

## NARRATIVE STATEMENT: EARTH STATION LICENSE APPLICATION

By this application, WorldVu Satellites Limited (“OneWeb”), seeks authority to operate thirteen technically identical CPI 3.5 meter antennas in Clewiston, FL (the “Clewiston Earth Station”). The Clewiston Earth Station will provide gateway connectivity to OneWeb’s low earth orbit (“LEO”), non-geostationary (“NGSO”), fixed-satellite service (“FSS”) system, which was granted U.S. market access in June 2017.<sup>1</sup>

The Clewiston Earth Station will allow OneWeb to expand its coverage and service in the United States. Additional gateway facilities are a critical part of OneWeb’s network infrastructure as it prepares to begin commercial service.<sup>2</sup> Grant of this application will serve the public interest by facilitating OneWeb’s ability to deliver ubiquitous, state-of-the-art broadband access to previously unserved and underserved populations in the United States.

### **I. Communications with Non-U.S.-Licensed Space Stations**

OneWeb hereby incorporates by reference the *OneWeb U.S. Market Access Grant* to demonstrate compliance with the requirements of Section 25.137 of the Commission’s rules for earth station applicants proposing to communicate with non-U.S.-licensed space stations.<sup>3</sup>

### **II. Spectrum Use and Sharing**

The Clewiston Earth Station will be mounted on fixed platforms. Although the angle at which the antennas point will change with the tracking of OneWeb’s in-orbit satellites, each platform will remain stationary. The Clewiston Earth Station will communicate with OneWeb’s system in the following frequency bands:

- 17.8-18.6 GHz (downlink)
- 18.8-19.3 GHz (downlink)
- 27.5-29.1 GHz (uplink)
- 29.5-30.0 GHz (uplink)

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<sup>1</sup> See *WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System*, Order and Declaratory Ruling, 32 FCC Rcd 5366 (2017) (“*OneWeb U.S. Market Access Grant*”) (granting OneWeb market access for its LEO NGSO FSS satellite constellation).

<sup>2</sup> OneWeb’s first application for a gateway earth station (located in Talkeetna, AK) was filed with the Commission on June 4, 2018 and remains pending. See IBFS File No. SES-LIC-20180604-01082. OneWeb anticipates filing a license application for the proposed Southbury, CT gateway earth station contemporaneously with the instant application.

<sup>3</sup> See 47 C.F.R. § 25.137.

As illustrated below, OneWeb’s Clewiston Earth Station will operate in a manner consistent with the Commission’s rules.

**A. Uplink**

**1. 27.5-29.1 GHz**

The Upper Microwave Flexible Use Service (“UMFUS”) has a primary designation in the 27.5-28.35 GHz band in the Commission’s *Ka-band Plan*, with a secondary designation for FSS.<sup>4</sup> FSS earth stations are permitted in the 27.5-28.35 GHz band and are not required to provide interference protection to future UMFUS operators if certain conditions are met.<sup>5</sup>

The Commission clarified in the *NGSO Order* that “NGSO FSS systems must operate on an unprotected, non-interference basis with respect to GSO FSS networks” in the 27.5-28.35 GHz band.<sup>6</sup>

FSS is primary in the 28.35-28.6 GHz band, and the *Ka-band Plan* designated NGSO FSS as secondary to GSO FSS in this band.<sup>7</sup>

In the 28.6-29.1 GHz band, NGSO FSS is primary in the U.S. Table of Frequency Allocations and has a primary designation in the Commission’s *Ka-band Plan*.<sup>8</sup>

*Terrestrial Coordination.* Section 25.136(a)(4) of the Commission’s rules allows earth station licensees in the 27.5-28.35 GHz band to operate in accordance with the terms of their authorization without providing additional interference protection to UMFUS stations when four

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<sup>4</sup> *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 7809, App. B (2017) (“*NGSO Order*”); *see also* 47 C.F.R. § 25.136(a) (“FSS is secondary to the Upper Microwave Flexible Use Service in the 27.5-28.35 GHz band.”). The Commission’s current *Ka-band Plan* is set forth in Appendix B to the *NGSO Order* (“*Ka-band Plan*”).

