SES
beyond frontiers

**Gerry Oberst**
President

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FILED ELECTRONICALLY

**Ms. Marlene H. Dortch**
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Subject: ***Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz***
**GN Docket No. 17-183**

Dear Ms. Dortch:

Attached on behalf of SES Americom, Inc. ("SES") is a technical analysis SES performed that addresses the constraints that would need to be placed on deployment of terrestrial mobile ("IMT") base stations operating co-frequency with fixed-satellite service ("FSS") earth stations in the C-band downlink spectrum. The SES calculations demonstrate that significant separation distances would be needed to prevent unacceptable interference to the critical services supplied by C-band satellites in the United States, which include the delivery of news, entertainment, and sports programming and emergency alerts to more than 100 million U.S. households.

SES's analysis focused on a cluster of five existing earth stations near Virginia Beach and determined that to prevent interference to the FSS operations, IMT base stations would need to be excluded from an area up to 65 kilometers from north to south and up to 75 kilometers from east to west. SES also noted that additional licensed earth stations near the Virginia Beach cluster would have protection contours that overlap with those in the cluster, creating a daisy chain that would extend the necessary protection area inland and up and down the Atlantic Coast.

The results of the SES analysis are consistent with data in the record showing that avoiding co-channel interference to an FSS receive earth station requires separation distances in the tens of kilometers.[1] SES has also assessed the aggregate impact of multiple IMT base stations and determined that such effects further increase the required separation distances. Thus, deployment of

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[1] *See, e.g.,* Comments of Ericsson, GN Docket No. 17-183, filed Oct. 2, 2017, at 8 and Attachment A at 1-3; Nokia Notice of *Ex Parte* Presentation, GN Docket No. 17-183, filed Jan. 22, 2018, Attachment at 20.

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an IMT base station along the edge of the single-entry protection contour would require subsequent IMT base station installations to be placed farther away to prevent interference to the FSS operations.

Given the ubiquitous deployment of C-band receive earth stations, enforcing these necessary separation distances would make deployment of terrestrial mobile services impossible in significant portions of the country. Thus, attempting to implement co-frequency sharing would create a lose-lose situation for the satellite community and prospective terrestrial service providers.

Please address any questions regarding this matter to the undersigned.

Yours Sincerely,

*/s/ Gerry Oberst*

Gerry Oberst

Attachment

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## Technical Annex

### 1. Introduction

In this Technical Annex, SES summarizes the analysis it has performed regarding the potential for co-frequency co-existence between IMT base stations and FSS earth stations within the frequency band 3700-4200 MHz. SES performed single entry I/N analyses to define a set of required separation distance contours surrounding a cluster of earth stations near Virginia Beach, VA with elevation angles ranging from 19 degrees to 39 degrees. SES also considered the additional impact of aggregate interference from multiple IMT base stations in the vicinity of the earth station cluster.

These analyses confirm the results of previous studies that have been submitted into the record demonstrating that separation distances in the tens of kilometers are required in order to protect FSS earth stations from unacceptable interference. The required separation distance increases further when the effect of aggregate interference from multiple IMT base stations near the earth station is taken into account.

### 2. Mobile Base Station Characteristics

The single-entry analysis was based on the assumptions regarding mobile base station operations set forth in Table 1, which reflect the parameters described in Report ITU-R M.2292 “Characteristics of terrestrial IMT-Advanced systems for frequency sharing/interference analyses.”

**Table 1. Mobile Base Transmit Station Characteristics**

| | |
|---|---|
| **Antenna Pattern** | Recommendation ITU-R F.1336 (*recommends* 3.1)<br>$k_a = 0.7$<br>$k_p = 0.7$<br>$k_h = 0.7$<br>$k_v = 0.3$<br>Horizontal 3 dB beamwidth: 65 degrees<br>Vertical 3 dB beamwidth: determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336. |
| **Antenna Sectors** | 3 |
| **Antenna Gain** | 18 dBi |
| **Antenna downtilt** | 6 degrees (suburban) |
| **Sectorization** | 3 sectors |

| | |
|---|---|
| **IMT BS Power** | 13 dBW |
| **IMT Bandwidth** | 10 MHz |
| **Activity Factor** | 50% |
| **Peak EIRP (taking into account activity factor)** | 28 dBW/10 MHz |
| **BS height above terrain** | 25 m (suburban) |
| **Propagation Model** | Rec. P.452-16 |
| **Clutter characteristics** | 25/9 m (suburban)[1] |

