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***Via Electronic Filing***

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

**Re: *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket No. 12-354**

Dear Ms. Dortch:

In response to the Commission's *Second FNPRM* in this proceeding, CBS, 21st Century Fox, Time Warner, Viacom, and the Walt Disney Company (collectively, the Joint Content Interests) filed comments and a study purporting to demonstrate that standoff distances of tens of kilometers will be required to protect fixed satellite service (FSS) operations in the 3700-4200 MHz band (the C Band) from Citizens Broadband Radio Service Devices (CBSDs) in the adjacent 3550-3700 MHz band (3.5 GHz band).[1] The study, prepared by Alion Science and Technology (Alion), merely updates earlier analyses without acknowledging critical aspects of the Commission's April 2015 *Report and Order*.[2] In particular, while the study appropriately recognizes that CBSD emissions *within* the 3.5 GHz band—as opposed to CBSD emissions into adjacent FSS spectrum—pose no threat of harmful interference to satellite operations above 3700 MHz, the Joint Content Interests otherwise start from two fundamentally mistaken presumptions:

- First, the Joint Content Interests assume that FSS operations in the C Band are entitled to geographic separation *in addition to* the strict emissions mask established in the *Report and Order*. In the *Second FNPRM*, however, the Commission indicated a willingness to consider physical separation as a potential *alternative* to emissions restrictions in some circumstances. The

[1] Reply Comments of CBS Corporation, 21st Century Fox, Inc., Time Warner Inc., Viacom Inc., and the Walt Disney Company, GN Docket No. 12-354 (filed Aug. 14, 2015) (Joint Content Interests Comments). Throughout this filing, we refer to the frequencies between 3700 and 4200 MHz as the C Band.

[2] *In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, 30 FCC Rcd. 3959 (2015) (*Report and Order* or *Second FNPRM*).

Joint Content Interests' suggested approach would overly restrict use of spectrum with little incremental protection to C Band facilities.

- Second, the Joint Content Interests persist in "using worst-case interference assumptions" in determining protection distances—an approach the Commission soundly rejected in the *Report and Order*.[3] As the Commission has found, to the extent geographic protection is adopted for C Band systems, protection distances should be based on the actual characteristics of both CBSDs and FSS systems whenever possible, and based on reasonable assumptions where installation-specific data is not available. Moreover, real world experience with FSS deployments in both the C Band and the 3650-3700 MHz band demonstrates that the specific separation distances set forth by Alion are both unnecessary and unrealistic.

**1. The Joint Content Interests acknowledge that using commonplace radar rejection filters addresses the risk of harmful interference from CBSD emissions below 3700 MHz.**

Two types of CBSD emissions theoretically could cause harmful interference to FSS operations in the C Band: emissions below 3700 MHz (in-band emissions) or emissions above 3700 MHz (out-of-band emissions). The Alion study presented by the Joint Content Interests focuses on the effect of out-of-band emissions.[4] In doing so, it recognizes that radar rejection filters are widely used by C Band operators to limit interference from emissions below 3700 MHz and implicitly acknowledges that the protection provided by such filters mitigates interference concerns such that interference from in-band emissions requires no additional remedial action.[5] Google agrees, and indeed, Google Fiber uses radar elimination filters to protect its own C Band dishes from interference.[6] In 2014, the Joint Content Interests disputed Google's observation that filters could be used to address emissions below 3700 MHz,[7] and this change of position reflects an important and welcome evolution in their advocacy on the issue.

