Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz	GN Docket No. 17-183

COMMENTS OF GOOGLE LLC AND ALPHABET ACCESS

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I. Introduction and Summary

Alphabet Access (Access) and Google LLC (Google) concur with the Commission that identifying new opportunities for fixed and mobile broadband uses of the 3.7–24 GHz range ("mid-band spectrum") will help to enable innovation and investment and maintain America's position of leadership in advanced wireless services. Additional commercial access to mid-band spectrum is important for several reasons, including:

- Mid-band spectrum offers more potential bandwidth than frequencies below the mid-band range ("low-band spectrum");
- Mid-band spectrum is optimal for some uses because it offers shorter-range propagation compared to low-band spectrum, yet longer-range propagation compared to spectrum above 24 GHz ("high-band spectrum");
- Device ecosystems already exist for some portions of the mid-band range, including standardized LTE equipment and mass-market Wi-Fi devices;
- Other countries and regions are studying the use of some portions of mid-band spectrum for wireless broadband services, potentially creating economies of scale for mid-band equipment;
- Antennas and antenna arrays are physically smaller at mid-band frequencies compared to low-band frequencies, enabling Multi-In/Multi-Out (MIMO), beamforming, and beam steering in smaller packages; and

- Radio frequency power generation is more efficient at mid-band frequencies compared to high-band, allowing battery-operated devices with the same battery capacity to operate for longer periods.

Given this unique combination of characteristics and the variety of users and use cases that could benefit from timely access to additional bandwidth in mid-band spectrum, the Commission should expeditiously issue a Notice of Proposed Rulemaking (NPRM) to move toward creating mid-band opportunities. Mid-band rules, moreover, should be optimized for speed and flexibility of entry.

Specifically, <u>the 3.7–4.2 GHz band is well-suited to support shared point-to-point and point-to-multipoint broadband access in the near term without precluding mobile use in the future</u>. 1) A necessary first step is improving the accuracy of the FCC's satellite earth station registration database. 2) The admission mechanism for new entrants should be as straightforward as possible, but a simple, database-supported authorization framework may be needed to avoid harmful interference to incumbents. 3) Newly constructed fixed systems would utilize a relatively small fraction of available bandwidth and geography, and would be reconfigurable in frequency to accommodate later deployment of mobile systems.

<u>The 5.925–6.425 GHz band is a high-priority opportunity for shared flexible use</u>. <u>The Commission should specifically consider unlicensed use of the band, given its proximity to the existing unlicensed 5 GHz U-NII bands</u>. While unlicensed access to the

band should be as straightforward as possible, a simple, database-supported authorization framework may be needed to avoid harmful interference to incumbents.

The 6.425–7.125 GHz band is also a high-priority opportunity for shared flexible use. While the access mechanism should be as straightforward as possible, a simple, database-supported authorization framework again may be needed to avoid harmful interference to incumbents.

At this time there is insufficient information to fully examine flexible sharing opportunities in other mid-band spectrum beyond the specific bands mentioned above. The vast majority of this spectrum is used for federal as well as non-federal purposes, yet few details on that federal usage are publicly available. The Commission should work with National Telecommunications and Information Administration (NTIA) to develop and publish this needed information.

The Commission should move speedily to propose and adopt rules for opening the 3.7–4.2 GHz and 5.925–7.125 GHz bands for additional commercial uses, even if the possibility of freeing up other mid-band spectrum requires more prolonged consideration.

II. The 3.7–4.2 GHz Band Can Support Shared Flexible Use Quickly, Without Precluding Mobile Use in the Future

The 3.7–4.2 GHz band (the space-to-Earth segment of the conventional C-band) is occupied primarily by fixed-satellite service (FSS) receive-only earth stations. Such systems are generally used by commercial and institutional users for program distribution, and the locations of the earth stations are registered in the Commission's

International Bureau Filing System (IBFS). The C-band is no longer used in the United States for direct-to-consumer broadcasting, as the vast majority of transmissions are now encrypted and available only to intended recipients.[1] Therefore, essentially all earth station sites that require protection are commercially operated and registered in IBFS. This makes the band well-suited for additional sharing, as explained below.