In the simulations, the sector antenna pointing azimuths are kept fixed and pointed at 0 degrees, 120 degrees, -120 degrees (*i.e.*, there is no artificial beam peak pointing towards the FSS earth station).

## 3. FSS Earth Station Characteristics

Table 2 provides the basic characteristics for the FSS earth stations analyzed.

**Table 2. FSS Earth Station Characteristics**

| **ES Description and Call Sign** | Cox E872907 | CBN E930230 | CBN WD58 | Norfolk St. E050120 | Cox E090089 |
|---|---|---|---|---|---|
| **Latitude (Degrees North)** | 36° 50' 35.0" | 36° 48' 1.0" | 36° 48' 1.5" | 36° 50' 50.9" | 36° 46' 23.4" |
| **Longitude (Degrees West)** | 76° 9' 51.0" | 76° 11' 27.5" | 76° 11' 29.2" | 76° 15' 36.4" | 76° 14' 33.7" |
| **Center Frequency (MHz)** | 3710 | 3710 | 3710 | 3710 | 3710 |
| **Antenna Pattern** | Rec S.465-5 | Rec S.465-5 | Rec S.465-5 | Rec S.465-5 | Rec S.465-5 |
| **Antenna Size (m) /efficiency** | 10 / 65% | 11 / 65% | 9 / 65% | 3.7 / 65% | 3.8 / 65% |
| **Rx System noise temp** | 100 K | 100 K | 100 K | 100 K | 100 K |
| **ES height above terrain (m)** | 3 | 3 | 3 | 3 | 3 |

[1] Recommendation ITU-R P.452-16 provides a model to estimate the losses due to shielding by clutter, based on a variety of clutter categories. For each category, the nominal distance to the clutter feature and the nominal clutter height are defined. For the suburban category, the distance to the clutter feature is 25 meters, and the height is 9 meters.

| | | | | | |
|---|---|---|---|---|---|
| **GSO Longitude** | 103° & 131° West Longitude | | | | |
| **Elevation Angle (°) (to 103°W.L./to 131° W.L.)** | 38.8/19.2 | 38.9/19.3 | 38.9/19.3 | 38.8/19.3 | 38.9/19.3 |
| **Protection Criteria** | I/N = -10 dB not to be exceeded more than 20% of the time (see Report ITU-R S.2368) | | | | |

SES used the locations of existing licensed earth stations in the Commission's IBFS database. The earth station antenna sizes utilized are also taken from the IBFS licenses for each earth station. The satellite orbital locations are two of the positions used by SES to distribute video programming to cable headends across the United States. Because earth stations in this frequency band are frequently deployed on the ground in suburban and rural areas, an earth station antenna height of 3 meters above ground level was used.

This analysis addresses only base stations and not mobile terminals, as base stations are significantly higher in EIRP.

## 4. Single Entry Analysis and Results

### 4.1. Single Entry Simulation Set-up

In order to determine the separation distance contour for an earth station located at each of the chosen geographic locations, an area analysis was performed using the "Visualyse Professional V7" interference analysis software tool (Visualyse). Through its "Area Analysis" module, the location of the mobile base station was placed within a pre-defined area around the FSS receive earth station. The mobile base station was moved in 1 kilometer test point intervals within the entire specified area of approximately 125 x 75 kilometers. At each point, the elevation and azimuth angles at the mobile base station antenna's boresight height towards the FSS earth station were determined, from which the off-axis angle of the mobile base station antenna relative to its maximum gain lobe was calculated. This off-axis gain data was used to derive the e.i.r.p. level of the mobile base station towards the earth station. Taking into account the propagation loss (including terrain and clutter) between the mobile base station and the FSS earth station, the I/N level at the FSS earth station location was computed. Contour lines were then plotted through the mobile base station locations for which the computed I/N value at the FSS earth station met the minimum required I/N level.