**2. Any geographic protections for out-of-band emissions should be based on actual deployment conditions, not the worst-case estimates.**

With respect to CBSD emissions above 3700 MHz, the Joint Content Interests appear to both misunderstand the framework of the *Second FNPRM* and disregard the principles set forth the *Report and Order*. First, the Alion study proceeds from the

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[3] *Report and Order* ¶ 288.
[4] Joint Content Interests Comments, Attachment A (Alion study).
[5] Alion study at 7, fig. 1.
[6] Letter from Aparna Sridhar, Telecom Policy Counsel, Google Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-354, at 3 (filed Sept. 3, 2013) (2013 Google Letter).
[7] Joint Content Reply Comments, GN Docket No. 12-354, at 2, Attachment A at 16 (filed Aug. 15, 2014).

premise that CBSDs should be and will be subject to both geographical restrictions as well as the highly stringent out-of-band emissions limitations established in the *Report and Order*.[8] This is mistaken. In the *Second FNPRM*, the Commission makes clear that a registration-based approach that protects individual C Band locations, "*in place of an across-the-board out-of-band limit*, could . . . benefit FSS operators and Citizens Broadband Radio Service users alike."[9] The Commission also specifically recognized that further amendments to the protections, including site-based protection, could provide additional flexibility, increase spectrum access for CBSDs, and provide more assurance for FSS licensees.[10] The Joint Content Interests' response to the *Second FNPRM*—which proposes to bind CBSDs to the mask adopted in the *Report and Order and* establish additional site based protections—fails to provide additional flexibility to CBSD users or "optimiz[e]" protection in any way.[11] Instead, it merely seeks protections beyond those established in the *Report and Order*, at the expense of spectrum availability for CBSDs. The Commission should reject this one-sided framing of the issues.

Although the Joint Content Interests' framing of site-based protection would fundamentally undermine the balance struck in the *Report and Order*, Google agrees that registration and site-based protection have the potential to improve sharing between FSS systems and CBSD deployments. But a site-based approach will optimize protection only if it is based on known characteristics of both FSS and CBSD operations, rather than worst-case assumptions. The Alion study, by contrast, generates inefficiently large protection distances by making unnecessary and overly conservative assumptions regarding the interference environment. Below, Google highlights a number of these assumptions and recommends alternative approaches that could lead to more appropriate protection. For each of the factors addressed, the best approach to protection will always be to collect and use all available information regarding actual operational parameters. In particular, taking into account individual elevation angles, FSS receive frequencies, CBSD channels of operation, and CBSD emissions is necessary to create a balanced, accurate interference mitigation framework.

### a. Elevation angle

As Google has explained in this proceeding, an earth station's elevation angle can have a dramatic impact on the station's vulnerability to interference.[12] A small elevation angle—which typically occurs when an earth station is receiving transmissions from a satellite that is located far to the east or the west of the earth station—will make

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[8] Joint Content Interest Comments at 2 (noting that prior claims regarding separation distances have been updated to reflect the out-of-band emissions limitations set forth in the *Report and Order*).

[9] *Report and Order* ¶ 443 (emphasis added).

[10] *Id.* ¶¶ 296, 443.

[11] *Id.* ¶ 443.

[12] *See, e.g.*, 2013 Google Letter at 4; Reply Comments of Google Inc. on the Further Notice of Proposed Rulemaking, GN Docket No. 12-354 (filed Aug. 15, 2014).

the earth station receiver more sensitive to interference from CBSD out-of-band emissions.[13] Although Alion considered multiple elevation angles in parts of its analysis,[14] it focused primarily on FSS installations with elevation angles of 5 degrees,[15] and the Joint Content Interests highlighted those results in their filing.[16] But such low elevation angles typically occur only in the extreme northeastern United States, where earth stations must listen for transmissions coming from the south and west, and as a result, the highlighted results are not representative of the needed protection for most sites. Making distorted assumptions regarding elevation angles is simply not necessary to calculate protection: The Commission has already decided that C Band earth stations seeking protection from CBSD operation must register their operations, including antenna elevation angle, with a SAS.[17] Therefore, the standoff distances discussed in the Alion study should be rejected consistent with the *Report and Order*.

