Christophe de Hauwer
Chief Strategy & Development Officer

Innovation, Science and Economic Development Canada
c/o Director, Spectrum Regulatory Best Practices
235 Queen Street (6th Floor, East Tower)
Ottawa ON K1A 0H5
Canada
Email: ic.spectrumauctions-encheresduspectre.ic@canada.ca

30 November 2020

Subject: **Consultation on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Band**
Canadian Gazette, Part 1, No. SLPB-002-20 (published Sep. 12, 2020)

SES S.A. ("**SES**") hereby submits its reply comments on the *Consultation on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Band* ("**Consultation**") issued by Innovation, Science and Economic Development Canada's ("**ISED**") on August 27, 2020.[1]

About SES

SES is a global provider of satellite and connectivity solutions headquartered in Luxembourg with operations around the world. SES provides services to broadcasters, governments, telecommunications companies, and enterprises in all parts of the world. Through its subsidiaries, SES operates a fleet of over 50 geostationary ("**GEO**") satellites in multiple frequency bands, including in the 3700-4200 MHz band with coverage of Canada. SES is the operator of the innovative O3b constellation of 20 high-throughput, low-latency satellites in Medium Earth Orbit ("**MEO**"). In 2021, SES will be launching its next-generation of MEO satellites called mPOWER, which will provide even higher throughput and more flexibility. Together, SES's satellites cover 99% of the world's population. SES is also the parent company of Ciel Satellite L.P., which operates the Canadian-authorized Ciel-2 satellite operating in the Ku-band Broadcasting Satellite Service frequencies at 129° W since late 2008.

[1] Innovation, Science and Economic Development Canada, SPLB-002-20, *Consultation on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Band* (Aug. 2020) ("Consultation"), available at https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/SLPB-002-20-2020-08EN.pdf/$file/SLPB-002-20-2020-08EN.pdf.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

I. The Impact of ISED's Proposal on FSS in the 3700-4200 MHz Band

In its comments, SES explained the impact that ISED's proposal to re-allocate the 3700-4000 MHz band would have on Fixed Satellite Service ("**FSS**") operations in Canada.[2]

As the FSS operators, Canadian broadcasting interests, and other FSS users in Canada have submitted, existing FSS operations in Canada in the 3700-4000 MHz band include: (a) distribution and collection of programming content for the Canadian broadcasting industry; (b) broadband connectivity to the North, such as Nunavik and Nunavut, and other rural and remote parts of Canada; (c) crucial narrowband communications for defence, emergency responders, and other public safety operations; and (c) maritime and other offshore connectivity.

For SES alone, more than **[REDACTED]** GHz of satellite capacity in the 3700-4200 MHz band is under contract for a wide range of FSS applications in Canada.[3] As SES explained in its comments, it is in the process of gathering information from its broadcaster and service provider customers on the extent of their services in Canada using SES satellite capacity.

The proposed reallocation of the 3700-4000 MHz band for flexible use services, including new 5G mobile services, would preclude FSS operators from using 60% of the bandwidth available on their C-band satellites to serve most of the Canadian market. As a result, it will be very challenging to maintain continuity of service for FSS users of the 3700-4000 MHz band in Canada and to meet growing demand. All FSS users would need to be repacked into the remaining 4000-4200 MHz of spectrum available for FSS, which may imply deploying additional C-Band satellites, or migrate some users in part or in whole to satellite systems in higher frequency bands, as determined on a case-by-case basis.

Due to the C-band's unique propagation characteristics, however, it will not be possible to move all existing FSS operations in the 3700-4000 MHz into other bands while maintaining current availability and service quality. Moreover, even after migration, all FSS earth stations continuing to operate in 4000-4200 MHz in Canada will need new filters installed to protect them from being receiver-blocked (or overloaded) by 5G transmissions in the adjacent 3700-4000 MHz band (along with other adjacent band protection measures).