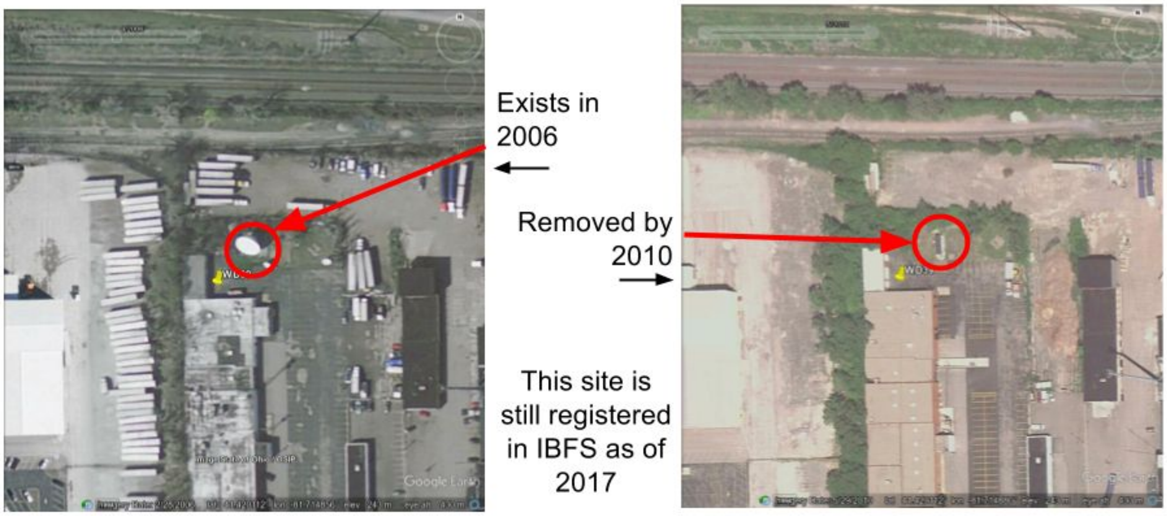
The 3.7–4.2 GHz band is also allocated on a co-primary basis to the fixed service, although the band is lightly used for this purpose due to the difficulty of coordinating long-haul, point-to-point fixed links with existing FSS incumbents.

A. The Commission Should Initiate a Cleanup of the FSS Database

Our analysis of Google Earth imagery[2] of 4,724 IBFS-registered C-band FSS sites indicates that at 1,371 of the sites there is no satellite dish within approximately 1 km of the listed coordinates. In other words, approximately 29% of these registered locations are clearly not being used for satellite services despite being registered in IBFS. Historical imagery (also available in Google Earth) shows that in many cases a satellite antenna once existed but has since been removed, sometimes several years ago.

[1] *See* Commr. Michael O'Rielly, *A Mid-Band Spectrum Win in the Making*, FCC Blog (July 10, 2017), https://www.fcc.gov/news-events/blog/2017/07/10/mid-band-spectrum-win-making.
[2] *See* Google Earth, https://www.google.com/earth/ (last visited Sept. 28, 2017).

Example of FSS site that was removed but not de-registered



This 29% figure is a lower limit on FCC over-registration, because it does not include inactive dishes that remain in place. Thus, it can confidently be said that approximately one-third of IBFS-registered C-band FSS sites *or more* do not require protection because they either do not exist or are not in operation.

