

Federated Wireless Inc. Comments

**Infocomm Media Development Authority
“Second Consultation on 5G Mobile Services and Networks”**

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I. Summary of Major Points

Federated Wireless, Inc. (Federated Wireless) hereby submits comments in response to the Infocomm Media Development Authority (IMDA) consultation entitled, “Second Consultation on 5G Mobile Services and Networks,” and IMDA’s proposals regarding the issuance of spectrum for the provision of 5G services and the development of the overall 5G ecosystem for Singapore.

We appreciate the opportunity to share our experience in implementing new commercial 4G (and soon 5G) services in the 3.5 GHz band in the United States and offer our perspectives on how:

- Dynamic shared spectrum technology can be readily deployed to meet IMDA’s goals for 5G and address the challenges IMDA has identified in accessing and transitioning spectrum bands occupied by incumbent systems; and
- Permitting licensees to lease their spectrum to new users and offering a combination of licensed and unlicensed access in the same band will help drive the development of a robust 5G ecosystem for Singapore.

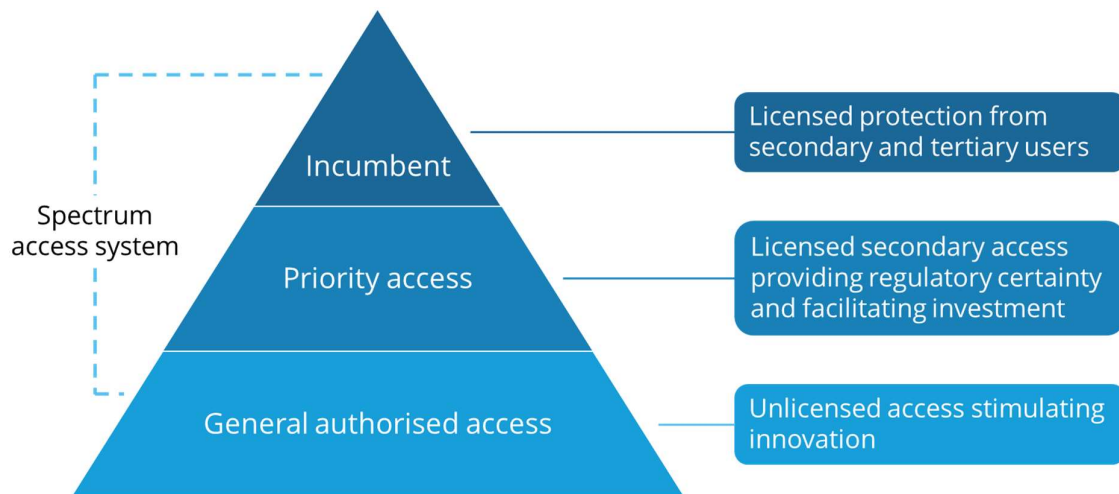
II. Statement of Interest

Federated Wireless is a U.S.-based wireless technology company (partly owned by the Government of Singapore Investment Corporation) that is assisting the U.S. Government and industry to launch new wireless broadband services in 3550-3700 MHz, known as the Citizens Broadband Radio Service (CBRS or 3.5 GHz) band, by managing dynamic sharing of these frequencies between incumbent military and commercial uses as well as between different tiers of commercial uses on both a licensed and unlicensed basis.

In 2015, the U.S. Federal Communications Commission (FCC) established rules to allow use of the CBRS band by commercial broadband service providers, while protecting the incumbent shipborne and land-based U.S. Department of Defense radars, commercial Fixed Satellite Service (FSS) receive earth stations, and commercial terrestrial fixed point-to-multipoint systems (see Figure 1 below). Federated Wireless is one of the entities authorized by the FCC to deploy and administer a Spectrum Access System (SAS) to enable dynamic spectrum sharing of the CBRS band.¹ This standards-based SAS is implemented as a Software as a Service (SaaS) in the cloud for efficiency, scalability, reliability, and ease of deployment.

