ATTACHMENT A
Technical Description

A.1 SCOPE AND PURPOSE

This Technical Description provides the Federal Communications Commission ("Commission") with the technical characteristics of Arcturus, a small Ka-band geostationary satellite orbit ("GSO") fixed-satellite service ("FSS") satellite manufactured by Astranis Space Technologies Corp. ("Astranis") and operated by Astranis Bermuda Ltd. ("Astranis Bermuda"), as required by 47 C.F.R. §25.114 and other relevant sections of the FCC Part 25 rules.

A.2 GENERAL DESCRIPTION

The Arcturus satellite will operate at the 163° W.L. orbital location and will provide high-speed, satellite-based connectivity to fixed and mobility (earth stations in motion or "ESIM") terminals located in Alaska and the surrounding Pacific region, including western Canada and adjacent air and maritime routes.

The gateway earth station supporting the provision of services will be located in Utah.[1] On-station TT&C communications will also be supported by this earth station. TT&C operations will be conducted by Astranis under contract with and subject to the ultimate direction and control of Astranis Bermuda.

A.3 SPACE STATION TRANSMIT AND RECEIVE CAPABILITY

The gateway and user channels will be able to use the uplink frequency segments 28-29.1 GHz and 29.3-30 GHz, and the downlink frequency segments 18.2-19.3 and 19.7-20.2 GHz.

Use of the frequency band 18.2-18.3 GHz will be on a secondary basis with respect to terrestrial services and U.S. government services in the United States. Use of the frequency band 18.8-19.3 GHz will be on a secondary basis with respect to NGSO systems licensed to provide services to the United States. Use of the frequency band 28-28.35 GHz will be on a secondary basis with respect to terrestrial services in the United States. Use of the frequency band 28.6-29.1 GHz will be on a secondary basis with respect to NGSO systems licensed to provide services to the United States.

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

A.4 FREQUENCY AND POLARIZATION PLAN

The Arcturus satellite frequency plan is provided in Figure 1, below.

[1] *See* File No. SES-LIC-20200925-01038, Call Sign E202162 (grant Nov. 16, 2020).