<sup>5</sup> *See* 47 C.F.R. § 25.136(a); *see also Use of Spectrum Bands Above 24 GHz For Mobile Radio Services*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, 8036 ¶ 54 (2016).

<sup>6</sup> *NGSO Order*, 32 FCC Rcd at 7817, ¶ 23.

<sup>7</sup> *See Ka-band Plan*.

<sup>8</sup> 47 C.F.R. § 2.106, NG165; *see also Ka-band Plan*. Additionally, in the *OneWeb U.S. Market Access Grant*, the Commission authorized OneWeb’s uplink operations in this band. *OneWeb U.S. Market Access Grant*, 32 FCC Rcd at 5366, ¶ 1.

conditions are met.<sup>9</sup> Appendix A to this Narrative Statement demonstrates that the Clewiston Earth Station will satisfy all four conditions.

The Comsearch Coordination Report attached separately as Exhibit B<sup>10</sup> to this application demonstrates that in the 27.5-28.35 GHz band: (1) OneWeb can operate the Clewiston Earth Station without causing harmful interference to existing terrestrial deployments, and (2) OneWeb coordinated with existing licensees in compliance with the Commission’s rules.

GSO Coordination. OneWeb makes no claim of interference protection from U.S.-licensed GSO FSS systems in the 27.5-28.6 GHz band. The ITU developed uplink equivalent power flux density (“EPFD<sub>up</sub>”) limits to protect co-frequency GSO FSS operations from unacceptable interference from NGSO FSS systems operating in the same frequencies. Specifically, in accordance with Article 22 of the ITU Radio Regulations, if the applicable EPFD<sub>up</sub> limits are met, then the Commission will consider the NGSO FSS satellite system to have met its obligations of protecting GSO FSS networks from unacceptable interference.<sup>11</sup> OneWeb has demonstrated that it meets the applicable ITU EPFD<sub>up</sub> limits in all frequency ranges where these limits apply and certifies that its operations will be compliant with Article 22 and

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<sup>9</sup> See 47 C.F.R. § 25.136(a)(4); see also *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, 32 FCC Rcd 10988, 11080, Appendix A (2017) (“*Second Spectrum Frontiers Order*”) (adopting changes to this rule section). Because these rule changes are not yet in effect, OneWeb requests the Commission evaluate this application under the updated Section 25.136(a)(4). Appendix A to this Narrative Statement demonstrates compliance with this updated rule. In the alternative, OneWeb respectfully requests a waiver of the current version of Section 25.136(a)(4) of the Commission’s rules to allow this application to be processed under the updated provision, as set forth in Appendix B to this Narrative Statement.

<sup>10</sup> The emission designators provided in the Comsearch Reports in Exhibit B reflect the carrier noise bandwidth (3 dB bandwidth), which is smaller than the necessary bandwidth (typically 15 dB bandwidth), that has been used for this earth station application and for the *OneWeb U.S. Market Access Grant*. The difference in bandwidth is less than ten percent. Therefore, this variance has no impact on the data culling function performed by Comsearch and provides a more accurate portrayal of the interference potential of OneWeb’s earth station emissions since the power-spectral density and the receiver noise bandwidth are computed based on the actual noise bandwidth instead of the necessary or occupied bandwidth.

<sup>11</sup> See *NGSO Order*, 32 FCC Rcd at 7820, ¶ 32 (“Any NGSO FSS system operating in compliance with these limits is considered as having fulfilled its obligation under Article 22 of the ITU Radio Regulations not to cause unacceptable interference to any GSO network.”).

Resolution 76 of the ITU’s rules.<sup>12</sup> Consequently, the transmissions from the Clewiston Earth Station will sufficiently protect GSO FSS systems.

## 2. 29.5-30.0 GHz

The 29.5-30.0 GHz band is allocated to the FSS on a co-primary basis with the Mobile Satellite Service (“MSS”), with NGSO FSS having a secondary designation to GSO FSS in the *Ka-band Plan*.<sup>13</sup>

OneWeb makes no claim of interference protection from U.S.-licensed GSO FSS systems in this band,<sup>14</sup> and the transmissions from the Clewiston Earth Station will sufficiently protect GSO FSS systems because the OneWeb system meets the applicable ITU EPFD<sub>up</sub> limits in all frequency ranges where these limits apply.<sup>15</sup>

### B. Downlink

*Federal Coordination.* Space-to-Earth operations in the bands between 17.7-20.2 GHz must complete coordination with U.S. Federal systems in accordance with footnote US334 to the United States Table of Frequency Allocations, 47 C.F.R. § 2.106, prior to being used. Footnote US334 lists several locations where federal space and earth station operations are primary. However, the Clewiston Earth Station is located outside the areas of concern in US334. Therefore, US334 is not applicable to the instant application.