¹ In addition to Federated Wireless, the FCC has conditionally approved the following additional SAS administrators: Amdocs, Inc., Comsearch, Google, Inc., Key Bridge, and Sony Electronics, Inc. All conditionally approved SAS Administrators were required to submit their systems for compliance testing before final approval. This compliance testing process is in the final stages leading to commercial launch of services.

Figure 1 – CBRS Tiered Sharing



The priority of spectrum access and protection of higher tier users in CBRS band is governed by the SAS, which maintains a database of all commercial CBRS devices (both base stations and outdoor access points) and works with environmental sensors, known as the Environmental Sensing Capability (ESC), to mitigate possible interference to the incumbent users. The functions of the Federated Wireless SAS+ESC are to:

- Register and authenticate the identity, location and technical characteristics of CBRS devices;
- Determine the available frequencies at a given geographic location and assign them to CBRS devices;
- Determine the maximum permissible radiated transmission power level at a given location and communicate that information to the CBRS devices.
- Enforce protection zones, including any future changes to such zones, to ensure compatibility between CBRS users and incumbent federal and commercial operations.

While the FCC’s rules for CBRS are specific to the United States and its incumbent users, the Federated Wireless SAS is readily adaptable to new frequency bands and challenges. Once protection criteria for incumbent users are established and a database of these incumbent users is updated with the most current information, it is straightforward to adapt the dynamic shared access system developed for CBRS to operate in other frequency bands, such as those IMDA has identified in this consultation.

In its consultation, IMDA identified a number of bands for future 5G services that are currently occupied by other commercial services, including Fixed Satellite Service (FSS) earth stations and Fixed Services (FS). The adoption of a dynamic shared access system can facilitate access for 5G services to these bands in an automated, flexible, and light-touch manner while protecting incumbents that may stay in the band or be transitioned over time to other bands. This same system can also facilitate the leasing of spectrum by licensees as well as sharing between different tiers of 5G users, namely licensed vs. unlicensed, which will provide future 5G users with a variety of spectrum access options. The regulatory certainty afforded to licensed use of the spectrum is critical to attract investment and develop a robust ecosystem, while unlicensed access can promote

innovation and new business models. The use of a dynamic shared access system and a multi-tiered licensing approach will help IMDA achieve the various goals it has set out in this consultation.

The FCC noted the myriad benefits of this multi-tiered dynamic sharing approach when it established the CBRS rules and framework:

“This regulatory adaptability should make the 3.5 GHz Band hospitable to a wide variety of users, deployment models, and business cases, including some solutions to market needs not adequately served by our conventional licensed or unlicensed rules. Carriers can avail themselves of “success-based” license acquisition, deploying small cells on a GAA [General Authorized Access or unlicensed opportunistic] basis where they need additional capacity and paying for the surety of license protection only in targeted locations where they find a demonstrable need for more interference protection. Real estate owners can deploy neutral host systems in high-traffic venues, allowing for cost-effective network sharing among multiple wireless providers and their customers. Manufacturers, utilities, and other large industries can construct private wireless broadband networks to automate processes that require some measure of interference protection and yet are not appropriately outsourced to a commercial cellular network. Smart grid, rural broadband, small cell backhaul, and other point-to-multipoint networks can potentially access three times more bandwidth than was available under our previous 3650-3700 MHz band rules. All of these applications could share common wireless technologies, providing economies of scale and facilitating intensive use of the spectrum.”²

As IMDA considers its options for the 3.5, 4.5, 26, and 28 GHz bands, dynamic spectrum access technology can be a powerful spectrum management tool to enable IMDA to harness additional spectrum for a variety of 5G services. In particular, we believe that dynamic shared access technology can be used to assist IMDA in addressing the challenges associated with making the heavily used FSS (3.5 GHz) and Fixed Service (4.5 GHz) bands available for 5G while minimizing impact to incumbent users. In addition, it can be used to enable the 3.4-3.5 GHz band to be harnessed with fewer operational restrictions. Finally, it can also minimize or possibly eliminate the need for a frequency guard band between 5G and FSS services at 3.6-3.7 GHz.