**b. FSS receive frequency ranges**

Spectral separation also mitigates significantly the potential for out-of-band interference. Instead of recognizing that C Band receivers operate throughout the 3700-4200 MHz band, Alion overstated the out-of-band issue by addressing the effects of CBSD emission on the closest possible C Band transponder—one with a center frequency of 3720 MHz.[18] Because additional spectral separation mitigates interference potential, focusing the analysis on the closest transponder frequency overstates the potential harm to FSS operations. Furthermore, the Commission has adopted a stepped approach to CBSD out-of-band emissions.[19] Under this approach, which is set forth graphically below, CBSDs are permitted to emit higher emissions in the frequencies between 3700 and 3720 MHz than above 3720 MHz. Above 3720 MHz, CBSDs must limit their emissions to -40 dBm/MHz.

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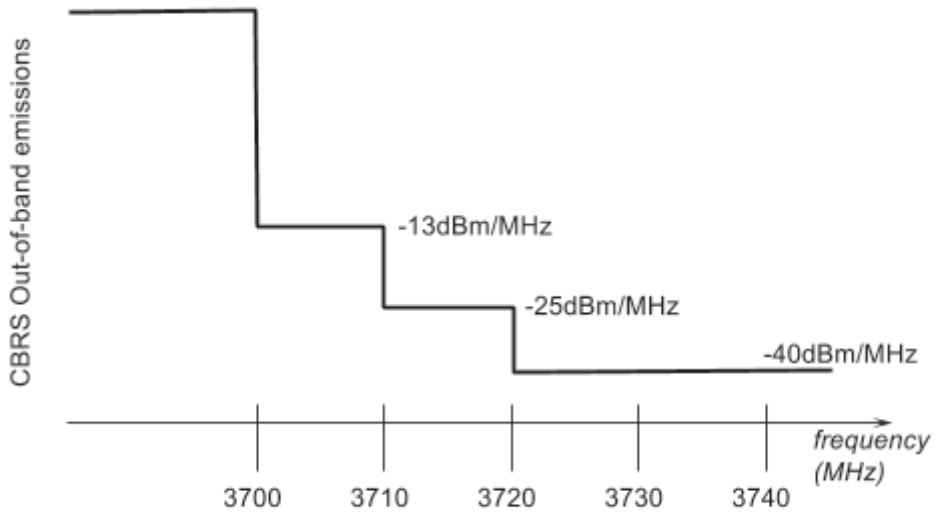
[13] 2013 Google Letter at 4.
[14] Alion study at 11.
[15] *Id.* at 1, 2, 13, 21.
[16] Joint Content Interests Comments at 2-3.
[17] 47 C.F.R. § 96.17(d)(1)(v).
[18] Alion study at 10, 13.
[19] *Report and Order* ¶ 184.




**CBSD out-of-band emissions restrictions**

Therefore, not only is the lowest C Band transponder frequency closest to CBSD operations, it is unrepresentative of higher-frequency transponders in that the Commission's rules contemplate higher levels of emissions in the bottom half of the lowest transponder. The Joint Content Interests illustrate protection of 500 MHz of C Band spectrum based on conditions that apply to only the lowest 20 MHz of that spectrum. Extrapolating that approach across the entire band would be a mistake.

Nor is it necessary to make inaccurate assumptions about out-of-band emissions from CBSDs. The Commission should require C Band licensees to specify their frequencies of operation when they register with a SAS, and this information could be used to determine actual interference potential from CBSDs.[20] If C Band operators seek site-based protection, then they should be welcome the opportunity to provide this basic data to put such protection on a firm foundation.[21]

### c. CBSD emissions

The parameters of CBSD operation are equally important to calculating effective protection. Here, again, Alion's analysis is extremely conservative: it assumes that CBSDs will be operating in the highest-frequency channel authorized for CBSD use, with a center frequency of 3695 MHz.[22] In fact, because a SAS will be aware of each CBSD's operating frequency,[23] the actual frequencies being used can be taken into account

[20] 47 C.F.R. § 96.17(d) (requiring annual registration of C Band operations seeking protection under the Part 96 rules).
[21] To provide appropriate incentives for C Band operators to comply with this requirement, the Commission should establish any default site-based protection based on an assumption that CBSD out-of-band emissions will be limited to -40 dBm/MHz.
[22] Alion study at 4, 5.
[23] *See* 47 C.F.R. § 96.59.