## 1. 17.8-18.3 GHz

In the *NGSO Order*, the Commission allocated the 17.8-18.3 GHz band on a primary basis to the terrestrial fixed service (“FS”) and on a secondary basis for FSS, subject to international power flux-density (“PFD”) limits.<sup>16</sup> OneWeb previously demonstrated that

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<sup>12</sup> See *WorldVu Satellites Limited, Petition for a Declaratory Ruling Granting Access to the U.S. Market for the OneWeb NGSO FSS System*, IBFS File No. SAT-LOI-20160428-00041, Technical Narrative (“*Market Access Application Technical Narrative*”) at 33-34; A2-9 – A2-12.

<sup>13</sup> 47 C.F.R. § 2.106; see also *Ka-band Plan*.

<sup>14</sup> See *OneWeb U.S. Market Access Grant*, 32 FCC Rcd at 5377, ¶ 23(j). Similarly, OneWeb will operate in this band without seeking protection or causing harmful interference to any co-frequency MSS operations.

<sup>15</sup> *Market Access Application Technical Narrative* at 33-34; A2-1 – A2-6. OneWeb believes that the EPFD<sub>up</sub> limits associated with the protection of GSO FSS networks would also adequately protect any GSO MSS network.

<sup>16</sup> *NGSO Order*, 32 FCC Rcd at 7812, ¶¶ 7-8.

secondary use of this band for its downlink operations will not cause harmful interference to FS operations because OneWeb’s system meets the ITU PFD limits.<sup>17</sup> Consequently, the Commission authorized OneWeb’s space stations to transmit in this band despite being on a non-conforming basis at the time.<sup>18</sup> Moreover, the Comsearch Interference Analysis Report attached as Exhibit B<sup>19</sup> to this application indicates that there will be no restrictions on OneWeb’s operations due to interference considerations in this band.

## 2. 18.3-18.6 GHz

The 18.3-18.6 GHz band is allocated on a primary basis to the FSS, as the *NGSO Order* amended the *Ka-band Plan* to “allow NGSO FSS systems to operate on an unprotected, non-interference basis with respect to GSO FSS networks in the 18.3-18.6 GHz . . . band[], subject to international equivalent power flux-density (“EPFD”) limits.”<sup>20</sup> The ITU developed downlink EPFD (“EPFD<sub>down</sub>”) limits to protect GSO FSS networks from unacceptable interference from NGSO FSS systems operating in the same frequencies. Like the EPFD<sub>up</sub> limits, if the NGSO FSS system meets the applicable EPFD<sub>down</sub> limits, then the Commission will consider the NGSO FSS satellite system to have met its obligations to protect GSO FSS networks from unacceptable interference. OneWeb provided calculations for transmissions in this band showing that the OneWeb system meets the applicable ITU EPFD<sub>down</sub> limits in all frequency ranges where these limits apply.<sup>21</sup> The Commission authorized OneWeb’s NGSO FSS system to transmit in this band.<sup>22</sup>

## 3. 18.8-19.3 GHz

The 18.8-19.3 GHz band is allocated to the FSS on a primary basis, and the Commission recently preserved the primary designation for NGSO FSS systems in the *Ka-band Plan*.<sup>23</sup> The Commission authorized OneWeb’s NGSO FSS system to transmit in this band.<sup>24</sup>

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<sup>17</sup> See *Market Access Application Technical Narrative* at 23-26; see also *id.*

<sup>18</sup> See *OneWeb U.S. Market Access Grant*, 32 FCC Rcd at 5373, ¶ 16, 23. At the time of this grant, the Commission had not adopted a secondary allocation for FSS.

<sup>19</sup> See *supra* note 10.