The impacts on FSS operations will be particularly acute if the FSS is to be cleared from the 3700-4000 MHz band by December 2023, as proposed by ISED, to align with the FCC's timeline for *accelerated* clearing of the same band. As SES and other FSS operators have explained, the FCC's 2023 accelerated clearance timeline is only achievable because of financial compensation, consisting of both clearing costs and incentives, offered by the FCC to enable FSS operators to implement costly clearance measures quickly. Without such compensation, the FCC recognized that clearance would take much longer and delay the deployment of 5G in the band by many years.[4]

---

[2] *See* SES Comments at Sections I & II.
[3] *See* SES Comments at Confidential Exhibit.
[4] *See* SES Comments at 2-3; Intelsat Comments at ¶¶ 32-43; Telesat Comments at ¶¶ 87-90.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

II. Compensation for Accelerated Clearing

As a result, SES continues to urge ISED to consider offering financial compensation, similar to the compensation offered by the FCC in the U.S., for the accelerated clearing of the 3700-4000 MHz band in Canada. Such compensation would need to include both reimbursement of clearance costs and additional compensation for timely completion of clearance by December 2023. As the FCC concluded, financial compensation is necessary to provide adequate incentives for FSS operators and users to engage in and complete the timely and orderly clearing of the 3700-4000 MHz band by 2023. Such compensation will also be needed in Canada if ISED wishes to complete an orderly clearance of the 3700-4000 MHz band by 2023 in support of the deployment of 5G within the same general timeframe as the adjacent 3500 MHz band, and to remain aligned with the U.S.[5]

Canada cannot simply rely on the U.S. clearance process alone to achieve timely clearance of the 3700-4000 MHz band in Canada by 2023. Additional work and significant associated cost are required in Canada to ensure a timely and orderly clearance of the band. There are Canadian-only broadcast and broadband services, as well as international broadcasting services, in the band that need to be re-packed or migrated separately, as well as thousands of Canadian FSS earth stations for which filters will need to be installed and which might need to be repointed in order to ensure continuity of services. This point was made clear in the submissions of satellite operators and Canadian FSS users in this Consultation.[6]

Providing compensation to the FSS sector to achieve the accelerated clearance of the 3700-4000 MHz is warranted considering the enormous benefits of faster 5G deployment in Canada enabled by such acceleration. Many commenters have already referred to the studies from Accenture and the Canadian Wireless Telecommunications Association which estimate a $40 billion increase in Canadian GDP in the 2020-2026 timeframe from the introduction of 5G.[7] More precisely, economists Debra Aron, Andy Baziliauskas, and Olga Ukhaneva from Charles River Associates (see **Annex A**) estimate that the impact of accelerating the repurposing of 3700-4000 MHz band in Canada from December 2025 to December 2023 would increase Canadian GDP by **$7.4 billion** over three years.[8] In their study, the economists use multi-country data to estimate the increase in 5G penetration that would be expected from greater mid-band spectrum availability[9] and the impact that such growth in penetration would have on Canadian GDP to derive a robust estimate of the specific impact of accelerated band clearing.[10]

---

[5] *Id*.
[6] *See*, *e.g.*, CBC/Radio-Canada Comments at response to Q9(c), response to Q25; North American Broadcasters Association Comments at 2; Corus Entertainment Comments at 3; Intelsat Comments at ¶¶ 30-31; SES Comments at 4, 17.
[7] *See* Accenture Strategy (in collaboration with the Canadian Wireless Telecommunications Association), *Accelerating 5G in Canada: Benefits for Cities and Rural Communities* (2019), at 3 ("*Accelerating 5G*"), *available at* https://www.cwta.ca/wp-content/uploads/2019/11/Accelerating-5G-in-Canada-V11-Web.pdf; Accenture Strategy, *Fuel for Innovation: Canada's Path in the Race to 5G*, at 2 nn.5 & 6 (2018)("*Fuel for Innovation*"), *available at* https://www.5gcc.ca/wp-content/uploads/2018/06/CWTA-Accenture-Whitepaper-5G-Economic-Impact_Updates_WEB_06-19-2018.pdf.
[8] *See* Annex A at 3, 23-25.
[9] *See id*. at Section IV.A.
[10] *See id*. at Section IV.B.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

Many commenters in this Consultation – representing a wide range of stakeholders and viewpoints – have indicated support for the principle of compensation to the FSS sector for accelerated clearing in the 3700-4000 MHz band, even as views differed on the form and manner that such compensation should take. Those that expressed concerns about compensation were mostly apprehensive about a single private entity, namely Telesat, driving the clearance process and obtaining compensation through secondary market transactions.