A straightforward first step toward more efficient use of the 3.7–4.2 GHz band, therefore, should be improving the existing database of C-band FSS sites. The Commission should require all operators of in-service C-band FSS sites to review their own IBFS registrations and certify that all registrations accurately reflect the geographic coordinates and receive frequencies of an active earth station, as well as the satellite orbital slots from which the active station receives signals. Any registrations that are not confirmed by a reasonable deadline should be deleted from IBFS and ineligible for interference protection.[3]

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[3] The Fixed Wireless Communications Coalition (FWCC) has raised similar points in its pending Petition for Rulemaking regarding Part 101 of the Rules; FWCC recommends specific rule

Once the FSS registrations have been updated, IBFS will accurately reflect greater opportunities to share the C-band with point-to-point and point-to-multipoint broadband access (hereafter "Fixed Broadband Access," or "FBA") systems. These FBA systems have the potential to provide high-speed (100 Mbps to over 1 Gbps) last-mile broadband distribution from a central site to homes, businesses, schools, hospitals, libraries, and other fixed locations through the use of next-generation wireless technologies. FBA can be especially useful in places where laying fiber or cable is not economically or physically feasible, such as in rural areas, historic districts, or areas with significant water features or rugged terrain.

Confirming these opportunities, Access has matched registered C-band earth station locations with the land classification categories established in the National Land Cover Database,[4] and has revealed that approximately half of the FSS sites are in urban areas, one-third are in rural areas, and 17% are in suburban areas. Given the greater land area of rural and suburban areas, there should, in general, be ample room in both for FBA systems. And because the locations of FSS earth stations will be static and searchable after IBFS has been updated, FBA systems can be engineered to avoid interference to in-service FSS earth stations. In addition to taking advantage of the propagation characteristics of mid-band spectrum to avoid harmful interference (discussed below), FBA systems can be designed so that their beams do not point

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changes that should be addressed expeditiously by the Commission. *See* Petition for Rulemaking of Fixed Wireless Communications Coalition, Inc., RM-11778, at 8-9 (filed Oct. 11, 2016).

[4] *See* Multi-Resolution Land Characteristics Consortium, *National Land Cover Database 2011*, *at* https://www.mrlc.gov/nlcd2011.php (last visited Oct. 2, 2017).

toward earth stations and, given advances in beamforming technology, may also actively direct nulls in antenna gain in the direction of FSS sites.

B. Propagation Characteristics in the 3.7–4.2 GHz Band Support FBA Use

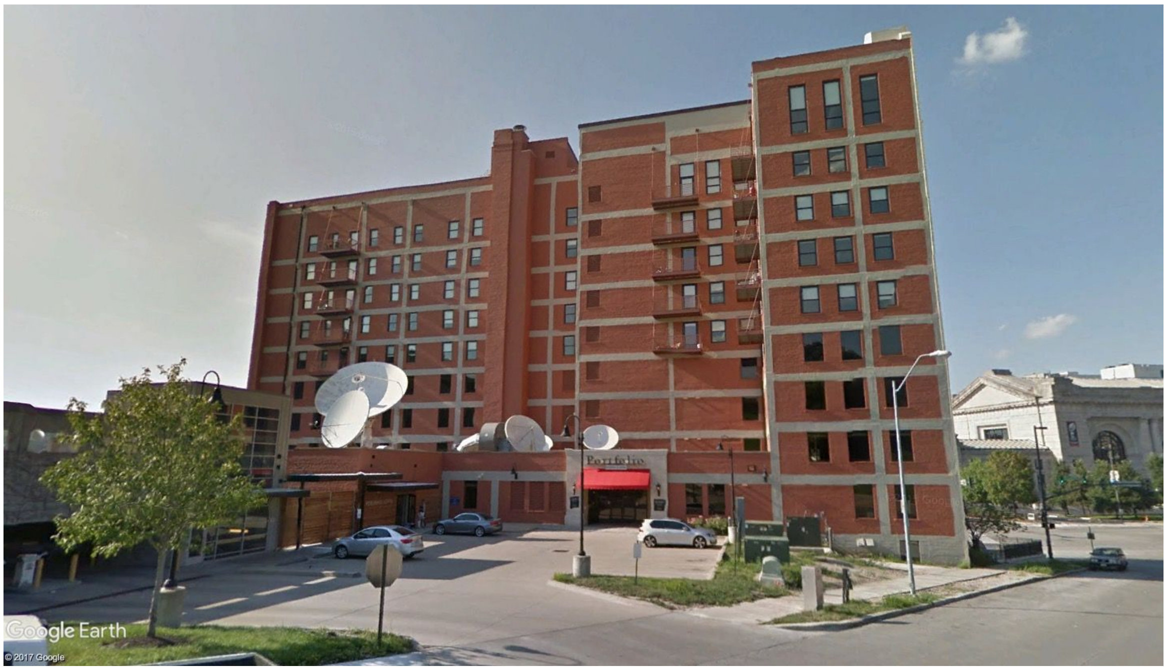
Access has performed extensive propagation testing in the 3.5–3.7 GHz band. This testing has confirmed that propagation in the 3.7 GHz range has characteristics that naturally mitigate interference concerns. For instance, propagation near 3.7 GHz is heavily impacted by clutter such as buildings and trees, with usable signal range limited to as few as several hundred meters when the propagation path is contained within the clutter layer. Propagation loss in the 3.7 GHz range is some 40–60 dB greater than predicted using common propagation models such as Longley-Rice that do not explicitly take clutter into account.