when calculating interference protection. Where individual CBSD emissions characteristics are available, these, too, should be an input into the interference protection analysis. This approach will allow SASs to tailor protections to real-world deployment conditions, while also providing equipment manufacturers an incentive to design devices with improved out-of-band emissions profiles (so as to have access to additional spectrum),[24] both resulting in improved spectrum utilization. Alion's approach combines worst-case assumptions regarding frequency separation and CBSD emissions. In cases where either (1) a CBSD is operating with a center frequency below 3695 MHz, (2) the FSS station receives on transponders with center frequencies above 3720 MHz, or (3) the CBSD out-performs the Commission's mandated out-of-band emissions restrictions, Alion's analysis could easily overstate path loss requirements needed to avoid harmful interference by 27 dB (i.e., -13 dBm minus - 40 dBm) or more.

**d. System noise temperature and interference/noise ratio**

Assumptions regarding the system noise temperature of FSS systems and the amount of interference they can tolerate must also be reasonable. The Commission's *Report and Order* establishing coexistence principles for FSS systems and Part 90 licensees operating in the 3650-3700 MHz band included assumptions for system noise temperature.[25] Without justification, however, the Alion study assumed a lower system noise temperature of 78 K.[26] This assumption has the effect of increasing the protection required for C Band facilities, compared to the approach in the Commission's coexistence framework for Part 90 operations. Yet Alion fails to support the 78 K figure with any facts or analysis, and it provides no reason to depart from the Commission's settled position regarding the appropriate system noise temperature for C Band dishes.

Alion further bases its worst-case scenarios on an interference to noise (I/N) ratio of -20 dB, or 1%.[27] As Google noted last year, reliance on this figure strains credulity.[28] This approach, especially when combined with a system noise temperature assumption of 78 K, would limit interference temperature to a minuscule amount *equivalent to less than half of the cosmic microwave background radiation.*[29] A more reasonable approach would be to limit interference to 6% of the system noise temperature, corresponding to an interference/noise (I/N) value of -12 dB. This value conforms with the ITU's recommendations regarding interference allowed to FSS earth

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[24] *See Report and Order* ¶ 445 (noting that "market incentives may be feasible to encourage industry to deploy radios with improved (lower) adjacent emissions and thereby have greater access to spectrum").
[25] *In the Matter of Wireless Operations in the 3650-3700 MHz Band*, *et al.*, Report and Order and Memorandum Opinion and Order, 20 FCC Rcd. 6502, Appendix D (2005).
[26] Alion study at 7, 8.
[27] *Id.* at 1, 11, 21.
[28] Reply Comments of Google Inc., GN Docket No. 12-354, at 12 (filed Aug. 14, 2015) (Google Second FNPRM Reply Comments).
[29] *Id.*

stations from co-primary operations,[30] represents only 0.25 dB in noise floor degradation, and represents an even smaller portion of the carrier-to-interference-plus-noise (C/(I+N)) ratio.[31] It is also more conservative than two of the three I/N values discussed by Alion.[32] For all these reasons, an I/N ratio of -12 dB, rather than -20 dB is sufficient to protect FSS operations.[33]

### 3. Using more reasonable operating parameters, rather than worst case assumptions, causes standoff distances to shrink dramatically.

A more reasonable approach that relies on both observed data and Commission precedent, as opposed to Alion's series of unrealistic assumptions, results in significantly smaller stand-off distances than those suggested by Alion. In deriving the illustrative separation distances set forth below, Google started from the following premises representing typical real-world scenarios:

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[30] *See* ITU-R Recommendation S.1432-1 (2006), *available at* https://www.itu.int/rec/R-REC-S.1432-1-200601-I/en.

[31] Google Second FNPRM Reply Comments at 12.

[32] Alion study at 11.

