V BAND (60 GHz):

THE KEY TO AFFORDABLE BROADBAND IN INDIA

Broadband India Forum

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A 2018 UPDATE

CONTENTS

EXECUTIVE SUMMARY

This paper was originally presented at the Broadband India Forum Workshop on "Acceleration of Broadband in India: Complementing OFC with Wireless Fiber" on 9th November, 2016. This revision reflects global developments in the V-band eco-system and technology since 2016. While the basic recommendations stand – *full de-licensing without channelization* – we provide refinements and additional supporting evidence based on recent progress at IEEE, Wi-Fi Alliance, ETSI and CEPT and learnings from field trials, academia and industry alliances.

High-speed broadband is the key to transforming India into a knowledge-based economy and for the success of the Digital India[1] initiative. Only approximately 30 percent of individuals in India are using the Internet[2] and a major effort is needed to boost broadband for all its citizens, both rural, suburban and urban.

Future urban broadband access will be driven by the deployment of Wi-Fi, WiGig, 4G and and soon 5G networks that require "fiber speed" backbone networks. These high-speed backbone networks will need to support a dense deployment of Wi-Fi access points and cellular base stations among other wireless networks . The cost structure of a fiber backbone for such deployments everywhere can be prohibitive. The next generation backbone networks will be wireless operating in the millimeter wave frequencies, in particular, the E (71-76, 81-86 GHz) and V (57-71 GHz) bands, which can provide multigigabit throughput for short to medium distances. These bands can not only be utilized for mobile backhaul but also act as a "fiber extension" to extend broadband connectivity from existing points of presence ("POPs") to nearby locations for a number of applications in urban, semi-urban, and rural areas.

In a dense environment many links are expected to operate in close proximity. Because of the spatial isolation between links and very low likelihood of interference, regulators worldwide are adopting 'light licensing' rules for the E-band based on the registration of links. In contrast, because of the high rate of oxygen absorption and corresponding signal attenuation, which naturally mitigates interference, regulators are moving forward with a license-exempt framework for the V-band.

In the V-band, to operate reliably at even short ranges, a highly focused, narrow-beam antenna must be employed to increase the level of signal availability to the target receiver. In addition, oxygen absorption makes frequency reuse possible within a very localized region of air space. High directionality and oxygen

1. *Digital India, Power to Empower, Vision of Digital India, at http://www.digitalindia.gov.in/content/vision-and-vision-areas*

2. *Percentage of Individuals using the Internet, Country ICT Data (Until 2016), ICT Statistics, International Telecommunication Union, available at https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.*

absorbtion enables very dense interference-free deployment of radio terminals using the same frequency channel within the V band spectrum. A license-exempt allocation thus enables the most efficient use of this band.

Furthermore, emerging technologies in the 60 GHz band (57-71 GHz) can reach cost points that are an order of magnitude less than deployed fiber with fiber-like reliability and multi-gigabit speeds.[3] Some of the new 60 GHz band technologies can now offer one or two orders of magnitude cost reduction over fiber and existing milli-metric band backbone networks. In this paper, we discuss the advantages of the 60 GHz band, provide updates on evolving standards, eco-system development, and studies on coexistence and why we continue to believe that with suitable policy support, it can provide for affordable broadband in India. The 60 GHz opportunity will allow India to leapfrog in broadband networks just as the country leapfrogged wireline phone with mobile voice networks.

A confluence of several factors makes some of the technologies in the 60 GHz band very cost attractive. *First*, the 60 GHz band which now includes 14 GHz of spectrum offers massive capacity compared to the existing milli-metric band allocations. *Second*, the high oxygen attenuation and narrow beams in the 60 GHz band reduce interference between links making it particularly suited for uncoordinated operation. Delicensing will boost innovations at many levels driving rapid technology advancement. *Third*, silicon technology innovations combined with global momentum behind the WiGig eco-system based on IEEE 802.11ad and its successor 802.11ay standard is making available very low cost semiconductors and system solutions. *Fourth*, the large bandwidth available in 60 GHz band allows for wide channelization (e.g. 2.16 GHz in 802.11ad and 802.11ay) and hence supports high-speed links with 10 Gbps and higher data rates.

It is noteworthy that many national administrations have delicensed the lower 60 GHz band (57-64 GHz) and also have not imposed specific channelization plans. Additionally, the US has opened the upper V-band (64 – 71GHz),[4] and countries around the world are considering doing the same.[5] This has begun to trigger technology innovation and eco-system growth. This process repeats the Wi-Fi story where the use of unlicensed 2.4 and 5 GHz bands enabled a massive eco-system around Wi-Fi and drove down broadband equipment and operation costs dramatically and facilitated affordable broadband access for the public . There would have been no Wi-Fi revolution if the 2.4 and 5 GHz bands had been licensed.

For these reasons, we believe that to unleash the full potential of the 60 GHz band India should delicense the 60 GHz band as well as avoid any mandates on specific channelization. These two initiatives will allow a spate of technology developers and connectivity providers to deliver high-speed mult-gigabit services at very low cost, which in turn will enable the proliferation of affordable broadband and introduction of a host of innovative products across India.

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3. Sanjai Kohli, interview by Professor Abhay Karandikar, October 2015

