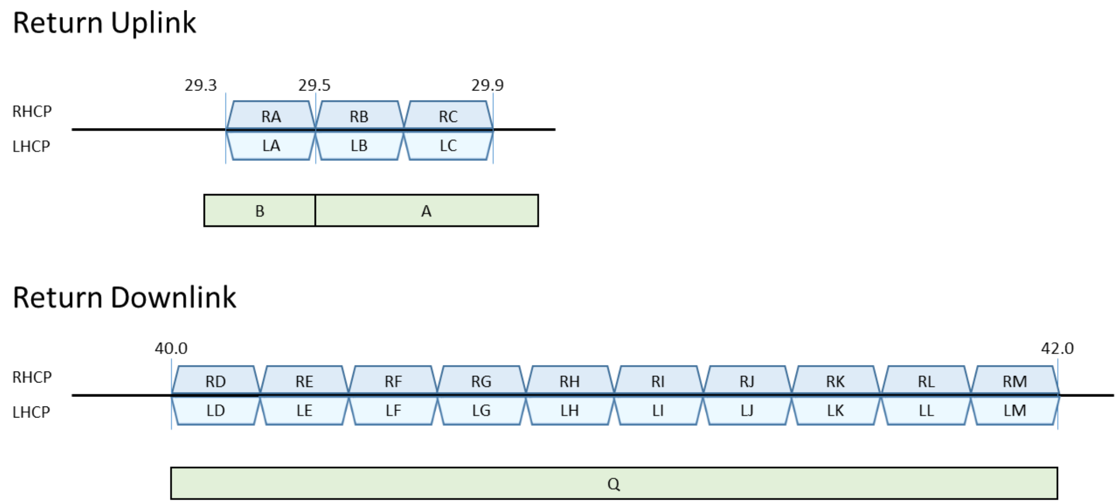

Figure 4-2. Frequency plan for the return link

Circular polarization will be used on both the uplink and downlink with the downlink polarization in any user beam being orthogonal to the uplink polarization.

A.5 BEAM INTERCONNECTIVITY

The beam-to-beam interconnectivity is as shown in the table below for all 286 user beams. The beams are not sequentially numbered.

Beam	GW	Fwd uplink	Fwd downlink	Ret uplink	Ret downlink
U_001	11	LALB	RYRZ	LC	RF
U_002	17	LCLD	RURV	LA	LJ
U_003	9	LMLNLELF	LULVLYLZ	RBRC	RERF
U_004	16	RCRD	RURV	LA	RG
U_005	13	RERF	RURV	LA	LD
U_006	15	RGRH	LULV	RB	LK
U_007	12	LGLH	RYRZ	LB	LK
U_008	12	RIRJ	RURV	LA	LG
U_009	8	RKRLLILJ	LULVLYLZ	RBRC	LKRF
U_010	8	LKLL	RYRZ	LC	RM
U_011	16	RMRNLOLP	LULVLYLZ	RARB	LDLH
U_012	16	RQRR	RURV	LB	RE
U_013	16	RSRTLQLR	LULVLYLZ	RBRC	RLRI
U_014	16	LSLT	RYRZ	LC	RF
U_015	16	LCLD	RURV	LB	LE
U_016	16	LMLNRARB	LULVLYLZ	RARB	LGLE
U_017	7	RORP	RYRZ	LC	LI
U_018	18	RCRD	RURV	LA	RD
U_019	12	RERFLALB	LULVLYLZ	RARB	LDLL
U_020	6	LELF	RYRZ	LC	RF
U_021	13	RGRH	RURV	LB	LK
U_022	12	RIRJLGLH	LULVLYLZ	RBRC	RELF

U_023	5	LILJ	RYRZ	LB	LL
U_024	18	RKRL	RURV	LA	LD
U_025	15	LKLL	RYRZ	LC	LF
U_026	15	RMRN	RURV	LA	RJ
U_027	15	RQRRLOLP	LULVLYLZ	RBRC	RHRM
U_028	15	LQLR	RYRZ	LC	LM
U_029	15	RSRT	RURV	LA	LJ
U_030	8	LCLDLSLT	LULVLYLZ	RARB	RGRE
U_031	4	RARB	RYRZ	LB	RE
U_032	15	LMLN	RURV	LA	RJ
U_033	2	RCRD	RURV	LA	LJ
U_034	7	RERFRORP	LULVLYLZ	RBRC	RERM
U_035	3	LALB	RYRZ	LC	RM
U_036	3	RGRH	RURV	LA	LG
U_037	11	RIRJLELF	LULVLYLZ	RARB	LJRH
U_038	2	LGLH	RYRZ	LB	RH
U_039	10	RKRL	RURV	LA	RJ
U_040	11	RMRNLILJ	LULVLYLZ	RBRC	RKLI
U_041	1	LKLL	RYRZ	LB	LH
U_042	15	RQRR	RURV	LA	RG
U_043	15	RSRTLOLP	LULVLYLZ	RARB	RJRK
U_044	7	LQLR	RYRZ	LC	RM
U_045	9	LCLD	RURV	LA	LG
U_046	12	LMLNLSLT	LULVLYLZ	RARB	RGRH
U_047	6	RARB	RYRZ	LB	LH
U_048	8	RCRD	RURV	LA	LG
U_049	15	RORP	RYRZ	LB	LK
U_050	5	LALB	RYRZ	LC	LI
U_051	7	RERF	RURV	LA	LD
U_052	10	RGRHLELF	LULVLYLZ	RARB	RJLH
U_053	4	LGLH	RYRZ	LC	LI
U_054	11	RIRJ	RURV	LB	RE
U_055	10	RKRLLILJ	LULVLYLZ	RBRC	RHLI
U_056	3	LKLL	RYRZ	LB	RH
U_057	10	RMRN	RURV	LA	LD
U_058	7	RQRRLOLP	LULVLYLZ	RARB	LJLH
U_059	2	LQLR	RYRZ	LC	RF
U_060	9	RSRT	RURV	LB	RL
U_061	6	LCLDLSLT	LULVLYLZ	RARB	RGRE
U_062	1	RARB	RYRZ	LB	LK
U_063	8	LMLN	RURV	LA	RG
U_064	9	RCRDRORP	LULVLYLZ	RARB	RGLH
U_065	7	RERF	RURV	LB	RK
U_066	18	RGRH	LULV	RA	RJ
U_067	9	LALB	RYRZ	LB	LK
U_068	6	RIRJ	RURV	LA	LG
U_069	9	RKRLLELF	LULVLYLZ	RBRC	LKLI
U_070	2	LGLH	RYRZ	LC	RF