At the same time, longer-range propagation is possible when the propagation path remains entirely above the clutter layer. In Access's experiments, usable signal was received over distances greater than 60 km over an unobstructed path from the top of a tall building to a distant mountain top. In these cases, propagation was consistent with predictions using non-clutter models such as Longley-Rice.

These results support the shared use of the 3.7–4.2 GHz band for FBA systems. When designing suburban FBA systems—serving, for example, multiple homes along a residential street—keeping the signal path below the treetops and rooftops in the area will, in practice, dramatically reduce the potential interference to FSS earth stations outside the immediate area, compared to expectations of interference based on non-clutter models such as Longley-Rice.

In urban areas, buildings can block FBA signals, while FSS antennas on rooftops are shielded from street-level FBA systems.

Urban FSS earth station facility with significant building blockage



In rural areas, many FSS earth stations are surrounded by trees. Access's analysis shows that groves of trees can add as much as 17 dB per km attenuation. Some major earth station facilities are purposely surrounded by artificial berms for interference protection, which also greatly reduces the amount of potential interference from FBA systems.

Traditionally, shared fixed service use in the 3.7–4.2 GHz band has been for long-haul, point-to-point links that use equipment located atop buildings and hills with clear line of sight between the endpoints—but also potentially clear line of sight toward FSS earth stations along or near the link path. This geometry (along with the use of

unsophisticated propagation models) has made coordination between long-haul fixed links and FSS earth stations in the 3.7–4.2 GHz band very difficult. Lower-power links, particularly within the clutter layer, can be accommodated much more readily, especially when clutter-aware geodata (for example, data gathered through Google Street View and other systems) are used to predict the impacts of clutter along the propagation path. Such innovations should be put to use to increase the efficiency with which mid-band spectrum is used; the 3.7–4.2 GHz band is an excellent place to start because of the static nature and known characteristics of the shared services, as well as the lack of federal incumbents in the band.

C. A Lightweight, Database-Supported Authorization Framework Would Enable Efficient Deployment of FBA Systems

The calculations required to ascertain whether a given FBA deployment can be authorized without causing interference to FSS earth stations could be done with an automated admission system that implements a simple algorithm. Indeed, interference calculations in the 3.7–4.2 GHz band are particularly straightforward because the locations of both the earth stations and the FBA systems would be well-known, and their operational parameters well-characterized. Furthermore, construction of new C-band earth stations happens relatively infrequently and is known in advance.

