

## NARRATIVE STATEMENT: EARTH STATION LICENSE APPLICATION

By this application, WorldVu Satellites Limited (“OneWeb”), seeks authority to operate twenty-six technically identical CPI 3.5 meter antennas in Southbury, Connecticut (the “Southbury Earth Station”). The Southbury 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 Southbury 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 Southbury 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 Southbury 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 Clewiston, FL gateway earth station contemporaneously with the instant application.

<sup>3</sup> See 47 C.F.R. § 25.137.

As illustrated below, OneWeb’s Southbury 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 Southbury 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 Southbury 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 Southbury 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 Southbury 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 Southbury 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 Southbury 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 Southbury Earth Station.

**VI. FAA Notification**

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

**VII. Conclusion**

As explained above, grant of OneWeb's Southbury 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 Southbury Earth Station without requiring additional protection for future UMFUS licensees in New Haven and Fairfield counties in Connecticut.

**1. § 25.136(a)(4)(i)**

The Southbury 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 New Haven County, Connecticut where the Southbury Earth Station is located.

**2. § 25.136(a)(4)(ii)**

Section 25.135(a)(4)(ii) provides that, in a UMFUS license area with a population greater than 450,000 people, no more than 0.1% of the population may be within an earth station’s PFD contour that is equal to or exceeds  $-77.6 \text{ dBm/m}^2/\text{MHz}$  to avoid having to provide interference protection to future UMFUS operators. The area around the Southbury Earth Station falling within this PFD contour is fully contained within both New Haven County with a population of just over 860,400 people and Fairfield County with a population of just over 949,900 people.<sup>26</sup> As demonstrated below, the Southbury Earth Station’s PFD contour contains far fewer than 860 people in New Haven County and 949 people in Fairfield County.

Using the ITU RR Appendix 7 Time-Variant Gain (TVG) method, each of the 26 antennas of the Southbury Earth Station would track a different OneWeb satellite above a minimum elevation angle of 5 degrees.<sup>27</sup> A composite (26 antennas) PFD contour was developed via proprietary software and compared with the Visualyse PRO software to ensure consistency. This composite assessed the cumulative distribution function (“CDF” or joint

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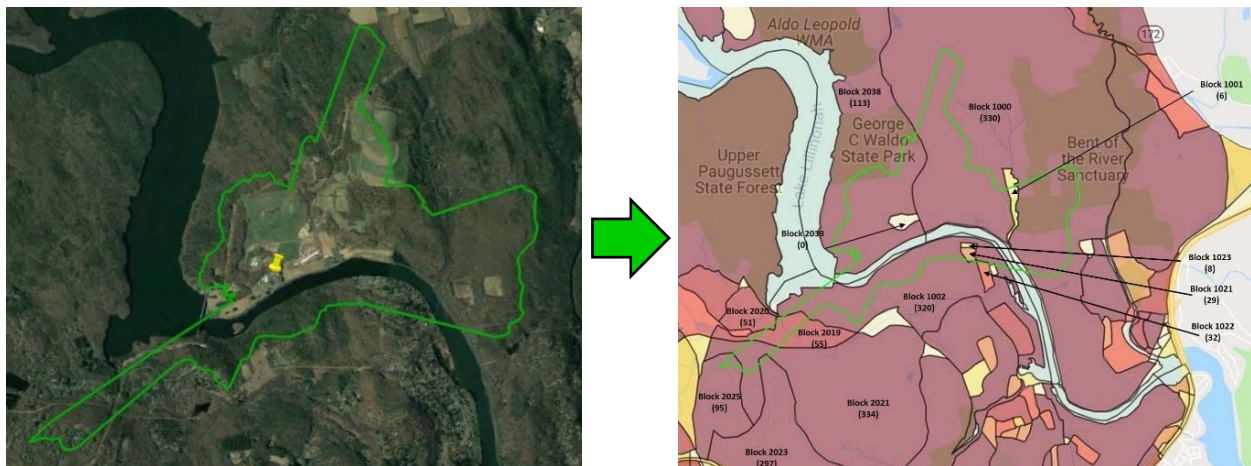
<sup>25</sup> See 47 C.F.R. § 25.136(a)(4).

<sup>26</sup> See QuickFacts New Haven County, Connecticut; Fairfield County, Connecticut, United States Census Bureau (last viewed June 26, 2018), <https://www.census.gov/quickfacts/fact/table/newhavencountyconnecticut,fairfieldcountyconnecticut/PST045217>.

<sup>27</sup> In this analysis, the population data for each census block within the Southbury 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.