U_071	5	RMRN	RURV	LA	LG
U_072	6	RQRRLILJ	LULVLYLZ	RBRC	LERF
U_073	12	LKLL	RYRZ		
U_074	4	RSRT	RURV	LA	LD
U_075	5	LCLDLOLP	LULVLYLZ	RBRC	LLRF
U_076	3	LQLR	RYRZ	LC	RM
U_077	3	LMLN	RURV	LA	LD
U_078	8	RCRDLSLT	LULVLYLZ	RBRC	RKLM
U_079	10	RARB	RYRZ	LB	LK
U_080	10	RORP	RYRZ	LB	LH
U_081	2	RERF	RURV	LA	LG
U_082	8	RGRHLALB	LULVLYLZ	RARB	RJRE
U_083	8	LELF	RYRZ	LB	RH
U_084	1	RIRJ	RURV	LC	LM
U_085	9	RKRLLGLH	LULVLYLZ	RARB	LDLL
U_086	9	LILJ	RYRZ	LB	RH
U_087	6	RMRN	RURV	LC	LM
U_088	7	RQRRLKLL	LULVLYLZ	RBRC	LKRI
U_089	9	LOLP	RYRZ	LA	RD
U_090	5	RSRT	RURV	LB	LK
U_091	5	LCLDLQLR	LULVLYLZ	RARB	RJRK
U_092	7	LSLT	RYRZ	LA	LJ
U_093	4	LMLN	RURV	LB	LK
U_094	3	RCRD	RURV	LB	RL
U_095	4	RERFRARB	LULVLYLZ	RARB	RJRH
U_096	8	RORP	RYRZ	LC	LF
U_097	2	RGRH	RURV	LB	RH
U_098	6	RIRJLALB	LULVLYLZ	RARB	LGRK
U_099	8	LELF	RYRZ	LB	RL
U_100	1	RKRL	RURV	LA	RJ
U_101	7	RMRNLGLH	LULVLYLZ	RARB	RJLK
U_102	7	LILJ	RYRZ	LB	LE
U_103	11	RQRR	RURV	LA	LD
U_104	12	RSRTLKLL	LULVLYLZ	LBRBRC	RLRHLI
U_105	10	LOLP	RYRZ	LC	LM
U_106	12	LCLD	RURV	LB	LL
U_107	11	LMLNLQLR	LULVLYLZ	RARB	LGRE
U_108	6	LSLT	RYRZ	LB	RE
U_109	10	RCRD	RURV	LA	RD
U_110	5	RERFRARB	LULVLYLZ	RBRC	LLLF
U_111	7	RORP	RYRZ	LC	LF
U_112	11	RGRH	RURV	LA	LD
U_113	6	RIRJLALB	LULVLYLZ	RBRC	LKLF
U_114	11	LELF	RYRZ	LB	RE
U_115	9	RKRL	RURV	LA	LJ
U_116	4	RMRNLGLH	LULVLYLZ	RBRC	RKLF
U_117	5	LILJ	RYRZ	LC	RF
U_118	10	RQRR	RURV	LB	LE

U_119	3	RSRTLKLL	LULVLYLZ	RARB	RDRL
U_120	6	LOLP	RYRZ	LB	RH
U_121	8	LCLD	RURV	LA	RJ
U_122	9	LMLN	RURV	LA	LD
U_123	17	RCRD	LULV	RA	LD
U_124	12	LQLR	RYRZ	LC	RI
U_125	7	RERF	RURV	LB	RE
U_126	4	RGRHLSLT	LULVLYLZ	RARB	RGRK
U_127	4	RARB	RYRZ	LC	RI
U_128	8	RIRJ	RURV	LA	RG
U_129	10	RKRLRORP	LULVLYLZ	RARB	LGRK
U_130	5	LALB	RYRZ	LB	RK
U_131	6	RMRN	RURV	LA	RD
U_132	5	RQRRLELF	LULVLYLZ	RARB	LDRE
U_133	11	LGLH	RYRZ	LB	RE
U_134	7	RSRT	RURV	LA	LG
U_135	3	LCLDLILJ	LULVLYLZ	RBRC	RERM
U_136	3	LKLL	RYRZ	LC	LI
U_137	6	LMLN	RURV	LB	RK
U_138	2	RCRDLOLP	LULVLYLZ	RBRC	RLRF
U_139	4	LQLR	RYRZ	LA	LG
U_140	6	RERF	RURV	LB	LH
U_141	3	RGRHLSLT	LULVLYLZ	RARB	RDLE
U_142	2	RARB	RYRZ	LC	RM
U_143	5	RIRJ	RURV	LB	LH
U_144	4	RKRLRORP	LULVLYLZ	RBRC	RHLM
U_145	10	LALB	RYRZ	LB	LL
U_146	5	RMRN	RURV	LA	RD
U_147	2	RQRRLELF	LULVLYLZ	RARB	LDLK
U_148	4	RSRT	RURV	LB	RH
U_149	16	LCLD	LULV	RC	RI
U_150	3	LGLH	RYRZ	LB	LK
U_151	4	LMLN	RURV	LC	RF
U_152	2	RCRDLILJ	LULVLYLZ	RBRC	LLRF
U_153	1	LKLL	RYRZ	LB	RE
U_154	3	RERF	RURV	LA	LJ
U_155	1	RGRHLOLP	LULVLYLZ	RBRC	LKLI
U_156	9	LQLR	RYRZ	LB	RK
U_157	3	RIRJ	RURV	LA	LD
U_158	2	RKRLLSLT	LULVLYLZ	RARB	LDLK
U_159	2	RARB	RYRZ	LB	RL
U_160	2	RMRN	RURV	LA	RJ
U_161	10	RQRRRORP	LULVLYLZ	RBRC	RELM
U_162	8	LALB	RYRZ	LB	LE
U_163	2	RSRT	RURV	LA	LG
U_164	11	LCLDLELF	LULVLYLZ	RBRC	RHRM
U_165	1	LGLH	RYRZ	LB	RK
U_166	1	LMLN	RURV	LA	LJ