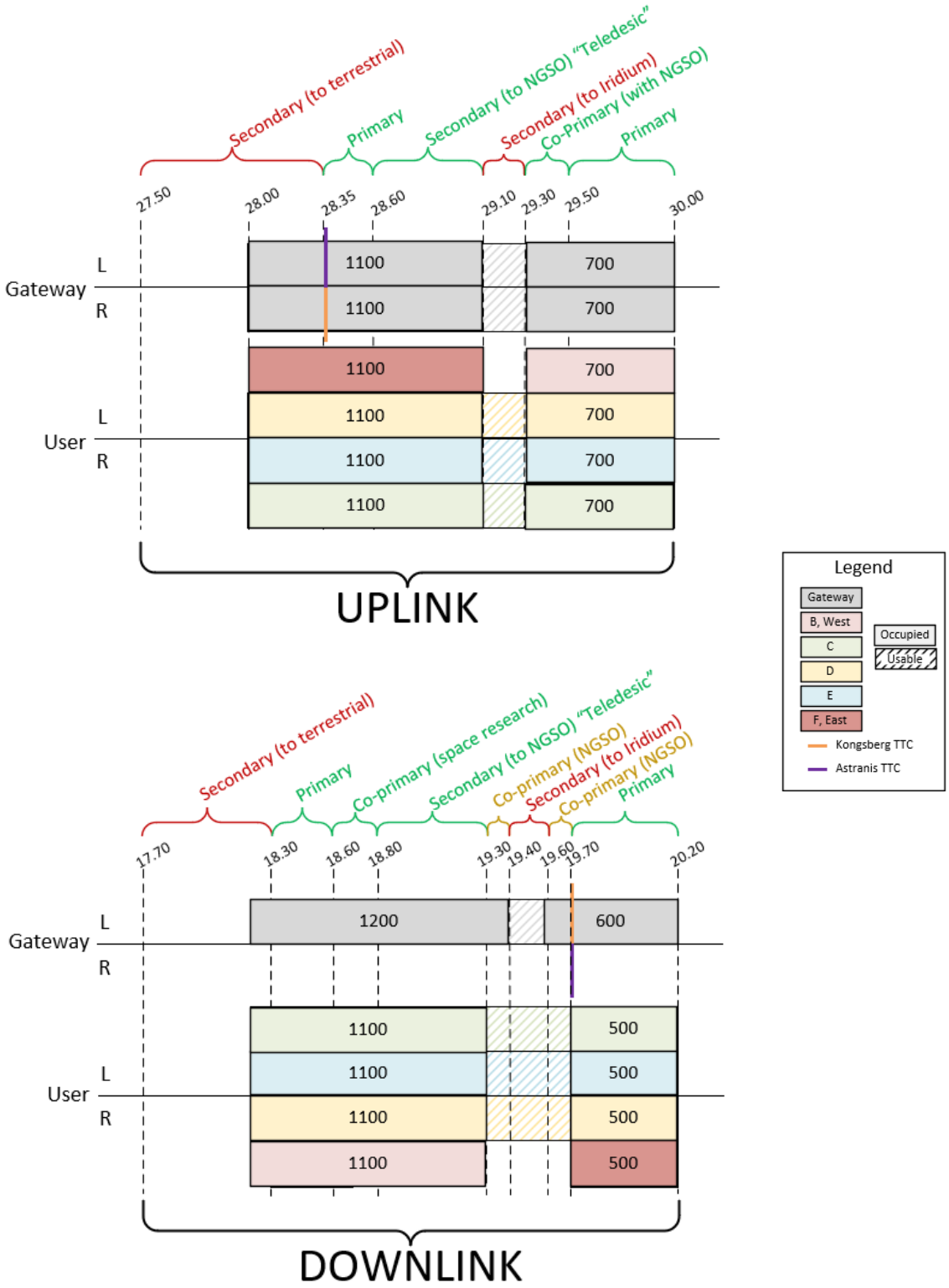

Figure 1. Arcturus Frequency Plan

A.5 DESCRIPTION OF SYSTEM FACILITIES, OPERATIONS AND SERVICES

A single teleport facility equipped to handle both payload and TT&C transmissions will be located in the Utah region. A single antenna in 9.4 m diameter range will be used for both types of transmissions.

The spot beam for the feeder links will cover the teleport station in the Utah region, and for service links there will be five spot beams, covering Alaska and coastal cruise routes between Alaska and Seattle. Each spot beam will be capable of operating variable bandwidth transponders of at least 100 MHz within the two pairs of band segments described above, in one or two senses of circular polarization as detailed in the accompanying Schedule S.

Uplink transmissions will be digitally processed and can be routed to any downlink beam at any downlink frequency in 18.2-20.2 GHz range. The actual transponder bandwidth and beam interconnectivity will be configured by telecommand according to customer requirements. The satellite will employ a two-fold frequency re-use pattern such that any channel will be re-used multiple times by a combination of polarization and spatial isolation.

A.6 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, per 47 C.F.R. §25.207.

A.7 POWER FLUX DENSITY AT THE EARTH'S SURFACE

47 C.F.R. §25.208(c) contains PFD limits that apply in the 18.2-19.3 GHz band. 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.

The maximum downlink EIRP that the Arcturus satellite can transmit in the Ka-band frequencies is 42.6 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 -119.5 dBW/m2/MHz at an elevation

angle of 90°. This level is less than the -115 dBW/m2/MHz PFD limit value that applies at elevation angles of 5° and below, and consequently compliance with the PFD limits in Section 25.208(c) is 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/m2. In the worst case, this will correspond to a PFD limit of -118 dBW/m2/MHz (*i.e.*, -95-10 log (200)). As noted above, downlink transmissions from the Arcturus satellite cannot exceed -119.5 dBW/m2/MHz at any angle of arrival, and therefore compliance with 47 C.F.R. §25.208(d) is also assured.