III. Comments on IMDA’s 5G Spectrum Proposals

Federated Wireless welcomes IMDA’s proposals for the issuance of spectrum for the provision of 5G services and the development of a 5G ecosystem for Singapore. We also agree strongly with IMDA’s objectives of creating a “secure and robust 5G ecosystem that enables innovation in new business models, the development of innovative products, services, applications and experiences.” We believe that the lessons learned in the development of the 3.5 GHz CBRS ecosystem, which is currently the largest LTE ecosystem in the world with over 30 equipment vendors supporting myriad new use cases, may be instructive as IMDA considers various options for the issuance of additional spectrum for 5G.

² Amendment of the Commission’s Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, FCC 15-47, Report and Order and Second Further Notice of Proposed Rulemaking (*CBRS R&O*), ¶ 6, (2015).

- A) Dynamic shared spectrum access technology can assist IMDA in its efforts to introduce 5G services in the 3.4-3.7 GHz band while also protecting FSS operations as they transition to the 3.7-4.2 GHz band.

As mentioned above, in 2015, the U.S. FCC adopted rules to permit the commercial use 3.5 GHz band for 4G and future 5G broadband services, while allowing the incumbent services, namely the U.S. Department of Defense radar systems and FSS space-to-Earth receive stations, to continue to use this same spectrum when and where they need it. The FCC's rules regarding protection of incumbent FSS systems in the C-band may be relevant to IMDA as it considers options for enabling 5G and FSS co-existence.

1) Background on FCC Rules for FSS Protection at 3.5 GHz

In order to protect FSS operations while enabling efficient use of spectrum for new 4G/5G services in the 3.5 GHz band, the FCC established protection of incumbent FSS earth stations on an **aggregate** interference basis. This novel approach affords much greater spectrum usage by new users than would a traditional static approach that relies on a fixed geographic area exclusion zones derived from a compilation of worst-case assumptions. The aggregate protection framework the FCC established requires SASs to account for in-band, co-frequency interference from all 3.5 GHz band CBRS devices (CBSDs) within 150 km of an FSS earth station and in-band adjacent frequency interference from all CBSDs within 40 km. These are not exclusion zones, but rather the areas within which SASs must account for interference contribution from CBSDs when calculating aggregate interferences for individual FSS earth stations (see Figure 2 below).

Figure 2 – FSS Exclusion Zone Impact on Spectrum Availability



As a first step in implementing these protections, the FCC required FSS earth station licensees to submit an annual registration that includes certain technical information that will be made available to SAS Administrators, including Federated Wireless. The SAS must be able to access detailed information on the technical and operational characteristics of each FSS earth station to provide protection. If these characteristics change, the operator must update the relevant registration. The registration requirement enables SASs to ensure protection of incumbent FSS earth stations and facilitate greater CBRS spectrum utilization.

To provide protection, the SAS calculates interference from each CBSD inside the respective coordination area to an individual FSS earth station based upon local terrain, pointing directions for the FSS antenna, antenna gain and receiving system noise temperature of the particular antenna, and other site-specific considerations. The FCC adopted an FSS antenna gain envelope in the

methodology for calculating exclusion distances (see Sections 25.209(a)(1) and 25.209(a)(4) of the Commission's rules) and an FSS system noise temperature of 142.8° K.

