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

In the Matter of	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	GN Docket No. 14-177
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	IB Docket No. 15-256
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	RM-11664
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	WT Docket No. 10-112
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	IB Docket No. 97-95

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I. Introduction and Summary.

The *Spectrum Frontiers* Further Notice of Proposed Rulemaking[1] is an opportunity for the Commission to continue its pro-innovation policies in the bands above 24 GHz. Those policies call for a variety of approaches, not uniformity. Different bands above 24 GHz offer different propagation characteristics and are home to different groups of incumbent users. The Commission should tailor its spectrum-assignment and technical rules to each band's unique characteristics, so as to support both established and new applications while protecting incumbents.

The Commission should particularly avoid prejudging the outcome of future innovation. New rules should not be designed to favor any specific business model. On the contrary, the Commission should ensure that its rules can support a wide range of services, from commercial mobile, to fixed broadband, to point-to-multipoint networks, to airborne platforms, to other services not yet conceived. If there has been one constant in wireless, it is that the most significant innovations were unexpected. Accordingly, in each of these bands, the Commission should adopt a flexible framework that can enable a broad range of applications, both traditional and new.

In the 70/80 GHz bands specifically, the Commission should retain the existing light licensing framework that is adaptable and working well today for a range of uses, instead of adopting a three-tiered architecture managed by a spectrum access system

[1] *In the Matter of Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al.*, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd. 8014 (2016) (Order & FNPRM).

(SAS) as the Commission has proposed. The propagation characteristics of these high frequencies favor point-to-point uses, and the existing link registration system is well-suited to manage such uses. Maintaining the existing rules, with updates to the registration parameters and minimum antenna gain for the band, is a straightforward and minimally disruptive approach to reducing barriers to entry and promoting innovative uses.

In the 24 GHz band, by contrast, a three-tiered, SAS-managed framework, like the Citizens Broadband Radio Service (CBRS) framework that the Commission adopted for the 3.5 GHz band,[2] could yield significant benefits. At a bare minimum, the Commission should modify its proposed approach to reduce the size of the license areas and thereby take better advantage of the re-use potential of 24 GHz frequencies.

II. The Commission Should Retain its Light-Licensing Approach for the 70/80 GHz Bands, with Modest Adjustments.

The Commission should continue its current, light-licensing approach for the 70/80 GHz bands. As the Commission notes, the existing rules are highly streamlined and effective, presenting only minimal administrative barriers to varied uses of this spectrum.[3] More than 400 national licensees collectively have registered tens of thousands of links in the bands, and new entrants readily can participate in the registration process. Google Inc. and Google Fiber Inc. have first-hand experience with the flexibility and utility of the current regime, having registered 70/80 GHz links for

[2] 47 C.F.R. § 95.401 *et seq*.
[3] Order & FNPRM ¶¶ 438-39.

diverse purposes ranging from the retail wireless broadband service of Webpass, Inc., to developing Project Loon's balloon-powered Internet access technology.

The current link registration approach fits well with the technical characteristics of these frequencies. The 70/80 GHz bands are generally not well suited to wide-area operations. Their comparatively poor propagation and atmospheric absorption characteristics mean that operations typically require high power and directional gain in order to achieve significant range. As a result, these bands are well suited to high-speed, point-to-point or short-range applications, but less suited to traditional wide-area operations.

Because any 70/80 GHz application with significant range is likely to be highly directional, operators can leverage narrow beamwidths to operate with little risk of harmful interference to nearby systems. Thus, various users can efficiently reuse this spectrum through required coordination and by maintaining minimal separation distances. Any wider-beamwidth applications will necessarily have much shorter range, again facilitating sharing through coordination at minimal separation distances.

These characteristics make changing to a three-tiered system, as proposed by the Commission,[4] unnecessary to facilitate sharing in the 70/80 GHz bands. Moreover, the kind of area-based licensing and incumbent protection zones that are specified in the 3.5 GHz CBRS rules would impair more spectrum than necessary, significantly reducing efficiency. Retaining the Commission's existing light-licensing regime would be

[4] *Id*. ¶ 440.

simpler and more efficient, and would adequately protect incumbents without raising entry barriers.