A lightweight admission system could work as follows:

1. Collect information on the proposed FBA system from the potential new entrant.

2. Pull (newly accurate) IBFS registration information for all earth stations operating in the C-band within a specified distance of the proposed endpoints, such as 150 km.
3. Calculate the interference from the proposed FBA system to all the relevant earth stations using clutter-aware propagation analysis and taking into account aggregate interference from any other FBA systems in the area; the algorithms used by the admission system would be jointly agreed upon in advance by the fixed service and FSS communities.
4. Provide the FBA system limits on EIRP as a function of azimuth.
5. Obtain confirmation from the FBA system that it will comply with the limits; otherwise, deny entry into the band.

Thereafter, the FBA system would query the admission system periodically (for example, once a month) to determine whether any new or deleted earth station registrations alter the FBA system's operational limits. Interaction with the FBA system could occur through either (1) manual queries (typically by a professional installer) or (2) automated and standardized communications protocols, in conjunction with capabilities such as GPS and other embedded systems that ensure the FBA equipment is installed in conformance with its registered parameters.

In essence, the automated admission system would modernize the manual coordination process that is now codified in Part 101 of the Commission's rules. It takes advantage of the evolution of computing systems over the past several decades

since the existing coordination process was developed, in order to provide more realistic propagation predictions while speeding the coordination process from up to 30 days[5] to just milliseconds.

D. Mobile Use of 3.7–4.2 GHz Requires More Complex Solutions But Is Not Precluded by FBA Use

Given the relatively large number of incumbent receive-only earth stations, mobile use of the 3.7–4.2 GHz band is currently much more challenging than fixed use. In the fixed use scenario, interference analysis can take into account the exact location of the proposed system, the beam pattern of its radiated energy, the combined interference power into FSS earth stations from all fixed systems operating in the surrounding area, and the frequency and bandwidth of the transmitted fixed signal. For mobile systems, however, most of these parameters (location, beam pattern, and aggregate interference) can change rapidly, and therefore interference calculations can quickly become obsolete. As a practical matter, therefore, successful use of 3.7–4.2 GHz for mobile broadband would most likely require decommissioning FSS earth stations in the mobile service area or shifting them to other bands to ensure that mobile devices can operate widely.

While modifying the Part 101 rules to enable deployment of FBA systems in the 3.7–4.2 GHz band would bring service benefits comparatively quickly and easily, those deployments would not preclude use of the band for mobile broadband in the future. If FBA systems are deployed soon, they will be constructed only in those frequencies and

[5] 47 C.F.R. § 101.103(d)(2)(iv).

geographic areas where coordination can be achieved with existing FSS incumbents. Given the extent of FSS deployments and frequency use, FBA systems will be able to utilize only a fraction of the total bandwidth and geography.

Because of the large amount of bandwidth to work with (500 MHz, which is more than cellular, PCS, AWS 1, AWS 2, AWS 3, both 700 MHz bands, and the 600 MHz band *combined*), even this limited opportunity is significant for FBA service in the near term. However, large blocks of frequencies and territory would remain unused by FBA. These would become available upon the removal of FSS operations. Furthermore, FBA systems necessarily would be frequency-agile, so they could avoid interference with FSS frequencies in the same area. If and when the FSS incumbents are relocated to another band, the FBA systems (assuming their continued operation) could be reconfigured to share more efficiently with other post-FSS licensees.

III. The 5.925–7.125 GHz Band Should Be Studied for Shared Flexible Use, Particularly Including Unlicensed Operations in the Lower 6 GHz Band

A. Freeing Spectrum in the Lower 6 GHz Band (5.925–6.425 GHz)

Incumbents in the 5.925–6.425 GHz range, or lower 6 GHz band, are fixed service links and FSS uplinks, plus one mobile satellite system uplink operating under a waiver. The lower 6 GHz band is allocated exclusively to non-federal operation.

The proximity of this band to the existing 5 GHz U-NII band presents a unique opportunity to expand the amount of available spectrum for unlicensed devices and services. Various portions of the 5 GHz band are available on an almost global basis

(including in the U.S.) for license-exempt systems, particularly 5 GHz Wi-Fi. The lower band could extend the available spectrum for such systems by up to 500 MHz.