Among FSS satellite operators, SES and Intelsat support financial compensation for accelerated clearing along the lines of the compensation offered by the FCC in the United States.[11] Telesat also supports compensation, but only for itself in the form of a direct spectrum assignment and monetization through private secondary market transactions (which SES addresses in more detail below).[12] Eutelsat supports cost reimbursement but not financial incentives.[13]

However, support for the principle of compensation was not limited to the satellite operators. Mobile operator BCE recommends that "transition costs for existing satellite operators, FSS users, and WBS systems (either under the Department's proposal or under Telesat's proposal) be covered by the proceeds received from the allocation of the 3800 MHz spectrum band and the 3650-3700 MHz spectrum band."[14] Such costs "are a direct result of the government's initiative to allocate more mid-band spectrum for flexible use and would not be otherwise incurred,"[15] and "[c]overing reasonable transition costs will allow existing users to continue to invest and provide service rather than spend scarce capital on relocation costs."[16]

Rogers agrees that "transition and displacement timing of legacy services should be accelerated"[17] and that "the Department should provide some additional funding to ensure a rapid transition of Canadian earth stations."[18] However, Rogers opposes the Telesat proposal for a direct spectrum allocation to Telesat, and a private sale and clearing by Telesat.[19] Similarly, Shaw is "not opposed to Telesat being reimbursed, out of any auction proceeds or other government funds, for any reasonably incurred and substantiated relocation costs,"[20] but rejects Telesat's clearing proposal.[21]

Broadcast users of the 3700-4000 MHz band in Canada also expressed support for compensation in line with what was offered by the FCC in the United States. CBC/Radio-Canada hopes that "ISED will consider the financial impact on users of this band and make fair and informed decisions to financially support existing FSS operators such as the United States does."[22] Similarly, the North American

[11] *See* SES Comments at 3-5; Intelsat Comments at ¶¶ 44-46.
[12] *See* Telesat Comments at ¶¶ 6, 21-22, and Annex H to the Consultation.
[13] *See* Eutelsat Comments at ¶¶ 11, A24.1-A24.3.
[14] BCE Comments at ¶ 21.
[15] *Id*.
[16] *Id*. at ¶ 20.
[17] Rogers Comments at ¶ E9.
[18] Rogers Comments at ¶¶ E9, 52.
[19] Rogers Comments at ¶ 272 et seq.
[20] Shaw Comments at ¶ 21; *see also* ¶ 29.
[21] Shaw Comments at ¶¶ 19 et seq.
[22] CBC/Radio-Canada Comments at response to Q25 ("Nous espérons cette fois-ci que ISDE considérera ces impacts financiers sur les utilisateurs de cette bande et prendra des décisions justes et éclairées afin de supporter financièrement les opérateurs SFS existants tel que le fait les États-Unis.").

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

Broadcasters Association submits that "[a]ny new cost borne by broadcasters due to the proposed spectrum change must be reimbursable" and that "all applicable costs must be reimbursable as the FCC mandated in the U.S."[23] Indeed, the FCC provided for cost reimbursement to earth station licensees, as well as financial incentives to FSS space station operators for accelerated clearing.

Similarly, Canadian satellite service providers using the 3700-4000 MHz band expressed support for the principle of compensation for clearing the band. Iristel submits that "Telesat and other satellite service providers required to vacate the 3800 MHz band deserve to be compensated for the prior investment made in C-band satellite infrastructure,"[24] while rejecting Telesat's proposal for a clearing managed solely by Telesat. SSi Canada notes the impact of ISED's proposals on their services and submits that they "are acceptable to us only on condition that FSS earth station licensees directly receive any compensation that is made available to enable the reorientation of existing FSS earth stations in affected areas."[25] Hunter Communications argues that "[i]f Telesat is to be compensated for the transfer of spectrum from satellite to other services then other participants – both operators and service providers of C-band services, must be compensated as well."[26]

Canadian satellite manufacturer MDA also supports "an approach similar to that of the US in terms of financial compensation to satellite operators" and "strongly advocate[s] that proceeds from this compensation should in turn be spent in Canada" by maximizing the Canadian content of the satellite constellations that have been proposed to serve the North and the rural and remote areas of Canada.[27] As SES has indicated in its comments, financial compensation for accelerated clearing in Canada would help advance SES's plan to launch its inclined O3b constellation to provide a competitive, high-throughput, low-latency satellite service throughout all of Canada. SES is willing to commit to procuring a significant portion of the components for its inclined satellites from Canadian manufacturers, thus ensuring that the financial compensation will benefit Canadian industry and promote high-skill employment in Canada.

Only Xplornet opposes compensation to FSS operators for displacement costs associated with vacating the 3700-4000 MHz band, relying on the Spectrum Policy Framework, which states that "any displaced spectrum users will be responsible for all costs incurred as a result of any reallocation of spectrum by the Department."[28] However, SES notes that the Spectrum Policy Framework also encourages the balanced use of economic incentives and market forces in spectrum management.[29] In SES's view, providing an appropriate mechanism for the mobile carriers, which stand to gain from rapid clearing of the 3700-4000 MHz band, to compensate the FSS sector for rapid clearance of the band is the very kind of balanced, market-based regulatory mechanism that the Spectrum Policy Framework embraces.