[33] Reply Comments of the Wireless Innovation Forum, GN Docket No. 12-354, at 12 (filed Aug. 14, 2015) (endorsing this standard).

| | |
|---|---|
| **FSS receiver elevation angle** | Variable. For elevation angles greater than 25 degrees, Google assumed CBSD emissions will be received in the back lobe of the receiver. This corresponds to a -10 dB earth station relative gain in Table 2. |
| **FSS receive frequency** | Center frequency above 3720 MHz |
| **CBSD transmit center frequency** | 3695 MHz |
| **CBSD emissions into the C Band** | -40 dBm/MHz |
| **CBSD height above average terrain** | Variable |
| **System noise temperature** | 142.8 K |
| **I/N ratio** | -12 dB |
| **Resulting system interference protection level** | -129 dBm/MHz |
| **Apportionment**[34] | Full apportionment |
| **Percentage of propagation situations exceeding the interference objective**[35] | 1% |
| **Clutter and building loss** | Google's analysis did not take into account clutter and assumed outdoor operation. |

**Table 1: Assumptions and typical operational parameters affecting CBSD/FSS coexistence**

[34] Apportionment refers to the portion of the 6% interference margin used by CBSDs, as opposed to other sources. Google's model allocates the full 6% of interference margin to CBSD operations. Based on a review of the Alion study, Google believes this approach is consistent with Alion's assumptions.

[35] This percentage reflects how often an interference model will allow interference to exceed the modeled value. In this case, the model will allow the I/N objective of -12 dB to be exceeded no more than 1% of the time.

Putting these representative figures into the same International Telecommunication Union P.452 propagation model that Alion used,[36] and employing conservative smooth-earth assumptions similar to Alion's, yields the following results.[37]

| **Earth station antenna elevation angle** | **Earth station relative antenna gain** | **CBSD Category** | **CBSD antenna height** | **CBSD Relative antenna gain** | **Path loss required for single-entrant protection** | **Standoff distance** |
|---|---|---|---|---|---|---|
| Off-axis (i.e., 50 degrees or greater) | -10 dB | A | 5 m | 0 dB | 79 dB | **60 m** |
| Off-axis (i.e., 50 degrees or greater) | -10 dB | B | 35 m | -10 dB | 69 dB | **20 m** |
| 25 degrees | -3 dB | A | 5 m | 0 dB | 86 dB | **130 m** |
| 25 degrees | -3 dB | B | 35 m | 0 dB | 104 dB | **1100 m** |

**Table 2: Illustrative standoff distances**

While the standoff distances vary considerably, the characteristics in the shaded row represent a typical small cell deployment case. Using the reasonably conservative assumptions described above, it is clear that many CBSD deployments could easily operate within 60 meters of an FSS installation—a tiny fraction of the 9.63 kilometer distance highlighted in the Joint Content Interests' filing.[38] And these results do not even take into account additional factors such as (1) placement of a CBSD in a channel below 3690 MHz, (2) CBSD emissions performance that may exceed the baseline performance required by the rules, and (3) building and clutter loss. For example, building attenuation and clutter loss can result in additional 30-60 dB of shielding between a transmitter and a receiver, even over short distances.[39] Such losses are highly significant because many Category A small cell devices will be deployed indoors.[40]

[36] Alion study at 4.
[37] The P.452 model does not have a direct log-linear relationship between path loss and distance, but in the smooth-earth approximation used by Alion, it is not far from free space at the short distances used.
[38] Joint Content Interests Comments at 2.
[39] See Letter from Aparna Sridhar, Counsel, Google Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-354 (filed Feb. 16, 2016), at 5-8 (highlighting the substantial effect of clutter on signal attenuation).
[40] For example, building loss alone can cause 10-20 dB of attenuation.

In the cases where FSS deployment characteristics warrant additional protection, a SAS can account for those unique characteristics. For example, in the extreme case where a receive station has a 5 degree elevation angle, the same model yields separation distance of 1080 meters for Category A CBSDs and 3800 meters for Category B devices, if those devices had 10 dB gain antennas pointed directly at the receiver. But it makes little sense to let these outlier cases drive protection for all devices operating in the band.