Scenarios were created in Visualyse for the earth station sites and macro suburban mobile base stations with the assumed characteristics discussed above. In addition, based on the frequency re-use factor provided in Report ITU-R M.2292, SES assumed that each sector of the base station antenna re-used the same frequency.[2] The separation distance contours generated using Visualyse were then exported to Google Earth in order to produce Figures 1 through 3.

[2] *See* Table 4, Page 11, of Report ITU-R M.2292.

### 4.2. Single Entry Protection Distance Results

Figures 1 and 2 provide plots of the separation distance contours for each scenario studied for the macro suburban mobile base station case.

**Figure 1**. Separation Distance Contours around Five Virginia Beach, VA Earth Stations communicating with 103° W.L.

Cox E872907 – White; Cox E090089 – Red; CBN E930230 – Purple; CBN WD58 – Blue; Norfolk St. E050120 – Green

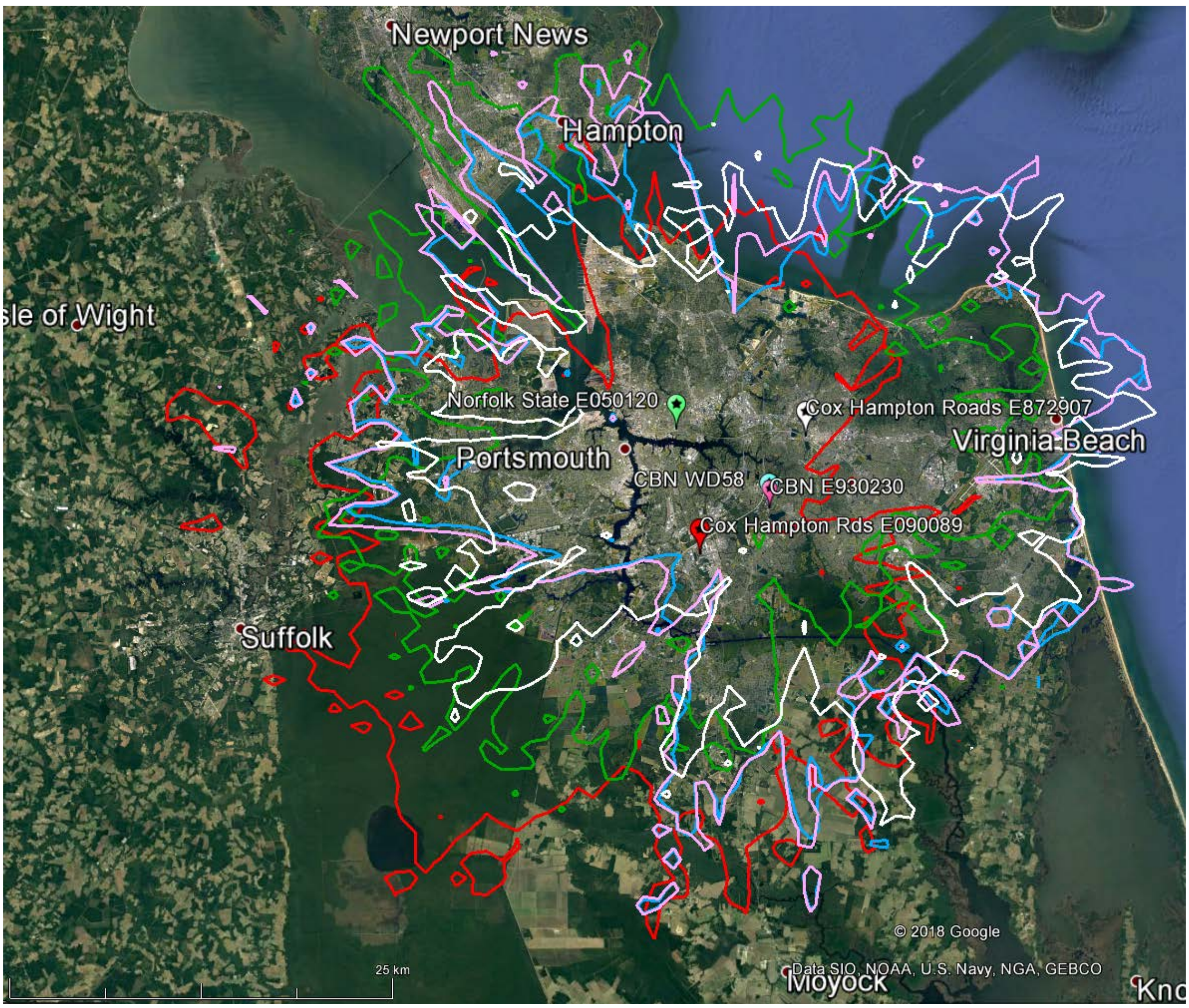
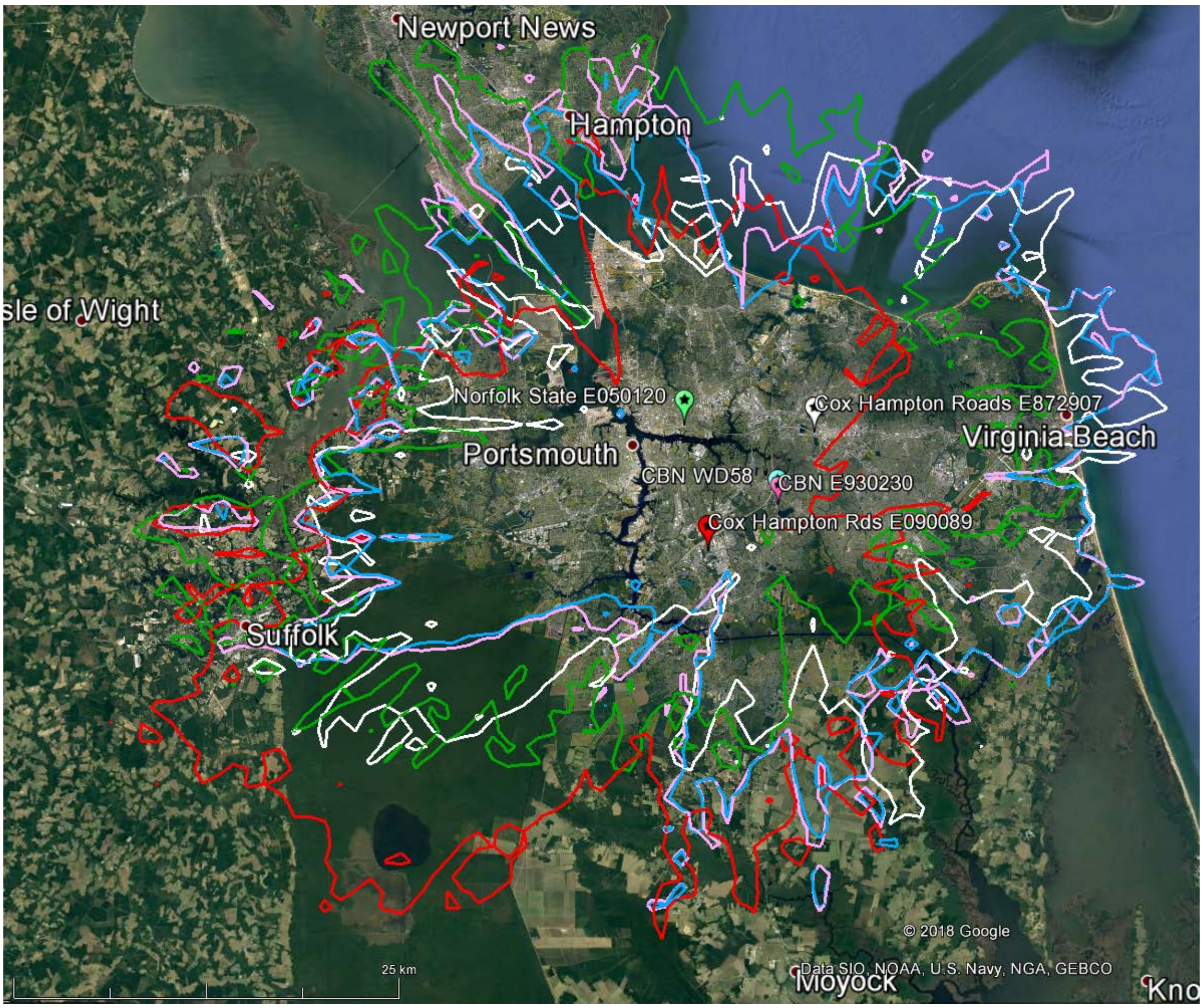