---

[23] North American Broadcasters Association Comments at 2.
[24] Iristel and Ice Wireless Comments at ¶ 121.
[25] SSi Canada Comments at ¶¶ 36-37.
[26] Hunter Communications Comments at 2.
[27] MDA Comments at 2-3.
[28] Xplornet Comments at ¶ 66, *quoting* Spectrum Policy Framework at 8.
[29] Spectrum Policy Framework at 4 ("A particular focus that emerged in the comments on the proposed revision to the Framework was the appropriate balance in spectrum management between the use of economic incentives and market forces compared to government intervention"), 6 ("The Framework reflects the Department's evolution toward more market-based policies and regulation where appropriate, and the government's recently stated commitment to this approach.").

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

Xplornet notes that "ISED has not provided for compensation of displacement costs in any recent re-allocation, whether in relation to the 3500 MHz Band, the 600 MHz band or the 2500 MHz band, even in situations where the spectrum is still in use."[30] SES expresses no view on whether it was reasonable for ISED to exercise its discretion not to provide financial compensation in any of those instances. SES would observe, however, that fixed wireless incumbents in the 3500 MHz band (including Xplornet) were able to retain a significant amount of their spectrum holdings with the option of voluntarily converting them into more valuable flexible use licenses.[31] Similarly, the 2500 MHz incumbent licensees were "mapped" into and obtained valuable licences under the new 2500 MHz band plan.[32] In contrast, FSS operators and users in the 3700-4000 MHz band in Canada will simply be displaced from the band, resulting in stranded investments in space.

ISED's repurposing of the 600 MHz band (a joint effort with the FCC) bears some resemblance to the 3700-4000 MHz band in that it also involves a massively complicated re-packing of many existing users in order to free up spectrum for new mobile services. At the direction of the U.S. Congress, the FCC conducted an incentive auction to provide U.S. broadcasters with financial compensation to re-pack within a tight 39-month transition timeframe from April 2017.[33] ISED, however, chose not to provide compensation to Canadian broadcasters, providing instead an extended 59-month transition timeframe from April 2017 in part to "relieve[] pressure on potentially limited resources."[34] In fact, the overall process of repacking the 600 MHz can be traced back even further to August 2015 when the decision to re-pack was issued.[35] In the case of the 3700-4000 MHz, ISED is proposing a similarly complex transition of FSS operations in less than 36 months to match an FCC deadline that the FCC deemed impractical to achieve without appropriate financial compensation.

Xplornet also attempts to distinguish the compensation offered by the FCC for the clearance of the 3700-4000 MHz band as something required "to comply with [the U.S.] legislative regime."[36] However, Xplornet misapprehends the basis of the FCC's decision. The FCC has the authority but is under no legislative mandate to provide compensation upon reallocation of spectrum.[37] Rather, the FCC chose to provide accelerated relocation payments in the circumstances because it was in the public interest

[30] Xplornet Comments at ¶ 68.
[31] *See* Telesat Comments at 2 n.2 ("in last year's 3500 MHz Decision band incumbents Bell, Inukshuk, Rogers, TELUS and Xplornet retained 94%, 43%, 86%, 100% and 79% of their spectrum, respectively, on a population-weighted basis; with band incumbents retaining an average of 52% nationally, while converting these holdings from fixed wireless to more valuable flexible use licences"); ISED, SLPB-001-10, *Decision on Revisions to the 3500 MHz Band to Accommodate Flexible Use and Preliminary Decisions on Changes to the 38000 MHz Band*, at ¶ 120 (2019).
[32] Industry Canada, SMSE 005-11, *Decisions on a Band Plan for Broadband Radio Service (BRS) and Consultation on a Policy and Technical Framework to License Spectrum in the Band 2500-2690 MHz*, at Section 2 (2011).
[33] *See* https://www.fcc.gov/wireless/bureau-divisions/broadband-division/600-mhz-band.
[34] ISED, DGEPS-002-17, *Objectives and Methodology for the Over-the-air Television Transition*, at ¶ 30 (2017) (providing a longer transition period than the FCC's 39 months); *see also* ISED, *Digital Television (DTV) Transition Schedule*, at 1 (2017) (initiating a 59-month transition period starting in April 2017).
[35] *See* Industry Canada, *Decision on Repurposing the 600 MHz Band* (2015), at https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11049.html.
[36] Xplornet Comments at ¶ 67.
[37] Section 316 of the Communications Act, referenced by Xplornet (at ¶ 67 n.24), provides procedural protections for modifications of radio station licenses, but does not require compensation for such modification.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