For these reasons, interference protections should be tailored to site-specific interference environments, rather than established on a one-size-fits-all basis. Most definitely, protections should not be based on the contrived scenarios the Joint Content Interests put forward.

**4. To maximize spectrum availability while protecting incumbent operations, the Commission should allow SAS providers to take advantage of improvements and innovation in propagation modeling.**

In order to facilitate comparisons between the Alion study and Google's analysis, we have relied above on the ITU P.452 model as implemented by Alion. But the propagation model selected also has a meaningful impact on standoff distances and spectrum availability. More accurate modeling can enable the deployment of higher densities of new entrants while still protecting existing operators, provided that they are reviewed and approved by the Commission through its SAS certification process.[41] For this reason, the Commission should recognize a safe-harbor propagation model, such as ITU P.452, but also allow and encourage the use of improved propagation models that may be developed in the future. Allowing their use will promote investments in better modeling that will benefit users of many services across a range of frequency bands.

Improved models also have the potential to expand dramatically spectrum availability. For example, as noted above, the modeling performed by Alion and by Google for this letter does not take into account the presence of clutter in the environment surrounding a CBSD. Because clutter can cause significant attenuation, using modern, accurate, empirically derived clutter models could allow users to use the 3.5 GHz band more intensively while avoiding interference to incumbent services. The use of such models should be permitted and, indeed, encouraged.

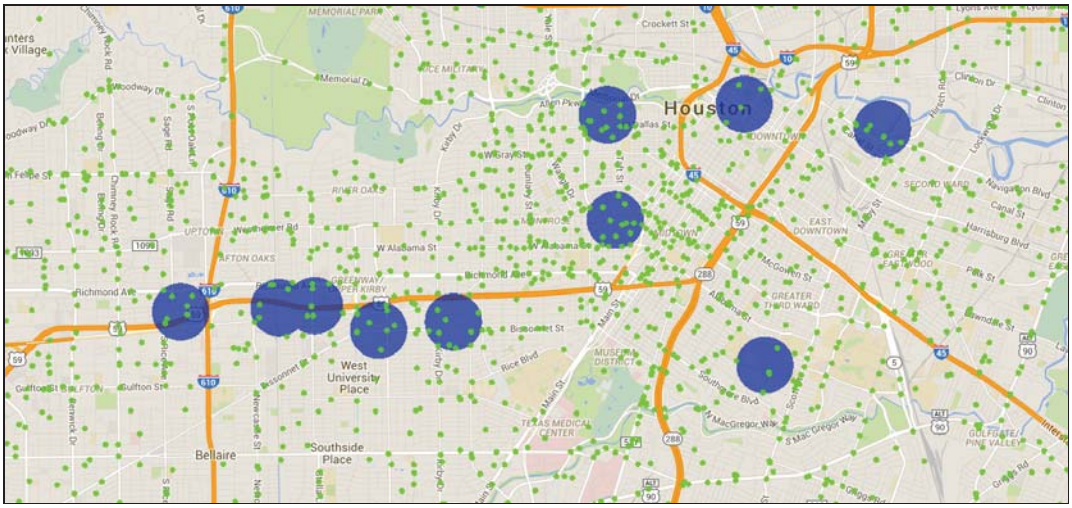
**5. The placement of C Band deployments today demonstrates that FSS receive stations can be sited in close proximity to 3.5 GHz operations.**

Should the record discussion regarding propagation models and mathematical calculations leave any question, real world deployment conditions establish that the Joint Content Interests' highlighted separation distances cannot be accepted. Today, C Band service providers routinely operate their receivers in very close proximity to

[41] Google Second FNPRM Reply Comments at 9, 13-17.