**Figure 2**. Separation Distance Contours around Five Virginia Beach, VA Earth Stations communicating with 131° W.L.

Cox E872907 – White; Cox E090089 – Red; CBN E930230 – Purple; CBN WD58 – Blue; Norfolk St. E050120 – Green



Consolidating the separation distance contours for the Virginia Beach cluster of earth stations produces a combined area roughly 60 kilometers from top to bottom and almost 75 kilometers wide for the 131° W.L. use case. Similarly, for the 103° W.L. use case, the consolidated separation distance contour is roughly 65 kilometers from top to bottom and almost 60 kilometers wide. In each scenario, only separation distances over land paths were summarized.

It is important to note that relatively high elevation angles were used in this analysis, ranging from 19 degrees to 39 degrees. Taking into account lower elevation angles that exist for current operations, such as antennas located in the northeast United States communicating with satellites at 131° W.L. or 135° W.L., the earth station off-axis gain would increase in some directions, leading to higher separation distances. In addition, terrain can differ notably from geographic location to geographic location, which would produce different results.

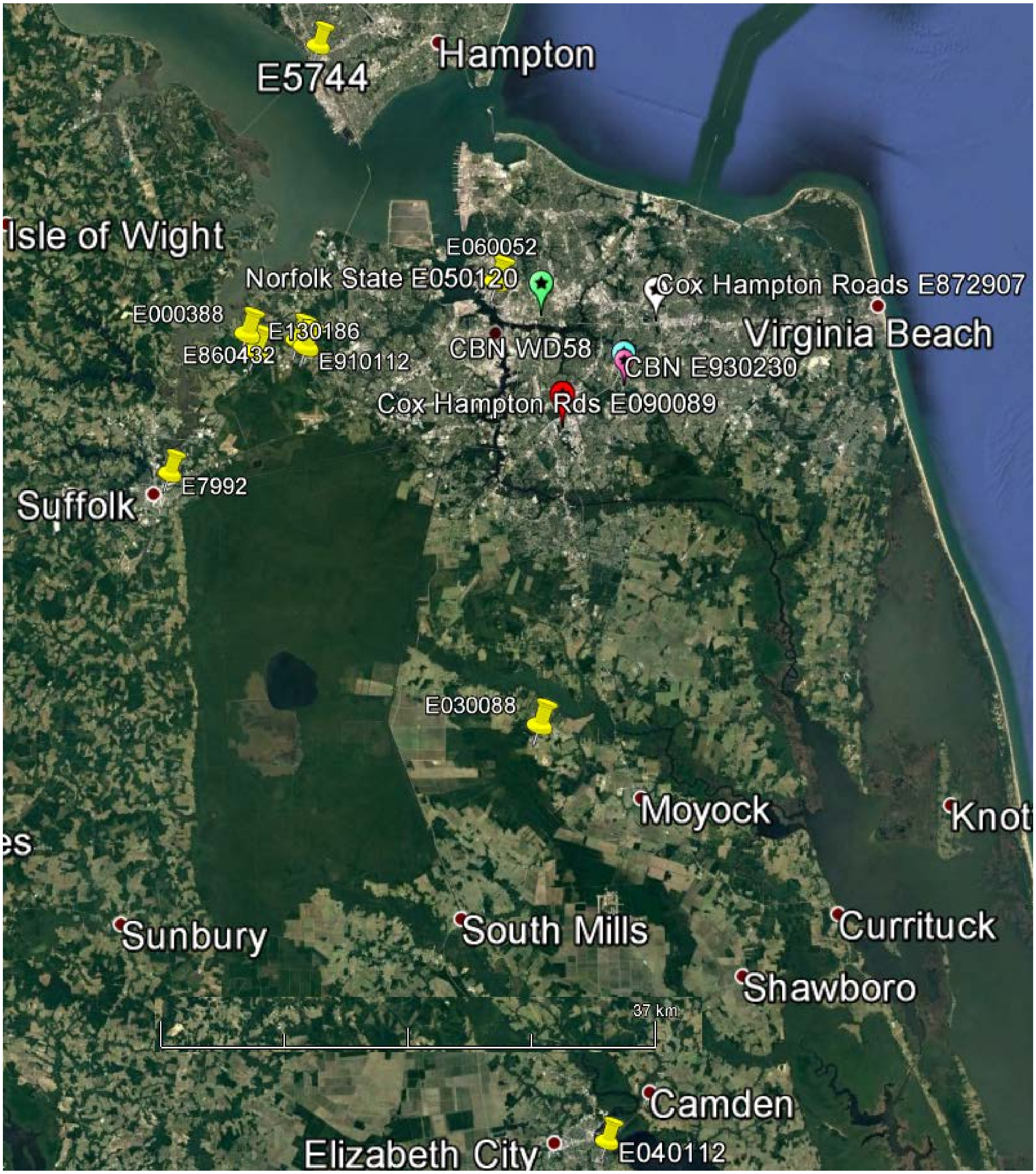
Further, this analysis does not take into account multiple earth station antennas at a single site pointing at multiple satellites, which is typical of cable headend deployments. Using a wider range of satellite orbital locations would increase the necessary separation distances. Moreover, even in azimuth directions where smaller separation distances are determined, an IMT base station could be deployed only within this limited area in order to take advantage of the smaller required separation distance. This specific location may not meet a mobile service provider's network requirements or deployment plan.