to do so, given the significant benefits of faster deployment of 5G and other flexible use services in the band.[38] Under the *Radiocommunication Act*, the Minister has similarly broad authority to achieve the same outcome.[39] SES respectfully submits that it would be both fair and reasonable for the Minister to exercise this authority to provide compensation to the FSS sector for the reallocation of the 3700-4000 MHz band in Canada, especially if such clearance is to follow the accelerated timeline provided for in the U.S.

Providing compensation will also ensure that Canada adheres to its international trade commitments.[40] Under various international trade agreements, Canada has committed to accord national treatment to foreign service suppliers, and not to directly or indirectly expropriate the investments of investors from the United States and European Union without adequate compensation.[41] This means that Canada cannot provide Telesat with a mechanism for compensation not available to its competitors, such as SES. It also means that Canada must be mindful of its commitments to compensate investors in the event of a direct or indirect expropriation of their investments. Under its trade agreements, an expropriation can occur even without a formal taking of title if government action interferes with distinct, reasonable investment-backed expectations.[42] There can be no doubt that (a) SES's U.S. and European Union subsidiaries have invested hundreds of millions of dollars in long-lived C-band satellite assets to provide valuable services in Canada; and (b) a decision to reallocate the 3700-4000 MHz band would render up to 60% of the capacity on such satellites unusable to serve most or all of the Canadian population.

III. Telesat Proposal

a. Proposal for Direct Spectrum Assignment, Secondary Market Transactions and Telesat-led Clearing

In its comments, SES supported the Telesat Proposal to the extent that it proposed a mechanism for FSS operators to receive financial compensation to accelerate the clearing of existing FSS users in the 3700-4000 MHz band.[43] However, due to uncertainty as to how Telesat's proposal would work, SES prefers a government-led financial compensation mechanism more like the one adopted by the FCC on the basis that it would provide greater certainty and fairness for all affected FSS operators, their customers and possibly for the mobile operators as well.[44]

---

[38] *Expanded Flexible Use Order* at ¶¶ 178 et seq.; ¶ 185 ("Given the significant public interest benefits of clearing terrestrial, mid-band spectrum more quickly, which would bring next-generation services like 5G to the American public years earlier and help assure American leadership in the 5G ecosystem, we find that requiring overlay licensees to make accelerated relocations is in the public interest.").

[39] *See*, *e.g.*, *Radiocommunication Act*, § 5.

[40] *See Canada (Minister of Citizenship and Immigration) v. Vavilov*, 2019 SCC 65, at ¶ 114 ("We would also note that in some administrative decision making contexts, international law will operate as an important constraint on an administrative decision maker. It is well established that legislation is presumed to operate in conformity with Canada's international obligations, and the legislature is 'presumed to comply with … the values and principles of customary and conventional international law' […]. Since *Baker*, it has also been clear that international treaties and conventions, even where they have not been implemented domestically by statute, can help to inform whether a decision was a reasonable exercise of administrative power […]") (citations omitted).

[41] SES Comments at 5 nn.11-12.

[42] *Id*. at 5 n.13.

[43] *See* SES Comments at 6-7, 32-33.

[44] *Id*.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

Many of the comments received by ISED reflect support for the principle of compensation while raising significant concerns about how the Telesat proposal would be carried out in practice. Rogers, Shaw, SaskTel, Quebecor, Bragg, Cogeco, CBC/Radio-Canada, SSi Canada, Hunter Communications, Iristel and ECOTEL all raise concerns about the delegation of authority to a single entity (Telesat) to clear and monetize the spectrum, the lack of clarity and impartiality of the Telesat compensation and clearing mechanism, and/or the potential competitive implications in 5G markets (especially for regional competitors) of a private sale or other secondary market transaction.[45] Even BCE, which generally supports the Telesat proposal, raises many questions about how the band clearing mechanism would actually work.[46]