U_167	3	RCRDLILJ	LULVLYLZ	RBRC	RHRI
U_168	7	LKLL	RYRZ	LB	LL
U_169	1	RERF	RURV	LA	RJ
U_170	5	RGRH	RURV	LA	RD
U_171	15	RIRJ	LULV	RA	LG
U_172	1	RKRLLOLP	LULVLYLZ	RBRC	RHRF
U_173	6	LQLR	RYRZ	LC	RF
U_174	4	RMRN	RURV	LA	RD
U_175	1	RQRRLSLT	LULVLYLZ	RARB	LDLH
U_176	5	RARB	RYRZ	LC	RF
U_177	11	RSRT	RURV	LB	LK
U_178	14	LCLD	LULV	RC	RM
U_301	12	LMLN	RURV	LA	LD
U_302	12	RORP	LYLZ	RC	LF
U_303	12	LALB	RYRZ	LC	RM
U_304	12	RCRD	RURV	LB	RK
U_305	11	LELF	LYLZ	RA	LJ
U_306	4	LGLH	RYRZ	LC	RF
U_307	3	RERF	RURV	LB	LK
U_308	1	LILJ	LYLZ	RC	RI
U_309	12	LKLL	LYLZ	RA	RJ
U_310	2	LOLP	RYRZ	LC	LF
U_311	4	RGRH	RURV	LA	LD
U_312	17	LQLR	LYLZ	RC	RF
U_313	3	LSLT	RYRZ	LC	RI
U_314	2	RIRJ	RURV	LB	RH
U_315	12	RARB	LYLZ	RC	LI
U_316	1	RORP	RYRZ	LC	LI
U_317	5	LALB	RYRZ	LC	LM
U_318	1	RKRL	RURV	LB	RK
U_319	17	RMRN	LULV	RA	RG
U_320	11	LELF	RYRZ	LC	RM
U_321	1	RQRR	RURV	LA	RJ
U_322	11	RSRT	LULV	RA	LD
U_323	4	LGLH	RYRZ	LB	LL
U_324	9	LCLD	RURV	LC	LF
U_325	11	LILJ	LYLZ	RC	LF
U_326	18	LMLN	RURV	LA	LG
U_327	12	RCRD	LULV	RA	RG
U_328	8	LKLL	RYRZ	LC	RM
U_329	7	RERF	RURV	LA	RJ
U_330	10	LOLP	LYLZ	RC	RM
U_331	9	LQLR	RYRZ	LC	RM
U_332	8	RGRH	RURV	LA	RJ
U_333	11	LSLT	LYLZ	RC	LM
U_334	7	RARB	RYRZ	LC	LI
U_335	10	RORP	RYRZ	LC	RF
U_336	17	RIRJ	RURV	LA	LD

U_337	10	RKRL	LULV	RA	LG
U_338	9	LALB	RYRZ	LC	RI
U_339	16	RMRN	RURV	LA	RG
U_340	1	RQRR	LULV	RA	LD
U_341	8	LELF	RYRZ	LC	LI
U_342	6	RSRT	RURV	LA	LJ
U_343	9	LGLH	LYLZ	LC	RI
U_344	5	LCLD	RURV	LA	RJ
U_345	10	LILJ	LYLZ	RC	RF
U_346	6	LKLL	RYRZ	LC	LI
U_347	1	LOLP	LYLZ	RC	RM
U_348	13	LQLR	RYRZ	LC	RI
U_349	14	LMLN	RURV	LA	LJ
U_350	14	LSLT	LYLZ	RC	LM
U_351	13	RARB	RYRZ	LC	LM
U_352	14	RCRD	LULV	RA	RD
U_353	14	RORP	RYRZ	LC	LI
U_354	14	RERF	RURV	LA	LJ
U_355	13	RGRH	LULV	RA	LD
U_356	14	LALB	RYRZ	LC	LI
U_357	14	RIRJ	RURV	LA	LG
U_358	14	LELF	RYRZ	LC	LM
U_359	14	RKRL	RURV	LA	RG
U_360	14	LGLH	LYLZ	RC	LI
U_361	14	LILJ	RYRZ	LC	LM
U_362	14	RMRN	LULV	RA	LD
U_363	13	LKLL	RYRZ	LC	RM
U_364	13	RQRR	RURV	LA	LJ
U_365	13	RSRT	LULV	RA	RG
U_366	13	LCLD	RURV	LA	LG
U_367	13	LOLP	LYLZ	RC	LM
U_368	13	LQLR	RYRZ	LC	LI
U_369	13	LMLN	RURV	LA	LD
U_370	13	LSLT	LYLZ	RC	LF
U_371	13	RARB	RYRZ	LC	RI
U_372	14	RCRD	RURV	LA	LD
U_373	13	RORP	LYLZ	RC	LF
U_374	13	RERF	LULV	RB	RH
U_375	18	RGRH	RURV	LB	RH
U_501	18	LALB	RYRZ	LC	RF
U_502	18	RARB	RWRX	LB	RK
U_503	18	RIRJRORP	LULVLWLX	RBRC	LKRF
U_504	13	RKRLLALB	LULVLWLX	RARB	RDLK
U_505	13	RMRNRARB	RURVRWRX	LALB	LDLH
U_506	15	RQRRRORP	RURVRWRX	LBLC	RHLI
U_507	18	RSRTLALB	LULVLWLX	RBRC	LLLI
U_508	17	LCLDRARB	RURVRWRX	LALB	LGRL
U_509	16	LMLNRORPLELF	LULVLWLXLYLZ	RARBRC	RDRHLI

U_510	18	RCRDLALBLGLH	RURVRWRXRYRZ	LALBLC	RJRHRF
U_511	16	RERFLCLDLILJ	LULVLWLXLYLZ	RARBRC	LDLERF
U_512	17	RGRHLCLD	RURVRWRX	LBLC	RLRM
U_513	17	RIRJLCLD	LULVLWLX	RARB	RJLK
U_514	16	LCLDLKLL	RWRXRYRZ	LBLC	RELM
U_515	17	RKRLLCLD	LULVLWLX	RBRC	LHRF
U_516	18	RMRNLOLP	RURVRYRZ	LALB	LJLH
U_517	18	LQLR	LYLZ	RB	RE
U_518	17	LSLT	RYRZ	LC	LM
U_519	17	LELF	LYLZ	RB	LL
U_520	15	LCLD	RWRX	LB	LH
U_521	15	LGLH	RYRZ	LC	RM
U_522	15	LILJ	LYLZ	RB	LH
U_523	14	LKLL	RYRZ	LB	RK
U_524	14	LOLP	LYLZ	RB	LE
U_525	17	LQLR	RYRZ	LC	RM
U_526	17	RQRRLSLT	LULVLYLZ	RBRC	RLLM
U_527	17	RSRT	RURV	LB	LL
U_528	15	LMLNLCLD	LULVLWLX	RBRC	RLLF
U_529	14	RCRDLCLD	RURVRWRX	LALB	LDRL
U_530	14	RERFLCLD	LULVLWLX	RBRC	RLLM
U_531	17	LELF	RYRZ	RB	LK
U_532	18	RGRHLGLH	RURVRYRZ	LBLC	LELF
U_533	18	LILJ	LYLZ	RC	RI

Table 5-1. Summary of beam-to-beam interconnectivity.