Finally, the above calculations are limited to the specific cluster of earth stations analyzed and do not consider other C-band receive earth station sites in use nearby. Each additional earth station will, of course, have its own separation distance contour that would need to be overlaid on the composite contours depicted above. In order to determine the possible locations at which a mobile base station could be deployed, separation distance contours for all the relevant receive earth stations in the vicinity would need to be determined, expanding the size of the composite contour. Table 3 lists the other IBFS earth stations within 60 kilometers of those in Table 1, and Figure 3 shows those sites as well as the Virginia Beach cluster. Given the extent of the separation distances shown in Figures 1 and 2, it is expected that the contours for these additional earth stations would overlap and extend the required separation distances well beyond the plots shown in Figures 1 and 2.

**Table 3. Additional FSS earth station locations within 60 km**

| Callsign | Name | City | State |
|---|---|---|---|
| **E000388** | FOX BROADCASTING | PORTSMOUTH | VA |
| **E130186** | Trinity Christian Center | SUFFOLK | VA |
| **E860432** | WVEC Television, LLC | SUFFOLK | VA |
| **E910112** | LOCAL TV VIRGINIA LICENSE | SUFFOLK | VA |
| **E030088** | ROME RESEARCH | CHESAPEAKE | VA |
| **E060052** | WVEC Television, LLC | NORFOLK | VA |
| **E7992** | CHARTER COMMUNICATIONS VI, L.L.C. | SUFFOLK | VA |
| **E040112** | ELIZABETH CITY STATE UNIVERSITY | ELIZABETH CITY | VA |
| **E5744** | ASSOCIATED PRESS | NEWPORT NEWS | VA |

**Figure 3**. Additional IBFS Earth Stations within 60 km of the Virginia Beach, VA Earth Stations studied (yellow markers)



