

Consultation on the Spectrum Outlook 2018 to 2022

SLPB-006-17

**Comments of the
Radio Advisory Board of Canada
February 16, 2018**

Question 1: What future changes, if any, should ISED examine with regard to the existing licensing regime to better plan for innovative new technologies and applications and allow for benefits that new technology can offer, such as improved spectrum efficiency?

1. Over the last two years, ISED, through the Spectrum Application Modernization – Commercial Software Implementation (SAM-CSI) project, has made a substantial change to its informatics infrastructure by changing the entire spectrum system. In the future, the RABC foresees a number of technology changes, including devices that will dynamically access spectrum. As we advance toward those changes, we believe that the demand through the Internet interface of the new SAM-CSI system will increase. We also understand that the industry will need to rely on one and only one official source of information in order to easily perform interference calculations and assessments. Therefore, the use of the ISED database information will become more frequent and it will be required to be robust and contain accurate data.
2. RABC members are active users of the current system, and we believe that ISED should consider the following:
 - When spectrum is shared, interference calculations are important and these require completely accurate technical data. A system should be put in place to identify invalid or incomplete system information, and the owner should be contacted and required to provide appropriate changes to their licence data. Given that the RABC foresees an increased level of spectrum sharing between licensed services (e.g., as proposed in the mmWave consultation for the coexistence of FSS and terrestrial flexible-use services in the 28 and 37-40 GHz bands), it is essential to ensure the accuracy of technical data stored in ISED's databases to enable effective coordination.
 - The SAM-CSI system will be heavily used by an increasing number of spectrum users. Overall system performance should be improved. Currently, a query sent to the system often takes several minutes to load or sometimes results in a 'timeout' issue.

Question 2: Do you agree with the above assessment on demand for commercial mobile services in the next few years? Is there additional information on demand, which is not covered above, that should be considered? If so, please explain in detail.

3. RABC agrees with the Department's assessment of the expected continuous growth in demand for commercial mobile services in the coming years,¹ as recognized in recent

¹ SLPB-006-17, paragraphs 34 and 35.

ITU-R documents that have estimated the spectrum needs of mobile service into the year 2025 and beyond.²

4. RABC also supports the Department's recognition that the "continued growth in data traffic generated by an increasing number of users in various sectors and the data-intensive applications running on mobile networks may not be sustainable with the use of existing mobile spectrum only."³
5. For example, Virtual Reality (VR) services give users the ability to access the sights and sounds of remotely located complex systems in real-time.⁴ With recent progress made in rendering devices, such as head mounted displays (HMD), a significant quality of experience can be offered. Third Generation Partnership Project (3GPP) has concluded a study on VR⁵ and, as a result, several studies and work items have been initiated in Rel-15, so that 3GPP NR (New radio) will be able to fulfil the VR requirements of enhanced bit rates and latency. This will put pressure on the existing spectrum to support these applications.
6. RABC would like to point to an in-depth study done by Arthur D. Little on 5G business (the "A.D. Little Study"), on demand and rollout models based on current activities from global carriers and non-traditional carriers.⁶ This study listed a number different rollout models, namely:
 - 1) Gigabit broadband to the home (Verizon);
 - 2) Next generation mobile user experience (T-Mobile);
 - 3) Future corporate networks (Vodafone); and,
 - 4) Digital industrial ecosystems (Korea Telecom).
7. In many of these rollout models, 5G capabilities such as very high speed, very low latency and a massive number of connected devices/users are absolutely needed. Sufficient spectrum at different frequency bands will be a critical component to the success of these models. Detailed descriptions of these models follow.

² ITU-R Recommendation M.2083 "IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond"; section 2.2

³ SLPB-006-17, paragraph 42.

⁴ Recommendation ITU-T Q.1702 and Recommendation ITU-T Q.1703

⁵ TR 26.918, "Virtual Reality (VR) media services over 3GPP"

⁶ http://www.adlittle.com/sites/default/files/viewpoints/adl_5g_deployment_models.pdf

#	5G rollout model	Target customer segment	Description	Key success factors for the telco	Benefit to the telco
1	Gigabit broadband to the home	Urban & sub-urban homes for high-speed BB	Provide gigabit speeds and better infotainment services to homes	<u>Spectrum</u> : mm wavelength spectrum <u>Infrastructure</u> : Complementary gigabit coverage to existing fiber with small cells, beam forming, MIMO, full duplex Verizon plans to provide 5G BB to 11 cities (Feb 2017)	Gigabit broadband to offer next-gen services to households, such as virtual reality, immersive sports
2	NextGen mobile user experience	Mobile customers	Provide high-speed enhanced mobile broadband and related services such as augmented reality	<u>Spectrum</u> : Low, high & mm wavelength spectrum <u>Infrastructure</u> : Nationwide mobile coverage, small cells, beam forming, MIMO, full duplex T-Mobile plans nationwide 5G in USA (May 2017)	Enhanced mobile broadband (eMBB) driving customer experience, augmented reality, etc.
3	Future corporate networks	Large corporates, enterprises, manufacturers	Provide high-speed and high-reliability networks to improve productivity and reduce costs	<u>Spectrum</u> : High band spectrum <u>Infrastructure</u> : Coverage of key business areas, FTTX, small cells, beam forming, MIMO, full duplex Vodafone plans to provide 5G to businesses – driving agility, efficiency, digital transformation	Position telcos as partners of corporates to drive efficiency and productivity for corporates
4	Digital industrial eco-systems	Multiple application/ services providers in a specific industry	Provide an ecosystem that brings multiple solution providers together	<u>Spectrum</u> : Different bands based on use case <u>Infrastructure</u> : High density coverage, massive machine type communication (mMTC), mastering IoT Korea Telecom developing 5G platform for 2018 Olympics with broadcasters, other vendors	Participate in value creation in ecosystems, e.g., smart city
5	NextGen Infra-as-a-Service	Other telecom operators	Provide high-quality, low-cost, nationwide 5G infrastructure	<u>Spectrum</u> : Low, high & mm wavelength spectrum <u>Infrastructure</u> : Nationwide mobile coverage, FTTX, small cells, beam forming, MIMO, full duplex	Enabling the ICT industry in the country by providing nationwide carrier-neutral 5G infrastructure

Source: Arthur D. Little

Gigabit broadband to the home

8. 5G is seen as complementary to other last mile technologies, such as fibre-to-the-home (FTTH) and cable-based broadband, as in the case with Verizon. Therefore, 5G is expected to deliver data streams rated at hundreds of megabits per second to gigabits per second. These faster data rates are needed to deliver television at resolutions beyond 4K (6K, 8K, and possibly beyond), as well as both VR and Augmented Reality (AR) applications.⁷

Next-gen mobile user experience

9. 5G could be used to simply provide better and faster mobile service (Enhanced Mobile Broadband or eMBB) nationally, as in the case with T-Mobile taking advantage of low band 600 MHz obtained in the most recent auction.⁸

Future corporate applications

10. For the global operator Vodafone, 5G is envisioned as providing super high speed and reliability. In collaboration with partners, Vodafone is developing specific enterprise applications and ecosystems to increase productivity;⁹ for example, with automobile companies such as BMW, Daimler, Ford, General Motors, etc. To achieve this objective,

⁷ <http://variety.com/2018/digital/news/nbc-2018-winter-olympics-vr-virtual-reality-live-streaming-1202657978/>

⁸ <https://newsroom.t-mobile.com/news-and-blogs/nationwide-5g.htm>

⁹ <https://www.mobileworldlive.com/featured-content/top-three/enterprises-key-for-5g-opportunity/>

Vodafone is relying on building a fully integrated access-agnostic core supporting all the different access technologies, such as fixed, fibre, DSL, all types of cellular and Wi-Fi.