A.8 KA-BAND TWO-DEGREE COMPATIBILITY

The Arcturus satellite will meet the Commission's two-degree spacing requirements. Transmissions of the earth stations communicating with the Arcturus satellite will not exceed the uplink off-axis EIRP density envelopes of 47 C.F.R. §25.218(i) and the Arcturus satellite will not generate PFD at the Earth's surface in excess of the limit of 47 C.F.R. §25.140(a)(3)(iii). If any non-routine uplink or downlink operations are contemplated, the Astranis Bermuda will seek modification of market access authority, will coordinate with operators of authorized co-frequency space stations at assigned locations within six degrees, and otherwise will ensure compliance with 47 C.F.R. §25.140(d). Likewise, to the extent a co-frequency satellite is assigned an orbital location that is less than two degrees from the assigned Arcturus location, Astranis Bermuda will either coordinate or submit an interference analysis demonstrating compatibility of the systems.[2]

The Arcturus satellite seeks to operate in spectrum that may be governed by Section 25.140(a)(3)(vi) (*i.e.*, 28.0-28.35 GHz). Out of an abundance of caution, Astranis Bermuda is including a two-degree spacing compatibility analysis. Since there are no commercial satellites operating within two degrees of Arcturus and providing coverage of CONUS, the impact from the operations of hypothetical satellites having the same or worst case two-degree spacing operating characteristics as Arcturus located at 161° W.L. and 165° W.L. was analyzed. The results of this interference configuration are included in the link budget provided in Exhibit 1, below. Furthermore, separate C/I calculations were conducted for the two-degree spacing analysis and are provided in Exhibit 2, below.

A.9 SHARING WITH NGSO FSS

In the United States, the 18.8-19.3 GHz and 28.6-29.1 GHz bands are designated for non-geostationary orbit fixed-satellite service ("NGSO FSS") on a primary basis and to GSO FSS on a secondary basis. Stations operating in a secondary service cannot cause harmful interference to or claim protection from harmful interference from stations of a primary service. Astranis Bermuda anticipates coordinating with Ka-band NGSO systems across a range of bands, including 18.8-19.3 GHz and 28.6-29.1 GHz.

Astranis Bermuda's proposed U.S. operations will be consistent with such coordination agreements and the obligations of a secondary user of spectrum. Several NGSO operators have been licensed in the United States for the use of the 18.8-19.3 GHz and 28.6-29.1 GHz

[2] *See* 47 C.F.R. § 25.140(a)(2).

bands. Astranis Bermuda will work with those authorized NGSO FSS operators to reach coordination or other arrangements to ensure no harmful interference to those systems.

A.10 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. 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). Arcturus' gateway earth station will meet these requirements.

With respect to user terminals operating in Alaska, Astranis Bermuda understands that applicants for FCC blanket earth station licenses will need to address compliance with the requirements of 47 C.F.R. §25.136(a) and seek any necessary waivers, as appropriate. Thus, the Commission can authorize Arcturus receive operations in this band subject to consideration and potential grant, as appropriately conditioned, of future earth station blanket license applications.

A.11 CARRIER FREQUENCY OF SPACE STATION TRANSMITTERS

Arcturus will comply with 47 C.F.R. §25.202(e).

A.12 EMISSION LIMITATIONS

Arcturus will comply with 47 C.F.R. §25.202(f)(1), (2) and (3).

A.13 TELEMETRY, TRACKING, AND COMMAND SIGNALS NOT AT A BAND EDGE

Arcturus will comply with 47 C.F.R. §25.202(g)(1). Telemetry, tracking, and command ("TT&C") operations are planned to avoid interference and will be coordinated with potentially affected satellite networks. Specifically, Arcturus' transmissions will cause no greater interference and require no greater protection from harmful interference than the communications traffic on the satellite network. Astranis Bermuda will also seek to coordinate with operators of authorized co-frequency space stations at orbital locations within six degrees of the assigned orbital location consistent with Section 25.202(g)(1).

TT&C communications will be supported by the Utah earth station described above.[3] TT&C operations will be conducted by Astranis under contract with and subject to the ultimate direction and control of Astranis Bermuda.

As required by Section 25.172 of the Commission's rules, this section provides contact details for the control station:

[3] *See* File No. SES-LIC-20200925-01038, Call Sign E202162 (grant Nov. 16, 2020).