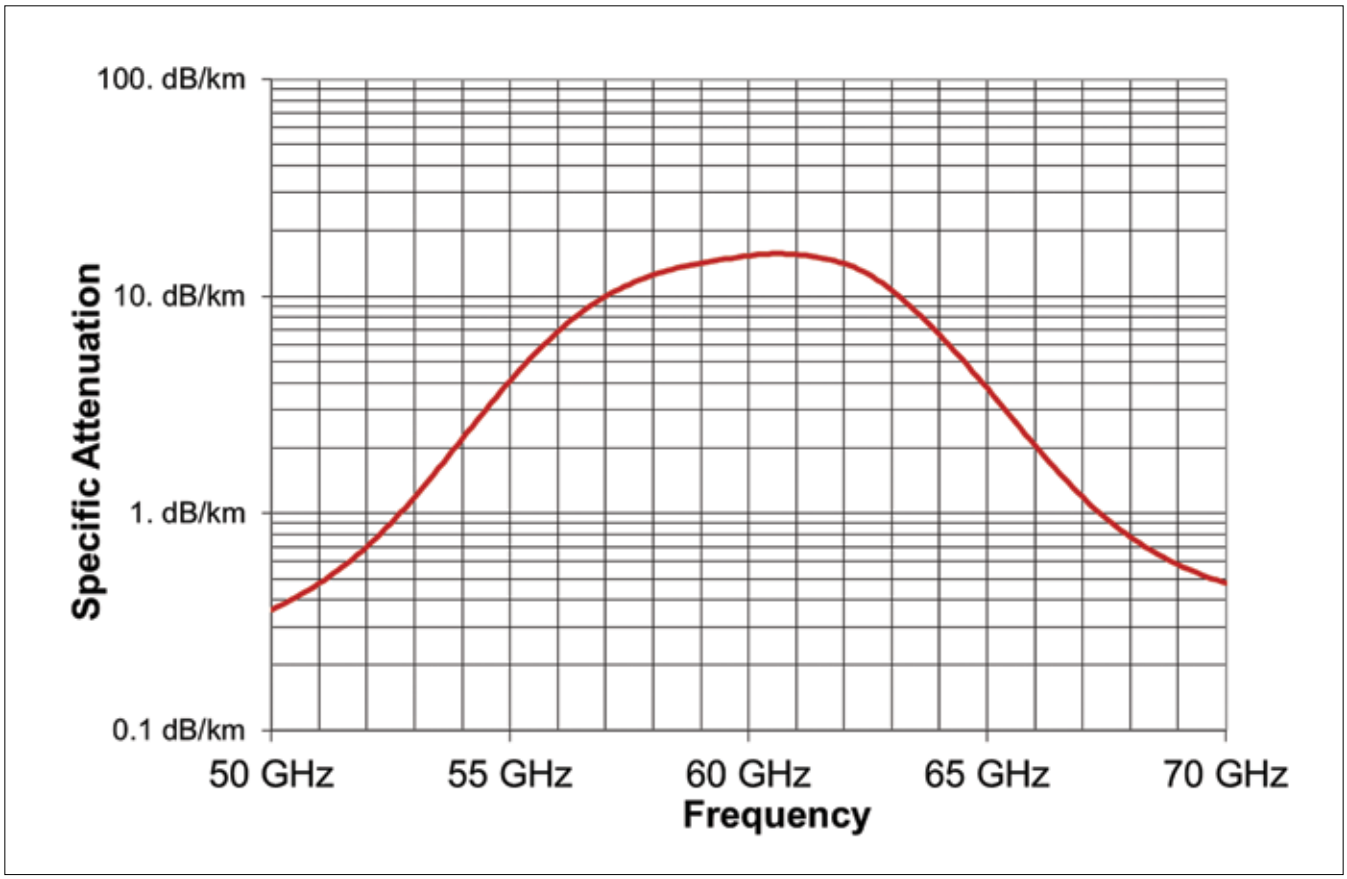
4. See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et. al, Report and Order and Further Notice of Proposed Rulemaking, FCC 16-89, 31 FCC Rcd. 8014 (2016) at https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-89A1.

5. See Radio Spectrum Policy Group, Strategic Spectrum Roadmap Towards 5G for Europe, DRAFT RSPG Second Opinion on 5G for Europe, Brussels, 21 November 2017, RSPG17-034 FINAL, at https://circabc.europa.eu/sd/a/fe1a3338-b751-43e3-9ed8-a5632f051d1f/RSPG18-005final-2nd_opinion_on_5G.pd; Innovation, Science and Economic Development Canada (ISED), Consultation on Releasing Millimetre Wave Spectrum to Support 5G, (Jun. 2017) at https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11298.html#s1; Ofcom UK, Fixed Wireless Spectrum Strategy, Consultation on proposed next steps to enable future uses of fixed wireless links, at https://www.ofcom.org.uk/__data/assets/pdf_file/0027/108594/Fixed-Wireless-Spectrum-Strategy.pdf.

01 60 GHz BAND CHARACTERISTICS

With 7 GHz and potentially 14 GHz of capacity, the 60 GHz band offers unmatched capacity compared with lower frequency spectrum. Moreover, the 60 GHz band has unique characteristics that set it apart from other high frequency bands. For example, the 60 GHz band propagation characteristics are significantly different from other fixed service bands, including the E-band (70/80 GHz). In the 60 GHz band, multiple oxygen absorption lines merge together to form a single, broad absorption band, as shown in the following figure. Atmospheric absorption peaks around 16 dB per kilometer at band center, and exceeds 10 dB per kilometer across 86% of the band. This renders the 60 GHz band unsuitable for traditional multi-kilometer fixed links. It also significantly mitigates interference between 60 GHz band systems.

In the E-band, atmospheric absorption is only 0.6 dB per kilometer. While this supports multi-kilometer fixed links, it necessitates some form of light-licensing to prevent interference. Many countries have appropriately adopted "light licensing" for E-band fixed links. Light licensing is a user self-coordination process typically based on a national database of previously coordinated links. But due to the high atmospheric attenuation in the 60 GHz band, there is significant isolation between links, which mitigates interference and makes link registration unnecessary.



02 60 GHz BAND TECHNOLOGY TODAY

One of the predominant technologies for the 60 GHz band is IEEE 802.11ad also known as WiGig. Formed in January 2009, the IEEE 802.11ad task group developed an amendment to modify both the PHY and medium access control (MAC) layers of the IEEE 802.11 protocol to achieve very high throughput in the 60 GHz band. The 802.11ad standard was released in December 2012 and established four 2.16 GHz wide channels in the 60 GHz band with center frequencies of 58.32 GHz, 60.48 GHz, 62.64 GHz, and 64.80 GHz. The 802.11ad market is expected to grow to $10.53 billion in 2019.[6] ABI Research reports that 69 Million WiGig chipsets will ship in 2018 and that will grow to 418 Million in 2022.[7]

Global momentum behind WiGig is key to driving opportunities in the 60 GHz band. Currently, the WiGig based 60 GHz band hosts a broad range of services including outdoor wireless links that extend the reach of fiber networks and personal networking technologies that deliver multi-gigabit speeds between devices such as wireless docking augmented reality/virtual reality, multimedia streaming, gaming, enterprise and other networking applications.[8] The band also is fostering innovations in technologies such as short-range, interactive motion sensing that hold the promise of making devices taking advantage of broadband connectivity more usable.