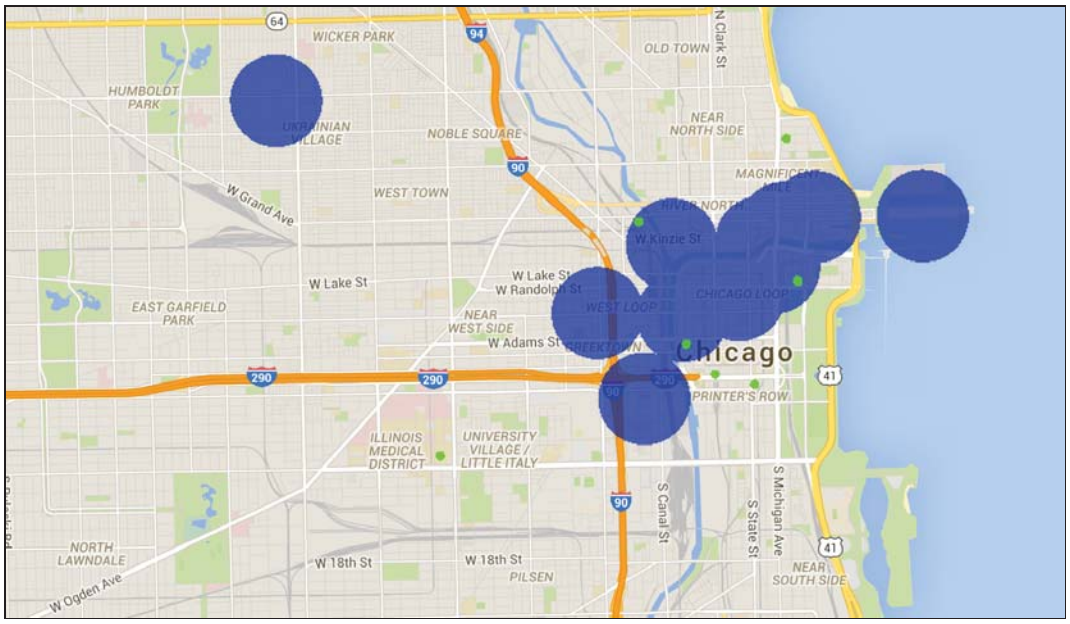
existing Part 90 users of the adjacent 3650-3700 MHz band. Part 90 users are under no obligation to maintain any physical separation between their operations and C Band installations,[42] and have -13 dBm/MHz limits on out-of-band emissions throughout the entire 3700-4200 MHz band.[43] Although C Band operators have argued in this proceeding that significant protections are necessary,[44] neither the rules regarding existing operations in the 3650-3700 band nor the facts on the ground support that claim.

The maps below illustrate representative deployments that are registered in the Commission's ULS and IBFS databases. Each blue circle represents a 500-meter radius around a C Band earth station. The green dots represent registered locations of equipment operating between 3650 and 3700 MHz.




**3650-3700 devices and C Band earth stations deployed near Houston, TX**

[42] See 47 C.F.R. § 90.1331 (requiring geographic separation from grandfathered in-band earth stations, but not C Band earth stations).
[43] *See* 47 C.F.R. § 90.1323.
[44] *See, e.g.*, Alion study at 22.




**3650-3700 devices and C Band earth stations deployed near Chicago, IL**

In the Houston, Texas, metropolitan area, FSS operators have chosen to deploy earth stations amid a dense thicket of Part 90 installations. And in Chicago, Illinois, as many as 10 different earth stations operate in close proximity to existing 3650 MHz operations, suggesting that the C Band operators believe their systems to be sufficiently protected against potential interference from these systems. To Google's knowledge, FSS operators in Houston and Chicago have not raised concerns regarding interference from these Part 90 service providers.