Digital industrial ecosystems

11. According to the A.D. Little Study, digital industrial ecosystems require network configurations from which involved industries can benefit. These include agriculture, smart cities (including urban transport), healthcare, etc. The technological requirements include ultra-reliable, low-latency communications networks (URLLCs) that provide dedicated features necessary for specific use cases.
12. For example,
KT is planning to set up a 5G ecosystem in Korea for the 2018 Winter Olympics. It plans to connect key Olympics venues via 5G-based networks, with a platform allowing connection by broadcasters, athletes, users and sponsors. Some of the services expected to be offered are a 360-degree virtual-reality view of key events, “Omni Focus” (multi-view streaming), “Time Slide” (multi-view videos), “Hologram Live” (to bring spectators closer to athletes), a 5G autonomous bus for transportation, drone-equipped remote video, and others.¹⁰

Question 3: What new technology developments and/or usage trends are expected to address traffic pressures and spectrum demand for commercial mobile services? When are these technologies expected to become available?

13. RABC agrees with the consultation’s reference to the ITU assessment on the “need to improve access to and efficient use of spectrum to accommodate the large amount of data traffic that is expected to be generated by advanced mobile devices”.¹¹ The Board also supports the Department’s assessment that technology development is important in maximizing use of spectrum,¹² as it is a limited resource that must benefit all Canadians. RABC also agrees with the Department’s view that massive multiple input, multiple output (MIMO) technology, full-duplexing, and carrier aggregation (CA) techniques are new emerging technologies that will assist in the much more efficient use of spectrum.¹³
14. CA techniques have been implemented to support the demand for services requiring very high data speeds in the absence of single radio frequency (RF) channels that have

¹⁰ http://www.adlittle.com/sites/default/files/viewpoints/adl_5g_deployment_models.pdf, Page 13-14.

¹¹ SLPB-006-17, paragraph 37.

¹² SLPB-006-17, last sentence of paragraph 38.

¹³ SLPB-006-17, paragraph 38.

sufficiently broad bandwidths. However, it is worth noting that there are limitations to CA regarding efficient spectrum use and the practical benefits it brings, including:

- The design of RF front ends (particularly in global stock-keeping unit user equipment (SKU UE)) is very challenging. Leakage, harmonics, and intermodulation products among multiple carriers effectively desensitize a smartphone's primary receiver. The consequence is reduced coverage and, within coverage, there is a reduced capability in the modulation coding scheme, in other words, a reduction in throughput compared to theoretical expectations.
 - To prevent interference, the filters in the RF front-end must provide very high rejection of the problem-causing harmonics, without adding unacceptable insertion losses that could compromise the system's ability to meet link budgets.
 - In spite of advances in filter technology, insertion losses are not zero, and practical CA devices suffer performance degradation with the addition of each carrier to the mix. The addition of narrow bandwidth carriers may in fact reduce the ability to design improved performance devices.
 - The implementation of MIMO requires more transmit and receive RF chains, costly in both dollars and power consumption. Obviously, implementation of MIMO on a single broadband carrier is more practical than on multiple carriers (now up to 32 carriers for LTE). One only has to imagine the implementation difference as the system moves from 4x4 to 8x8 to 16x16 antennas, then to massive MIMO.
 - CA as currently implemented in standards is asymmetrically weighted in favour of downlink over uplink. Essentially, this relates again to the complexity of UE front-end design. Added uplink component carriers exacerbate intermodulation issues encountered in CA. Practically, uplink CA beyond 2 carriers is seen by 3GPP as pointless. As such, higher data rates in the uplink through the use of CA in FDD is very limited.
15. Such limitations are not the case for larger, single carrier deployments, and spectral efficiency is even better with TDD implementations. Therefore, the Department should take into account that the use of wider, single carrier bandwidths over the use of CA is preferable to achieve broadband capacity in the most spectrally efficient manner. This is recognized in ITU-R Report M.2410, which states a minimum bandwidth requirement of 100 MHz and the need to "support bandwidths up to 1 GHz for operation in higher frequency bands (e.g. above 6 GHz)."¹⁴

¹⁴ ITU-R Report M.2410, section 4.13 "Bandwidth"

16. One important technology development in implementing 5G commercial mobile services in frequency ranges above 24 GHz will be antenna beamforming. Such emerging technology, relying on a large number of antennas (physically small in these frequency ranges) and sophisticated control mechanisms, is expected to have two advantages. First, it is expected to provide higher gain that will compensate for the higher propagation loss, which in turn will allow the range to be sufficient to address high traffic urban areas. Second, the antenna beam is expected to be highly directive providing the gain towards a specific user, while minimizing gain in other directions and therefore potential interference to other users. Such beams will also be dynamic, meaning they can track users as they move. Such technology is expected to be implemented as 5G networks above 24 GHz are deployed.

Question 4: Recognizing the trend of increasing commercial mobile traffic, what operational measures (e.g. densification, small cells or advanced traffic management) are being taken to respond to, and support, increasing traffic? To what extent are these measures effective?

17. RABC agrees with the Department's assessment that, "Mobile operators have several options available to optimize the use of their spectrum to meet increased traffic demand, such as densifying their networks, deploying efficient equipment and employing more sophisticated traffic management techniques."¹⁵
18. One such promising operational measure is Self-Optimized Network (SON), a new feature allowing more effective planning, implementation and optimization of an access network. One of its expected benefits is to allow in real time the changing of frequency allocation to accommodate moving traffic (such as morning and after-work traffic), so SON can allocate spectrum where needed and not use it where there is no traffic demand. This, on top of other spectrum management techniques, is expected to further optimize spectrum use. However, such spectrum optimization techniques, although helpful, are not expected by themselves to meet the growing pressure on commercial mobile spectrum as reflected in the Department's comment, leading to the need to identify further frequency ranges.¹⁶

Question 5: Do you agree with the above assessment of demand for licence-exempt spectrum in the next few years? Is there additional information regarding demand, which is not covered above, that should be considered? If so, please explain in detail.

19. RABC understands that this question relates to new on-demand dynamic spectrum access technologies, such as that of white space devices. We believe this technology

¹⁵ SLPB-006-17, paragraph 42.

¹⁶ SLPB-006-17, paragraph 42-43.

shows great possibility, but broadcasters are concerned about the availability of reliable bandwidth for wireless microphones. There is currently a serious issue in the market regarding the operation and the communication reliability of wireless microphones. The 700 MHz band was exceptional for these small devices. It is now allocated to public safety among others. When wireless microphone users lost this band in March 2012, new wireless microphones operating in the 600 MHz band had to be purchased. This band was also reallocated only three years later.

20. From an operations standpoint, it is impractical for a team of press reporters or a live news reporting team to have to reserve a UHF RF channel through the portal created by Keybridge. Newsworthy events develop unexpectedly in unforeseen locations. News teams then go on location, and their wireless microphones must be working, which may be challenging if the white spaces are being used in the future.
21. With the new DTV plan making for an increasingly congested UHF band, and with the implementation of white space device technology, reliable and quality spectrum is a major requirement for any activity making use of a wireless microphone and intercoms, such as the radio and television broadcast industry, shows, press conferences, etc. So, from a technical standpoint, it is desirable that frequency bands dedicated to wireless microphones and intercoms be identified.
22. RABC agrees with the Department's assessment that, "Moreover, with the increase in commercial broadband traffic, service providers are also deploying Wi-Fi hot spots to off-load some of the traffic from their commercial broadband networks."¹⁷ However, it should be noted that, as in the United States, Wi-Fi offloading for commercial mobile service is seen as a requirement, not because it is a good technical choice, but simply because there is no other choice due to a lack of sufficient licensed spectrum. Increasing unlicensed spectrum alone will not meet quality-of-service needs for all applications and should be seen as a complement to licensed spectrum for the future of broadband service delivery to Canadians. "Best-in-class" service delivery is not achievable through Wi-Fi's "best-effort" communications.
23. The Board also wishes to reinforce the growing need for licence-exempt spectrum for industrial IoT, in particular for Canadian electric utilities (CEUs). Automation will continue to expand into the distribution system to enable integration of distributed energy resources (including and especially renewable resources) and to facilitate system reliability and safety. There will be more sensors and actuators and more traffic with these field devices. Licence-exempt can meet some of these needs and is often used because (i) there is low cost equipment available in these bands, and (ii) these bands are not constrained by an onerous licensing process or costly fees. Licence-exempt is also commonly used by CEUs in rural Canada, where there are fewer customers, less

¹⁷ SLPB-006-17, paragraph 50.

interference, and less return on investment to support pursuing more costly licensed options.