Use of the lower 6 GHz band by unlicensed or other new services, however, should not cause harmful interference to existing licensed users. The NPRM should seek detailed studies that examine the compatibility of any new services with the incumbent fixed and fixed-satellite services, as well as methods that could be used to mitigate the potential for harmful interference. New rules adopted for the lower 6 GHz band should take into account any interference issues revealed by the studies.

B. Freeing Spectrum in the Upper 6 GHz Band (6.425–7.125 GHz)

The upper 6 GHz band, 6.425–7.125 GHz, has a more diverse and complex array of incumbent commercial services, including FSS (predominantly uplinks, but also some downlinks, depending on band segment), fixed, and mobile. Because the upper 6 GHz band is allocated exclusively to non-federal operation, and is adjacent to the lower 6 GHz band, this band also should be considered by the Commission for flexible-use sharing by broadband systems, with studies to establish the conditions under which new entrants could operate without causing harmful interference to incumbents.

C. A Lightweight, Database-Supported Authorization Framework Could Enable Shared Use of the Lower and Upper 6 GHz Bands

Expanded use of the lower and upper 6 GHz bands should be accomplished with the restrictions on systems and devices that are necessary to prevent harmful interference to incumbents—but nothing more. If shared access can be granted without

any positive central control, that would be the best outcome. However, given the incumbents in these two bands, some form of control may be needed.

Similar to the 3.7–4.2 GHz band, and for many of the same reasons, a lightweight, database-driven authorization framework could be used if necessary. There are no federal incumbents, and information about the commercial systems that need protection is publicly available. Use of the bands (particularly the lower 6 GHz range) is also relatively static, so frequent updates to the data on underlay services are not needed.

With regard to FSS systems, the 6 GHz bands are predominantly uplink bands for geostationary satellites, meaning that the central interference concern is aggregate interference from ground-based transmitters into the satellite-based receivers. Protection could likely be accomplished on a straightforward statistical basis. The total interference level is, essentially, the average emission level of incumbent devices toward the geostationary arc, multiplied by the area of the satellite beam on the surface of the Earth, multiplied by the average density of deployed devices (in units per square kilometer, for instance). An automated authorization framework could keep records of satellite beam patterns and ensure that the maximum permissible number of devices is not exceeded within the satellite footprint.

With regard to fixed service protection, fixed links in the 6 GHz bands use high-gain antennas with very narrow beams and good suppression of off-axis signals. It therefore is conceivable that new entrants in the band will be able to operate over substantial geographic areas without causing harmful interference to fixed links. Should

some form of positive control be needed, it could also be facilitated by a simple database-driven authorization framework that is aware of the fixed links' locations and beam patterns. A device desiring entrance into the band could check with the centralized authorization system, which would compute potential interference into any fixed links in the area, and determine whether the device can be authorized. As in the 3.7–4.2 GHz band, the device need only re-check with the authorization system on an infrequent basis to take into account any new or decommissioned fixed links. In the case of unlicensed devices, they could leverage existing capabilities under the Institute of Electrical and Electronics Engineers (IEEE) standard 802.11af to accomplish registration and re-authorization.[6]

IV. Improved Tools Are Needed to Adequately Analyze Other Opportunities for Flexible Shared Use of Mid-Band Spectrum

The Notice of Inquiry (NOI) appropriately requests comment on potential shared use of portions of the 3.7–24 GHz range, outside of the specific bands at 3.7–4.2 GHz and 5.925–7.125 GHz. That inquiry requires extensive consideration of federal spectrum uses: As shown in the following table, the vast majority of spectrum within this range is shared between federal and non-federal uses.

[6] The IEEE 802.11af standard incorporates protocols enabling access to white spaces based on centralized database-driven authorization mechanisms. *See* IEEE Standards Association, *IEEE Standard 802.11af-2013*, *at* https://standards.ieee.org/findstds/standard/802.11af-2013.html.