The Commission should, however, adjust the current rules to enable greater point-to-multipoint use of these bands. Because of the propagation characteristics described above, operators of 70/80 GHz point-to-multipoint systems with significant range will likely employ dynamic beamforming. These point-to-multipoint operations are akin to a cluster of point-to-point links; accordingly, it is possible to achieve point-to-multipoint operations under the current rules by registering and coordinating a cluster of links. But technology may advance to allow more intensive use of the 70/80 GHz spectrum on a point-to-multipoint basis, which would render link-by-link registration more cumbersome.

To accommodate this evolution, the Commission should add to its existing registration rules so that operators can register and coordinate a coverage area instead of only specific paths.[5] Specifically, an operator should be allowed to register a polygon defined by the locations to which it expects its 70/80 GHz base station to communicate. Because a beamforming antenna can be steered electronically at will, its main beam (or beams) can be pointed at particular points as traffic dictates. Instead of specifying a static beam pattern, the licensee would specify a probability density function that describes the relative likelihood the beam will be pointed to each point within the polygon, or, equivalently, the time-averaged antenna gain toward each point.

[5] 47 C.F.R. § 101.21.

This supplement to the current registration system would allow operators to coordinate with a point-to-multipoint system on a statistical basis (e.g., two operators could choose to serve the same location with base stations that are expected to direct beams to that location only a small percentage of the time, accepting the risk of occasional interference). Or operators could coordinate based on channel selection, power levels, polarization, etc., just as is done today for point-to-point operations.

Finally, the Commission should liberalize its technical rules for the 70/80 GHz bands to align with international standards. In particular, the minimum antenna gain of 43 dBi[6] is unnecessarily high and out of line with Europe's ETSI standards, which impose a minimum antenna gain of 38 dBi for these bands.[7] The Commission should adopt a gain requirement no higher than the ETSI standard, both to maximize technical flexibility for potential new uses by reducing minimum antenna size, and to improve global economies of scale for 70/80 GHz equipment. As long as the Commission continues to rely on coordination to prevent harmful interference, lowering the minimum antenna gain will not increase the risk of harmful interference. It would simply be a factor considered in the coordination process, with the large amount of available 70/80 GHz spectrum affording ample room for successful arrangements.

Finally, it should be noted that the newly expanded 60 GHz unlicensed band is complementary to link registration in the 70/80 GHz bands, and the combination of

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[6] *Id.* § 101.115(b).

[7] ETSI, *Fixed Radio Systems; Characteristics and Requirements for Point-to-Point Equipment and Antennas; Part 4-2: Antennas; Harmonized EN Covering the Essential Requirements of Article 3.2 of R&TTE Directive*, ETSI EN 302 217-4-2 V1.4.1 (2008-11) § 4.4.

these approaches offers substantial flexibility for operations at high frequencies.[8] By maintaining two different regulatory environments, both with low barriers to entry but offering differing levels of protection from harmful interference, the Commission will foster diversity in the innovations that take root in this range of bands. For example, while the Part 15 unlicensed rules for 57-64 GHz may encourage breakthroughs in small-cell and other mobile technologies, the light-licensed 70/80 GHz regime will foster further development of highly directional applications. This combination of approaches will best align the radio frequency characteristics of these bands with their potential uses.

III. The Commission Should Reduce the Size of its Proposed License Areas and Consider Implementing a SAS-Managed, Three-Tiered Sharing Architecture in the 24 GHz Band.