Question 6: *What new technologies and/or sharing techniques are expected to aid in relieving traffic pressures and addressing spectrum demand for licence-exempt applications? When are these technologies expected to become available?*

24. Previously, licence-exempt spectrum has been allocated to specific services. Given the migration to Internet Protocol (IP), the Department should consider allowing all uses of licence-exempt spectrum provided they meet the spectrum occupancy and emission regulations.
25. As software defined radio technology improves and cost decreases, users will be able to dynamically select bands to best avoid interference.

Question 7: *What existing licence-exempt frequency bands will see the most evolution in the next five years? Are there any IoT applications that will have a large impact on the existing licence-exempt bands? If so, what bands will see the most impact from these applications?*

26. With the 600 MHz repack in the UHF band and the new rules around white space devices in that band, the 600 MHz band will be more and more occupied, leaving very little freely available bandwidth for unlicensed use. Details concerning WSD and wireless microphones have been given to ISED through the Board's responses to the consultations SMSE-018-17 and SMSE-019-17.
27. RABC anticipates continued deployment of smart metering in the 915 MHz band by CEUs. Additionally, electricity customers (industrial, commercial, and residential), are increasingly investing in customer generation and energy management, and making use of licence-exempt spectrum for monitoring, automation, and control of these applications.

Question 8: *Will the trend for offering carrier-grade or managed Wi-Fi services continue to increase over the next five years? If so, will this impact congestion in Wi-Fi bands and which bands would be most affected?*

28. The Board has not responded to Question 8.

Question 9: ISED is seeking comments on the above demand assessment for MSS and earth observation applications for the period 2018-2022. Is there additional information on demand, which is not covered above, that should be considered?

Earth Observation Satellites

29. RABC agrees with the Department's views as outlined in paragraph 87 and 88 of the Consultation. As noted by the Department, Earth observation satellites (passive and active) are very important in producing reliable monitoring and management decisions in different areas such as agriculture sustainability, climate change, Earth system science, energy management, biodiversity and ecosystem studies, water resources management, disaster risk reduction, national security and sovereignty. As a result, many Earth Exploration-Satellite Service (EESS) satellites have been launched due to the growing user demand, as well as the technological advancements in satellite sensor and imaging design techniques.
30. The design features of EESS satellites are being customized around user and application demands (e.g. the panchromatic datasets are acquired in higher spatial resolutions and the spectral resolutions have been increased from multispectral to hyperspectral sensors). These technological advances in imaging have resulted in reducing the distinguishable size of objects on the Earth's surface and have reduced the intervals between imagery acquisitions.
31. Nowadays, small satellites can provide capabilities that larger and more expensive systems could not do in the past. Small satellites are able to produce higher quality imagery, and can achieve attitude-change maneuvers much faster than larger platforms. Due to the continuing advances in the technology, small spacecraft now have low mass, shorter development time, and are low cost to build and launch. As a result, they have enabled the emergence of new EESS missions. There are now many private companies that have already launched their constellation of EESS satellites and many more are expected to join them shortly.
32. Private firms in the past never seriously considered launching Synthetic Aperture Radar (SAR) EESS due to the heavy investment involved. Due to the advances in technologies, private firms have begun to develop SAR satellite systems. For example, a Finnish Company (Iceye), is in the process of launching a constellation of 21 SAR satellites.
33. All these new low cost and powerful small satellites will need increasing amounts of radio spectrum beyond what has been witnessed to date. As a result, RABC's view is that ISED should not only consider above comments regarding EESS in its decision regarding the current Consultation, it should also consider new allocations for use by small satellites. RABC also recommends safeguarding the currently allocated spectrum

to earth observation (passive and active), and space research domestically and internationally in general, and at the upcoming WRC-19 Conference.

All Satellite Services

34. RABC agrees with the Department that the Canadian territories include vast land masses and widely dispersed population and, as a result, satellite systems play a vital role in providing communications capabilities in rural, remote and northern communities. As the consultation states (para 58), “In these communities, satellite systems provide the backbone for, or direct access to, essential services such as basic telephone, broadcasting and Internet services.” Also, in both urban and rural areas, satellite services play a critical role in times of emergency, such as natural disasters. It is, however, noted that provision of services in the northern territories and unpopulated areas is only economic when the satellite can also provide services over populated and urban areas.
35. It is anticipated that there will be a significant market for satellite systems to provide Narrow Band-Internet of Things (NB-IoT) networks especially for rural and remote areas with low terrestrial network connectivity. RABC believes that this is why satellite operators are further investing and collaborating to develop services and hardware that can improve Internet of Things (IoT). It has been stated that the global satellite Machine-to-Machine (M2M) and IoT market will reach 5.96 million in-service satellite M2M/IoT terminals by 2025.¹⁸ The report finds the most lucrative application is land transport; however, other key verticals will also record strong growth. Longer term, IoT-dedicated smallsats will also enter the market, providing unique and potentially compelling value propositions allowing more cost efficient IoT/M2M services than existing satellites can provide.
36. As discussed more fully in the response to Question 10, RABC agrees with the Department’s description of the key role that satellite services, including mobile satellite services, play in Canada. With specific reference to MSS, RABC in particular notes that:
- Many services provided by MSS are not addressable by means other than satellite systems due to mobility demands that need to be global (i.e. maritime and aeronautical), or at least multi-regional in nature. In addition, MSS is capable of serving rural and remote/unconnected parts of a given country.
 - MSS applications have increased in the last few years due to advances in both space segment and ground segment technologies. The forecast is that the trend will continue for years to come, especially for in-flight connectivity and maritime satellite communications, where both applications are mainly driven by data communication.

¹⁸ Northern Sky Research’s (NSR) “M2M and IoT via Satellite, 7th Edition M2M7”

- A critical component of mobile communications via satellite is the antenna at the user segment of the network. This is currently being addressed by advances in development of Flat Plate Antennas (FPA).
- FPA, together with advances in spacecraft technologies with very powerful spot beams, will make MSS accessible to users everywhere.
- Many of the new mobile applications will require MSS to deploy future technologies in order to move to new and/or higher frequency bands. There are broadly three such categories of demand drivers: (i) video, (ii) weather, navigation, traffic and other environmental data, and (iii) IoT related data from connecting billions of sensors, devices, machines, connected and self-driving cars, etc.
- As in the case of FSS, (see response to Question 11), advances in technologies related to Closed-Circuit Television (CCTV) and associated security requirements, and the need for precision GPS in agriculture high frequency data analysis could drive the spectrum pressure due to IoT over MSS.
- Since satellite networks are believed to be less vulnerable to physical attacks and natural disasters and given their wide and ubiquitous coverage areas and advances in technologies, satellites are often a suitable delivery method for highly secure and mission-critical services. This is driving demand for MSS (as well as for FSS).

Question 10: ISED is seeking comments on the above demand assessment for FSS/BSS for the period 2018-2022. Is there additional information on demand, which is not covered above, that should be considered with regards to the below bands?

37. Environment Canada is using FSS to provide warning of natural and environmental disasters and detailed understanding of the status of global water resources. This service is important to CEUs for the monitoring and management of water systems necessary to generate hydro-electric power.
38. Explosive growth in demand for ubiquitous data services and new and expanding usage trends and markets, such as Internet of Things/M2M¹⁹, aeronautical and maritime connectivity, OTT video, 5G backhaul, connected cars, 4K TV, security applications, the need for precision GPS and near real-time data analysis in agriculture and other sectors, and new and enhanced navigational, weather, traffic and other environmental data applications, are expected to significantly increase demand for fixed-satellite services

¹⁹ ibid

(FSS) over the next five years. To meet this increased traffic, and in particular to deliver the highest quality services in all regions of Canada, including the most remote, the requirement pressure for satellite spectrum is anticipated to continue increasing.