In the Ka-band frequencies, the satellite will employ a three-fold frequency re-use pattern such that any channel will be re-used multiple times by a combination of polarization and spatial isolation. In the Q/V-band frequencies, each channel will be used eighteen times through a combination of polarization and spatial isolation. The requirements of 47 C.F.R. §25.210(f) of the Commission's rules will be satisfied.

A.6 SERVICES TO BE PROVIDED

The HNS 95W satellite will provide a variety of FSS services including broadband services at speeds well in excess of 25/3 Mbps and support next-generation communications services, such as 5G, machine-to-machine, and the Internet of Things.

A.7 TT&C CHARACTERISTICS

The information provided in this section complements that provided in the associated Schedule S submission.

The TT&C sub-system will provide communications during pre-launch, transfer orbit and on-station operations, as well as during spacecraft emergencies. Beacon transmissions will be used to control on-station spacecraft attitude, gateway uplink power control and the pointing of the satellite's antennas. Telecommand and telemetry functions will use the Ka-band frequencies, and the TT&C sub-system will operate at the edges of the 20/30 GHz frequency bands during all phases of the mission.[14] The command frequency is expected to be 29401.00 and 29403.00 MHz and the telemetry frequency is expected to be 19701.00 and 19703.00 MHz. These frequencies will be coordinated with adjacent satellites.

During transfer orbit and on-station emergencies the TT&C subsystem will employ a dual omnidirectional antenna configuration. During normal on-station operation, the telecommand transmissions will be received via one of two uplink gateway beams (primary plus backup). The TT&C earth station locations have not yet been finalized, however it is expected that the TT&C earth stations will be located in Cheyenne, WY and Gilbert, AZ.

A.8 CESSATION OF EMISSIONS

All downlink transmissions can be turned on and off by ground telecommand, thereby causing cessation of emissions from the satellite, as required.[15]

A.9 KA-BAND POWER FLUX DENSITY AT THE EARTH'S SURFACE

47 C.F.R. §25.208(c) contains PFD limits that apply in the 18.3-18.8 GHz band.[16] The PFD limits of 47 C.F.R. §25.208(c) are as follows:

- -115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- -115 + 0.5 (δ-5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- -105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

In addition, 47 C.F.R. §25.208(d) contains PFD limits that apply in the 18.6-18.8 GHz band produced by emissions from a space station under assumed free-space propagation conditions as follows:

- -95 dB(W/m^2) for all angles of arrival. This limit may be exceeded by up to 3 dB for no more than 5% of the time.

47 C.F.R. §25.208(e) contains PFD limits in the 18.8-19.3 GHz band that apply to non-GSO FSS constellations, nevertheless, fixing the parameter "n" to 1 (the geostationary case) the PFD limits are identical to those in 47 C.F.R. §25.208(c). Compliance with the applicable FCC PFD limits is demonstrated below using a simple worst-case methodology.[17]

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[14] *See* 47 C.F.R. § 25.202(g).

[15] *See* 47 C.F.R. § 25.207.

[16] *See also* 47 C.F.R. § 25.114(c)(8).

[17] *See* ITU Radio Regulations, Article 21 (ed. 2012).

The maximum downlink EIRP that the HNS 95W satellite can transmit in the Ka-band frequencies is 42.3 dBW in 1 MHz. The shortest distance from the satellite to the Earth is 35,786 km, corresponding to a spreading loss of 162.06 dB. Therefore, the maximum possible PFD at the Earth's surface will not exceed -119.8 dBW/m^2/MHz at an elevation angle of 90°. This level is less than the -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below, and consequently compliance with the PFD limits in Sections 25.208(c) and (e) are assured.

In addition, 47 C.F.R. §25.208(d) provides an additional aggregate PFD limit in the 200 MHz wide band 18.6-18.8 GHz of -95 dBW/m^2. In the worst case, this will correspond to a PFD limit of -118 dBW/m^2/MHz (*i.e.*, -95-10 log(200)). As demonstrated in the previous paragraph, downlink transmissions from the HNS 95W satellite cannot exceed -119.8 dBW/m^2/MHz at any angle of arrival, and therefore compliance with 47 C.F.R. §25.208(d) is also assured.

A.10 Q/V-BAND POWER FLUX DENSITY AT THE EARTH'S SURFACE

This section demonstrates that the Q/V-band payload of the HNS 95W satellite will not exceed the applicable geostationary space station PFD limits of 47 C.F.R. §25.208.

A.10.1 40-40.5 GHz Band PFD Limits

The PFD limits that apply to the 40-40.5 GHz band are those of 47 C.F.R. §25.208(s). As demonstrated below, the HNS 95W satellite will comply with the PFD limits of 47 C.F.R. §25.208(s). The PFD limits of 47 C.F.R. §25.208(s) are as follows:

- −115 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- −115 + 0.5 (δ -5) dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 25 degrees above the horizontal plane; and
- −105 dB(W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

In the 40-40.5 GHz band, the maximum downlink EIRP density that the HNS 95W satellite will transmit is 24.8 dBW/MHz. The shortest distance from the satellite to the Earth is 35,786 km, which corresponds to a spreading loss of 162.06 dB. Therefore, the maximum possible PFD at the Earth's surface will not exceed approximately -137.3 dBW/m^2/MHz. The PFD over the HNS 95W satellite's actual service area will be necessarily slightly lower due to the longer slant paths.

This level is less than the -115 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below, and consequently compliance with the PFD limits is assured.

A.10.2 40.5-42.0 GHz Band PFD Limits

The PFD limits that apply to the 40.5-42.0 GHz band are those of 47 C.F.R. §25.208(u). As demonstrated below, the HNS 95W satellite will also comply with the PFD limits of 47 C.F.R. §25.208(u). The PFD limits of 47 C.F.R. §25.208(u) are as follows:

- -120 dB(W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
- $-120 + (\delta - 5)$ dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 5 and 15 degrees above the horizontal plane;
- $-110 + 0.5 (\delta - 15)$ dB(W/m^2) in any 1 MHz band for angles of arrival δ (in degrees) between 15 and 25 degrees above the horizontal plane; and
- -105 dB(W/m$_2$) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

In the 40.5-42.0 GHz band, the maximum downlink EIRP density that the HNS 95W satellite will transmit is 24.8 dBW/MHz. The shortest distance from the satellite to the Earth is 35,786 km, which corresponds to a spreading loss of 162.06 dB. Therefore, the maximum possible PFD at the Earth's surface will not exceed approximately -137.3 dBW/m^2/MHz. The PFD over the HNS 95W satellite's actual service area will be necessarily slightly lower due to the longer slant paths.