Standardization often leads to widespread adoption, and this has been true for 802.11ad. The huge global demand for spectrum capacity is driving investment in 60 GHz band unlicensed technologies for fixed wireless access, wireless backhaul and short-range uses, particularly as the technology is evolving to allow for non-line-of-sight applications.[9] Since the release of the 802.11ad standard, there has been participation by not only large, established communications semiconductor manufacturers such as Broadcom, Intel, and Qualcomm, but also wireless semiconductor startups.[10] [11]

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6. *Wireless Gigabit (WiGig) Market (IEEE 802.11ad, 60 GHz, 7Gbps Wi-Fi, Wireless Gigabit Alliance, Access Points, Routers, Residential Gateways, Backhaul Equipment) - Worldwide Forecasts, Business Models, Technology Roadmap and Analysis (2014 - 2019) available at http://www.marketsandmarkets.com/PressReleases/wigig.asp.*

7. *ABI Research, 802.11ad Chipset Market to Reach Critical Juncture in 2017 with WiGig Certification Now Underway, ABI Research Forecasts WiGig Will Play Key Role in the Transition to Cable Free Devices, (9 Nov. 2016) at https://www.abiresearch.com/press/80211ad-chipset-market-reach-critical-juncture-201/.*

8. *See Revision of Part 15 of the Commission's Rules Regarding Operation in the 57-64 GHz Band, Federal Communications Commission Report and Order, ET Docket 07-113, 28 FCC Rcd. 12517, 12519 ¶ 5 (2013).*

9. *See Mario Giovanni Luigi Frecassetti, ETSI White Paper No. 9, E-Band and V-Band Survey on status of worldwide regulation at 4 (June 2015) available at https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp9_e_band_and_v_band_survey_20150629.pdf; see also Dan Jones, Light Reading, 60 GHz: A Frequency to Watch (July 10, 2014) available at http://www.lightreading.com/mobile/backhaul/60ghz-a-frequency-to-watch/d/d-id/709910 (noting investments made in 60 GHz technology driven by WiGig and wireless backhaul).*

10. *Wi-Fi CERTIFIED WiGig™ brings multi-gigabit performance to Wi-Fi® devices, https://www.wi-fi.org/news-events/newsroom/wi-fi-certified-wigig-brings-multi-gigabit-performance-to-wi-fi-devices.*

11. *HiSilicon Receives WiGigTM Certification from Wi-Fi Alliance for the Industry's Most Integrated 60 GHz Solution, http://www.hisilicon.com/en/Media-Center/News/CES2018_hisilicon_60gwifi.*

Building on the 802.11ad standard are highly innovative approaches that are being proposed utilize the significant 60 GHz bandwidth and WiGig technology elements to form novel network topologies[12] [13] in addition to established point-to-point and point-to-multipoint topologies.[14] [15] Draft 1.2 of 802.11ay, the successor standard to 802.11ad was released May 2018 and defines support for a broad set of use-cases ranging from mmWave Mesh Network Usage Model in support of Fixed Wireless Access deployment scenarios, as well as wireless virtual/augmented reality, networking, and mobile. The technologies defined in 802.11ay enable operation in both line-of-sight and non-line-of-sight environments. Non-line-of-sight operation exploits alternate paths generated by deterministic reflectors which exist at 60 GHz.

Subsequent improvements to 802.11ay specification include techniques for managing interference and coexistence in high density scenarios including those with multi-hop multi-point network topologies. Key innovations include scheduled media access control, more efficient beamforming protocols catering to different usages, peak data rates in excess of 100 Gbps, support for cloud based link planning, and advanced coding schemes that enable predictable performance in a complex mesh deployment with a single frequency network. Participation and support for 802.11ay has expanded to include not only semiconductor manufacturers but also communications system vendors, consumer internet and services companies and network service providers.

Recent innovations and announcements in the 60Ghz band include the following:

In April 2016 *Facebook* announced Terragraph, its 60 GHz wireless system for dense urban environments[16] with the motivation to support its mission of connecting the unconnected and improving the experience of the underserved. Terragraph uses a standard WiGig chipset and implements a number of software features to enhance network performance and achieve gigabit speeds at fraction of the cost of laying traditional fiber optic.[17] Facebook has deployed a network in the City of San Jose, California, USA covering 4 sq km with over 400 sectors delivering Wi-Fi access to City employees. Facebook is making the Terragaph technology available through its contributions to IEEE, ETSI and the Telecom Infrastructure Project mmWave Working Group. Faceback is also actively participating in the Wi-Fi Alliance and CEPT working groups.

Huawei has recently developed and successfully tested in several live trials, a new Point-to-Multipoint (PtMP) product in the V-Band as a best-fit solution for dense urban networks for Fixed Wireless Access and Small Cell Backhaul applications. The system, which leverages IEEE 802.11ad technology, utilizes innovative phased array antennas in order to implement beam-steerable PtMP and MultiPoint-to-

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12. *Id; "EdgeHaul™ Millimeter Wave Small Cell Backhaul System," available at http://www.interdigital.com/presentations/edgehaul-millimeter-wave-small-cell-backhaul-system.*

13. *Wireless Gigabit (WiGig) Market (IEEE 802.11ad, 60 GHz, 7Gbps Wi-Fi, Wireless Gigabit Alliance, Access Points, Routers, Residential Gateways, Backhaul Equipment) - Worldwide Forecasts, Business Models, Technology Roadmap and Analysis (2014 - 2019) available at http://www.marketsandmarkets.com/PressReleases/wigig.asp.*

14. *Id; "EdgeHaul™ Millimeter Wave Small Cell Backhaul System," available at http://www.interdigital.com/presentations/edgehaul-millimeter-wave-small-cell-backhaul-system.*

15. *Wireless Gigabit (WiGig) Market (IEEE 802.11ad, 60 GHz, 7Gbps Wi-Fi, Wireless Gigabit Alliance, Access Points, Routers, Residential Gateways, Backhaul Equipment) - Worldwide Forecasts, Business Models, Technology Roadmap and Analysis (2014 - 2019) available at http://www.marketsandmarkets.com/PressReleases/wigig.asp.*

16. *""Introducing Facebook's new terrestrial connectivity systems – Terragraph and Project ARIES" available at https://code.facebook.com/posts/1072680049445290/introducing-facebook-s-new-terrestrial-connectivity-systems-terragraph-and-project-aries/.*

17. *Kohli, Sanjai. Cloud Controller for next Generation Data Network. FACEBOOK, INC., assignee. Patent 9,277,480. 1 Mar. 2016; and Kohli, Sanjai. Distribution Node and Client Node for next Generation Network. FACEBOOK, INC., assignee. Patent 9,215,644. 15 Dec. 2015.*

Multipoint (MPtMP) topologies to backhaul Access Points in meshed networks or to extend broadband connectivity from fiber points of presence to residential locations in urban and suburban areas. The wide band, favorable propagation and directive, steerable antenna beams provide very high throughput, very good performance and very low probability of interference, making this system and the V-band an attractive solution for delivering broadband with a favorable total cost of ownership.