39. Satellites are well suited to address these trends in demand for, and usage of, data services, given their broad coverage areas and ability to support anywhere, anytime connectivity. Key areas of strong and growing demand for satellite services include consumer, business and government demand for data services to areas that are beyond the practical reach of terrestrial networks, including demand for connectivity in unserved and underserved areas and on ships and planes, and from IoT and other applications that require global connectivity. Demand for satellite backhaul services, supporting 5G extension, IoT and other services, is also expected to increase. The significant improvement in spectral efficiency and satellite broadband capacity due to new satellite technologies described in response to Question 11, such as high throughput satellite (HTS), will enable satellite networks to meet this increased demand for satellite services, provided that sufficient spectrum is available.
40. Meanwhile, longstanding broadcasting use of C-band and Ku-band satellite spectrum should remain relatively constant, with some increasing demand pressure from 4K TV. Therefore, demand for satellite services is forecast to grow significantly and outstrip available spectrum in the Ku and Ka-bands over the next 5 years, while demand for C-band satellite services and spectrum is expected to be stable.

C-band

41. For over 45 years, C-band FSS has been used to support the delivery of critical telecommunications services to Canadians. As indicated in the Consultation Document, C-band is used extensively in Canada for the delivery of Canadian and United States broadcasting signals to cable head-ends. C-band FSS is also used by organizations such as NAV Canada and National Defence to support critical systems (e.g. advanced surveillance systems, aircraft communications, and emergency response communications), as well as for vital telephone and broadband communications to rural and remote communities. CBC, for example, relies on C-band for the delivery of its signal throughout Canada, while the North Warning System (NWS) depends on C-band to connect stations above the Arctic Circle to the South to support air surveillance under the North American Aerospace Defence Command. Numerous remote Canadian communities also rely on C-band FSS to communicate with the rest of Canada and elsewhere.
42. The robustness of the C-band signal is critical to existing uses and users. In addition, C-band permits wide-beam coverage that is essential for a vast country such as Canada, especially for coverage beyond the Arctic Circle. These characteristics of C-band are a key reason why CBC/Radio-Canada recently invested more than \$20 million in its C-band

distribution infrastructure, which includes more than 425 receiver sites in Canada. More generally, there is a huge amount of deployed C-band satellite infrastructure servicing existing C-band users, including in urban areas.

43. Broadcasting demand for C-band satellite services is not expected to decline in the near future, and may in fact increase as 4K TV is rolled out. While some existing C-band satellite broadband use may migrate to new Ku- and Ka-band solutions, this will free up C-band for higher capacity/speed broadband service in other communities. If satellite is used for transport to a community earth station (the community aggregator model), the size of antenna required for C-band reception is not an issue. Moreover, where C-band satellite infrastructure already exists, it can be used to support highly cost-effective and rapid rollout of enhanced broadband service.
44. Therefore, demand for C-band FSS is expected to remain relatively constant over the next five years.
45. Measures must also be taken to ensure that, despite future allocations, Canada will continue to offer reliable satellite service to reach Canadian northern communities with a strong reliability.

Ku-band

46. RABC agrees with the Department that Ku-band satellite spectrum is highly congested today and will remain so over the foreseeable future. The Ku-band is used for a wide variety of services, including broadcasting (to cable head-ends and DTH), for VSAT services such as credit card transactions, satellite news gathering, aircraft and maritime applications, government services and Internet services. DTH demand for Ku-band satellite services is not expected to be affected by reductions in the number of DTH subscribers. Some DTH subscribers in urban areas have migrated to IPTV, but DTH remains critical to bring the full range of entertainment options to rural and remote areas. Demand for Ku-band satellite broadband services is, and is expected to remain, strong in general and in particular market segments such as the aeronautical and maritime sectors. In addition, although satellite-enabled IoT is currently dominated by narrowband providers, the advent of new satellite networks in Ku and Ka-band will also serve the growing IoT and M2M sectors.
47. New satellite technologies (see response to Question 11) are being rolled out to meet this demand and, in turn, are driving additional satellite traffic and demand for spectrum. While HTS technology and compression support more efficient use of Ku-band spectrum, these technologies may not off-set increased demand for Ku-band satellite broadband data services and from 4K TV. Accordingly, Ku-band satellite spectrum is expected to remain highly congested. Some new LEO systems (see response to Question 11) propose to use Ku-band for their communications with user terminals,

due to the favourable propagation conditions relative to Ka-band. The sharing of Ku-band spectrum between non-GSO and GSO satellites, through the concept of EPFD limits developed by the ITU and detailed in Article 22 of the Radio Regulations will significantly increase the efficiency of spectrum usage in these bands.

Ka-band

48. As recognized in the Consultation Document, demand for Ka-band satellite services is growing and will continue to grow significantly over the next five years, fueled by growth in demand for broadband Internet and data intensive applications. As discussed in the response to Q.11, new Ka-band HTS GSO satellites and low earth orbit (LEO) satellite constellations are being deployed to meet the growing demand for satellite data and satellite backhaul services. These new satellite systems as well as other technology developments (such as earth station in motion systems and advancements in antenna technology) are, in turn, driving increased satellite traffic and demand for Ka-band spectrum.
49. Demand for Ka-band satellite services is therefore expected to exceed the capacity of Ka-band spectrum that has been allocated to satellite services.

Question 11: What and how will technology developments and/or usage trends aid in relieving traffic pressures and addressing spectrum demand for satellite services? When are these technologies expected to become available?

50. Satellite technology advancements are being rolled out in response to the explosive growth in demand for ubiquitous data services and new or expanding usage trends and markets. In particular, developments in satellite technology, such as HTS technology, earth-station-in-motion (ESIM) systems, LEO satellites, and flat panel earth station antennas (FPAs), cater to these usage trends. HTS technology, for example, substantially increases satellite broadband capacity and speed. LEO constellations will support fibre-like high-speed fixed broadband services anywhere in Canada, including in currently unserved and underserved areas. LEO constellations will also support, through backhaul or direct-to-user services, the extension of advanced mobile service capability to areas where low population density makes terrestrial deployment challenging. Similarly, ESIM systems and advances in FPAs support anywhere, anytime connectivity.
51. While HTS satellites significantly increase spectral efficiency, HTS satellites, ESIM systems and LEO satellites along with other technological developments such as advances in Close-Circuit Television (CCTV) and 4K TV are all expected to result in increased satellite traffic over the next five years.

HTS Technology

52. HTS satellites employ a large number of spot beams, enabling multifold reuse of the same spectrum, thereby increasing spectrum efficiency and significantly enhancing satellite broadband capability. FSS geo-stationary satellites are using HTS technology today and LEO satellites will also employ this technology. Telesat's GSO Telstar 12 Vantage, 18 Vantage and 19 Vantage HTS satellites all include Ku-band or Ka-band spot beams that make intensive use of the spectrum to meet growing customer demand for high-speed data services. A number of other satellite operators have also launched and/or are poised to launch HTS satellites. For example, Echostar and ViaSat launched new HTS satellites last year supporting high-speed broadband service in the Americas and have announced plans for additional HTS satellites. The next generation of BSS satellites will also incorporate HTS technology to support on-demand video capability, with individual streams dedicated to single users. However, HTS technology cannot address spectrum requirements for the delivery of DTH or broadcasting services to cable head-ends. These services require the delivery of the same content across wide geographic areas, for which wide-coverage beams are best suited.
53. Both user terminal and feeder link (gateway) satellite spectrum is required to support HTS services. Because user terminals are ubiquitous and are well suited to blanket licensing, user terminal spectrum is not amenable to sharing with other services. Gateways are relatively few in number, are usually individually licensed, and typically have larger aperture antennas than user terminals. Gateway spectrum can therefore be shared with other services, provided there exists an appropriate and well-defined regulatory framework.