<sup>20</sup> *NGSO Order*, 32 FCC Rcd at 7813, ¶¶ 9-10 (citing Section III.D.1).

<sup>21</sup> See *Market Access Application Technical Narrative* at 33-34; A2-1 – A2-8.

<sup>22</sup> *OneWeb U.S. Market Access Grant*, 32 FCC Rcd at 5366, ¶¶ 16, 23.

<sup>23</sup> *NGSO Order*, 32 FCC Rcd at 7814, ¶ 14.

<sup>24</sup> *OneWeb U.S. Market Access Grant*, 32 FCC Rcd at 5366, ¶ 1.

**III. Waivers**

Appendix B to this Narrative Statement requests any necessary waivers of the current Section 25.136(a)(4) rule.

**IV. Antenna Patterns**

Appendix C certifies that the Clewiston Earth Station antenna patterns are in compliance with the relevant sections of Section 25.209.

**V. Radiation Hazard Report**

Appendix D provides the radiation hazard analysis for the Clewiston Earth Station.

**VI. FAA Notification**

FAA notification is not required as the Clewiston Earth Station will not exceed 6.1 meters above ground.

**VII. Conclusion**

As explained above, grant of OneWeb's Clewiston Earth Station application is in the public interest and meets the requirements of the Commission's rules.

Respectfully submitted,

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**APPENDIX A: 47 CFR § 25.136(a)(4) – UMFUS COMPLIANCE**

The Commission’s rules define four elements that, if met, permit an earth station licensee to operate in accordance with the terms of its authorization without providing additional interference protection to UMFUS stations in the 27.5-28.35 GHz band.<sup>25</sup> Based on the following analysis, the Commission should authorize the OneWeb Clewiston Earth Station without requiring additional protection for future UMFUS licensees in Hendry County, Florida.

**1. § 25.136(a)(4)(i)**

The Clewiston Earth Station complies with this section of the Commission’s rules because there are no other earth stations in the 27.5-28.35 GHz band in Hendry County, Florida.

**2. § 25.136(a)(4)(ii)**

Section 25.135(a)(4)(ii) provides that, in a UMFUS license area with a population between 6,000 and 450,000 people, no more than 450 people may be within an earth station’s PFD contour that is equal to or exceeds -77.6 dBm/m<sup>2</sup>/MHz to avoid having to provide interference protection to future UMFUS operators. The area around the Clewiston Earth Station falling within this PFD contour<sup>26</sup> is fully contained within Hendry County which has a population of just over 40,000 people.<sup>27</sup> As demonstrated below, the Clewiston Earth Station’s PFD contour contains far fewer than 450 people.

Using the ITU RR Appendix 7 Time-Variant Gain (TVG) method, each of the 13 antennas of the Clewiston Earth Station would track a different OneWeb satellite above a minimum elevation angle of 10 degrees.<sup>28</sup> A composite (13 antennas) PFD contour was

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<sup>25</sup> See 47 C.F.R. § 25.136(a)(4).

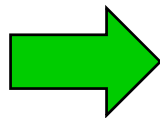
<sup>26</sup> The PFD contour of the Clewiston Earth Station was first computed using existing terrain features, including earth berms or mounds that exist east and north of the site. As explained in Section 3 below, these would not be sufficient to comply with the PFD limit in Section 25.136(a)(4)(iii). To comply with the PFD limit set forth in Section 25.136(a)(4)(iii), an additional earth berm will be built at the site and the results described herein assume this additional feature will be present.

<sup>27</sup> See QuickFacts Hendry County, Florida, United States Census Bureau (last viewed June 25, 2018), <https://www.census.gov/quickfacts/fact/table/hendrycountyflorida,fl/PST045217>.