Intel has announced numerous products over the years that are based on the WiGig technology operating in the 60 GHz band. Back in 2015, Intel announced a wireless docking solution that removed the cables between a portable device such as a PC and a docking station.[18] In early 2018, Intel announced its cooperation with HTC to bring wireless virtual reality to the HTC Vive.[19] Also in 2018, Intel announced its support for the Terragraph project with an Intel based reference solution based on the WiGig technology.[20] This solution aims at bringing low cost broadband access and help address the need to deliver gigabit broadband wirelessly complementing metro fiber. Intel also announced that it has been closely collaborating with industry leaders to contribute the Terragraph specification to the IEEE 802.11ay standard development.

In October 2016 *Nokia* demonstrated a Fixed Wireless Access solution that uses IEEE 802.11ad technology in V-band. Nokia's Wireless PON (WPON) solution is an industry first that allows operators to bring gigabit services to customers using WiGig wireless technology, eliminating the need to bring fiber all the way to a home or building. WPON integrates WiGig to the home with a PON network, providing operators with a new FTTx option for delivering ultra-broadband access. Easily mounted to telephone poles, street lights or a building facade, the solution uses beamforming to bring connections of up to 1 Gbps to Nokia WPON home units located in excess of 100 meters away on the outside of a building or home. With the ability to connect multiple access points in a row, operators can now bring fiber to a street corner or neighborhood instead of a building and avoid the costs of adding subscribers, reduce up-front investment cost and deploy faster.

Following WPON initial launch, Nokia announced a technology partnership with Facebook in February 2018. Combining WPON with Terragraph's mesh-routing and multi-hop capabilities allows broadband providers to wirelessly deliver gigabit services over wider areas with high reliability and meet growing demands for ultra-broadband access. Nokia combines its worldwide delivery capabilities and WPON with Facebook's Terragraph technology to launch global gigabit broadband trials in 2018 with select customers.

Qualcomm Atheros (QCA) has been an active contributor to 802.11ad and 802.11ay over the last decade and a pioneer and worldwide leader in making 802.11ad and 802.11ay mainstream and widely available with a range of products spanning mobile platforms such as the Snapdragon 845 Mobile platform which enables forward looking features sucah as immersive XR and the QCA6438 and QCA6428 family of pre-802.11ay chipsets which enables high-speed broadband connections to consumers in dense urban areas vis fixed wireless access (FWA).[21]

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18. *https://www.pcworld.com/article/2873512/intels-wireless-dock-takes-laptops-closer-to-a-wirefree-life.html*

19. *https://www.tomsguide.com/us/htc-vive-wigig-wireless-upgrade,news-26387.html*

20. *https://wifinowevents.com/news-and-blog/facebook-announces-multiple-partnerships-terragraph/*

21. *See https://www.qualcomm.com/news/releases/2018/05/21/qualcomm-and-facebook-bring-high-speed-internet-connectivity-over-60ghz; https://www.fiercewireless.com/wireless/qualcomm-quietly-advances-vr-technology-prep-for-5g; https://www.qualcomm.com/products/snapdragon-845-mobile-platform; https://www.qualcomm.com/news/onq/2017/09/21/new-asus-zenfone-4-pro-first-gigabit-lte-and-multi-gigabit-80211ad-wi-fi; https://i.mt.lv/routerboard/files/wAP60-180420095743.pdf; http://www.iotevolutionworld.com/iiot/articles/432456-qualcomm-extends-benefits-80211ad-wi-fi-enterprises.htm; https://www.qualcomm.com/solutions/networking/features/80211ad*

The ASUS zenFone 4 Pro with Gigabit connectivity is the world's first commercially available smartphone to feature 802.11ad Wi-Fi connectivity from QCA. Users of this smartphone can enjoy ultra-fact connectivity and excellent user experiences like downloading 4K movies and TV shows in seconds or syncing and sharing entire phot albums with incredible speed. They can also enjoy delay-free VR and gaming. Enterprise users can download presentations quickly, access the cloud as if it's on their phone, and take advantage of lag-free wireless docking.

At MWC 2018 QCA demonstrated multiple 802.11ad based technologies showcasing positioning, mm wave radar, enterprise SON and VR on a Snapdragon 835 based smartphone exploiting 802.11ad's extremely low latencies. The Wireless Wire is another innovative solution enabled by QCA chipsets which replaces a Gigabit Ethernet cable with two small devices that connect to each other over a GHz wireless link offering full duplex 1 Gbps speeds over a 200 meter range or more.

In September 2017 the *Telecom Infrastructure Project (TIP)*, the Facebook-backed open-source hardware and software group of over 500 telecom stakeholders including Broadcom, Intel, Deutsche Telekom, Vodafone, Telefonica, SK Telecom and Nokia launched the Millimeter Wave Networks Project Group, co-chaired by Facebook and Deutsche Telekom, with a focus on bringing more bandwidth to dense, highly populated areas[22]. At MWC 2018, Deutsche Telekom stated they were actively evaluating use cases across Europe for this technology and areplanning to deploy a Terragraph field trial in the Budapest area (via its subsidiary Magyar Telekom).[23]

V-Band also enables compelling short-range applications. Google has developed Project Soli, which uses a sensor operating between 57 and 64 GHz to capture motion in a three-dimensional space using a radar beam.[24] Data collected by the Project Soli sensor can be used to enable touchless control of device functions or features. For instance, sensor data allows devices to be more "aware" of their surroundings to allow them to enter sleep mode due to inactivity in their environment, or to allow users to trigger simple actions without having to touch the device. This could be particularly meaningful for users with mobility, speech, or tactile impairments.

Smaller companies and startups are also pursuing development of 60 GHz solutions. Startup companies include Peraso[25] and Blu Wireless.[26] An earlier pioneer of CMOS based 60 GHz chipsets, SiBEAM[27] (A Lattice Semiconductor Company) continues development of both indoor and outdoor solutions.

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22. *See https://telecominfraproject.com/mmwave/*

23. *See https://telecominfraproject.com/tip-at-mwc-2018-new-trial-deployments-project-groups-and-a-growing-ecosystem/*

24. *See Soli at https://atap.google.com/soli/.*

25. *""Peraso WiGig USB Adapter Among First Products to Achieve Wi-Fi Alliance Certification" available at http://www.perasotech.com/2016/10/peraso-wigig-usb-adapter-among-first-products-achieve-wi-fi-alliance-certification/*

26. *Blue Wireless Technology, at http://www.bluwirelesstechnology.com/.*

27. *"MM-Wave Radio Spectrum Becomes Tangible 5G Path" available at http://electronicdesign.com/communications/mm-wave-radio-spectrum-becomes-tangible-5g-path*

03 COUNTRIES AROUND THE WORLD ARE ADOPTING A LICENSED-EXEMPT APPROACH IN THE 60 GHz BAND

Around the world, countries across regions have adopted a licensed-exempt framework, including Germany, the United Kingdom, China, Japan, South Korea, Singapore, the United States, Canada, Brazil, Mexico and South Africa. Table 1 below provides a timeline of the countries that have adopted license-exempt 60 GHz band regulations.

