Kepler Communications Application for Licensing of Earth Stations

Seeking terrestrial fixed-earth blanket authority for specified commercial VSAT systems

This report is presented in compliance with 47 C.F.R. §25.115

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Attachments to this Application:

1) Radiation Hazard Analysis
2) Waivers
3) Non-U.S. Licensed Satellite Requirements

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1 OVERVIEW

Kepler Communications Inc. (Kepler) is deploying a next-generation telecommunications network to push the boundaries of satellite-based communication on Earth and in space. In November 2018, the Commission granted permission for Kepler's innovative CubeSat network to deliver a Ku-band Fixed Satellite Service (FSS) to the U.S. market.[1] This application hereby seeks a blanket authorization for the terrestrial customer user terminals expected to receive this service.

1.1 Spectrum Sharing

Terminals will strictly operate within the 11.7 – 12.2 GHz and 14.0 – 14.5 GHz bands for downlink and uplink respectively. Both of these bands are allocated to the FSS on a primary basis, and the downlink band is not shared with other services, either a primary or secondary basis.[2] All transmissions in these bands will conform to the applicable power flux density (PFD) and equivalent power flux density (EPFD) levels specified by Article 21, Article 22, and Resolution 76 of the ITU Radio Regulations.[3] For both bands, sharing will be accommodated in accordance with the rules, procedures, and conditions imposed on the Kepler Grant, as well as the appropriate FCC and ITU regulations. The sharing efforts discussed within the Kepler Grant consider both the space and ground network segments and are hereby incorporated by reference.

[1] *See* Kepler Communications Inc., *Petition for Declaratory Ruling to Grant Access to the U.S. Market for Kepler's NGSO FSS System*, Order and Declaratory Ruling, FCC 18-162 (Nov. 19, 2018) ("Kepler Grant").
[2] *See* 47 C.F.R. §2.106.
[3] In accordance with 47 C.F.R §25.146(a)(2).

Kepler's early satellites facilitate their transmissions in the FSS using fixed Ku-band antenna arrays capable of communicating with only one user terminal at a time (no multiple-access schemes are supported). On later-generation satellites, including those primarily discussed within its market access authorization, Kepler will carry out these functions using a *phased/multi*-array system capable of multiple access. This will be accomplished in a reasonable manner using a standard frequency division multiple access (FDMA) protocol.[4] In theory, satellites will be capable of supporting an arbitrarily large number of simultaneous users by appropriately channelizing the available bandwidth – at the cost of link performance per user. Realistically, Kepler does not expect a given satellite to ever exceed 10 simultaneous user connections at any given time.

1.2 Public Interest Benefits

Kepler's FSS service is positioned to fill two specific connectivity gaps in the greater digital divide. First, the lack of an affordable means to offload the substantial quantities of research, instrumentation, and other data generated by remote land and marine facilities. Second, by offering a connectivity option that is uniquely effective for polar operations. The vast majority of satellite communication networks currently in operation cannot offer an effective data service beyond 60 degrees latitude. Those that do operate in high-latitude regions are bandwidth constrained, and are not capable of meeting data-heavy demands of scientific and industrial customers that operate near the poles, including U.S. entities stationed in Alaska and the Antarctic. Kepler's store and forward service cleanly fills this niche, and does so while

[4] *See* 47 C.F.R. §25.130(a)(4) on the requirement to identify a random-access technique, if available.

remaining cost-effective for the end customer. Kepler's decision to build its constellation using the CubeSat standard has kept its operational costs comparatively low, allowing it to carry over those savings to its customers and offer competitive service rates.

1.3 Communication with Kepler's Non-U.S.-Licensed Satellite Constellation

§25.137(a) of the Commission's rules require Canadian-licensed systems to demonstrate that U.S.-licensed satellite systems have effective competitive opportunities to provide analogous service in Canada, and any other country in which communications with U.S. earth stations will originate or terminate. In accordance with §25.137(b), Kepler hereby incorporates its grant for market access to fulfill this condition.[5]

Further, Kepler has complied with all applicable Commission requirements up to the filing of this application, including those pertaining to milestones, reporting requirements, surety bond requirements, and all other service rules associated with its market access grant.[6]

1.4 Waivers

§25.115(j): Requirement to notify the FAA of certain antenna structures

Kepler requests a waiver of the requirement to notify the FAA of antenna structures that exceed a height above ground level of 6.1 meters, due to the blanket nature of the requested authorization. As Kepler is unable to control the locations that its users set up their terminals, it is

[5] *See* Kepler Grant.
[6] In accordance with 47 C.F.R §25.137(d).

not reasonably possible to fulfill this condition. Users will be responsible for notifying the FAA in circumstances under which their antenna installations would be required to do so in accordance with §17.7 of the Commission's rules.