ESIMs

54. Technological advancements in ESIMs over the next four years, such as higher efficiency phased array antennas and advanced digital signal processing, will facilitate the delivery of broadband capacity via satellite to ships and planes to support a multiplicity of end-user applications using both GSO and non-GSO (e.g., LEO) satellites. The resulting increase in satellite traffic is expected to put increased pressure on satellite spectrum.

LOW EARTH ORBIT NGSO satellites

55. LEO systems are also being deployed to meet demand for ubiquitous high-speed satellite data services. These systems will offer fibre-like connectivity anywhere, and are expected to both compete with and complement fibre and terrestrial wireless infrastructure. High capacity, low latency LEO systems will support the extension of 5G compatible services to rural and remote communities, IoT/M2M and connected cars, air and maritime data markets, public and private sector demand for high-speed broadband

services. 3GPP is studying²⁰ the inclusion of satellite within 5G. Satellite systems provide geographic coverage of all of Canada, including territorial waters. Where terrestrial backhaul networks are not economic or are temporarily affected by natural disaster, satellite provides backhaul solutions for mobile networks. Innovative new LEO satellite systems²¹ will be capable of providing backhaul/transport connectivity and capacity for 5G as well as 5G compatible mobile satellite service/IOT. Three such LEO systems have already been licensed by Canada – Telesat’s Ka-band and V-band constellations and OneWeb’s Ku/Ka-band constellation. Telesat launched its first Phase 1 LEO satellite in January 2018 and OneWeb has announced that it will launch its initial satellites in the very near future. Several other constellations that would cover all or portions of Canada have also been proposed.

56. As with HTS, LEO constellations require satellite spectrum for ubiquitous user terminals, as well as for a limited number of gateway earth stations. LEO constellations will significantly increase satellite requirements for both user terminal and gateway spectrum.

4K TV

57. As noted in the Consultation Document, 4K TV increases bandwidth and spectrum requirements relative to lower definition signals, although advances in video compression technologies offset to some extent the increased spectrum requirements. Roll-out of 4K TV during the next four years will be driven by consumer demand and is expected to be gradual. Even with advanced compression technologies, it is expected that 4K TV will put increased pressure on BSS and FSS spectrum, the latter being used for distribution of television programming to network affiliates and cable headends.

Flat Panel Antennas

58. A critical component for the provision of mobile satellite services and many fixed satellite services is the user terminal antenna. Advances in FPAs have greatly improved user terminal performance and cost-effectiveness. FPAs, together with new spacecraft that employ signal processing and very powerful spot beams, have increased MSS and FSS capabilities and spectral efficiency, but the increased traffic resulting from these capabilities has increased, and is expected to continue to increase the pressure on satellite spectrum.

²⁰ See, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Study on New Radio (NR) to support Non Terrestrial Networks (Release 15), Technical Report, 3GPP TR 38.811 v.0.10 (June 06, 2017).

²¹ Ka-band and V-band satellite and constellation designs provide higher throughput and capacities while maintaining nationwide and even global coverage.

Question 12: What satellite applications (e.g. broadband Internet, video broadcasting, backhaul, etc.) do you consider a priority for the period 2018-2022?

59. All three applications mentioned above, namely broadband Internet, video broadcasting, and backhaul, are likely to be the main type of traffic on FSS satellites in the next five years. Broadband Internet is poised to become the highest growth application in this period, and such services are likely to be delivered directly to consumers (HTS-DTH, LEO-DTH), or backhauled over satellite to reach remote and rural communities, through a community earth station model and is then distributed locally via wireline, wireless fixed access or mobile (5G) technologies. As stated previously, with the arrival of 4K TV and possibly 3D-TV and Virtual Reality broadcasting, the transmission of video programming should remain strong. Some of the existing applications, like the traditional VSATs may lose some ground and be replaced by broadband Internet applications.

Question 13: Do you agree with the above assessment on demand for backhaul in the next five years? Is there additional information on demand, which is not covered above, that should be considered? If so, please explain in detail.

60. Demand for backhaul will be driven by the demand for greater capacity in broadband Internet, mobile bandwidth, video on demand, IoT and many other services. All of the services need to be delivered to and from cable head ends, central processing facilities and telephone exchanges. As the demand for capacity increases, the demand for network capacity in backhaul also increases. To keep up with demand, backhaul networks are offering more and more throughput for a given channel size by deploying higher modulation levels and compression and error correction techniques.
61. In the language of Broadcasters, those links named “backhaul” are in fact studio-transmitter (STL) and transmitter-studio links (TSL). With the SMPTE-2110 including the audio over IP AES-67, the amount of data that will need to be exchanged and sent to a transmitter site will increase. This is only one example of the result of the switch to TCP/IP in the broadcast world, such that broadcasters require more capacity for their point-to-point links. The advent of 4K technology; HDR imaging and IP ATSC 3.0 connectivity also requires higher throughput links between television studios and transmitters. A 40 MHz bandwidth must now be used at the STL level, and it is the same at the TSL level, which means a total of 80 MHz is therefore needed to ensure a high throughput two-way link between the studio and the transmitter to feed both FM Radio and HDTV transmitters.

Question 14: Backhaul service in Canada is delivered using a variety of solutions, including fibre optics, microwave radio and satellites. What changes, if any, are anticipated to the mix of backhaul solutions employed?

62. The choice of technology used for backhaul delivery is often determined by costs (including equipment, installation, operations and licensing).
63. Releasing spectrum bands and equipment certification standards in a timely manner is very important for adoption of wireless backhaul. Wireless backhaul spectrum in the 70/80 GHz (also known as E-Band) and equipment certification standards have been available for years. Around the world, E-band equipment has been widely and successfully deployed to support wireless carriers and enterprise business. However, the fee structure in Canada, based on throughput capacity, has been a very negative factor in getting the E-band in use.
64. When the cost of radio spectrum is simply a multiple of the number of voice channel equivalents and very large channels are available (as is the case in 70 and 80 GHz), then the high cost of fibre backhaul becomes more cost-effective than the recurring cost for radio spectrum. The cost equations artificially begin to favour fibre even more quickly when you consider that the distances for the paths is expected to be small, and so the cost to trench for fibre will be much less than it would have been for longer paths. With the current fee structure, an artificial bias towards fibre is being created.
65. Some RABC members are of the view that with the current fee structure, an artificial bias towards fibre is being created. Additionally, they indicated that without removing the cost barrier, available spectrum and equipment could sit idle.

Question 15: What and how will technology developments and/or usage trends aid in relieving traffic pressures and addressing spectrum demand for backhaul services? When are these technologies expected to become available?

66. RABC agrees with the Department's assessment that wireless backhaul is an essential part of successful deployment of the various telecommunication services offered to Canadians. It also agrees that trends in demand for these services will continue to put pressure on spectrum used for backhaul applications.
67. As rightly stated by the Department, to address pressure on bands being used for backhaul wireless service providers are constantly working on improving spectrum efficiency, for example through the use of adaptive modulation, higher order modulation, co-channel dual polarization (CCDP) and intra-band RF channel bonding. In addition to cross-band RF channel bonding already identified by the Department in the

consultation,²² a future technology advancement expected to assist in further maximizing terrestrial backhaul spectrum use is massive MIMO, as described in revision of Report ITU-R F.2323-0 “Fixed service use and future trends” approved at the ITU-R Study Group 5 November 20th, 2017 meeting.²³