Table 1: Timeline of Countries That Have Adopted License-Exempt 60 GHz Band Regulations

Country	Date of Adoption of License-Exempt 60 GHz Band Framework
Austria	Feb-09
Australia	July-14
Belgium	May-14
Brazil	July-08
Canada	Dec-10
China	Jun-15
Japan	May-14
Korea	April-13
Malaysia	Feb-15
Mexico	Nov-17
New Zealand	Oct-14
Phillipines	Jan-16
Poland	Dec-14
Singapore	April-13
Slovakia	Feb-15
Spain	Dec-11
South Africa	Mar-15
Switzerland	Jan-11
UK	Oct-10
US	Dec-2010, Jul-2016 (64-71 GHz)

*(countries that allow outdoor operation for multi-gigibit wireless systems in **bold**)*

At the international level, Article 5 of the International Telecommunication Union (ITU) Radio Regulations[28] includes co-primary fixed service (FS) and mobile service (MS) allocations in the 60 GHz band for all three ITU Regions.

Recommendation ITU-R F.1763, Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz[29], identifies specific radio interface standards which may be utilized for broadband wireless access (BWA) systems in the fixed service operating below 66 GHz. In developing this recommendation, the ITU Radiocommunication Assembly (RA) considered that:

- It is useful to identify standards for broadband wireless access (BWA) systems in the fixed service for international use
- The standards for BWA systems for fixed services are developed by standardization development bodies with broad international participation
- Standards for systems operating in the mobile service can be utilized to provide fixed BWA
- Standards for BWA support a wide range of fixed and nomadic broadband applications, such as voice and videoconferencing, in urban, suburban, and rural areas

F.1761-1 recommends that Recommendations ITU-R M.1450, M.1457, M.1801, M.2003, and M.2012, which can also be utilized to provide fixed BWA operations below 66 GHz, should be used.

Recommendation ITU-R M.2003, Multiple Gigabit Wireless Systems in frequencies around 60 GHz[30], provides general characteristics and radio interface standards for Multiple Gigabit Wireless Systems (MGWS) in frequencies around 60-GHz. In developing this recommendation, the RA considered that:

- MGWS are widely used for fixed, semi-fixed (transportable) and portable computer equipment for a variety of broadband applications
- MGWS are expected to encompass applications for wireless digital video, audio, and control applications, as well as multiple gigabit wireless local area networks (WLAN)
- MGWS standards have been developed for operation in the 60 GHz frequency range
- MGWS should be implemented with careful consideration to compatibility with other radio applications
- Many administrations permit MGWS, including radio local area networks (RLANs) devices to operate in the 60 GHz frequency range on a license-exempt basis
- Harmonized frequencies in the 60 GHz frequency range for the mobile service would facilitate the introduction of MGWS including RLANs

28. *International Telecommunication Union Radiocommunication Sector; Radio Regulations, Edition of 2012.*

29. *Recommendation ITU-R F.1763-1 (02/2014) Radio interface standards for broadband wireless access systems in the fixed service operating below 66 GHz.*

30. *Recommendation ITU-R M.2003-1 (01/2015) Multiple Gigabit Wireless Systems in frequencies around 60 GHz.*

The RA further recognized that both consumers and manufacturers will benefit from global harmonization of the 60 GHz spectrum for MGWS and that although MGWS systems have been predominantly used for indoor applications there are administrations which allow outdoor use of these systems.

Noting that several standards provide options for MGWS implementation, the RA recommends that the MGWS standards and their system characteristics contained in Annex 1 of M.2003-1 should be used. Annex 1 states that "a 2160 MHz channel bandwidth is required. It is important that MGWS standards employ the same channelization in order to promote better coexistence. Four center frequencies are recommended to be at 58.32, 60.48, 62.64, and 64.80 GHz." These are the same channel bandwidths and center frequencies standardized in the internationally developed IEEE Standards 802.11ad-2012 and 802.15.3c-2009.

3.1 Outdoor Usage of the 60 GHz Band

Even though the V-band is available around the world on a license-exempt basis for indoor use and to a lesser, but still significant extent for outdoor use, outdoor usage has often been *limited to point-to-point fixed services*, in particular in Europe. This restriction was based on legacy technologies developed prior to the advent of phased-array antenna systems and beam-steering and deployments have been very limited.[31] With the recent developments in WiGig and interest in low-cost *fixed point-to-multi point services*, or *Fixed Wireless Access*, there has been significant effort towards revising the CEPT framework for the 60 GHz band to allow Fixed Wireless Access.

1. ETSI mmWave Transmission Industry Specification Group
    a. Ray-Tracing Analysis multi-company submission to SE19[32]
    b. ETSI White Paper No. 25 – Microwave and Millemeter-wave for 5G Transport[33]
    c. Update on ISG View on V Band and E-band Regulations[34]
2. CEPT SE-19 (Spectrum Engineering for Fixed Services) Work Item being drafted to present results of interference analysis studies, conducted to assess the compatibility of Multiple Gigabit Wireless Systems (MGWS) with the Fixed Service (FS) in the 60 GHz band (V-band) to be used as input from SE19 to assist SRD/MG in assessing the feasibility of establishing a common set of technical conditions under which fixed service applications and other outdoor envisaged uses/applications, including Fixed Wireless Access, may coexist within the 57 – 66 GHz range.[35]

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31. *See, e.g., Draft Revision of ECC Report 173- Fixed Service in Europe: Current use and future trends post 2016 (last updated 27 Apr. 2018), § A.1.29 at 75 https://www.ecodocdb.dk/download/6fd0de6b-f796/ECCRep173.PDF (reporting that the 57-64 GHz band is open in 27 countries but that only 400 links have been deployed in just 6 countries); see also id. § A.1.30 at 76 (reporting that the 64-66 GHz band is also open in 27 countries but that no links are reported to be deployed).*

32. *See V-band 3D Ray-Tracing Interference and Network Analyzes, Doc.SE19(17)36, at https://cept.org/Documents/se-19/37789/se19-17-36_60-ghz-3d-ray-trac-analyzes.*

33. *See ETSI White Paper No. 25 – Microwave and Millemeter-wave for 5G Transport -- http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp25_mwt_and_5g_FINAL.pdf*

34. *See ETSI mwT ISG presentation on V band and E-band Regulations -- https://portal.etsi.org/Portals/0/TBpages/mWT/Docs/mWT-0014v200.pptx*

35. *See SE 19- Fixed Service, Group info at https://www.cept.org/ecc/groups/ecc/wg-se/se-19/client/introduction/; see ECC Work Programme Database, SE19_39 (In progress) at https://eccwp.cept.org/default.aspx?groupid=45.*

3. UK Ofcom Consultation on Fixed Wireless Strategy [36]

    a. Proposes regulatory changes to enable point to multipoint/mesh technologies on a licence exempt basis in 57-66 GHz.