Form 312, Schedule B, Items E35, E36, E37, and E39: Specifications of antenna height

For clarity and out of an abundance of caution, Kepler requests a corresponding waiver of Schedule B Items E35, E36, E37, and E39 under Form 312 in alignment with the previously requested waiver of *§25.115(j): Requirement to notify the FAA of certain antenna structures*. Because of the blanket nature of this application, the antenna descriptions given within the Schedule B are non-specific and the corresponding sections pertaining to antenna heights cannot be accurately completed. In light of this, Kepler has entered a value of zero in each of these fields.

1.5 Conclusion

Grant of this application would allow Kepler to carry out the same vision that the Commission approved of when granting its request for access to the U.S. market. Kepler's store-and-forward service in the FSS is optimized to transfer massive quantities of data at blisteringly fast rates, and is immensely valuable to customers that struggle with bandwidth, speed, and latitude limitations of existing networks. The specific terminal types requested are discussed in the technical annex to this document, and are entirely comprised of commercially available, industry-standard equipment.

Respectfully Submitted
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2 TECHNICAL ANNEX

The information in this annex is intended to supplement that which has been provided in the associated Schedule B to Form 312 of this application.

2.1 Terminal Descriptions

The attached radiation hazard analysis provides a detailed specification of the antenna parameters of the requested systems. For reference, a summary of the basic parameters is provided in the table below.

Table 1: Basic parameters of requested antenna systems.

Manufacturer	Model	Reflector Diameter (m)	HPBW (°)	Transmit Gain (dBi)	Max Input Power (W)
C-Com	Fly 981	0.98	1.53	41.2	8
Intellian	v65	0.65	2.27	37.7	8
Intellian	v85 NX	0.85	1.52	40.7	8
Intellian	v240MT	2.4	0.88	47.4	40 (min)
Intellian	v240MT	2.4	0.88	47.4	125 (max)
Cobham	Sailor 900	1.03	1.46	41.6	8

All antennas requested by this application are commercially available models that are required by default to meet all applicable technical standards for related radiofrequency devices specified under Federal regulations. Kepler is seeking to initially license ten units of each of the five above-listed models. Because there is a wide range of BUC options available for the Intellian v240MT system, the parameters and associated radiation hazard analyses have been provided for that system for both its lowest and highest power configurations (40 and 125 Watts respectively). To clarify, Kepler is only requesting ten units of this system in total. Because Kepler can not be certain

which configuration is optimal for its future customers, it has filed all ten of the Intellian v240MT systems in their highest power configuration in the associated Schedule B.

2.2 Minimum Elevation Mask

All user terminals types will employ a 10° horizon elevation mask to protect fixed services operating in the bands adjacent to 11.7 – 12.2 GHz. When communicating to NGSO, terminals will apply a variable avoidance mask to GSO to ensure that $EPFD_{up}$ limits are met.[7]

2.3 Antenna Gain Patterns

§25.209 of the Commission's rules detail the requirements pertaining to antenna performance standards, but the existing items are applicable only to GSO networks and NGSO gateway stations – the Commission's rules do not enforce particular performance standards for *user terminals* communicating with NGSO networks.[8]

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[7] Depending on both the EIRP of a given user terminal and the number of antennas transmitting from a single location, exclusion angles to the GSO arc will vary between 5° and 20°.

[8] *See* 47 C.F.R. §25.132(a)(1) on the requirement to test FSS earth stations and ensure that the results "demonstrate that the equipment meets relevant off-axis gain standards in §25.209". Since no standards apply to from §25.209 to NGSO FSS user terminals, this section and the associated testing requirement is therefore generally inapplicable to NGSO user terminals. The Commission chose not to adopt such standards after undertaking its own investigations, concluding in 2000 that it "[did] not see the need at this time to specify an NGSO FSS customer premise earth station reference antenna pattern", and then deferring the issue to later proceedings. After further considerations the Commission chose to maintain this position. *See* Amendment of Parts 2 and 25 of the Commission's Rules to Permit Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range, 16 FCC Rcd. 4096, ¶ 240 (2000). *See also* Establishment of Policies and Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band, 16 FCC Rcd. 9680, ¶ 48 (2001) (On the relative ineffectiveness of limitations on NGSOs user terminals towards overall sharing, and the concern that limitations would also introduce unnecessary regulatory burdens to NGSO operators). *See also* Establishment of Policies and Rules for the Non-Geostationary Satellite Orbit, Fixed Satellite Service in the Ku-Band, 17 FCC Rcd. 7841, ¶ 60 (2002) (Decision not to adopt an antenna reference pattern for NGSO FSS user terminals). *See also* Comprehensive Review of Licensing and Operating Rules for Satellite Services, 30 FCC Rcd. 14713, ¶ 213 (2015) (The Commission reiterates that it "has