The protection criterion for FSS earth stations was intensely debated during the FCC's rulemaking process. At its conclusion, the FCC, notwithstanding concerns from new market entrants, adopted a conservative I/N of -12 dB (as set forth in ITU-R S.1432-1) at the FSS earth station's receiver as a long-term median threshold to provide protection for in-band FSS earth stations. However, the FCC agreed it would monitor industry efforts to study the real world protection needs of FSS earth stations in the band as well as the effects of CBRS equipment on such earth stations, and stated that it may revisit the interference threshold in the future if justified by future technical studies and real world observations.³

Despite adopting the protection criteria set forth in ITU-R S. 1432-1, the FCC did not agree with the assumptions and methods used in ITU-R S. 1432-1. It noted that that the specifications in ITU-R S.1432-1 are design criteria for FSS earth stations, not interference protection criteria relating to terrestrial mobile services. The FCC stated that ITU-R S.1432-1 specifically addresses degradations to FSS signals from time invariant interference and noted that there are currently no recommendations dealing with interference from co-primary allocated mobile systems into FSS systems. The FCC found that the assumptions in ITU-R S. 1432-1 are based on an arbitrary allotment of time invariant interference and do not clearly define the time allowance corresponding to other sources of interference, and that the assumptions are unsupported by either performance measurements or operational experience. Therefore, the FCC found that the ITU approach itself was inappropriate for use with terrestrial mobile service and while it adopted a -12 dB I/N protection criterion it did not adopt the analysis methodology described in ITU-R S.1432-1 for the 3.5 GHz Band.

Finally, the FCC addressed the concerns about interference from End User Devices. The FCC rules focus on the potential for interference from CBSDs – which operate at significantly higher power levels than End User Devices. In light of their low power of operation, the FCC did not believe that it was necessary to adopt rules to directly address potential interference from End User Devices. The FCC encouraged industry to develop standards for analyzing and modeling interference from End User Devices and encouraged SAS administrators to take such models into account when developing interference protection strategies. It also directed the Wireless Telecommunications Bureau and Office of Engineering and Technology to review such approaches during and after the SAS approval process and take appropriate steps to address any such interference if it arises.

2) Protecting Singapore's FSS Systems Using a Dynamic Shared Access System

Federated Wireless believes that a similar approach to what the FCC implemented in the CBRS band will assist IMDA in transitioning the 3.4-3.7 GHz band for new 5G services. Spectrum sharing could serve as a transitional mechanism to put spectrum rapidly in the hands of new 5G operators and jump-start the equipment and device ecosystem as IMDA implements the longer-term transition of the band. A shared spectrum access system can manage both 5G and FSS uses, while minimizing interference and protecting incumbent operations. The strength of dynamic spectrum sharing lies in its ability to adapt quickly: as spectrum is cleared, incumbent protection parameters can be changed easily to facilitate spectrum access. This capability, made possible through simple updates to

³ It is useful to note that changing the amount of protection afforded to an FSS earth station is very straightforward to implement given that each CBSD must register and maintain a persistent connection with the SAS. This provides significant regulatory and operational flexibility in the spectrum sharing paradigm and allows both the incumbent and new entrant services to grow and evolve.

software code, will allow new 5G operations to commence during the transition, in real-time, avoiding delays associated with waiting for a “critical mass” of spectrum to be cleared before ramping up new 5G operations. A SAS can also manage and minimize interference between the services at the 3.7 GHz border, eliminating the need for a 100 MHz guard band.

We recommend the following steps for IMDA to work with dynamic shared access systems to enable the introduction of new 5G services while protecting incumbent FSS stations:

- a) Federated Wireless recommends that IMDA develop incumbent protection criteria for the protection of FSS earth stations as it begins the transition to the 3.7-4.2 GHz band. The FCC’s protection criteria for 3.5 GHz FSS systems described above could be the basis for IMDA’s rules.
- b) We recommend that IMDA require FSS earth station licensees to submit a registration that includes detailed information on the technical and operational characteristics of each FSS earth station. This information can be maintained by IMDA in a publicly accessible database or, depending on the sensitivity of the incumbent use, could be maintained in a confidential database. If any changes occur to these operational parameters, FSS licensees must update the database in order to continue to receive protection from new 5G users.
- c) It will also be important for shared spectrum access system administrators to have access to the information about new 5G users, including accurate location and technical information that be used to conduct the computations needed to identify what spectrum is available for new users to operate in accordance with the incumbent protection criteria. The provision of this location and technical information, such as antenna height, orientation, and power level, is fundamental to enable spectrum access system administrators to perform intended incumbent protection functions. Without knowledge of a new user’s location and operational parameters, shared access systems would be unable to demonstrate to IMDA that they are effectively enforcing incumbent protections, nor would they be able to assess and implement any needed modifications to their interference calculations in the event of unexpected interference to an incumbent licensee.
- d) In order to ensure ongoing compliance with IMDA’s incumbent protection criteria, it will be imperative for new users to send a periodic query back to a shared access system to receive updated frequency availability information. The combination of regular synchronization between a shared access system and an IMDA database with respect to incumbent licensee operations in addition to a mechanism under which new users regularly query a shared access system to obtain frequency availability creates a “closed loop” ecosystem. A closed loop system ensures that the shared access system has an accurate picture of the local RF environment to facilitate spectrum access for new users and ensure incumbent protection. This periodic querying mechanism would also provide additional flexibility for incumbents to grow their operations, as the regular updates between Ofcom’s databases, shared access systems, and new users would ensure appropriate protection for newly deployed incumbent systems.
- e) Should IMDA determine that revised protection criteria for incumbents is warranted, whether more or less stringent than what is initially adopted, a dynamic shared access system that is in periodic contact with both IMDA databases and new users will be

capable of updating its interference calculations in real-time and providing up-to-date frequency availability to new users.

3) Maximizing 5G Spectrum Access Through Dynamic Shared Access Technology

In its consultation, IMDA proposed limiting access to parts of the 3.4-3.7 GHz band, namely:

- Operational restrictions (indoor and/or underground only) in the 3.4-3.5 GHz band; and
- Using the 3.6-3.7 GHz band as a guard band between 5G and FSS systems.

Federated Wireless recommends that IMDA instead consider leveraging the availability of dynamic shared access technology to maximize the use of these sub-bands for new 5G services while providing adequate protections to other users in the same and adjacent bands. IMDA listed the efficient use of spectrum as a critical goal. Although there are alternative ways to address the shortage of usable spectrum (e.g., clear and auction, repackaging, co-location, sharing), of all the methods, dynamic spectrum sharing holds the greatest promise of achieving this important goal quickly. The dynamic shared access systems are already well suited to manage access on a less restrictive basis than what IMDA has proposed.

Rather than imposing restrictions based on worst-case assumptions, such as static separation distances or indoor/underground deployment limitations, Federated Wireless recommends that IMDA allow a dynamic shared access system to take into consideration variables, such as building penetration loss, clutter, or antenna patterns, to more accurately pinpoint what interference protection is actually needed in a given area and thereby improve the efficiency of spectrum use in both the 3.4-3.5 and 3.6-3.7 GHz bands.

B) Dynamic shared technology can facilitate a secondary market for licensed 5G spectrum, while multiple tiers of commercial access will maximize opportunistic access for the largest number of diverse users and encourage investment and the development of a robust 5G ecosystem.

In its efforts to develop a robust 5G ecosystem and enable access to spectrum by as many diverse users as possible, Federated Wireless recommends that IMDA consider adopting two key licensing approaches that can be supported by the use of a dynamic shared spectrum system. First, we recommend that IMDA allow licensees of the 3.4-3.7 GHz band to lease their spectrum to other parties. Second, we suggest that IMDA also adopt a tiered licensing approach that includes both licensed and opportunistic (unlicensed) access in the **same** band and include a use-it or share-it provision for the licensed access tier. Together, licensed and opportunistic shared access assure the largest possible ecosystem for equipment and devices, resulting in more choice and lower cost for network operators and end users.