4. EU Radio Spectrum Policy Group

    a. In STRATEGIC SPECTRUM ROADMAP TOWARDS 5G FOR EUROPE RSPG Second Opinion on 5G networks recommends *General Authorisation in 66-71 GHz.*[37]

36. *Ofcom UK, Fixed Wireless Spectrum Strategy, Consultation on proposed next steps to enable future uses of fixed wireless links, at https://www.ofcom.org.uk/__data/assets/pdf_file/0027/108594/Fixed-Wireless-Spectrum-Strategy.pdf.*

37. *See Radio Spectrum Policy Group, Strategic Spectrum Roadmap Towards 5G for Europe, DRAFT RSPG Second Opinion on 5G for Europe, Brussels, 21 November 2017, RSPG17-034 FINAL, at https://circabc.europa.eu/sd/a/fe1a3338-b751-43e3-9ed8-a5632f051d1f/RSPG18-005final-2nd_opinion_on_5G.pdf.*

04 RECOMMENDATIONS FOR LICENSING OF THE 60 GHz BAND IN INDIA

Transforming India into a "digitally empowered society and knowledge economy" as envisioned by the Digital India Programme, will require connecting millions of citizens to high-speed broadband.[38] To date, mobile has been a key on ramp to Internet connectivity in India. Of the more than 400 million Internet users in India, more than 306 million access the Internet through their phones.[39]

However, in India, as in the rest of world, the proliferation of new mobile devices and bandwidth-hungry applications is putting more pressure than ever before on mobile networks and the spectrum they rely on. Globally, mobile data traffic grew 74 percent in 2015.[40] India is no exception. In India last year, mobile data traffic grew by 50 percent and consumption of 3G data alone rose by 85 percent.[41] With operators poised to launch 4G LTE networks across the country, analysts expect that faster speeds could lead to an up to fourfold increase in traffic as it has in other parts of the world.[42] Still others have projected that smartphone penetration could reach 58 percent by 2020, further propelling large increases in data traffic.[43]

Keeping up with this surging demand for data and meeting the government's goals for a Digital India through expanded digital infrastructure will require adding capacity to existing networks and upgrading network architectures, and promoting new forms of local networking, such as device-to-device. To do this in an affordable way, increasing access to delicensed spectrum for both access and backhaul must become a key part of India's digital strategy. Last year, around the world, more than half of mobile data traffic was offloaded onto fixed networks through Wi-Fi or femtocells.[44] But in India, analysts have

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38. *Digital India, Power to Empower, Vision of Digital India, at http://www.digitalindia.gov.in/content/vision-and-vision-areas.*

39. *"India to surpass U.S. with 402 million Internet by 2016: IAMAI," The Indian Express Tech, at http://indianexpress.com/article/technology/tech-news-technology/india-to-have-402-mn-internet-users-by-dec-2015-will-surpass-us-iamai-report/Mobile internet users in India to reach 371 million by June: Report, Times of India (Feb. 4, 2016) at http://timesofindia.indiatimes.com/tech/tech-news/Mobile-internet-users-in-India-to-reach-371-million-by-June-Report/articleshow/50846649.cms (citing reports by the Internet and Mobile Association of India).*

40. *Cisco Visual Networking Index: Global Mobile Data Traffic Update, 2015-2020 White Paper (Feb. 3, 2016) available at http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html ("Cisco Report").*

41. *Rohit KVN, "India's 'mobile data traffic grew by 50 percent in 2015' says Nokia," International Business Times, India Edition (March 8, 2016) available at http://www.ibtimes.co.in/indias-mobile-data-traffic-grew-by-50-percent-2015-says-nokia-669928.*

42. *Nokia study shows multimedia and expanding device ecosystem will fuel mobile data traffic growth as India moves toward 4G LTE, Press Release, Nokia Networks, (March 8, 2016) available at http://company.nokia.com/en/news/press-releases/2016/03/08/nokia-study-shows-multimedia-and-expanding-device-ecosystem-will-fuel-mobile-data-traffic-growth-as-india-moves-towards-4g-lte ("Nokia Networks Report").*

43. *Deloitte, Indian Tower Industry: The Future is Data, Figure 1 (June 2015) available at http://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-indian-tower-industry-noexp.pdf.*

44. *Cisco Report.*

observed that consumers are not typically offloading data from their mobile networks.[45] Moreover, the Telecom Regulatory Authority of India (TRAI) has noted that the existing delicensed bands available for Wi-Fi spectrum channels are already congested.[46] TRAI furthur goes on to comment on the number of hotspots today in India as compared to the rest of the world. While there are 45 Million hotspots worldwide, as of 2016 India has only 31,518 hotspots. Today's Global average is 1 hotpsot for every 150 persons. For India to reach today's Global Average of 1 hotspot for 150 persons, India would need another 8 million hotspots .

For these reasons, we recommend that India's digital strategy should include opening up unrestricted, delicensed access to the 60 GHz band (also called the V-Band). TRAI has noted that "there is an urgent need to identify new candidate bands which can be delicensed to cater to the huge demand in the near future. The V-band is a strong candidate band for the same."[47]

As noted above, the 60 GHz band offers unmatched capacity with 14 GHz of available spectrum, particularly when compared with lower frequency bands. In addition, the natural propagation characteristics of the band mitigate interference, making it particularly suited to delicensed use. For these reasons, many countries around the world, including Canada, China, Germany, Japan, South Korea and the United States, have already opened up delicensed access to the 60 GHz band.[48] Innovative technologies have flourished in the countries that have opted for a delicensed framework to make suitable use of the band for acceleration of broadband penetration

Keeping the above in the backdrop, Broadband India Forum makes the following recommendations:

a. Recommendation (1): The 60 GHz band should be opened up under a delicensed framework for optimal utilisation

Like other countries have, India should open the 60 GHz band up under a delicensed framework. However, TRAI in its recommendations of November 2015 has proposed that the 60 GHz band may be delicensed for access purposes and lightly licensed for backhaul usage . We believe this may not be the best approach for three reasons.

First, link registration (light or otherwise) for backhaul use is not required for 60 GHz operation due to the characteristics of the band. Link registration is used in other licensed spectrum to avoid interference between geographically proximate links, but due to the high oxygen attenuation within the 60 GHz band, the links here are of very short distance and highly focused, and hence interference is severely reduced. The high probability of LOS interruption and constrained transmit power levels because of clearance distance for public safety makes the band unattractive for small-cell backhaul.