This level is less than the -120 dBW/m^2/MHz PFD limit value that applies at elevation angles of 5° and below, and consequently compliance with the PFD limits is assured.

A.11 ADAPTIVE POWER CONTROL

Earth stations operating with the HNS 95W satellite will employ adaptive power control to compensate for fading due to precipitation and to facilitate transmission of uplinks at power levels required for desired link performance. Operation of such features will minimize interference to terrestrial networks and will comply with 47 C.F.R. §§25.204(e)(1) and (e)(3).

A.12 KA-BAND TWO-DEGREE COMPATIBILITY

The HNS 95W satellite will meet the Commission's two-degree spacing requirements, as discussed below. All Ka-band frequency transmissions of the HNS 95W satellite earth stations will not exceed the uplink off axis EIRP density and downlink PFD levels of 47 C.F.R. §25.138, regardless of whether the frequency band used is subject to 47 C.F.R. §25.138.

A.12.1 Frequency Bands Subject to 47 C.F.R. §25.138

The frequency bands subject to 47 C.F.R. §25.138 will comply with the Commission's two-degree spacing policy because HNS 95W will comply with the following requirements:

1) The uplink off-axis EIRP density levels of 47 C.F.R. §25.138(a)(1) of the Commission's rules for uplink transmission from associated earth stations will not be exceeded; and

2) The maximum PFD levels transmitted from the space station are lower than the PFD values given in 47 C.F.R. §25.138(a)(6) of the Commission's rules.

The clear sky uplink off-axis EIRP density limits of 47 C.F.R. §25.138(a)(1) are equivalent to a maximum uplink input power density of -56.5 dBW/Hz. No authorized uplink transmissions towards the HNS 95W satellite will exceed the clear sky uplink off-axis EIRP density limits of 47 C.F.R. §25.138(a)(1). In addition, authorized transmitting earth station antennas will meet the requirements of 47 C.F.R. §25.209(a) and (b).

Section A.8 above demonstrates that the maximum PFD that can be transmitted by the HNS 95W satellite, at an elevation angle of 90 degrees, is -119.8 dBW/m^2/MHz, and therefore the PFD levels at other elevation angles will necessarily be somewhat lower. Consequently, the maximum PFD that can occur on the Earth's surface as a result of HNS 95W transmissions will be well below the -118 dBW/m^2/MHz limit of 47 C.F.R. §25.138(a)(6).

Even though the segments 18.3-18.55 GHz and 28.35-28.6 GHz are not licensed at the 93º W.L. location, the above analysis is also valid for the use of such segments, as all Ka-band transmissions of the HNS 95W satellite network will not exceed the uplink off axis EIRP density and downlink PFD levels of 47 C.F.R. §25.138, regardless of whether the frequency band is used or not in an adjacent orbital location.

A.12.2 Frequency Bands Not Subject to 47 C.F.R. §25.138

This section demonstrates that uplink transmissions in the 27.5-28.0 GHz and 28.1-28.35 GHz band, and downlink transmissions in the 18.8-19.3 GHz band are two-degree compatible.

Currently there are no operational GSO Ka-band satellites that use the 27.5-27.85 GHz band within two degrees of the 95.2º W.L. location, and the only operational GSO Ka-band satellite that uses the 18.8-19.3 GHz and 27.85-28.35 GHz bands within this arc is EchoStar XIX, which is licensed to Hughes.

Because, as indicated above, all Ka-band transmissions of the HNS 95W satellite network will not exceed the uplink off axis EIRP density and downlink PFD levels of 47 C.F.R. §25.138, regardless of whether the frequency band used is subject to 47 C.F.R. §25.138, and because these limits ensure two-degree compatibility in the band subject to 47 C.F.R. §25.138, it is safe to conclude that they also ensure two-degree compatibility in the band immediately adjacent to the bands subject to 47 C.F.R. §25.138.

Additionally, as HNS 95W will be located 1.9 degrees from EchoStar XIX (at 97.1º W.L.), in order to comply with 47 C.F.R. §25.140(a)(2) Hughes hereby certifies that EchoStar XIX operations will accommodate the operation of HNS 95W to avoid interference between both satellites.[18]

[18] *See* 47 C.F.R. § 25.140(a)(2).

A.13 Q/V-BAND TWO-DEGREE COMPATIBILITY

This section demonstrates that the Q/V-band transmissions of the HNS 95W satellite network are two-degree compatible.[19]

Currently there are no operational or proposed Q/V-band satellites that use the 47.2-51.4 GHz and 40.0-42.0 GHz bands within two degrees of the 95º W.L. location.[20] In order to demonstrate two degree compatibility, the transmission parameters of the HNS 95W satellite have been assumed as both the wanted and victim transmissions.

Table 13-1 provides a summary of the uplink and downlink transmission parameters. These parameters were derived from the HNS 95W clear-sky link budgets. The interference calculations assumed a 1 dB advantage for topocentric-to-geocentric conversion, all wanted and interfering carriers are co-polarized and all earth station antennas conform to a sidelobe pattern of 29-25 log(θ). The C/I calculations were performed on a per Hz basis.

Table 13-2 shows the results of the interference calculations in terms of the C/I margins. The table is provided in a format similar to that of the output of the Sharp Adjacent Satellite Interference Analysis program. It can be seen that the C/I margins are positive in all cases.

Carrier ID	Emission Designator	Bandwidth (MHz)	Tx E/S Gain (dBi)	Uplink EIRP (dBW)	Downlink EIRP (dBW)	Rx E/S Gain (dBi)	C/I Criterion (dB)
1	500MG7W	500	69.6	76			17
2	250MG7W	250			47.4	68.5	17
3	125MG7W	125			44.4	68.5	17
4	3M67G7W	3.67			29.0	68.5	15
5	1M22G7W	1.22			24.3	68.5	15
6	612KG7W	0.612			21.3	68.5	15

Table 13-1. HNS 95W Q/V-band transmission parameters.

[19] 47 C.F.R. §§ 25.114(d)(7); 25.140(a)(2), (a)(3)(iii), (v), (d).

[20] Hughes will coordinate the operations of HNS 95W with licensed space research service operations pursuant to Recommendation ITU-R SA.1396. *See Northrop Grumman Space & Mission Systems Corp.*, Order and Authorization, 24 FCC Rcd 2330, 2352 ¶ 65 & n.126 (IB 2009); *see also Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz, et al.*, Second Report and Order, 18 FCC Rcd 25428, 25445 ¶ 39 (2003) ("*V-Band Second Report and Order*").