**5. Impact of Aggregate Interference from Multiple Transmitting Mobile Base Stations**

The above analysis illustrates the separation distances required between a single mobile base station and a cluster of FSS earth stations. If multiple co-frequency mobile base stations were deployed in the general vicinity of the earth station cluster in question, the resulting aggregate interference would increase the required separation distances. For example, deploying three co-frequency IMT base stations at the edge of the single-entry separation distance of an FSS earth station would create an aggregate impact that would reduce the received I/N by approximately 10 log (3) or 4.7 dB, and the earth station's protection criteria would not be met. To avoid this result, the expected number of co-frequency IMT base stations in the vicinity would need to be taken into account to determine the ultimate separation distance required to adequately protect each earth station from aggregate interference.

**6. Conclusions**

The record in this proceeding contains ample evidence that separation distances of tens of kilometers are required in order to prevent unacceptable interference to FSS earth stations from co-frequency mobile base stations. For example, in its comments, Ericsson presented a study showing that without considering terrain effects, avoiding co-channel interference to an FSS receive earth station requires a separation distance greater than 30 kilometers even under the best circumstances, and the distance increases to between 50 and 70 kilometers when more typical earth station operating parameters and required protection levels are used.[3] Similarly, Nokia has concluded that terrestrial wireless facilities cannot feasibly operate in proximity to co-frequency FSS earth stations.[4]

The SES analyses described herein confirm these findings. Specifically, in order to protect the cluster of five existing earth stations near Virginia Beach that SES studied, IMT base stations would need to be excluded from a total area measuring up to 65 kilometers from north to south and up to 75 kilometers from east to west. Moreover, outside this cluster are additional licensed earth stations whose separation distance contours would overlap with the composite zone for the Virginia Beach cluster. The result is a daisy chain effect that would extend the protection area inland and up and down the Atlantic Coast. Considering aggregate interference due to multiple IMT base stations in the vicinity of an earth station would increase the required separation distances even further.

As discussed above, these analyses are conservative in many respects. For example, relatively high elevation angles were used, and the analysis did not consider multiple antennas at a single site pointing at multiple satellites. These factors would add to the separation distances required in an actual operational scenario.

In short, substantial separation distances will be needed surrounding each earth station operating in these frequency bands across the country. The evidence before the Commission establishes that thousands or tens of thousands of C-band FSS receive earth stations are ubiquitously

[3] Comments of Ericsson, GN Docket No. 17-183, filed Oct. 2, 2017, at 8 and Attachment A at 1-3.

[4] Nokia Notice of *Ex Parte* Presentation, GN Docket No. 17-183, filed Jan. 22, 2018, Attachment at 20.

deployed nationwide. The Commission's IBFS database lists antennas scattered throughout every state in the union,[5] but these stations represent only a fraction of the actual operating receive antennas. For example, the American Cable Association has estimated that 90% of its members' receive earth stations are unregistered,[6] a figure that suggests there could be tens of thousands of C-band receive earth stations currently in use.[7]

Given the need to protect critical and intensive use of C-band satellite networks, the SES studies described above demonstrate that co-frequency sharing between FSS earth stations and IMT base stations is not feasible. Required separation distances would severely restrict the places in which terrestrial mobile networks could be deployed, preventing the use of this spectrum to support planned 5G implementation. Moreover, any limited terrestrial facilities that are put in place would constrain the satellite industry's ability to expand operations in response to customer demand. The end result would be a lose-lose scenario for prospective incoming terrestrial providers and the satellite community.

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[5] The SES reply comments in this proceeding included maps depicting 30-kilometer and 70-kilometer separation distances surrounding the earth stations listed in IBFS, and these maps make clear that earth stations have been deployed extensively throughout the nation. *See* Reply Comments of SES Americom, Inc., GN Docket No. 17-183, filed Nov. 15, 2017 ("SES Reply Comments") at 21-22.

[6] Comments of the American Cable Association, GN Docket No. 17-183, filed Oct. 2, 2017, at 4 n.6.

[7] *See* SES Reply Comments at 9-10.