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Response to Additional Inquiries

On July 1st, 2019 Kepler Communications Inc. (Kepler) received a correspondence from the FCC (the Commission) in association with its application for experimental, special temporary authorization (File No: 1129-EX-ST-2019). The correspondence requested the following additional information.

1) Please demonstrate that your proposed operations in the 14.1875-14.3125 GHz frequency band via Kepler Communications Inc. (Kepler)'s NGSO satellites will be in compliance with the equivalent power Flux-density limit (-160 dBW/m2/40 KHz) in Article 22.5D of the ITU Radio Regulations (see Annex B of O3b Limited's epfd demonstration in experimental application (File NO.0712-EX-ST-2019) for reference).

All earth station operations maintain a 5° exclusion zone to the GSO arc to comply with the EPFD↑ limits set by ITU-RR Article 22. Earth stations immediately cease all transmissions when tracking a Kepler NGSO satellite within this exclusion zone.

See question 2 below for a worst-case calculation using the antenna parameters specified by the application and a transmission directed to a point 5° away from the GSO arc.

2) Please provide the detail calculation, data/number/value and formula that used to calculate the EPFD for the 14.1875-14.3125 GHz frequency band, emissions (125M01W) and its associated powers (3.4MW (ERP).

ITU RR Article 22.5D specifies an EPFD↑ limit in the 13.75 – 14.5 GHz band of:

$$EPFD_{\uparrow} = -160\ dB\left(\frac{W}{m^2 \cdot 40\ kHz}\right)$$

This limit may not be exceeded for any percentage of time. From ITU RR 22.5C.1, the EPFD generated by a system of earth stations towards stations in the GSO is calculated as follows:

$$EPFD = 10\log_{10}\left[\sum_{i=1}^{N_a} 10^{\frac{P_i}{10}} \times \frac{G_t(\theta_i)}{4\pi d_i^2} \times \frac{G_r(\varphi_i)}{G_{r,max}}\right]$$

Where i is the index of a given transmitting earth station, P_i is the antenna input power for the earth station in the appropriate reference bandwidth, θ_i is the off-axis angle between the earth station boresight and the GSO arc, $G_t(\theta_i)$ is the transmit antenna gain (as a ratio) of the earth station, d_i is the

distance between the earth station and the GSO arc, φ_i is the off-axis angle of the geostationary receive antenna to the offending earth station, and $G_{r,max}$ is the max gain (as a ratio) of the antenna of the geostationary receive station. This application concerns only a single earth station, therefore the equation can be simplified as follows:

$$EPFD = 10\log_{10}\left[10^{\frac{P}{10}} \times \frac{G_t(\theta)}{4\pi d^2} \times \frac{G_r(\varphi)}{G_{r,max}}\right]$$

The concerned operation filed by the application will use the following parameters:

Table 1: EPFD input parameters

Parameter	Value	Justification
P_i	40 W	Maximum input power delivered to the antenna.
θ	5°	Kepler earth stations maintain a 5° exclusion zone around the GSO arc at all times. As the earth station is tracking Kepler's NGSO satellites, it will automatically cease transmissions at θ <= 5°.
G_t (θ)	G_t (θ) = 29-25log$_{10}$(θ) = 11.52 dB = 14.21 (real)	Off-axis gain derived from NGSO gateway antenna performance standard given by 47 C.F.R. §25.209(h) (used in lieu of the fact that no specific standards apply to NGSO user terminals). Alternatively and to be conservative, one could use the higher gain value specified by §25.209(a)(5) that typically applies to GSO FSS user terminals transmitting in the plane perpendicular to the GSO arc. This limit is given as G_t (θ) = 32-25log$_{10}$(θ), and its use would have the effect of increasing the final calculated EPFD value by 3 dB. However, the final calculation result demonstrates that even with this change the earth station would still operate well under the Article 22 limit.
d	37340 km	Using ES latitude 38°, assuming spherical Earth
G_r (φ) / $G_{r,max}$	1	We have assumed that the boresight of the victim GSO receive antenna is pointed directly at the offending earth station. Therefore G_r (φ) = $G_{r,max}$ and the resulting ratio is 1.

Further, we calculate our expected power density based on the 125MG1W transmission filed with the application.

$$P = \frac{P_i}{BW} = \frac{40\ W}{125 \times 10^6\ Hz} = 3.2 \times 10^{-7}\frac{W}{Hz}$$

Placing this into a 40 kHz reference bandwidth:

$$P_d = \left(3.2 \times 10^{-7} \frac{W}{Hz}\right) * \left(\frac{40{,}000\ Hz}{40\ kHz}\right) = 1.28 \times 10^{-2} \frac{W}{40\ kHz} = -18.93 \frac{dBW}{40\ kHz}$$

Using these values, we have:

$$EPFD = 10 \log_{10}\left[10^{\frac{-18.93}{10}} \times \frac{14.21}{4\pi(37{,}340{,}000)^2} \times 1\right]$$

$$EPFD = -169.84 \frac{dBW}{m^2 \cdot 40\ kHz}$$

Therefore, when transmitting at full power in the worst-case geometry (i.e. earth station boresight has an angular separation to the GSO arc of 5°), the power received at the GSO will be 9.84 dB below the limit set by Article 22.

3) Please certify that your proposed operations and communication between earth stations (user terminals) and satellites are in compliance with all existing and future coordination agreements between Canada and other administrations. In the absence of a coordination agreement, such communications must comport with applicable provisions of the ITU Radio Regulations.

Kepler hereby certifies that its operations as proposed will comply with all existing and future coordination agreements between Canada and other administrations and where applicable, as well as agreements made directly between Kepler and other NGSO, GSO, and terrestrial operators. Such operations will also comply with all terms and conditions listed in its associated market access grant.