<sup>28</sup> In this analysis, the population data for each census block within the Clewiston Earth Station PFD contour comes from the 2010 U.S. Census data. The propagation model implements a 1-arc second resolution SRTM Digital Terrain Elevation Data (DTED) profile based on the ITU-R Recommendation P.452-15.

developed via proprietary software and compared with the Visualyse PRO software to ensure consistency. This composite assessed the cumulative distribution function (CDF or joint probability) of potential interference representing the EIRP towards the horizon and the propagation statistics by performing the convolution of the individual CDFs. As a result, the TVG method calculates the area where the PFD limit could be exceeded, assuming a PFD value that is not exceeded for 99% of the time. The following contains the Clewiston Earth Station parameters<sup>29</sup> and the resulting PFD contour of the analysis.<sup>30</sup>

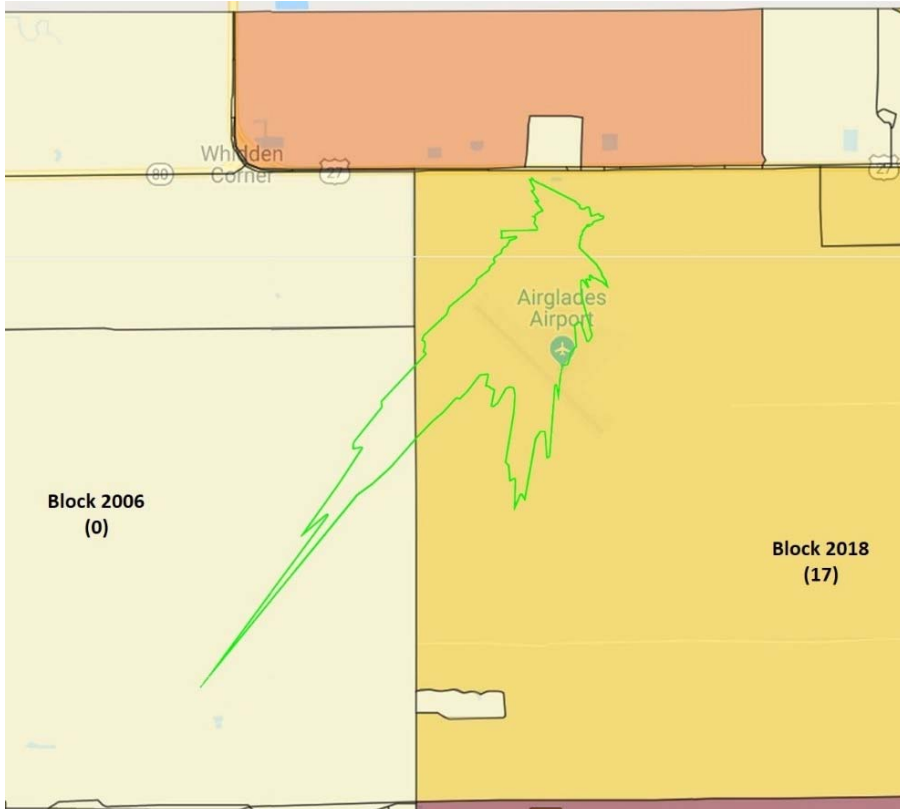
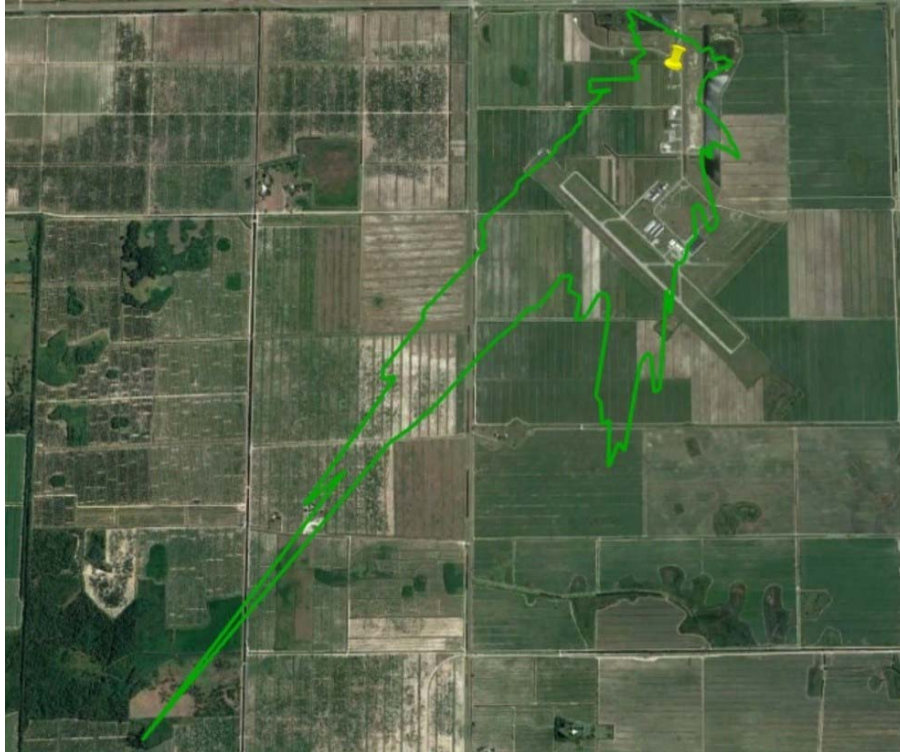
Clewiston Earth Station Parameters	
ES latitude (NAD 83)	26° 44' 51.8" N°
ES longitude (NAD 83)	81° 2' 57.2" W°
Ground Elevation (AMSL)	5.49 m
ES antenna size	3.5 m
ES input power spectral density	-19.0 dBW/MHz
ES antenna pattern	FCC (§25.209(a)(1))
ES minimum elevation angle	10°
Number of antennas at site	13