Exclusive vs. Shared Mid-band Spectrum

Use	Bandwidth	% of Total
Exclusive Non-Federal	2,950 MHz	17%
Exclusive Federal	2,365 MHz	13%
Non-Federal & Federal	12,510 MHz	70%

After excluding exclusively federal spectrum, which is outside the scope of the current proceeding,[7] 81% of the spectrum under consideration includes federal users.

In practice, assessing the potential for additional sharing is very difficult, given the extensive federal utilization and lack of available information about that utilization. NTIA maintains two resources that nominally provide information on current federal spectrum use. The most detailed information is available in the Federal Government Spectrum Use Reports.[8] These contain information on specific federal spectrum use applications in each band, and provide a count of Government Master File (GMF) assignments, by agency. Although such reports are helpful to understanding federal spectrum use at a high level, they do not include spectrum in the range 7.125–24 GHz, which encompasses the majority of the spectrum under consideration in the NOI. Even for the spectrum that is covered by these reports, the number and location of federal systems and services are difficult to glean. For example, a band could contain only one GMF assignment, but that assignment could be nationwide, and, in theory, thousands or

[7] *In the Matter of Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Inquiry, 32 FCC Rcd. 6373, ¶ 3 (2017).
[8] *See* Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz, https://www.ntia.doc.gov/page/federal-government-spectrum-use-reports-225-mhz-7125-ghz (last visited Sept. 28, 2017).

even millions of devices spread around the country could be operating under that sole assignment.[9] While some reports contain maps of the locations of some of the GMF-assigned systems, not all reports provide such specificity. For many bands, there is no way to tell the actual extent of use, either by frequency or by geography.

The second NTIA resource is the Federal Spectrum Use Summary, last updated in 2010.[10] The information in this document is very general. For example, the entire entry for the shared band 8500–8550 MHz is:

> This band is used by the federal agencies for military and non-military radar systems, including meteorological, airborne navigation, transportable artillery-locating, weapons fire control, and ballistic missile defense imaging.

The Federal Spectrum Use Summary thus does not allow an assessment of compatibility between incumbent federal operations with various commercial systems.

Access and Google accordingly suggest that FCC work with NTIA to embark upon a study to develop and make public detailed information about federal spectrum use in the 4.2–5.15 GHz and 7.125–24 GHz ranges, perhaps as an extension of NTIA's Fast Track Report from 2010.[11]

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[9] As noted in each of these reports: "The number of actual systems, or number of equipments, may exceed and sometimes far exceed, the number of frequency assignments in a band. Also, a frequency assignment may represent, a local, state, regional or nationwide authorization. Therefore, care must be taken in evaluating bands strictly on the basis of assignment, counts or percentages of assignments." *See*, *e.g.,* 512-608 MHz report at 2 (Dec. 1, 2015), *at* https://www.ntia.doc.gov/files/ntia/publications/compendium/0512.00-0608.00_01DEC15.pdf.
[10] NTIA Office of Spectrum Management, *Federal Spectrum Use Summary 30 MHz – 3000 GHz* (June 21, 2010), https://www.ntia.doc.gov/files/ntia/publications/spectrum_use_summary_master-07142014.pdf.
[11] U.S. Department of Commerce, *An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and*

V. Conclusion

The Commission should promptly issue an NPRM proposing rules for shared flexible use of the 3.7–4.2 GHz band, as well as the 5.925–7.125 GHz band to the extent interference concerns can be resolved. The Commission should also work with NTIA to develop and make public detailed information about federal spectrum use in the 4.2–5.15 GHz and 7.125–24 GHz ranges, in order to support subsequent rulemakings that enable shared commercial access to additional mid-band spectrum on a non-interfering basis.

Respectfully submitted,

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4200-4220 MHz, 4380-4400 MHz Bands (Oct. 2010), https://www.ntia.doc.gov/files/ntia/publications/fasttrackevaluation_11152010.pdf.