The Commission proposes to add a new co-primary mobile allocation in the 24.25-24.45 and 24.75-25.25 GHz sub-bands, and a new co-primary fixed allocation in the 24.75-25.05 GHz sub-band,[9] both to be governed by the Part 30 Upper Microwave Flexible Use Service (UMFUS) rules. It also seeks comment on how best to facilitate these operations while managing interference related to incumbent broadcasting-satellite service feeder links.[10]

The Commission's goal of opening up 700 MHz of spectrum for flexible fixed and mobile applications is a good one. But the proposed implementation does not go far

[8] *See* Order & FNPRM ¶ 125.
[9] *Id.* ¶ 383.
[10] *Id*. ¶ 384.

enough to allow this band to meet its full potential. Compared to much lower frequencies, signals in the 24 GHz band are subject to higher foliage loss, deeper shadowing due to lower levels of diffraction, and higher free space loss over the same distance.[11] Consequently, the spectrum re-use potential at 24 GHz is much greater than at lower frequencies. Compared to lower frequencies, many more devices can coexist in a geographic area of similar size, providing more users with more bandwidth.

Yet the proposed rules[12] would default to licensing 24 GHz spectrum on a Partial Economic Area (PEA) basis, where the U.S. and its possessions consist of 416 PEAs. Compare this to the licensing structure in the 3.5 GHz CBRS band, where licenses are based on 74,134 census tracts across the U.S. and possessions.[13] The default license areas for 24 GHz spectrum would be some 178 times larger, on average, than at 3.5 GHz, despite propagation characteristics dictating that 24 GHz signals will travel significantly shorter distances. In effect, the proposed licensing structure for 24 GHz UMFUS mirrors homogeneous legacy wide-area, exclusive use models, which is exactly opposite of the heterogeneous flexible use model that will best support 5G services and beyond.

To the extent that more granular license areas present administrative challenges, the CBRS framework provides a useful resource. The Commission will be developing procedures and systems for rapidly assigning a large number of Priority Access

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[11] FCC Office of Engineering and Technology, Bulletin 70, "Millimeter Wave Propagation: Spectrum Management Implications," (1997), *available at* https://transition.fcc.gov/bureaus/oet/info/documents/bulletins/oet70/oet70a.pdf.
[12] 47 CFR § 30.5(a), as proposed in Appendix G of the Order & FNPRM.
[13] 47 C.F.R. § 96.3 (defining "License area" as an area "consist[ing] of one Census Tract").

Licenses in the 3.5 GHz band, and similar mechanisms can be applied to support granular licensing in the 24 GHz band.

In fact, the Commission should consider licensing 24 GHz spectrum under a SAS-managed framework such as the Part 96 regime for CBRS, instead of the Part 30 UMFUS rules. Under SAS control, the 24 GHz band could provide extremely dense deployments of high-bandwidth, gigabit-class connectivity.

As in the 3.5 GHz band, the Commission would authorize three tiers of users: incumbent, priority access, and general authorized access. Incumbent users would receive protection from both priority- and general-access operations under a methodology similar to the one the Commission developed to protect fixed-satellite service (FSS) earth stations in the 3.5 GHz band. Although the precise implementation of these protection methodologies should account for the different propagation characteristics of these frequencies and different characteristics of the incumbent systems, the fundamental database-management system would remain the same.

General-access users, in turn, would protect priority-access users through spectral and/or spatial separation as directed by a SAS. As with CBRS, the Commission should license general-access users by rule, and permit these parties to operate in any spectrum identified by a SAS as general-access in a given location. And also as in the 3.5 GHz band, the Commission's rules should ensure that an adequate amount of general-access spectrum remains available nationwide so that virtually anyone can access this spectrum to deploy innovative new devices and services.

The nature of incumbent operations in the 24 GHz band makes this an especially attractive opportunity to extend the CBRS rules. The FSS uses in the band are few: Across the U.S. there are only six 24 GHz earth stations, clustered at just three sites. The handful of earth stations operate only in the uplink (Earth-to-space) mode in this band, and receive in a different band (typically 17 GHz). Therefore, potential coexistence issues among users of the band can be readily resolved with SAS-managed sharing.[14] The propagation characteristics of the 24 GHz band, moreover, would facilitate sharing, as the zone surrounding an earth station in which underlay services could be impacted by the earth station's signal would be very small due to high path losses.