Although no standards apply to NGSO FSS user terminals, Kepler has also requested that the Permitted Space Station List be authorized as a point of communication for the requested stations. In accordance with FCC regulations regarding FSS terminals transmitting to GSO,[9] Kepler hereby certifies that the requested antennas conform to the appropriate gain performance standards of §25.209 and EIRP density standards of §25.132 and therefore qualify for routine processing. Further, input power density supplied to the antennas will not exceed the limit specified by §25.212 when communicating with space stations in GSO (see section *Power Limitations*, below). Therefore, in accordance with §25.115(g)(2) Kepler has not included these test results with this application.

2.4 Power Limitations

Provided below are the transmission characteristics for each of the requested antennas.

not yet determined what off-axis gain envelopes might be appropriate for earth stations operating with NGSO FSS space stations, either to facilitate NGSO-to-NGSO or NGSO-to-GSO interference protection).

[9] *See* 47 C.F.R. §25.115(c)(1), §25.115(g), and §25.212(c)(2). To quality for routine processing, FSS earth stations transmitting to GSO in the conventional Ku-band must not exceed an input power of -14 dBW/4 kHz and must certify pursuant to §25.132(a)(1) that the antenna meets the gain performance requirements of §25.209(a) and (b).

Table 2: Power densities of the requested systems. The maximum EIRP density is calculated with the system operating at full input power and transmitting at a bandwidth of 1 MHz. The minimum EIRP density is calculated with the system operating at full input power and transmitting at a bandwidth of 125 MHz.

Manufacturer	Model	Max EIRP[10] (dBW)	Max EIRP Density (dBW/Hz)	Min EIRP Density (dBW/Hz)
C-Com	Fly 981	50.23	-9.77	-30.74
Intellian	v65	46.73	-13.27	-34.24
Intellian	v85 NX	49.73	-10.27	-31.24
Intellian	v240MT (40 W)	63.42	3.42	-17.55
Intellian	v240MT (125 W)	68.37	8.37	-12.60
Cobham	Sailor 900	50.63	-9.37	-30.34

NGSO

Although no antenna performance standards specifically apply to NGSO FSS user terminals, we can use the performance limit for NGSO FSS gateways given by §25.209(h) to obtain a reasonable estimate for expected power densities measured at the horizon.

Table 3: Antenna performance standards for NGSO FSS gateways.

Formula	Unit	Range
$29\text{-}25\log_{10}(\theta)$	dBi	for $1° \leq \theta \leq 36°$.
−10	dBi	for $36° \leq \theta \leq 180°$.

Since Kepler employs a minimum horizon elevation mask of 10°, the estimated gain at the horizon from a given antenna will be:

$$29 - 25\log_{10}(10) = 4\ dBi$$

[10] The formula is $EIRP = G + P - L$, where G is the antenna gain in dBi, P is the power supplied to the antenna input in dBW, and L is the total fixed losses. Values in Table 2 have been calculated assuming no losses (i.e. L=0).

Using the worst-case transmission configuration (a bandwidth of 1 MHz and a power of 125 W), the total received power at the horizon will be 24.97 dBW in this scenario, with a corresponding power density of -35.03 dBW/Hz.

GSO

When communicating to GSO, Kepler will use appropriate transmission characteristics on all antennas to ensure compliance with the input power density limitation of -14 dBW/4 kHz specified by 47 C.F.R. §25.212(c)(2). As indicated previously and in the associated Schedule B, the minimum bandwidth employed will be 1.0 MHz, which limits the maximum permissible input power to approximately 9.95 W. Most of the requested antennas are already limited in this regard by the specifications of their block up-converter hardware.[11] However, in all cases (including that of the Intellian 240MT system), Kepler expects a typical transmission to GSO to use about 6 W input power and 1.5 MHz bandwidth – yielding a corresponding power density of -17.96 dBW/4 kHz. Kepler notes that regardless of the limitations under 47 C.F.R. §25, this power density often can not be substantially increased beyond this point due to saturation flux density limitations of the GSO satellite receivers.

[11] Most of the antenna models use block up converters that can only supply a maximum of 8 W of power to the antenna input.