1) Spectrum leasing rights

We recommend that IMDA include in the licence conditions for the two blocks of spectrum it plans to award in the 3.4 - 3.6 GHz band the right for the licence holder to lease the spectrum to others – whether on a geographic basis (partitioning) or by sub-dividing the spectrum (disaggregating). Once IMDA establishes eligibility criteria for lessees as well as protection criteria amongst users, a dynamic

shared access system, such as the Federated Wireless SAS, can facilitate leasing arrangements by automating the process and ensuring protection criteria are met. Such a secondary market will drive innovation, allow new technology to be deployed by leased spectrum users, and support niche sectors, such as enterprise networks and industrial uses.

In addition, in order to incentivize more efficient spectrum use, IMDA should consider allowing licence holders to include any coverage and deployments undertaken by leased spectrum users to count towards the licence holder's performance obligations. This condition would not be an obligation to lease spectrum, merely an option available to license holders.

2) Tiered licensed and opportunistic access

In addition to enabling a secondary market for 5G spectrum, Federated Wireless recommends that IDMA consider implementing a tiered licensing approach to enable both licensed and unlicensed access in the same band. With a tiered licensing approach, manufacturers will build devices to satisfy both the needs of licensed and unlicensed users, particularly if there is a band-wide interoperability mandate for equipment. Without this combination, a market where equipment is purpose-built for specific customers and their exclusively licensed bands will continue. Limiting the potential size of the equipment and device ecosystem will similarly limit the potential for new and innovative uses of these bands, and it increases the likelihood that these bands will be licensed only by those with sufficient size and capital to drive ecosystem development (e.g., the incumbent MNOs). Federated Wireless recommends that IMDA instead consider a licensing approach similar to what the FCC established for the 3.5 GHz CBRS where lower tier users are allowed to access higher tier spectrum if the high tier licensee is not using it as described in the following section.

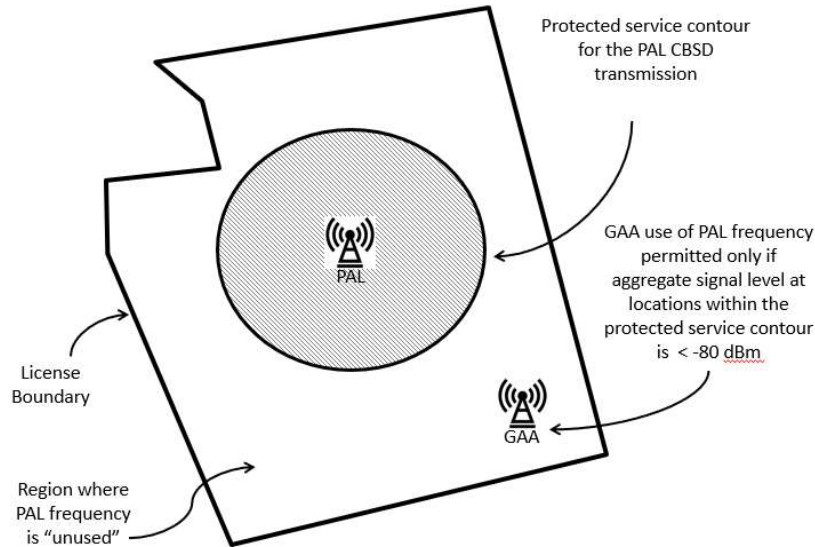
a) *Background on CBRS Use-It or Share-It Rules*

By way of background, the FCC intends to auction up to seven, 10 MHz PALs in the CBRS band per county across the United States sometime in 2020. Opportunistic access users, known as the General Authorized Access (GAA) tier, will have access to the remaining 80 MHz of CBRS spectrum whenever incumbent protection does not otherwise restrict spectrum access. GAA users are also allowed to access licensed PAL spectrum in areas where the PAL licensee has not deployed equipment, making the PAL licenses subject to a "use-it or share-it" condition.