<sup>29</sup> It should be noted that the earth station input power spectral density is 3.4 dB lower than the maximum provided in the application since the latter includes maximum uplink power control for rain events exceeding 6 dB. The clear sky value is the most appropriate calculation for this analysis because uplink power control is not used for fade levels less than 6 dB.

<sup>30</sup> The Clewiston Earth Station’s PFD contour is displayed using Google Maps and then superimposed on a U.S. Census map to estimate the population within the contour—note that the population counts for each census block are in parentheses. These images are larger on the next page.





The next table displays the calculated population for each census block that is within the Clewiston Earth Station PFD contour:

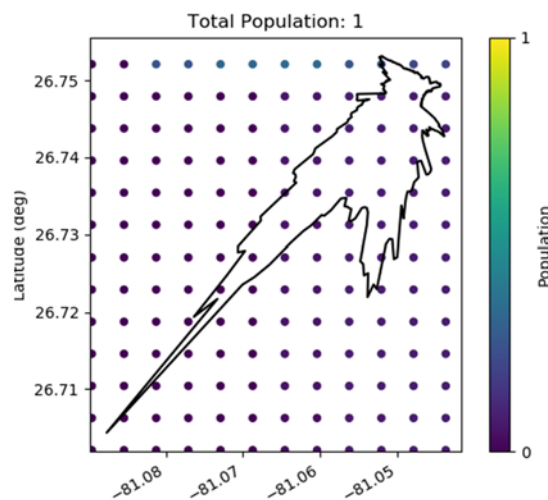
Block ID	Population	Proportion Covered (estimated)	Assumed Population of Contour Coverage		
			Only Completely Covered Blocks	Include Partially Covered Blocks	100% of Pop. in all Blocks
2006	0	15%	0	0	0
2018	17	20%	0	4	17
<b>Total Population</b>			<b>0</b>	<b>4</b>	<b>17</b>

The summation of the population in the Clewiston Earth Station PFD contour is approximately:

- 0 people (looking at only the populations of those census blocks that are wholly contained within the contour and assuming that the populations of the partially covered blocks fall outside the PFD contour) or
- 4 people (assuming a very conservative proportion of the population in Block 2018 with partial contour coverage, based on the estimated geographical area of this Block that falls within the PFD contour over its total area).

The third column in the above table would likely never occur because the interference contour only covers a small portion of Block 2018.

To verify the population-count in this study and underscore the conservativeness of the estimated 4-population value, the interference contour was superimposed on a population distribution grid,<sup>31</sup> as depicted in the following figure:



<sup>31</sup> See *Gridded Population of the World*, NASA Socioeconomic Data and Applications Center available at <http://sedac.ciesin.columbia.edu/data/collection/gpw-v4/maps/services>. Note that due to the low population density in the area surrounding this planned earth station, no data point in the graph even has a population of 1 person.

The estimated population within the contour is 1 person. Consequently, the conservative estimate of 4 people illustrates that the total population covered by the Clewiston Earth Station's PFD Contour is much less than the 450-person limit as set out by this subsection.