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45. *"85% in growth in 3G data consumption in India last year: Report," Business Standard, March 8, 2016 at http://www.business-standard.com/article/companies/85-growth-in-3g-data-consumption-in-india-last-year-report-116030801015_1.html.*

46. *Telecom Regulatory Authority of India, Recommendations on Allocation and Pricing of Microwave Access (MWA) and Microwave Backbone (MWB) RF Carriers, (Response to reference received from Department of Telecommunications on recommendations of 16th October 2015) at 5-6 (Nov. 17, 2015) available at http://www.trai.gov.in/WriteReadData/Recommendation/Documents/Response%20to%20back%20reference%20on%20Microwave_17.11.2015.pdf. ("TRAI Recommendations").*

47. *Id.*

48. *See ETSI White Paper No. 9: E-Band and V-Band Survey at 4, First Edition—June 2015 available at http://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp9_e_band_and_v_band_survey_20150629.pdf.*

Second, it is the unrestricted, delicensed framework promoted by the IEEE standards that has allowed innovation in the 60 GHz band to flourish and has allowed the technology to be affordable. Without the steep upfront costs of obtaining licenses, innovators can experiment with technologies that work well in a delicensed environment. As discussed in Section 1, new network topologies are being developed that would allow for non-line-of-sight links. Such a system might use an infinite combination of paths to expand the reach of high-speed wireless broadband and can be used both for both access and backhaul.

Third, there are, and will continue to be for some time, far more consumer access devices with Wi-Fi capabilities at 2.4 GHz and 5 GHz, such as smartphones, than consumer access devices with 60 GHz capabilities. Wi-Fi access points are available and affordable as well. What is missing in many cases is low-cost, simple-to-provision, high-speed backhaul from the nearest fiber path. V-Band offers great promise to reduce this bottleneck. A delicensed approach would speed its deployment for this use case.

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Hence, we suggest that the Lower V band (57-66Ghz) may be permitted for short range access devices (based on 802.11ad standard) and short range devices operating pursuant to the ETSI EN 305 550 standard and for mesh networks (based on 802.11ay standard) on a license exempt basis while the Upper V band (66-71Ghz) be opened up for Point-to-Point links on a link-by-link basis through a self coordinated (registration) manner.

Ideally, the entire V-Band should be tech neutral, including use of .11d and .11ay, and that license-exempt should apply everywhere in V.-Band. For generic fixed wireless , the applicable ETSI rules for the backhaul use case are **Section H of ETSI EN 302 217-2,** and suitable both for .11ad and .11ay. The power limits in this specification are substantially higher than in the Short Range Device (SRD) standard and necessary for the wireless backhaul use case. Interference between the two classes of devices -- SRD and backhaul -- could be controlled by restricting the higher power units to outdoor use, directive antennas, and minimum antenna heights.

Recommendation (2): India's policy for 60 GHz band spectrum should allow for flexible use and should not establish coordination or channelization requirements.

We further recommend that India's 60 GHz band spectrum policy should allow for flexible use and should not establish specific coordination or channelization requirements. As discussed in Section 1 above, the availability of a delicensed 60 GHz band in major markets already, in addition to broad adoption of the WiGig standard, will ultimately result in the emergence of new applications. Furthermore, it is the large production base of WiGig chipsets that could be leveraged to facilitate

low cost 60 GHz infrastructure. However, to utilize WiGig chipsets, equipment in a point-to-point or point-to-multi-point configuration would have to operate with the same frequency channelization. This means that in order for India to reap the benefits of low cost backbone infrastructure and avoid the costs of nonstandard equipment, it would be in its interest to delicense the 60 GHz band without specifying any pre-fixed channelisation plan (similar to delicensing for 2.4 GHz & 5 GHz bands in India).

Instead, the plan originally recommended by TRAI with 50 MHz channelization could result in fragmentation and be incompatible with the 802.11ad channel plan,[49] even with aggregation. Misalignment with international standards may hinder development of a vendor ecosystem, increase equipment costs for India and result in underutilization of the band.

b. Delicensing the 60 GHz Band could also lead to broader benefits for India.

A delicensed framework would bring India broader economic and social benefits that would further the government's Digital India goals. Globally, the availability of delicensed spectrum has driven substantial economic benefit.[50] This economic benefit is real and substantial. The World Bank estimates a 1.38 percentage point increase in Gross Domestic Product for every 10 percentage point increase of broadband penetration.[51] In the United States alone, researchers have estimated that delicensed spectrum bands generated a total economic surplus of $222B in 2013, and contributed $6.7B to GDP.[52] By 2017, the same researchers have conservatively estimated that in the United States, delicensed bands will drive at least $547.2B in economic surplus annually, and contribute at least $49.7B to GDP.[53]

Moreover, the allocation of additional delicensed spectrum delivers a number of broad social benefits, including:

- Enhancing the value of wireline infrastructure and improving the performance of cellular services;[54]
- Delivering substantially higher speeds than existing services through new developments like WiGig based on 802.11ay standard and alleviating congestion on existing Wi-Fi bands;[55]

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49. *See Telecom Regulatory Authority of India, Recommendations on Allocation and Pricing of Microwave access (MWA) and Microwave Backbone (MWB) RF carrier, Recommendation 4.37(b) (29 August 2014), available at http://www.trai.gov.in/WriteReadData/Recommendation/Documents/MW%20Reco%20Final29082014.pdf*

50. *Milgrom, Paul; Levin, Jonathan; Eilat, Assaf. "The Case For Unlicensed Spectrum." Stanford University, October 2011. Available at http://web.stanford.edu/~jdlevin/Papers/UnlicensedSpectrum.pdf.*

51. *Kim, Yongsoo; Kelly, Tim; Raja; Siddhartha. "Building broadband: Strategies and policies for the developing world." Global Information and Communication Technologies Department, World Bank, January 2010. Available at: http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1208273252769/Building_broadband.pdf*

52. *Katz, Raul, TELECOM ADVISORY SERVICES, LLC. "ASSESSMENT OF THE ECONOMIC VALUE OF UNLICENSED SPECTRUM IN THE UNITED STATES" February 2014. available at http://www.wififorward.org/wp-content/uploads/2014/01/Value-of-Unlicensed-Spectrum-to-the-US-Economy-Full-Report.pdf*

53. *Katz, Raul, TELECOM ADVISORY SERVICES, LLC. "ASSESSMENT OF THE FUTURE ECONOMIC VALUE OF UNLICENSED SPECTRUM IN THE UNITED STATES" August 2014. available at http://www.wififorward.org/wp-content/uploads/2014/01/Katz-Future-Value-Unlicensed-Spectrum-final-version-1.pdf*

54. *Id.*

55. *Id.*

- Enabling new technologies and business model opportunities for a variety of established and emerging ecosystem players – innovations which ultimately benefit end-users[56]
- Supporting the expansion of services into unserved and underserved communities because the availability of delicensed spectrum helps support the provision of affordable services to new geographies and populations.