68. RABC also notes trends at the international level to open new bands supporting the use of wireless backhaul in urban areas, where wired backhaul solutions (i.e. fibre optic, cable, copper) cannot be used due to various factors (technical, financial or timeliness). This is driven by ever increasing traffic, especially for 5G as noted by the Department.²⁴ The two bands currently foreseen are the 130-174.8 GHz (called D-Band) and 275-450 GHz (being addressed in WRC-19 study cycle under agenda item 1.15). For the D-Band, vendors are already developing prototypes and products could be available as early as around 2020. It is RABC’s view that the D-band band equipment could become available within the Department’s current spectrum outlook period and therefore recommends that the Department make the band or a portion of it available as early as possible. For the 275-450 GHz band, as a decision is not expected until WRC-19 (November 2019), it is anticipated that the band will not be identified for backhaul use during the 2018-2022 timeframe. However, RABC recommends that the Department closely monitor developments in the ITU-R to take advantage of this potential new band.
69. In addition to the bands indicated in Table 4 of section 5.5 of the consultation, RABC recommends that the Department consider the following proposal made by RABC in its response to SMSE-018-12²⁵ related to promotion of efficient use of spectrum for backhaul:
- Spectrum users should be encouraged to be spectrum efficient while being rewarded by economic incentives. The backhaul licence fee formula should be defined in a manner that will encourage operators to maximize transmission throughput over a given channel.
- Economic incentives for modern technology could be developed and applied to the licensing process. A Licence fee regime based on bandwidth used rather than throughput capacity (equivalent voice circuit) could encourage users to adopt spectrum efficient technologies.
70. It is anticipated that technology development in the area of network function virtualization (NFV) may have an impact on backhaul (transport). The virtualization of

²² SLPB-006-17, paragraph 102

²³ ITU-R Document 5/78

²⁴ SLPB-06-17, paragraph 104

²⁵ RABC response to SMSE-018-12 “Consultation on Spectrum Utilization Policies and Technical Requirements Related to Backhaul Spectrum in Various Bands, Including Bands Shared With Satellite, Mobile and Other Services”, section 5.10

base stations may assist in reducing delay in the transport of traffic between the base station and the core subsystem of mobile services networks leading to lower latency supporting delay sensitive services, such as critical communication applications and VR or AR.

Question 16: Will the demand for commercial mobile, licence-exempt, satellite, or fixed wireless services/applications impact the demand for backhaul spectrum? If so, how and which of these services/applications will create the most impact?

71. Licence-exempt equipment located indoors is less likely to require backhaul spectrum, whereas equipment located outdoors is more likely to require backhaul spectrum. Most private indoor licence-exempt devices will be connected to the wireline network requiring no backhaul spectrum. Fixed wireless services and commercial mobile will generate most of the increased pressure for backhaul spectrum. As noted in the satellite section, satellite operators intend to offer backhaul services. If so, this may increase the pressure for satellite spectrum.

Question 17: Is there a range or ranges of frequencies that will be in higher demand over the next five years? Why is higher demand anticipated for these frequency ranges?

72. As demand for increased capacity grows, frequencies that offer greater throughput will be in higher demand. The frequency bands such as E-band (71-76 GHz and 81-86 GHz), W-band (92-114.25 GHz) and D-band (130-174.8 GHz) have much larger available channel sizes than the traditional microwave bands. New radio system designs that combine the distance capabilities of lower frequencies with the large throughput of the frequency bands just mentioned, create systems that offer very large throughput, yet retain some high priority traffic when propagation conditions are less than ideal. As explained in response to Question 15 with an appropriate fee structure, there could be a lot of growth in the E, W and D bands.
73. RABC notes that increased investment in electric supply protection, automation, and control has increased demand for 7125-7725 MHz microwave channels for Canadian Electrical Utilities (CEUs). Increased demand for rural monitoring and control has increased demand for C-band Satellite backhaul for CEUs.

Question 18: Will allowing flexible fixed and mobile services within the same frequency band change how backhaul is planned and used?

74. Flexible licensing may enable the use of self-backhaul as an option under certain deployment conditions, and improve spectrum utilization. Self-backhaul may not be ubiquitous and, thus, may not preclude the need for other forms of backhaul. Self-backhaul, with flexible licensing, may be more cost effective than traditional backhaul in some scenarios.

Question 19: Provide, with rationale, your view of the above assessments on the bands being considered internationally for commercial mobile, fixed, satellite, or licence-exempt.

C-band

75. In 2014, in its decision DGSO-007-14 concerning the C-band, ISED has permitted IMT to be in the band 3.475 MHz to 3.650 MHz, which is separated by 50 MHz from the C-band downlink (3.7 GHz to 4.2 GHz). In order to prevent potential interference from mobile operators using the above mentioned band, the satellite industry using the C-band downlink would need to plan major investment to modify their infrastructure: the LNB needs to be replaced and filtering added in order to reject such potential interference from mobile operators. The satellite industry using the C-band will need to know the long term plans for the C-band in order to invest in the continuous use of the band.

L-band

76. As indicated in its SP-1435 policy decision in December 2012, the Department stated its intent to “review the spectrum utilization policy for the range 1435-1525 MHz at a later date, likely within a three to five year time frame”.²⁶ RABC agrees with the Department’s acknowledgement that:
- the L-band (1427-1518 MHz) is a frequency band that was identified for International Mobile Telecommunications (IMT);
 - the majority of the L-band is expected to be globally harmonized for mobile service;
 - there is little current use of this band in Canada; and,
 - there is expectation of a global equipment ecosystem.
77. Therefore, RABC supports the Department’s view that the L-band or portions thereof could be released for fixed and mobile use. RABC is of the view this would happen within the current Spectrum Outlook period.

Backhaul

78. RABC welcomes the work being undertaken to support wider RF channel bandwidth in current frequency ranges available in Canada for backhaul (e.g. 6 and 11 GHz bands), as well as opening new bands to alleviate congestion (e.g. 13 GHz). RABC will continue to

²⁶ SP-1435, section 3.1.1

actively participate in such activities, including the opening of the 32 GHz band (31.8-33.4 GHz) for two-way backhaul.

Question 20: ISED is seeking comments on the potential frequency bands for release in table 7:

a) the proposed services and/or applications for each frequency band

b) the potential timing of releasing for each frequency band

c) the priority of the release of the frequency bands

Provide supporting rationale for your responses.

814-824 paired with 859-869 MHz (800 MHz)

Public Safety

79. 800 MHz spectrum has been authorized for commercial mobile service in Canada (and the U.S.) since 1995²⁷ and played a unique role in Canadian 2G commercial mobile innovation. Commercial mobile narrowband systems (due to a restrictive channelization standard) became less relevant with the availability of robust mobile broadband over the last decade. 3GPP Band 26 mobile broadband over 800 MHz was authorized²⁸ in 2012 in the United States as a natural extension of the cellular band.
80. The 800 MHz band has been used by Public Safety for their narrowband voice systems for decades and evolved to support digital narrowband systems including P25 interoperable systems. This not only includes systems in the 821-824 / 866-869 MHz Public Safety sub-band, but also includes systems in the commercial sub-band allocations, as adequate 800 MHz Public Safety band spectrum was not available. Many Public Safety agencies have deployed new systems or have upgraded original 800 MHz systems in the 700 MHz band (narrowband) spectrum; however, many remain in the 800 MHz band including agencies that have recently upgraded to P25 systems.
81. The RABC agrees with the Department when it states, "Given that there is an available commercial mobile ecosystem and a reduced demand for commercial narrowband wireless systems, ISED believes that it would be beneficial to review this band for potential commercial mobile services in the next five years. Additionally, harmonizing this band would ease cross-border coordination, interoperability, economies of scale and roaming between countries."

²⁷ RP-014, *Radio Systems Policies RP-003 and RP-005 Relevant to the Level of Usage of Mobile Systems and Also the Definition of a Cellular Mobile Radio Service as Originally Set Out in October 1982*, Canada Gazette DGTP-009-95, August 1995. Decision DGTP-009-95

²⁸ *Improving Spectrum Efficiency Through Flexible Channel Spacing and Bandwidth Utilization for Economic Area-based 800 MHz Specialized Mobile Radio Licensees*, FCC 12-55, May 24, 2012.