### 3. § 25.136(a)(4)(iii)

Based on a search in Google Maps, there are no major event venues, urban mass transit routes, passenger railroads or cruise ship ports within the Clewiston Earth Station's PFD contour. The PFD contour was calculated based on the existing terrain profile (illustrated in red in the figures below) showing overlap with portions of Highway 27—which is identified as an Other Principal Arterial by The Federal Highway Administration Office of Planning, Environment, and Realty Executive Geographic Information System map.<sup>32</sup> Nevertheless, UMFUS deployments will not be impacted by the Clewiston Earth Station because OneWeb will build a berm (illustrated in blue in the figure below on the next page) resulting in a PFD contour (illustrated in green in the figures below) that will not overlap with any portion of Highway 27, thus complying with the requirements of this subsection.



OneWeb plans to build a 2-meter high earth berm around the location of the proposed earth station antennas (roughly centered as depicted by the push pin on the above figures). The berm would follow the curvature of the access road (east to north of the antenna farm) and along its western border. The proposed berm is shown in blue in the figure below. Should the Commission approve this application, the berm will be constructed and its impact in terms of signal attenuation will be measured at the site before commencing transmissions.

<sup>32</sup> See National Highway System Map, U.S. Department of Transportation, Federal Highway Administration (last visited Mar. 2, 2018), <https://hepgis.fhwa.dot.gov/fhwagis/>.



Therefore, the Clewiston Earth Station complies with the requirements of this subsection.

**4. § 25.136(a)(4)(iv)**

The Comsearch Coordination Report in Exhibit B<sup>33</sup> demonstrates that OneWeb completed coordination in compliance with the Commission's rules.

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<sup>33</sup> See *supra* note 10.

**Appendix B: 47 CFR § 25.136(a)(4) – Waiver Request**

OneWeb requests that the Commission consider this application under the newly adopted Section 25.136(a)(4) as OneWeb fully complies with the updated rule as illustrated in Appendix A. In the alternative, since the rule changes are not in effect as of the submission of this application, OneWeb requests any necessary waivers of the current Section 25.136(a)(4) rules.

Grant of this waiver request is consistent with Commission precedent.<sup>34</sup> First, in the *Second Spectrum Frontiers Order*, the Commission altered the population limits for earth station coverage specified under Section 25.136(a)(4)(ii) to give satellite operators additional deployment flexibility.<sup>35</sup> Second, requiring OneWeb to comply with the current Section 25.136(a)(4) would become unnecessary as soon as the newly adopted Section 25.136(a)(4) comes into effect. Third, grant of this waiver is in the public interest because it will facilitate OneWeb’s ability to build-out the ground infrastructure providing critical support to its LEO constellation in a timely manner. OneWeb notes the Commission recently granted an earth station application that contained a similar waiver request.<sup>36</sup> For these reasons, OneWeb respectfully submits that this waiver request is in the public interest.

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<sup>34</sup> *PanAmSat Licensee Corp.*, 17 FCC Rcd 10483, 10492 (Sat. Div. 2002) (finding that a waiver is appropriate so long as the requested relief “would not undermine the policy objective of the rule in question and would otherwise serve the public interest”).

<sup>35</sup> *See Second Spectrum Frontiers Order*, 32 FCC Rcd at 11029-32, ¶¶ 124-133.

<sup>36</sup> *See O3b Limited*, IBFS File No. SES-LIC-20180122-00053, Call Sign E180005 (granted Mar. 8, 2018).

**Appendix C: 47 CFR § 25.132 – Antenna Patterns Certification**

I, Marc Dupuis, Senior Director of Spectrum Affairs for OneWeb, hereby certify that I

- reviewed the results of a series of radiation pattern tests for the CPI 3.5 meter antenna performed by the antenna manufacturer on representative equipment in representative configurations, and
- found the test results demonstrate that the CPI 3.5 meter antenna meets relevant off-axis gain standards in Section 25.209 of the Commission’s rules, measured in accordance with Section 25.132(b)(1).