		Interfering Carriers					
	Carrier ID	1	2	3	4	5	6
Wanted Carriers	1	14.8					
	2		13.8	13.8	13.8	13.8	13.8
	3		13.8	13.8	13.8	13.8	13.8
	4		15.8	15.8	15.8	15.8	15.8
	5		15.8	15.8	15.8	15.8	15.8
	6		15.8	15.8	15.8	15.8	15.8

Table 13-2. Summary of the C/I margins (dB).

A.14 SHARING WITH NGSO FSS

In the United States, the 18.8-19.3 GHz band is allocated for NGSO FSS, but not for GSO FSS. The HNS 95W satellite's proposed U.S. operations will avoid harmful interference into, and accept any interference received from, NGSO FSS systems operating in this band.

The highest interference levels that can occur into NGSO networks from the HNS 95W network are when there is an "in-line" event. On the downlink, an in-line event occurs when the GSO satellite, the NGSO satellite and the victim NGSO earth station are all in a line. As the NGSO satellite continues to move within its orbit, an angle between the NGSO satellite and the GSO satellite, subtended at the NGSO earth station, is created. As long as the GSO satellite does not transmit when the NGSO satellite is within a certain angle, no harmful interference to the NGSO earth station will occur. The amount of angular separation required will be dependent on the orbital and transmission characteristics of the NGSO FSS networks, their earth station locations, and their interference criteria.

O3b has received U.S. market access for its constellation of NGSO satellites. O3b has Commission authorization to use the 18.8-19.3 GHz band to communicate with fixed earth stations located in Hawaii, Texas, Virginia as well as for earth stations on vessels ("ESV") operating within U.S. waters.[21] O3b has Commission authorization for blanket license operation of fixed earth stations (1.2 meter, 1.8 meter, 2.2 meter and 2.4 meter) in CONUS, Hawaii, Puerto Rico and the U.S. Virgin Islands.[22] O3b has also received licenses from the Commission for

[21] *See e.g.*, O3b Limited, Stamp Grant, File No. SES-LIC-2010723-00952 (granted Sept. 25, 2012); O3b Limited, Stamp Grant, File No. SES-LIC-20141022-00809 (granted June 5, 2015); O3b Limited, Stamp Grant, File No. SES-LIC-20130124-00089 (granted June 20, 2013) and O3b Limited, Stamp Grant, File No. SES-LIC- 20130618-00516 (granted June 24, 2015); O3b Limited, Stamp Grant, File No. SES-LIC-20130528-00455 (granted May 13, 2014); O3b Limited, Stamp Grant, File No. SES-LIC-20150310-00138 (granted Sept. 30, 2015); *see also* O3b Limited, Stamp Grant, File No. SAT-LOI-20141029-00118 (granted Jan. 22, 2015).

[22] *See* O3b Limited, File No. SES-LIC-20141001-00781 (granted June 8, 2015).

fixed earth stations located in Hawaii, Texas and Virginia to communicate with O3b's constellation of NGSO satellites using the 27.6-28.35 GHz band on a secondary basis.[23]

The interference analysis presented in A.12.1 demonstrates that no harmful interference between the O3b system and the HNS 95W satellite network will occur for earth stations located in the United States operating in the 27.6-28.35 GHz and 18.8-19.3 GHz bands. Further, Hughes has already reached coordination agreements with O3b for Hughes' other satellite operations, and the same principles used to achieve technical compatibility will be applicable to the coordination process for the HNS 95W satellite. Hughes has also reached coordination agreements with OneWeb for Hughes' other satellite networks, and the same principles used to achieve technical compatibility will be applicable to the coordination process for the HNS 95W satellite network.[24]

Other satellite operators have filed applications requesting authority to launch, operate and/or obtain market access for non-geostationary satellite systems in the FSS using the Ka-band frequencies[25] and the V-band frequencies.[26] Using the same principles used to achieve technical compatibility with OneWeb and O3b, Hughes will work with licensed NGSO operators to reach corresponding coordination agreements.

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[23] *See* O3b Limited, Stamp Grant, File No. SES-LIC-20100723-00952 (granted Sept. 25, 2012); O3b Limited, Stamp Grant, File No. SES-LIC-20141022-00809 (granted June 5, 2015); O3b Limited, Stamp Grant, File No. SES-LIC-20130124-00089 (granted June 20, 2013); O3b Limited, Stamp Grant, File No. SES-LIC-20130618-00516 (granted June 24, 2015); O3b Limited, Stamp Grant, File No. SES-LIC-20150310-00138 (granted Sept. 30, 2015).

[24] *See* Comments of EchoStar Satellite Operating Corp. and Hughes Network Systems, LLC, IB Docket No. 16-408, at 4 (filed Feb. 27, 2017).

[25] Telesat Canada, File No. SAT-PDR-20161115-00108 (filed Nov. 15, 2016); The Boeing Company, File No. SAT-LOA-20161115-00109 (filed Nov. 15, 2016); Space Norway AS, File No. SAT-PDR-20161115-00111 (filed Nov. 15, 2016); LeoSat MA, Inc., File No. SAT-PDR-20161115-00112 (filed Nov. 15, 2016); Karousel LLC, File No. SAT-LOA-20161115-00113 (filed Nov. 15, 2016); Kepler Communications Inc., File No. SAT-PDR-20161115-00114 (filed Nov. 15, 2016); O3b Limited, File No. SAT-AMD-20161115-00116 (filed Nov. 15, 2016); Audacy Corp., File No. SAT-LOA-20161115-00117 (filed Nov. 15, 2016); Space Exploration Holdings, LLC, File No. SAT-LOA-20161115-00118 (filed Nov. 15, 2016); ViaSat Inc., File No. SAT-PDR-20161115-00120 (filed Nov. 15, 2016); Theia Holdings A, Inc., File No. SAT-LOA-20161115-00121 (filed Nov. 15, 2016); WorldVu Satellites Limited d/b/a OneWeb, File No. SAT-LOI-20160428-00041 (filed Apr. 28, 2016).

[26] The Boeing Company, File Nos. SAT-LOA-20170301-00028, SAT-AMD-20170301-00030 (filed Mar. 1, 2017); O3b Limited, File No. SAT-AMD-20170301-00026 (filed Mar. 1, 2017); Space Exploration Holdings, LLC, File No. SAT-LOA-20170301-00027 (filed Mar. 1, 2017); Telesat Canada, File No. SAT-LOI-20170301-00023 (filed Mar. 1, 2017); Theia Holdings A, Inc., File No. SAT-AMD-20170301-00029 (filed Mar. 1, 2017); WorldVu Satellites Limited d/b/a OneWeb, File No. SAT-LOI-20170301-00031 (filed Mar. 1, 2017).