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 Southbury Earth Station parameters<sup>28</sup> and the resulting PFD contour of the analysis:<sup>29</sup>

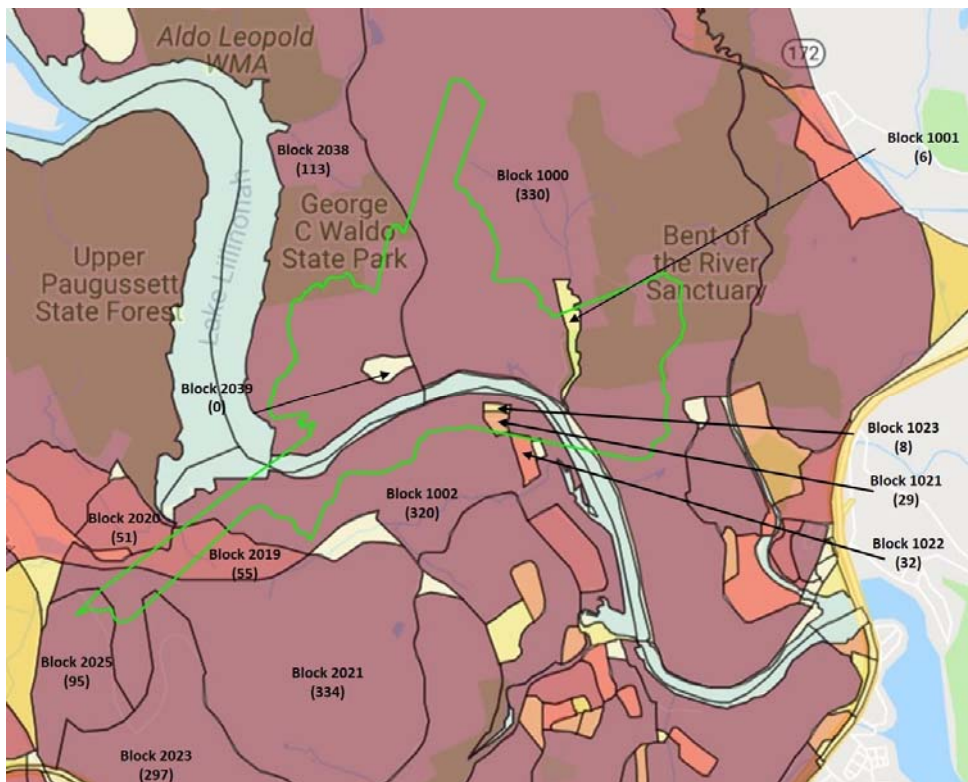
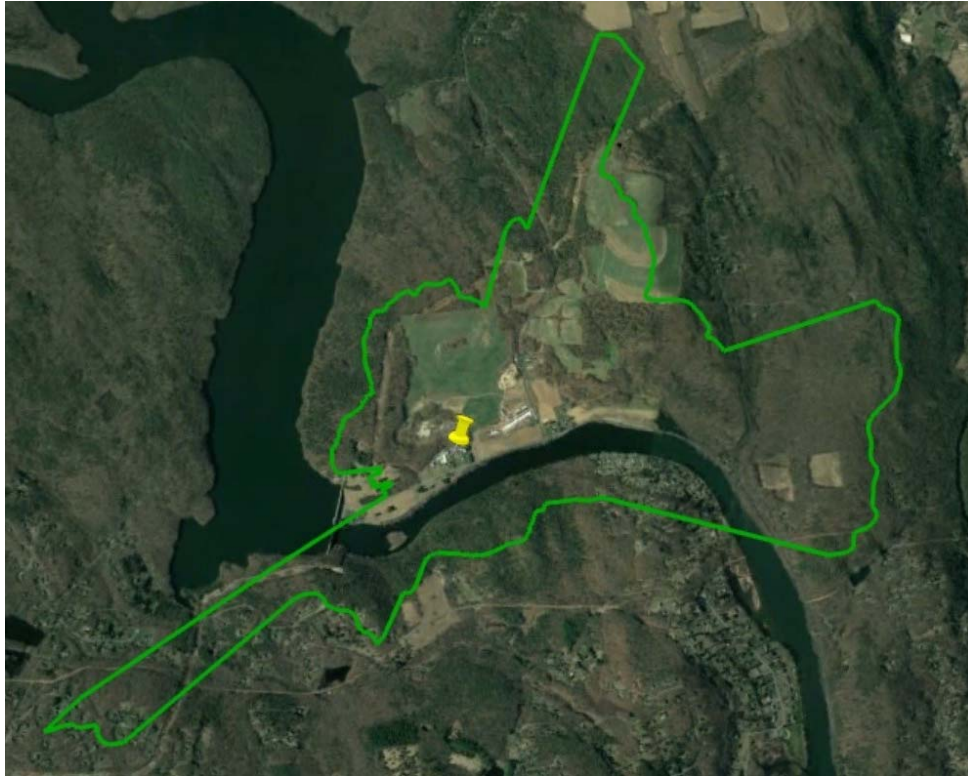
Southbury Earth Station Parameters	
ES latitude (NAD 83)	41° 27' 6.4" N°
ES longitude (NAD 83)	73° 17' 21.6" W°
Ground Elevation (AMSL)	38.99 m
ES antenna size	3.5 m
ES input power spectral density	-19.0 dBW/MHz
ES antenna pattern	FCC (§25.209(a)(1))
ES minimum elevation angle	5°
Number of antennas at site	26