Instead of requiring PAL users to predict with any amount of certainty where they will not deploy and where spectrum available could be available to other users for a set time period, the FCC defined PAL protection criteria that SAS administrators, including Federated Wireless, will enforce on a real-time basis. To protect PAL CBRS devices, a SAS must not authorize other CBRS devices on the same channel in geographic areas and at maximum power levels that will cause aggregate interference in excess of -80 dBm/10 MHz channel within a PAL Protection Area. This aggregate co-channel interference level was defined utilizing common inputs and assumptions – including the propagation model and any clutter or terrain assumptions – during the SAS approval process. This approach is consistent with the methods that will be used to model and measure the aggregate interference to protect incumbent FSS earth stations and incumbent Federal radar systems. Said another way, the SAS will authorize GAA use of PAL spectrum so long as the -80 dBm/10 MHz channel protection level is met (see Figure 3 below). If a PAL licensee registers a new CBRS device in its licensed PAL Protection Area that would conflict with the previously authorized lower-tier user,

the SAS will inform the GAA user that it may no longer have access to that spectrum and that it must request a new authorization.

Figure 3 – PAL Protection Area



This use-it or share-it approach provides higher tier users with enough certainty that the spectrum they have purchased via auction is available to them when and where they need it without having to make business decisions years in advance. It also provides opportunistic access for lower tier users who may only need the spectrum on a temporary basis to support a particular event or who are looking to tailor their network to a specific set of needs, such as Industrial Internet of Things (IIoT) or security.

We anticipate that PAL license holders will opt to lease their unused spectrum to other users rather than allowing GAA users to operate under the use-it or share-it rules. By offering leases to GAA users, the PAL license holders will be able to monetize any unused portions of their licensed spectrum and count the deployments of their lessees towards their own FCC performance obligations. In turn, the GAA users are likely to enter into leases with PAL license holders in order to have greater certainty regarding spectrum access rights. The Federated Wireless SAS will facilitate these secondary market transactions through the automation of spectrum leasing and the elimination of transaction costs and administrative burdens.

b) Maximizing Spectrum Access for a Variety of 5G Use Cases

As the tiered shared access licensing approach in the CBRS band becomes commercial reality in the United States, we are seeing an unprecedented number of new uses cases emerging as the result of new spectrum access options becoming available. These new use cases include:

IN-BUILDING	PUBLIC SPACES	INDUSTRIAL IoT
<ul style="list-style-type: none"> • Education • Military • Hospitality • Healthcare • Multi-family Residential • Office Space 	<ul style="list-style-type: none"> • Entertainment • Government • Retail 	<ul style="list-style-type: none"> • Manufacturing • Mining • Oil and Gas • Power and Utilities • Transportation

The flexible multi-tier licensing framework lowers the barrier to spectrum and promotes success-based investment for new entrants. While focused on LTE initially, the CBRS band will soon transition to 5G as equipment becomes available, offering cost-effective solutions for both indoor and outdoor applications, opening up new use cases, and encouraging business innovations from old and new players alike.

As IMDA seeks to encourage the development of a robust 5G ecosystem for Singapore, we believe a combination of licensed, shared-licensed and unlicensed in the **same** band will best achieve IMDA’s goals of encouraging innovation and “enabling enterprises and operators the ability to develop new business models, applications, services, products and capabilities.”

IV. Conclusion

Federated Wireless appreciates the opportunity to share its perspectives on IMDA’s proposals for the issuance of spectrum to support 5G services. Dynamic sharing technology is available today that can be readily adapted to meet the unique challenges of the Singaporean market. We encourage IMDA to consider the use of shared spectrum access system to maximize access to the 3.4-3.7 GHz band for 5G services while providing protection to FSS services at the same time. We also encourage IMDA to consider enabling license holders to lease spectrum on a voluntary basis and to enable both licensed and unlicensed access to 5G bands to drive the development of a robust ecosystem and the rapid introduction of a wide variety of 5G technologies and use cases.