A third example, involving co-channel (rather than merely adjacent) signals, illustrates that FSS operators have affirmatively chosen to deploy in close proximity to Part 90 operations. Below, the green dots represent Part 90 operations in the 3650-3700 MHz band. The pink circle represents a 50-kilometer radius around co-channel earth stations that also operate in the 3650-3700 MHz band. The four Part 90 operations closest to Hagerstown, Maryland, are no more than 10 kilometers from the co-channel earth station, and the closest operation is a mere 3 kilometers from the earth station, a far cry from the maximum separation distance of 126 kilometers that Alion claims may be required to protect *adjacent* band operations.[45] And importantly, this co-channel earth station was registered as operating in-band at this location after the Commission authorized Part 90 operations in the 3650-3700 MHz band.[46]

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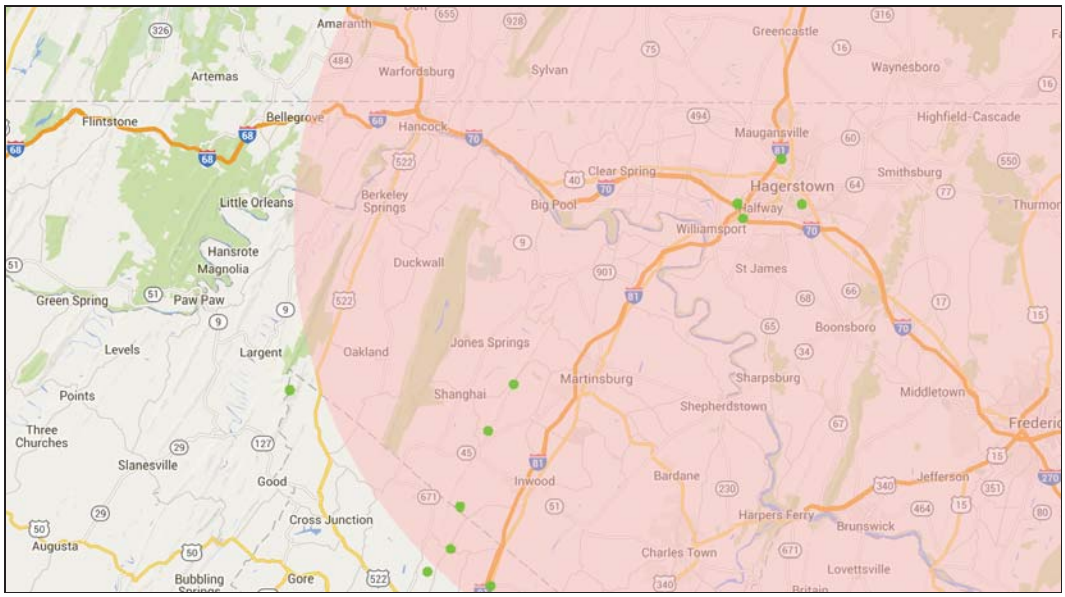
[45] Alion study at 1.

[46] Station KA262 was registered in Clarksburg, Maryland, until 2011, and that location was included in the list of grandfathered earth stations operating in the 3650-3700 band. List of Grandfathered FSS Stations, http://licensing.fcc.gov/prod/ib/forms/help/GrandFatherList.pdf. That same station is now listed as operating in Hagerstown, Maryland. *See* 3.5 GHz Band - Protected Fixed Satellite Service (FSS) Earth Stations, https://www.fcc.gov/general/




**Non-grandfathered (station moved subsequent to 3650-3700 licensing)**
**FSS earth station operating in-band near Hagerstown, MD**

The plain fact, therefore, is that FSS providers do not base their real-world operational decisions on worst-case assumptions like Alion's. The Commission likewise should not credit the Joint Content Interests' inflated claims when drafting its rules. The Commission instead should base its FSS protection rules on available information regarding actual FSS and CBSD operations and location-specific characteristics, such as terrain and clutter. This approach will allow industry to take advantage of ongoing improvements in SAS technology, provide protection from harmful interference, and maximize use of the 3.5 GHz spectrum, thereby benefiting all users.

Respectfully submitted,

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Aparna Sridhar
*Counsel*
Google Inc.

35-ghz-band-protected-fixed-satellite-servicefss-earth-stations; IBFS File Nos. SES-MFS-20071207-01676 and SES-MFS-20110128-00070.