If necessary, the SAS also could prevent harmful interference to space station receivers caused by transmitters on the ground, by calculating and then limiting aggregate interference as received by a space station. The SAS would use models of the space station's antenna footprint on the Earth, and knowledge of terrestrial fixed and mobile deployments, to manage the rise in interference as received by the space station due to co-channel operation of terrestrial fixed and mobile devices in its receive band. Interference management could include limiting the number of underlay users within the space station's footprint, and not authorizing terrestrial fixed stations whose beams are pointed toward the space station.

[14] The sole earth station licensee in this band, AT&T/DirecTV, has supported SAS-managed sharing between earth stations and terrestrial operations in the 3.5 GHz band. Comments of AT&T in GN Docket No. 12-354 at 6 (filed July 15, 2015).

A 24 GHz SAS could protect legacy fixed licensees within their licensed Economic Areas, in a similar manner to the protections provided for grandfathered Part 90 Subpart Z operations between 3.65 and 3.7 GHz.[15] The relatively short-range propagation at 24 GHz would make sharing less challenging in the 24 GHz band than in 3.5 GHz, and should allow for further improved spectral efficiency compared to 3.5 GHz through the creation of smaller protection zones for incumbents and new fixed and mobile licensees.

Finally, Google and other prospective CBRS SAS operators are developing, and plan to deploy, clutter-aware propagation modeling technology that can increase efficiency by more accurately predicting coverage and interference. Including in-building propagation losses, this technology would offer the capability to, in effect, license spectrum in three dimensions, such that operators could operate over the same geography but at different heights (typically different floors of a building). Such SAS-applied, clutter-aware modeling could be highly valuable in the 24 GHz band given the significant clutter loss and building loss for signals in these frequencies.

To illustrate the benefits of this approach, a SAS-based system for the 24 GHz band would facilitate the use of neutral-host arrangements where a number of operators offer service through a common physical infrastructure. A licensing scheme based on exclusive use of large geographic areas like PEAs, by contrast, could prevent such

[15] *See generally* Public Notice, *Wireless Telecommunications Bureau and Office of Engineering and Technology Announce Methodology for Determining the Protected Contours for Grandfathered 3650-3700 MHz Band Licensees*, GN Docket No. 12-354 (rel. Aug. 19, 2016).

arrangements by precluding multiple users from operating in this spectrum at the same location. Although operators may be able to negotiate around these limitations through secondary market transactions, such arrangements would require an initial, well-financed licensee to purchase the license with a view towards potentially making it available to third parties. Such a licensee, though, might be unwilling to share spectrum with an actual or potential competitor. Nondiscriminatory assignments through an efficient Commission mechanism would be preferable.

For the foregoing reasons, adoption of a Part 96 SAS-based architecture for the 24 GHz band not only would be well-suited to processing large numbers of applications for this spectrum, but also would provide improved protection for incumbents due to active interference management, promote open access to 5G spectrum for a range of businesses and business models, enable diverse 5G devices, and further improve efficiency through superior propagation and interference modeling.

IV. Conclusion

In making additional high-frequency spectrum available for innovative new technologies and services, the Commission should ensure that the rules governing each frequency range are well aligned with the relevant propagation characteristics and incumbent environment. The recommendations above serve these goals. By maintaining the existing light-licensing approach in the 70/80 GHz bands while adjusting registration rules to support beamforming and harmonizing antenna-gain requirements with European standards, the Commission would preserve a

light-licensing system that has proven successful, while preparing for the next generation of technical advances. In the 24 GHz band, the Commission could significantly improve the efficiency of its current proposal by reducing the size of the UMFUS license areas to better match the propagation potential of this band. It should also consider adopting a three-tiered, SAS-managed licensing scheme in the 24 GHz band to protect incumbents more efficiently and leverage the band's particular propagation characteristics.

Respectfully submitted,

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