For these reasons a delicensed regime for the 60 GHz band could be economically and socially beneficial for India and could help to transform India into a "digitally empowered society and knowledge economy" as envisioned by the Digital India Programme.[57] Under a delicensed framework, the unique characteristics of the 60 GHz band and existing global standards for the band will enable a multitude of new technologies and business models and help accelerate broadband penetration to underserved communities.

56. *Id.*

57. *Digital India, Power to Empower, Vision of Digital India, at http://www.digitalindia.gov.in/content/vision-and-vision-areas.*

05 CONCLUSION

Today, India faces growing demands on its existing networks and increasing pressure to expand its broadband infrastructure and meet its Digital India goals. With its unmatched capacity, the 60 GHz band has the potential to be a key piece of India's digital strategy. By making the 60 GHz band available under delicensed framework without specified channelization, India could unleash the full potential of the 60 GHz band and leapfrog to multi-gigabit wireless services. By adopting a delicensed approach, India could benefit from the economies of scale of existing investments and innovation in the band. And such an approach would allow India to reap the same economic and social benefits that other countries which have delicensed the band are expected to enjoy.

SUGGESTED V BAND PROPOSAL

The lower V band (57-64 GHz) today has three primary use cases, viz.

1. High Capacity Multi Gigabit Wireless for short-range communication links

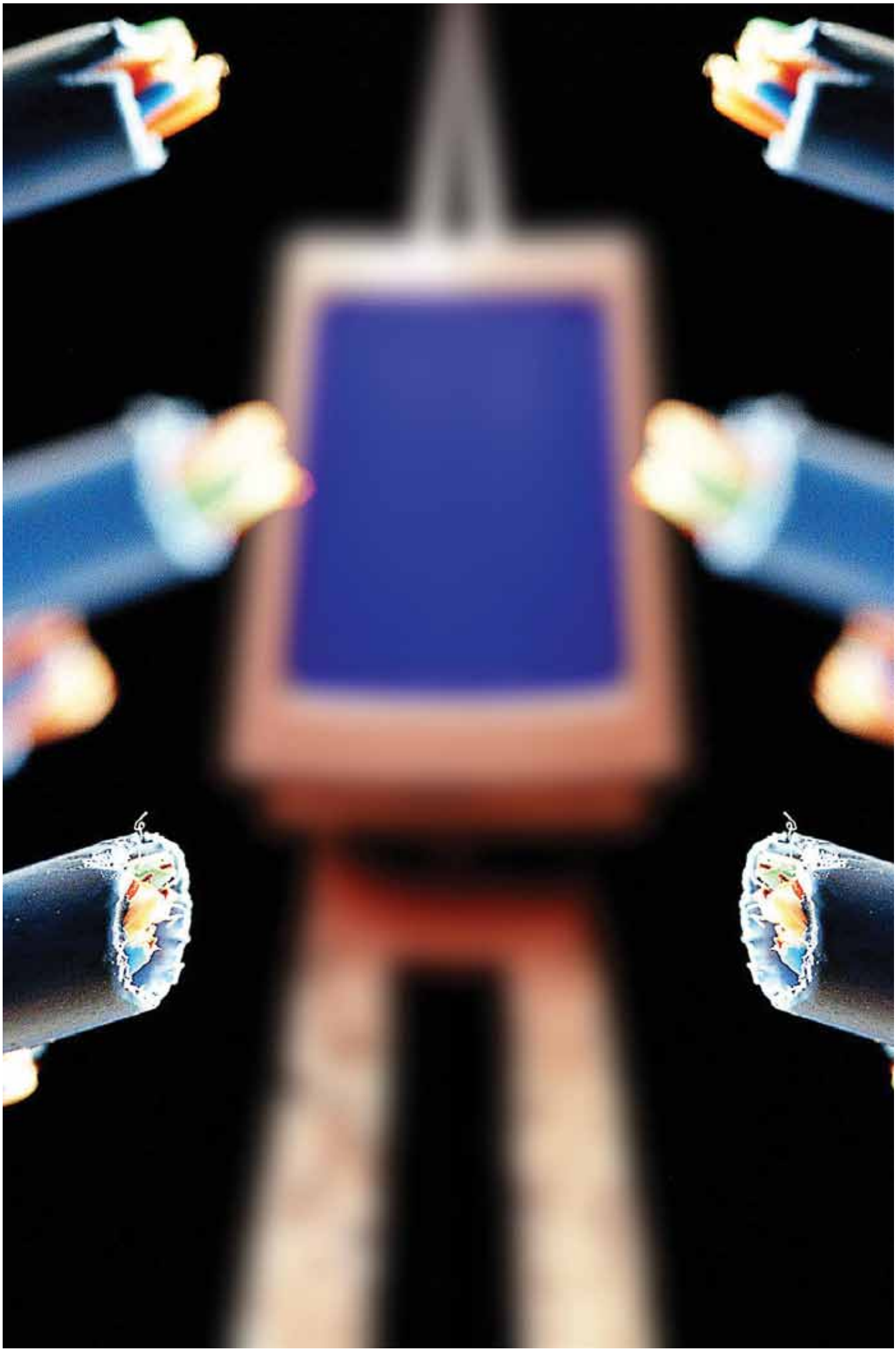
2. Fixed Wireless Access Networks (Mesh Networks) - also known as 'Wireless Fiber'

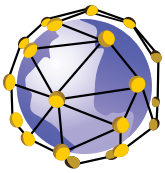
3. Point to Point Links for Cellular Backhaul

Ideally, the entire V-Band should be tech neutral, including use of .11d and .11ay, and that license-exempt should apply everywhere in V.-Band. For generic fixed wireless usage, the applicable ETSI rules for the backhaul use case are **Section H of ETSI EN 302 217-2,** and suitable both for .11ad and .11ay. The power limits in this specification are substantially higher than in the Short Range Device (SRD) standard and necessary for the wireless backhaul use case.

Recommendation:

The lower V band (57 – 66 GHz) may be permitted for all use cases on a license exempt basis while other bands (such as upper V band from 66 GHz to 71 GHz) may be opened up for point-to-point backhaul on a link-by-link basis through a self coordinated manner.





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