This certification is dated July 27, 2018 and signed by:

/s/ Marc Dupuis

Marc Dupuis  
Senior Director, Spectrum Affairs  
OneWeb  
1785 Greensboro Station Place  
Tower 3, Floor 8  
McLean, VA 22102

**APPENDIX D: RADIATION HAZARD REPORT**

In accordance with OET Bulletin 65, this Radiation Hazard Report measured radiation exposure levels in seven zones for two cases—general population and occupational. The radiation levels calculated for each zone in Section II are derived from the calculations made in Section I. The results in Section III for OneWeb’s 3.5 meter CPI antenna illustrate any radiation hazard that may exist for the general public and/or occupationally will be mitigated by limited access and various protocols to ensure safe exposure levels.

**I. Defined Variables for OET Bulletin 65 Calculated Variables**

Variables	Value	Unit	OET 65 Calculated Variables	Formula	Value	Unit
$D =$ Aperture Diameter	3.5	Meters	$\lambda =$ Wavelength	$c/F$	0.0104	Meters
$d =$ Subreflector Diameter	0.406	Meters	$P_1 =$ Total Antenna Input Power	$P * p$	114	Watts
$\eta =$ Aperture Efficiency	57%	Percentage	$A =$ Area of reflector	$\pi(D/2)^2$	9.62113	Meters <sup>2</sup>
FCC Designation	Ka	Band	$a =$ area of sub-reflector	$\pi(d/2)^2$	0.12946	Meters <sup>2</sup>
$F =$ Frequency	28750	MHz	$G =$ Antenna Gain	$G = 4\pi\eta A/\lambda^2$	630965.68	Linear
$P =$ Transmitter Power Watts	114.1	Watts	Antenna Gain dB	$10\log_{10}(G)$	58.00	dBi
$p =$ Number of Transmitters	1	#	$R_{nf} =$ Near-Field Region	$R_{nf} = D^2/4\lambda$	293.69	Meters
$R_{ua} =$ Closest Point to Uncontrolled Area	25	Meters	Transition Region	$>R_{nf} < R_{ff}$	293.69	>Meters
$R_{ua} =$ Elevation angle at closest point	10	Degrees			704.86	<Meters
			$R_{ff} =$ Far-Field Region	$R_{ff} = 0.6D^2/\lambda$	704.86	Meters
					124	Meters AGL

## II. Radiation Levels in Each Zone

Radiation Analysis Zone	Formula	Level	Value	Exposure Limits Met		
				General Public	Occupational	
				<1mW/cm <sup>2</sup>	<5mW/cm <sup>2</sup>	
1	Power Sub-reflector	$4P_I/a$	352.48	mW/cm <sup>2</sup>	No	No
2	Antenna Surface	$4P_I/A$	4.74	mW/cm <sup>2</sup>	No	Yes
3	Main Reflector Ground	$P_I/A$	1.19	mW/cm <sup>2</sup>	No	Yes
4	$S_{nf} =$ Near-Field Power Density	$4\eta(P_I/A)$	2.69	mW/cm <sup>2</sup>	No	Yes
5	Transition Max Power Density	$S_{nf} * R_{nf}/R_{nf}$	2.69	mW/cm <sup>2</sup>	No	Yes
6	Far-Field Max Power Density	$P_I * G/4\pi R^2$	1.15	mW/cm <sup>2</sup>	No	Yes
7	Off-axis Near Field	$S_{nf}-20dB$	0.03	mW/cm <sup>2</sup>	Yes	Yes

## III. Results

*General Public Analysis.* OneWeb’s 3.5 meter CPI antennas will be located in an area clearly marked with Radiation Hazard signage with no access by the general public. Zones 1 through 5 create no concern for the general public as they lie behind this signage where only authorized personnel may enter. Likewise, Zone 6—Far Field—also creates no concern for the general public because it develops 124 meters above ground level at a minimum elevation angle of ten degrees where the general public cannot access. Accordingly, there is no risk of radiation exposure beyond the acceptable limits.

*Occupational Analysis.* Only around the Power Sub-reflector are any radiation levels exceeded. This measurement is taken at a point between the feed and the sub-reflector. Power to the transmitters will be turned off remotely whenever work needs to be performed in this Zone. Signage will mark the area for Radiation Hazard and access by qualified personnel only, facilitating awareness and safety. Consequently, there is no risk of radiation exposure beyond the acceptable limits.