Earth Station Contact Information:

LBISat LLC
1082 East 2400 North
Eagle Mountain, Utah 84005
Phone: (801) 501 9090
rusty@lbisat.com

Satellite Control Center Addresses and Telephone Numbers:

Astranis Control Center
420 Bryant St.
San Francisco, CA

Short-term interference and emergency response contact:
Roshena MacPherson, Mission Operations and Ground Software Lead
Phone: 925-257-3617
Email: roshena@astranis.com

Long-term engineering and technical design contact:
Andrew Ramsey, Payload Engineer
Phone: 925-257-3615
Email: andrew@astranis.com

Secondary POC:
Astranis Bermuda Ltd.
Continental Building,
25 Church Street, Hamilton,
HM12, Bermuda

John Gedmark
Phone: 415-854-0586
Email: regulatory@astranis.com

A.14 STATE-OF-THE-ART FULL FREQUENCY REUSE

Arcturus will comply with 47 C.F.R. §25.210(f), as discussed in Section A.5 above. In particular, Arcturus will employ full-frequency reuse through both orthogonal polarization and spatial reuse of frequencies. As demonstrated in the Frequency Plan, above, every unique pair of frequency and polarization is used by two beams (stacking), which allows for reuse of every set of frequencies. User beams will employ spatial isolation with one polarization to each beam, while gateway will utilize dual polarization on the same beam.

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING ENGINEERING INFORMATION

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

_____/s/_____
Steve Joseph

Exhibit 1: Satellite Link Budget – Nominal Interference Conditions

Parameter	Units					
Case		Beam B	Beam C	Beam D	Beam E	Beam F
Bandwidths						
Bandwidth per Beam	Hz	250.0E+06	750.0E+06	750.0E+06	750.0E+06	500.0E+06
Allocated Bandwidth	Hz	250.0E+06	750.0E+06	750.0E+06	750.0E+06	500.0E+06
Rolloff	%	0.05	0.05	0.05	0.05	0.05
Symbol Rate	sps	238.1E+06	714.3E+06	714.3E+06	714.3E+06	476.2E+06
in dBHz	dBHz	83.77	88.54	88.54	88.54	86.78
Gateway						
Fractional power	%	16.74%	50.23%	50.23%	50.23%	33.49%
Fractional power	dB	-7.76	-2.99	-2.99	-2.99	-4.75
Uplink Terminal Description		9.4m GW	9.4m GW	9.4m GW	9.4m GW	9.4m GW
EIRP		84.38	84.38	84.38	84.38	84.38
EIRP for Shared Carrier	dBW	76.62	81.39	81.39	81.39	79.63
EIRP Density	dBW/GHz	82.85	82.85	82.85	82.85	82.85
Uplink Path						
Uplink elevation angle	degrees	21.1	21.1	21.1	21.1	21.1
Uplink Slant Range	km	39451.0	39451.0	39451.0	39451.0	39451.0
Uplink Frequency	MHz	29200	29200	29200	29200	29200
Path Loss:	dB	213.68	213.68	213.68	213.68	213.68
Atmospheric Link Degradation (dB)	dB	1.00	1.00	1.00	1.00	1.00
Total path loss	dB	214.68	214.68	214.68	214.68	214.68
Spacecraft Rx						
Equiv. Isotropic Signal Level at Spacecraft	dBW	-138.06	-133.29	-133.29	-133.29	-135.05
Signal Flux density at Spacecraft	dBW/m^2	-87.29	-82.52	-82.52	-82.52	-84.28
G/T	dB/K	14.10	14.10	14.10	14.10	14.10
Directivity		45.70	45.70	45.70	45.70	45.70
S/No	dBHz	104.64	109.41	109.41	109.41	107.65
Receive C/N	dBc	20.87	20.87	20.87	20.87	20.87
Cross-Pol Interference	dBc	25.00	25.00	25.00	25.00	25.00
Adjacent Beam Interference (ABI)	dBc	30.89	30.89	30.89	30.89	30.89