82. Specifically, the RABC recommends that ISED conduct a review of the 800 MHz band to support the introduction of mobile broadband in one portion of the band while ensuring its coexistence with legacy narrowband applications including Public Safety, public works, and commercial users in another portion of the band. Such coexistence could be enabled by re-channeling or replacing incumbent systems that require continued narrowband operations to the 806-814 / 851-859 MHz portion of the band. Commercial mobile broadband services could then be introduced in the 814-824 / 859-869 MHz portion of the band (as part of 3GPP Band 26), and appropriate out-of-band-emissions requirements could be introduced to ensure the protection of narrowband operations in the adjacent sub-band. This would allow United States and Canadian jurisdictions to align border agreements for commercial mobile broadband, public safety and other narrowband applications, as well as avoiding the creation of new international issues (such as those that have arisen in the BRS band where the incongruous band plans between Canada and the U.S. are resulting in the impairment of the BRS spectrum of Canadian operators in Canada's top markets). The 3GPP band-plan is provided in Appendix A for reference.
83. Despite the final long-term objective to re-band the spectrum according to the paragraph above, the RABC would like to clarify that re-allocating PS users out of the 821-824 / 866-869 MHz sub-band will be very costly and operationally complicated.
84. The RABC recommends that ISED conduct a detailed analysis of the incumbent use of the 800 MHz band and include an assessment of the operational and financial impact of a band redesign. The RABC also recommends that ISED assign 700 MHz channels and/or channels in the 806-813.5 MHz sub-band to new Public Safety systems or to systems that are being upgraded or expanded. If 700 MHz or 806-813.5 MHz spectrum is not available and assignments within Band 26 are proposed, ISED should advise the applicants that their channel assignments may change in the future. Some RABC members recommend that ISED immediately implement a moratorium on putting any new users in the 814-824 / 859-869 MHz sub-band.
85. The RABC further recommends that ISED open a consultation on a Band 26 transition to allow all stakeholders to provide input on how best to affect a transition in terms of scheduling and staging, incentives and cost recovery and measures to minimize the impact to Canadians relying on the nation's Public Safety agencies.
86. Of specific concern for the Public Safety community in any redesign of the 800 MHz band is a requirement to have sufficient frequency separation between 700 MHz public safety narrow band channels and 800 MHz public safety channel assignments. Many Public Safety agencies, including the RCMP and Provincial and Municipal Governments, use vehicular repeaters to extend fixed infrastructure mobile radio coverage to user-worn portable radios. These repeaters require a minimum of 5 MHz of separation

between fixed infrastructure channel assignments and the vehicular repeater assignments which exist today between the 700 MHz and 800 MHz public safety bands. If the 800 MHz band review includes a shift of narrow channel assignments to the 806-814 / 851-859 MHz portion of the band, Public Safety requires allocations that provide 5 MHz of spacing between the existing 700 MHz Public Safety band and redesigned 800 MHz band assignments. It is recommended that further study include detailed measurements to assess how to optimally mitigate interference between fixed infrastructure and vehicular repeaters before a final decision is taken.

Railways

87. Canadian railways are currently spectrum licensed nationally for one channel in the 814/859 MHz along with two channels in the adjacent band 812/857 MHz through the Railway Association of Canada (RAC) for Remote Control Locomotive (RCL) applications and are not, as stated in paragraph 119, licensed on a site-by-site, first-come, first-serve basis.
88. RCL is widely used across Canada for train switching operations in yards and potential changes to the use of 814-824 / 859-869 MHz should take into consideration that replacement spectrum and significant resources will be required should ISED decide to proceed with repacking the band.

896-960 MHz (900 MHz)

89. Canadian railways are currently spectrum licensed nationally through the RAC for six channels in the 896-935 MHz for its point to multipoint, mission-critical Centralized Train Control (CTC) network. Again, ISED should take into consideration that replacement spectrum and significant resources will be required should they decide to proceed with repacking the band.
90. It should be noted that those six channels are shared with U.S. railways and, following FCC Public Notice entitled Wireless Telecommunications Bureau seeks comment on supplement to enterprise wireless alliance and Pacific Datavision, Inc. petition for rulemaking regarding realignment of 900 MHz spectrum, American railways have been approached by Pacific Datavision (PDV) to discuss various options, including spectrum swapping and compatibility testing.
91. RAC is also spectrum licensed, on a shared basis, in the 902-928 ISM band used for its Automatic Equipment Identifier (AEI) network.

24.25-27.5 GHz

92. The 24.25-27.5 GHz band is under study by the ITU under Agenda Item 1.13 for mobile use, and portions of the band (24.25-24.45 GHz and 24.75-25.25 GHz) have been allocated by the FCC for flexible use in the United States. The band is being considered

by the European Commission as the pioneer band for 5G millimeter wave applications. 3GPP has already standardized the entire band for NR in Release 15 and the band is anticipated by the mobile industry to develop into a global ecosystem. In Canada, SRSPs for fixed services currently exist in the 24.25-24.45 GHz / 25.05-25.25 GHz and 25.25-26.5 GHz frequency ranges. The RABC supports both fixed and mobile co-primary allocations within this band where needed to enable terrestrial flexible use.

93. The 24.75-25.05 GHz portion of this band is currently allocated to FSS on a primary basis, while the 25.05-25.25 GHz band is allocated to FSS on a co-primary basis, subject to priority of the fixed service in accordance with Canadian footnote C44. As discussed above, satellite demand for Ka-band spectrum is expected to grow significantly and outstrip supply over the next five years and the 24.75-25.25 GHz band provides suitable spectrum for satellite user terminals and for feeder link or gateway applications.
 94. Therefore, and consistent with the Department's proposal for the 28 GHz band in *Consultation on Releasing Millimetre Wave Spectrum to Support 5G*, if the Department decides to release some or all of the 24.25-27.5 GHz bands to other uses, consideration should be given to maintaining FSS use of the 24.75-25.25 GHz band. Continued FSS access to these portions of the band will provide satellite operators with important flexibility in designing and implementing new satellite systems, particularly if there are restrictions on FSS use of other portions of the Ka-band.
 95. RABC specially notes that the Canadian Table of Frequency Allocation as well as Article 5 of the Radio Regulations have allocated the frequency band 23.6-24 GHz to EARTH EXPLORATION-SATELLITE (passive), RADIO ASTRONOMY, and SPACE RESEARCH (passive) on primary basis subject to footnote 5.340 that prohibits all emissions in the band. Although the band 23.6-24 GHz is not adjacent to 24.25 GHz, it is sufficiently close to the 24.25-27.5 GHz frequency band that careful analysis of unwanted emission levels is required.
- 31.8-33.4 GHz (32 GHz)
96. RABC notes that the adjacent 31.3-31.8 GHz band is allocated to EESS/SRS (passive), as well as Radio Astronomy, and must be protected under RR No. 5.340. The service would be seriously affected by unwanted emissions if appropriate consideration has not been used in deployments of any services. The frequency band is also subject to footnote 5.340 that prohibits all emissions in the band.
- 40-42.5 GHz, 45.5-50.2 GHz and 50.4-52.6 GHz (51 GHz)
97. Dedicated and shared V-band spectrum allocations to satellite services will be required for the new HTS satellites and LEO constellations that are already being planned today and that will be planned over the next five years. Thus, portions of the identified bands should be allocated for dedicated use by FSS, suitable for ubiquitous user terminals.

Other portions of these bands should be allocated for shared use by FSS and terrestrial services, so that they may be accessed by a limited number of individually-licensed gateway earth stations.