A.15 SHARING WITH UMFUS

In the United States, FSS (Earth-to-space) is allocated on a co-primary basis with fixed and mobile services in the 27.5-28.35 GHz band in the U.S. Table of Frequency Allocations.[27] Under the Commission's rule 47 C.F.R. §25.136(a), FSS is secondary to UMFUS in the 27.5-28.35 GHz band. An earth station operating in this band may operate consistent with the terms of its authorization and will not be required to take additional actions to provide interference protection to UMFUS licensees if it meets the requirements of 47 C.F.R. §25.136(a).[28] All of Hughes' gateway earth stations will meet these requirements.

A.16 SHARING IN THE 40.0-42.0 GHz BAND

The 40.0-42.0 GHz frequency band covers several sub-bands with different allocations but broadly similar usage that can be considered together. Each sub-band within this range contains a primary FSS allocation for Federal and non-Federal users and various co-primary services. In the 40.0-40.5 GHz band, MSS is the co-primary service; in the 40.5-41.0 GHz band, Broadcasting and BSS are co-primary to FSS; and in the 41.0-42.0 GHz band, Fixed, Mobile, Broadcasting, and BSS are all co-primary. This band is subject to the "soft-segmentation" plan adopted by the Commission following WRC-2000 to allow for clear-sky PFD levels 12 dB higher than in the adjacent 37.5-40.0 GHz band.[29] As discussed above, Hughes will meet those requirements.[30] The Commission's IBFS and ULS database systems do not identify any non-Federal users of these bands, satellite or terrestrial.[31] Hughes will coordinate its operations with Federal operations in this band.[32]

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[27] *See* 47 C.F.R. § 2.106.

[28] 47 C.F.R. §25.136(a); *Use of Spectrum Bands Above 24 GHz for Mobile Radio Servs*., Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014 (2016) ("*Spectrum Frontiers FNPRM*").

[29] *See V-Band Second Report and Order*, 18 FCC at 25428 ¶¶ 8, 12-14.

[30] *See supra* Section A.10.

[31] The only satellite systems licensed by the Commission in this band were surrendered years ago. *See, e.g., Northrop Grumman Order*.

[32] *See* Federal Spectrum Use Summary, 30 MHz – 3000 GHz, National Telecommunications and Information Administration, Office of Spectrum Management at 76-77 (Jun. 21, 2010), https://www.ntia.doc.gov/files/ntia/Spectrum_Use_Summary_Master- 06212010.pdf; *Use of Spectrum Bands Above 24 GHz for Mobile Radio Servs.*, Notice of Proposed Rulemaking, 30 FCC Rcd 11878 ¶ 173 (2016) (noting that VLBA receivers include the 41.0-45.0 GHz band); *see also* 47 C.F.R. § 2.106 G117.

A.17 SHARING IN THE 50.4-51.4 GHz BAND

According to the Commission's IBFS and ULS databases, there are currently no licensed terrestrial or satellite operations in this frequency band. The FCC has also not established terrestrial service rules applicable to the 50.4-51.4 GHz band or any inter-service sharing requirements. Nonetheless, Hughes' limited use of these frequencies for a small number of individually licensed gateway stations in areas that meet the FCC's rules in the *Spectrum Frontiers Order and FNPRM*[33] for Ka-band earth stations will create minimal risk of interference with any existing or future terrestrial operations in this band.

A.18 PROTECTION OF THE EARTH EXPLORATION-SATELLITE SERVICE (EESS) (passive)

For HNS 95W earth stations transmitting in the 49.7-50.2 GHz and 50.4-50.9 GHz bands, the unwanted emission power in the 50.2-50.4 GHz band will not exceed −20 dBW/200 MHz (measured at the input of the antenna) for earth stations having an antenna gain of less than 57 dBi and −10 dBW/200 MHz (measured at the input of the antenna) for earth stations having an antenna gain greater than or equal to 57 dBi. These limits will apply under clear-sky conditions. During fading conditions, the limits may be exceeded by earth stations when using uplink power control. Consequently, compliance with 47 C.F.R. §25.202(j) will be ensured.[34]

A.19 COMPLIANCE WITH DEFAULT SERVICE RULES

As provided in 47 C.F.R. §25.217(c)(1),[35] a GSO-like satellite licensee in a frequency band for which the Commission has not adopted frequency band-specific service rules at the time the license is granted will be required to comply with the technical requirements listed below. The HNS 95W satellite will comply with all applicable default service rules.

47 C.F.R. §25.142(d). This rule prohibiting certain types of agreements is not applicable because Hughes will not provide MSS.

47 C.F.R. §25.143(b)(2)(iv). This rule requiring certain geographic service area coverage is not applicable because Hughes will not provide MSS.

47 C.F.R. §25.204(e). Hughes will employ adaptive power control requirements as discussed in Section A.11 above.

47 C.F.R. §25.210(f). Hughes will comply with the full frequency reuse requirements of this rule, as discussed in Section A.5 above.

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[33] *See Spectrum Frontiers FNPRM*, Appendix A (adopting 47 C.F.R. §25.136(a)).

[34] *See also* ITU Radio Regulation 5.340.1 (50.2-50.4 GHz) (Ed. 2016).

[35] 47 C.F.R. § 25.217(c)(1); *see also Fixed Satellite Service in the Ka-Band*, Report and Order, 18 FCCR 14708, 14731 Appendix C (2003). The Commission's rules also require compliance with 47 C.F.R. § 25.210(d), but that rule was since been removed.

47 C.F.R. §25.210(i). The Commission eliminated the cross-polarization requirement for FSS in 2016.[36] In any event, as indicated in Schedule S, the cross-polarization isolation is 30dB for all transmitting and receiving beams.

47 C.F.R. §25.210(j). As indicated in the Schedule S, the longitude tolerance (or east/west station-keeping) is +/- 0.05°, meeting the station-keeping requirement.

A.20 PREDICTED RECEIVER AND TRANSMITTER CHANNEL FILTER RESPONSE CHARACTERISTICS

The predicted receiver and transmitter frequency responses of the 250 MHz and 125 MHz channels for both the Ka-band and Q/V-band frequencies, as measured between the receive antenna input and transmit antenna, fall within the limits shown in Table 20-1 below. The frequency tolerances of 47 C.F.R. §25.202(e) and the out-of-band emission limits of 47 C.F.R. §25.202(f) (1), (2) and (3) will be met.