Receiver Parasitics	dBc	40.00	40.00	40.00	40.00	40.00
Receive C/I	dB	23.90	23.90	23.90	23.90	23.90
Receive C/(N+I)	dBc	19.12	19.12	19.12	19.12	19.12
Uplink C/I	dB	23.90	23.90	23.90	23.90	23.90
Uplink C/(N+I)	dBc	19.12	19.12	19.12	19.12	19.12
Spacecraft Tx						
Fraction of BW per HPA	%	100.00%	100.00%	100.00%	100.00%	100.00%
Fraction of Power per Beam	%	100.00%	100.00%	100.00%	100.00%	100.00%
EIRP	dBW	51.43	57.21	57.22	56.81	54.51
Noise Power Stealing	dB	0.05	0.05	0.05	0.05	0.05
EIRP per Shared Carrier	dBW	51.38	57.16	57.17	56.76	54.46
EIRP Density	dBW/GHz	57.61	58.62	58.63	58.22	57.68
HPA Intermodulation	dBc	17.00	17.00	17.00	17.00	17.00
Transmitter Parasitics	dBc	99.00	99.00	99.00	99.00	99.00
Transmit C/(N+I)	dBc	14.92	14.92	14.92	14.92	14.92
Downlink Path						
User Elevation Angle	deg	29.1	23.0	20.6	20.9	23.4
User Slant Range	km	38691	39263	39497	39463	39222
User Downlink Frequency	MHz	18500	19000	19000	19000	20000
Path Loss:	dB	209.56	209.92	209.97	209.96	210.35
Atmospheric Link Degradation (dB)	dB	0.70	0.70	0.70	0.70	0.70
Total Path Loss	dB	210.26	210.62	210.67	210.66	211.05
Ground User						
Downlink Ground Terminal		1.2m, 6W	1.2m, 6W	1.2m, 6W	1.2m, 6W	1.2m, 6W
Equiv. Isotropic Signal Level at User Terminal	dBW	-158.88	-153.46	-153.50	-153.91	-156.60
Signal Flux density at Ground Station	dBW/m^2	-112.1	-106.4	-106.5	-106.9	-109.1
Size (m)		1.20	1.20	1.20	1.20	1.20
G/T	dB/K	22.20	22.20	22.20	22.20	22.20
Link						
Receive S/No	dBHz	91.92	97.34	97.30	96.89	94.20

Receive C/N	dBc	8.15	8.80	8.76	8.36	7.42
Cross-Pol Interference	dBc	29.00	29.00	29.00	29.00	29.00
Adjacent Beam Interference (ABI)	dBc	21.65	22.87	22.92	22.33	25.50
Receive C/I	dBc	20.92	21.92	21.96	21.48	23.90
Receive C/(N+I)	dBc	7.93	8.59	8.56	8.15	7.33
Clear Sky Forward Link C/(N+I)	dBc	7.14	7.68	7.65	7.32	6.63
MODCOD		8PSK 25/36	8PSK 13/18	8PSK 13/18	8PSK 25/36	8PSK 2/3
Required C/(N+I)	dBc	7.09	7.59	7.59	7.09	6.59
Link Margin	dB	0.05	0.09	0.06	0.23	0.04

Exhibit 2: C/I Calculations for Two-Degree Spacing Analysis

The minimum antenna size expected within the Arcturus service area is 1.2 m. The following table describes the delta to peak used for calculating adjacent satellite C/I to and from a terminal this size. This analysis assumes two identical satellites operating with identical configurations at +/- 2 degrees. For the purposes of C/I analysis the C/I is the power level received from the intended target relative to the power received from the interferer(s). PSDs are presented in dBW/GHz and C/Is are given in dBc.

Table 1: Arcturus PSD for two-degree -Spacing Analysis.

	On-axis PSD	
	Uplink	Downlink
Forward	82.3	58.2
Return	73.2	54.1

Table 2: Adjacent Satellite PSD for two-degree -Spacing Analysis.

	Uplink	Downlink
	PSD towards Arcturus	Peak PSD
Forward	36.5	58.2
Return	45.3	54.1

Table 3: C/I Analysis for two-degree Spacing.

	Uplink		Downlink	
	1 Satellite C/I	2 Satellite C/I	1 Satellite C/I	2 Satellite C/I
Forward	45.8	42.8	42.1	39.1
Return	27.9	24.9	24.2	21.2