98. The FCC in the U.S. retained 40-42 GHz for exclusive satellite (space-to-Earth) use. Also, the FCC allocated 47.2-48.2 GHz for terrestrial flexible use in the U.S. and retained the 48.2-50.2 GHz for exclusive satellite (Earth-to-space) use. Individually-licensed satellite earth stations are permitted in the 47.2-48.2 GHz band, subject to siting restrictions by the FCC. The RABC urges the Department to allocate spectrum for both terrestrial flexible use and satellite use within the 40-42.5 GHz, 45.5-50.2 GHz, as well as in 50.4-52.6 GHz bands.
 99. RABC notes that certain frequency bands given in the range above as well as 52.6–54.25 GHz (allocated to Earth Exploration (passive) and Space Research (passive) on a primary basis) are subject to footnote 5.340 that prohibits all emissions in the band. It is important to ensure adequate protection of these services.
- 71-76 GHz and 81-86 GHz
100. In the longer term and in light of demand projections, E-band spectrum will be required for satellite and fixed services. As in the case of other spectrum, use of dedicated satellite spectrum would be required to support user terminals, while gateway earth stations may be able to share spectrum with other services. It is also noted that this band, recently opened in Canada (SRSP-371.0), is particularly well suited for fixed wireless backhaul in urban and suburban areas due to the wide bandwidth available to terrestrial network operators. The wide channel bandwidth available in E-band spectrum supports fixed service of upwards of 10 Gbps today, and support for 20 Gbps speeds is planned for 2018 and will be critical for 5G rollouts.
 101. The RABC recommends that domestic allocation of mobile service in the identified E-band spectrum should not occur in the near term but, rather, should be deferred. Some RABC members are of the view that the allocation should be deferred until there is adequate evidence that lower frequency bands have been exhausted for mobile services. Other RABC members are of the view that the allocation should be deferred until it is clear whether a mobile ecosystem would emerge in the band. This will ensure that E-band spectrum remains available to satisfy longer-term requirements for the various allocated services.
 102. The Board also recommends that the protection of EESS (passive) sensors in the 86-92 GHz band from any emissions of any services be protected. It is also noted that the frequency band is subject to footnote 5.340 that prohibits all emissions in the band.

Question 21: Are there any other bands that should be considered for release in the next five years for commercial mobile, fixed, satellite, or licence-exempt that are not discussed above? Provide rationale for your response.

103. In addition to the bands indicated in Table 7 of section 6.3.9 of the consultation, it is recommended that the Department consider 23 GHz for backhaul in its planned activities during the period 2018-2022 based on the following:
- a. In response to SMSE-018-12, *Consultation on Spectrum Utilization Policies and Technical Requirements Related to Backhaul Spectrum in Various Bands, Including Bands Shared with Satellite, Mobile and Other Services*, RABC recommended that “the Department initiate consultations on adding more backhaul spectrum to the existing assigned 23 GHz P-t-P band covered by SRSP 321.8 (bands 21.8-22.4 GHz and 23.0-23.6 GHz). This could be done by adding the unused sub-bands 21.6-21.8 GHz and 22.8-23.0 and to re-purpose the vacant MCS bands 21.2 GHz-21.6 GHz and 22.4-22.8 GHz for backhaul applications.”
 - b. Further, in its March 2013 “Commercial Mobile Spectrum Outlook”, the Department concluded that for backhaul in the frequency range 11-23 GHz, “The evidence of congestion further suggests that additional spectrum may be needed to address the demand.”²⁹
 - c. Finally, the Department in its SMSE-022-14 “Decisions on Spectrum Utilization Policies and Technical Requirements Related to Backhaul”, welcomed RABC input for “its technical and strategic planning functions”, indicating it “may initiate consultations in the future, as warranted.”³⁰
104. Considering the above, it is recommended that the Department consider a consultation on potential allocation to backhaul in the 23 GHz band, as proposed by RABC above, as early as possible in its 2018-2022 planning activities. It is believed that this would assist in relieving some of the congestion experienced in this frequency range, as well as allowing larger transport capacity for wireless backhaul.
105. RABC recommends that the Department consider removing the current restriction on FSS in the 39.5-40.5 GHz band to government use only. This spectrum is not restricted to government use in the U.S., where a portion of the band (40-40.5 GHz) is also allocated for exclusive FSS use. Removal of the current restriction would provide non-government satellite operators with additional flexibility in designing and deploying efficient satellite systems. However, as the Department is currently consulting on flexible use within the 37-40 GHz band as part of its *Consultation on Releasing Millimetre Wave Spectrum to*

²⁹ Section 3.2, paragraph on “Mid-range frequency bands (11-23 GHz)”

³⁰ Section 5.4

Support 5G, any actions with the 39.5-40.5 GHz band should incorporate ISED's decisions on band sharing with other services and treatment of existing users within 37-40 GHz.

106. There are discussions internationally on the potential to allocate spectrum below 24 GHz to commercial mobile service.³¹ Although this is not part of WRC 19 agenda item 1.13, it is possible that such spectrum could become available within the next 5 years. It is recommended that the Department monitor developments in this area and considers its use in Canada. However, because of the ubiquitous nature of satellite user terminals in 14-14.5 GHz and 11.7-12.7 GHz, these bands would not be conducive to the addition of terrestrial services. The Department should be careful not to designate any use of these bands for terrestrial services.
107. RABC recommends increasing the stock of licence-exempt spectrum (i) by expanding into bands adjacent to existing licence-exempt bands and (ii) by adopting license-exempt bands from other regions (for example 466 MHz and 475 MHz). In particular, the lower frequency bands are preferred for license exempt industrial IoT uses due to their favorable propagation characteristics in cluttered urban and rural environments.
108. By expanding existing licence-exempt bands manufacturers can reuse existing products with only minor modifications, while still taking advantage of regional and global ecosystems to justify their business cases. Similarly, adopting licence-exempt bands from other regions increases the global footprint and potential market resulting in more technically advanced, lower cost, sustainable products.
109. As 3GPP pursues licence-exempt LTE and Listen-Before-Talk requirements, pairing 950 to 960 MHz with a portion of the existing 902 to 928 MHz ISM band (specifically 905 to 915 MHz), may enable use of low power Band 8 LTE equipment on a licence-exempt basis. As there is an increasing demand for Private LTE for industrial IoT users, this may enable further technology and network consolidation maximizing the innovation investment. While 915 MHz Wi-Fi is also being pursued, there are technical advantages to LTE resulting in a more secure, reliable and predictable service.

Question 22: Are there specific frequency ranges/spectrum bands that should be made available for specific applications?

1815 MHz Spectrum for Smart Grids

110. For more than half a century, CEUs have operated purpose built, private telecommunications networks to ensure the safe and reliable operation of the bulk

³¹ GSMA report on "5G Spectrum Public Policy Position", November 2016 (<https://www.gsma.com/spectrum/5g-spectrum-policy-position/>)

electric system. The continued reliability of these systems is challenged by aging infrastructure, increasing electrification of transportation and the integration of Distributed Energy Resources (DER)s in the electrical grid.

111. Meanwhile the reliance on reliable electric supply has grown, and now most sectors of the Canadian economy and the wellbeing of the public depend on a well-managed electric supply. To maintain a safe and reliable electricity system CEUs deploy protection, control and monitoring technologies which rely on communications infrastructure more than ever before. The provisions for the management of the electric supply afforded in SRSP 301.7 should be retained with technical rules, fee structures and licensing processes commensurate with the importance of this critical service.

Below 1 GHz for EESS

112. As RABC has already pointed out in response to Q9, small satellites can now provide capabilities that larger and more expensive systems could not do in the past - they are now able to produce higher quality imagery at low cost that was not envisioned a decade ago. Due to the continuing advances in the technologies, small spacecraft now have low mass, they are low cost to build, have shorter development time, and have low cost to launch. As a result, new EESS missions by private companies have emerged. Private companies have already launched a number of EESS constellation satellites and many more will join them shortly.
113. As a result of these new advances in technologies and applications that have stemmed from the development of these low-cost satellites, demand for the spectrum has significantly increased. As a result, RABC believes that additional spectrum for these small satellites below 1 GHz, as well as at higher frequency bands, should be made available.

401-403 MHz and 1675-1695 MHz for Weather Service

114. The Geostationary Operational Environmental Satellite system (GOES), operated by the United States' National Oceanic and Atmospheric Administration's (NOAA), supports weather forecasting, severe storm tracking, and meteorology research. This service uses uplinks in the 401 to 403 MHz band, coupled with downlinks in the 1675 to 1695 MHz band. Improvements in technology capabilities are allowing for improved sensing and more efficient use of this spectrum. It would be important to ensure that future use of spectrum below 1675 MHz and above 1695 MHz takes into account this service. Additionally, in the 401 to 403 MHz band there has been increased demand due to an increase in small, inexpensive, spacecraft deployed in large constellations by Planet Labs and Spire.

Question 23: Are there any factors that would impact the potential release of these frequency bands between 2018 and 2022?

115. RABC has not responded to Question 23.

APPENDIX A