<sup>28</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>29</sup> The Southbury 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 Southbury Earth Station PFD contour:

County	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
New Haven	1000	330	50%	0	165	330
	1001	6	80%	0	5	6
	2038	113	30%	0	34	113
	2039	0	100%	0	0	0
	<b>Total Population</b>				<b>0</b>	<b>204</b>
Fairfield	1002	320	50%	0	160	320
	1021	29	100%	29	29	29
	1022	32	10%	0	4	32
	1023	8	100%	8	8	8
	2019	55	50%	0	28	55
	2020	51	5%	0	3	51
	2021	334	10%	0	34	334
	2023	297	5%	0	15	297
	2025	95	10%	0	10	95
	<b>Total Population</b>				<b>37</b>	<b>291</b>

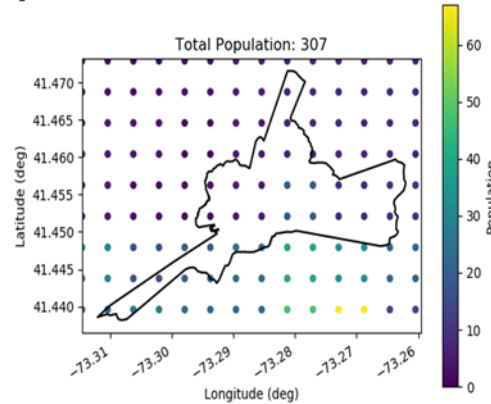
The summation of the population in the Southbury Earth Station PFD contour is approximately:

- 0 people in New Haven County and 37 people in Fairfield County (looking at only the populations of those census blocks that are wholly contained within the PFD contour and assuming that the populations of the partially covered blocks fall outside the PFD contour) or
- 204 people in New Haven County and 291 people in Fairfield County (adding the populations of the completely covered census blocks with the populations of the partially covered census blocks and assuming a proportion of the population in these blocks based on a very conservative estimate of the geographical area of the corresponding block inside the contour).

The third column in the above table would likely never occur because the interference contour only covers a small proportion of a number of census blocks, but as a point of reference, it includes the entire population of any partially overlapped block.

To verify the population-count in this study, and underscore the conservativeness of the estimated 204-population value for New Haven County and the 291-population value for

Fairfield County, the interference contour was superimposed on a population distribution grid,<sup>30</sup> as depicted in the following figure:



The estimated population within the contour is 307 people. The conservative combined estimate of both counties is 495 people within the PFD contour when using the map estimation approach. Consequently, the total population covered by the Southbury Earth Station's PFD contour is much less than the limits 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 Southbury Earth Station's PFD contour. Additionally, the PFD contour does not overlap with any Interstates, Other Freeways and Expressways, or Other Principal Arterials as defined by The Federal Highway Administration Office of Planning, Environment, and Realty Executive Geographic Information System map.<sup>31</sup> Therefore, the Southbury Earth Station complies with the requirements of this subsection.

### 4. § 25.136(a)(4)(iv)

The Comsearch Coordination Report in Exhibit B<sup>32</sup> demonstrates that OneWeb completed coordination in compliance with the Commission's rules.

<sup>30</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 the population is not necessarily distributed along this grid structure and merely serves to verify the analysis.

<sup>31</sup> See National Highway System Map, U.S. Department of Transportation, Federal Highway Administration (last visited June 25, 2018), <https://hepgis.fhwa.dot.gov/fhwagis/>.

<sup>32</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>33</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>34</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>35</sup> For these reasons, OneWeb respectfully submits that this waiver request is in the public interest.

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<sup>33</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>34</sup> *See Second Spectrum Frontiers Order*, 32 FCC Rcd at 11029-32, ¶¶ 124-133.

<sup>35</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	40	Meters	Transition Region	$>R_{nf} < R_{ff}$	293.69	>Meters
$R_{ua} =$ Elevation angle at closest point	5	Degrees			704.86	<Meters
			$R_{ff} =$ Far-Field Region	$R_{ff} = 0.6D^2/\lambda$	704.86	Meters
					61.67	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 61.67 meters above ground level at a minimum elevation angle of five 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.