Offset from Channel Center Frequency (MHz)	Receiver Filter Response (dB) 250 MHz Channel	Transmitter Filter Response (dB) 250 MHz Channel	Receiver Filter Response (dB) 125 MHz Channel	Transmitter Filter Response (dB) 125 MHz Channel
± 50			> -0.5	> -0.6
± 62.5			> -3.0	> -3.5
± 100	> -0.5	> -0.6		
± 125	> -3.0	> -3.5	< -30	< -25
±250	< -30	< -25		

Table 20-1: Predicted Channel Receiver and Transmitter Frequency Responses.

A.21 SPACECRAFT CHARACTERISTICS

The spacecraft manufacturer for the HNS 95W satellite has not yet been selected. Hughes will provide the Commission any updated information when the satellite manufacturer has been selected.

The HNS 95W satellite will be designed and constructed for a 15-year operational life.[37] The probability of the entire satellite successfully operating throughout this period is estimated at 70% with the probability of the payload and bus being of 84% and 84%, respectively. These

[36] *See Comprehensive Review of Licensing and Operating Rules for Satellite Services*, Second Report and Order, 30 FCC Rcd 14713, 14817 ¶ 332-33 (2015). The current version of the rule requires broadcasting-satellite service satellites to have a 25 dB cross-polarization isolation. 47 C.F.R. § 25.210(i).

[37] 47 C.F.R. § 25.114(c)(10).

numbers are based on documented failure rates of all critical components in the satellite bus and payload.

A.22 ORBITAL DEBRIS MITIGATION PLAN

Although the spacecraft manufacturer for the HNS 95W satellite has not yet been selected, Hughes will incorporate the objectives of Section 25.114(d)(14) into its satellite Technical Specifications, Statement of Work and Test Plans. The Statement of Work will include provisions to review orbital debris mitigation as part of the preliminary design review and the critical design review and to incorporate its requirements, as appropriate, into its Test Plan, including a formal Failure Mode Verification Analysis for orbital debris mitigation involving particularly the TT&C, propulsion and energy systems. During this process, some changes to the Orbital Debris Mitigation Plan may occur and Hughes will provide the Commission with updated information, as appropriate.

A.22.1 Spacecraft Hardware Design

The satellite will not undergo any planned release of debris during its operation. Furthermore, all separation and deployment mechanisms, and any other potential source of debris will be retained by the spacecraft or launch vehicle.

Hughes does not expect that the satellite will undergo any release of debris during its operation. Furthermore, all separation and deployment mechanisms, and any other potential source of debris will be retained by the spacecraft or launch vehicle.

In conjunction with the spacecraft manufacturer, Hughes will assess and limit the probability of the satellite becoming a source of debris by collisions with small debris or meteoroids of less than one centimeter in diameter that can cause loss of control and prevent post-mission disposal. Hughes will take steps to limit the effects of such collisions through shielding, the placement of components, and the use of redundant systems.

Hughes will incorporate a rugged TT&C system with regard to meteoroids smaller than 1 cm through redundancy, shielding, and appropriate physical separation of components. The TT&C subsystem will have no single points of failure. The TT&C system will be equipped with near omni-directional antennas mounted on opposite sides of the spacecraft. These antennas, each providing greater than hemispherical coverage patterns, are extremely rugged and capable of providing adequate coverage even if struck, bent or otherwise damaged by a small or medium sized particle. Either one of the two omni-directional antennas, for both command and telemetry, will be sufficient to enable orbit raising. The command receivers and decoders and telemetry encoders and transmitters will be located within a shielded area and will be totally redundant and physically separated. A single rugged thruster and shielded propellant tank provide the energy for orbit-raising.

The propulsion subsystem will be designed such that it will not be separated from the spacecraft after de-orbit maneuvers. It will be protected from the effects of collisions with small debris through shielding. Moreover, propulsion subsystem components critical to disposal (e.g.

propellant tanks) will be located deep inside the satellite, while other components, such as the thrusters, externally placed, are redundant to allow for de-orbit despite a collision with debris.

A.22.2 Minimizing Accidental Explosions

Hughes will assess and limit the probability of accidental explosions during and after completion of mission operations. The satellite will be designed to ensure that debris generation will not result from the conversion of energy sources on board the satellite into energy that fragments the satellite. The propulsion subsystem pressure vessels will be designed with high safety margins. Bipropellant mixing will be prevented by the use of valves that avoid backwards flow in propellant lines and pressurization lines. All pressures, including those of the batteries, will be monitored by telemetry. At end-of life and once the satellite has been placed into its final disposal orbit, Hughes will remove all stored energy from the spacecraft by depleting any residual fuel, leaving all fuel line valves open, venting the pressure vessels and the batteries will be left in a permanent state of discharge.

A.22.3 Safe Flight Profiles

In considering current and planned satellites that may have a station-keeping volume that overlaps the HNS 95W satellite, Hughes has reviewed the lists of FCC licensed satellite networks, as well as those that are currently under consideration by the FCC. In addition, non-U.S.-licensed networks for which a request for coordination has been published by the ITU within ±0.15° of 95° W.L. have also been reviewed.

There are no pending applications before the Commission to use an orbital location ±0.15° from 95° W.L and Hughes is not aware of any satellite, besides the satellite Spaceway 3, operated by Hughes, with an overlapping station-keeping volume with the HNS 95W satellite that is the subject of an ITU filing that is either in orbit or progressing towards launch.

Hughes therefore concludes that physical coordination of the HNS 95W satellite with another party is not required at the present time.

A.22.4 Post-Mission Disposal

At the end of the operational life of the HNS 95W satellite, Hughes will maneuver the satellite to a disposal orbit with a minimum perigee of 300 km above the normal GSO operational orbit. The post-mission disposal orbit altitude is based on the following calculation, according to 47 C.F.R. §25.283:

Total Solar Pressure Area “A” = 155 m2
“M” = Dry Mass of Satellite = 5817 kg
“CR” = Solar Pressure Radiation Coefficient = 1.3

Therefore, the Minimum Disposal Orbit Perigee Altitude is calculated as:

= 36,021 km + 1000 x CR x A/m
= 36,021 km + 1000 x 1.3 x 155/5817
= 36055.6 km
= 267 km above GSO (35,786 km)

To provide adequate margin, the disposal orbit will be increased to 300 km. This will require approximately 4 kg of xenon propellant, taking account of all fuel measurement uncertainties, which will be allocated and reserved in order to perform the final orbit raising maneuver.