SES is concerned that some commentators in the Consultation are under the impression that Telesat is the sole provider of C-band satellite services and is somehow equipped to manage the relocation of all satellite services using this band. This is simply not the case. Telesat is one of several satellite operators sharing the same spectrum band that have made significant investments to provide a wide range of satellite services in Canada. Indeed, several other commenters point out that Telesat is not the sole provider of C-band FSS capacity in Canada (others include SES, Intelsat and Eutelsat), and that it would be unfair to compensate Telesat and Telesat alone for accelerated clearing (or even to appoint Telesat to distribute the compensation or to manage other operators' customer relocation).[47] As SES pointed out in its comments, any mechanism for compensation that excludes Telesat's competitors, who are authorized to provide satellite services in Canada and have made significant investments to do so, implicates Canada's national treatment and non-expropriation commitments under various international trade agreements.[48] Similar concerns have also been raised by Intelsat in its own comments.[49]

In addition, contrary to Telesat's proposal, there is no need for Telesat to coordinate the clearing of all FSS users of the 3700-4000 MHz in Canada. There are obviously both operational impediments and anti-competitive risks of entrusting a single operator to handle not just the migration of its own customers, but those of its competitors as well.[50] In fact, each satellite operator (in consultation with its customers) is best placed to coordinate the migration and switchover of its customers to higher frequencies, other satellites or other bands. There is no need to interpose Telesat into that process.

It may be possible for ISED to address the uncertainties in Telesat's proposed compensation mechanism by prescribing just what Telesat (or a consortium of FSS operators) should do with its Tier

[45] *See* Rogers Comments at ¶¶ 272-281; Shaw Comments at ¶¶ 19-34, ¶¶ 125-129; SaskTel Comments at ¶¶ 25-32, ¶¶ 128-140; Quebecor Comments at ¶ 6, ¶¶ 91-95; Bragg Comments at ¶ 5, ¶¶ 15-24; Cogeco Comments at ¶¶ 95-96; CBC/Radio-Canada Comments at response to Q53, response to Q58; SSi Canada Comments at ¶¶ 22-25, ¶¶ 79 et seq.; Hunter Communications Comments at 2, Iristel and Ice Wireless Comments at ¶7, ¶¶ 120-137; and ECOTEL Comments at ¶ 130.
[46] BCE Comments at ¶¶ 15-19.
[47] *See*, *e.g.*, Hunter Communications Comments at 1, 2; Iristel and Ice Wireless Comments at ¶¶ 120-122; SSi Canada Comments at ¶ 89.
[48] *See* SES Comments at 5-6.
[49] Intelsat Comments at ¶¶ 22, 57.
[50] *See*, *e.g.*, Iristel and Ice Wireless Comments at ¶ 140 ("Iristel is curious to see what SES and Intelsat have to say on the matter in their answer to this Consultation and on which system Telesat anticipates they would relocate SES and Intelsat subscribers (perhaps on Telesat's own LEO system?)").

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

1 license. Then again, it might be just as simple for ISED to prescribe how compensation is to be paid or distributed as part of competitive bidding rules for the 3700-4000 MHz band. At the end of the day, as SES and other commenters have indicated, the mechanism for compensation must be fair and transparent, and compensation must flow not just to Telesat but also to Telesat's foreign competitors in the marketplace sufficient to incentivize and cover the costs of an accelerated transition. Canada's international commitments require no less.

b. Proposal to Clear 4000-4100 MHz

In its comments, SES opposed Telesat's proposal to clear the 4000-4100 MHz band for 5G and other flexible use services, in addition to the 3700-4000 MHz band.[51] As SES explained, maintaining continuity of service for its customers remains a priority. In SES's view, continuing to provide FSS in just the 4100-4200 MHz in Canada is likely unsustainable in the short and long term. With 200 MHz of spectrum (4000-4200 MHz), re-packing existing users into the remaining spectrum remains viable. With just 100 MHz of spectrum (4100-4200 MHz), not only does re-packing become impractical, but the business case for future satellites in the C-band (including replacement satellites) becomes extremely difficult to justify.

Other commenters from the FSS community also raise concerns at the proposed reduction of remaining FSS spectrum to just 100 MHz in 4100-4200 MHz. Eutelsat believes that ISED should "generally align its approach in the 3800 MHz band with that of the FCC and should reject the Telesat Proposal" as this should "preserve sufficient spectrum to provide satellite broadband connectivity to all areas of Canada, including rural and remote regions […]."[52] Intelsat similarly prefers alignment with the U.S., highlighting the problems from non-alignment that would otherwise result in Canada.[53] Hunter Communications is concerned that restricting FSS supply to just 100 MHz of spectrum "by economic certainty will result in a material increase in price for services delivered to satellite-dependent communities."[54] SSi Canada urges ISED "to consider very carefully whether 100 MHz will provide enough capacity" for Telesat and its competitors to continue serving rural and remote parts of Canada.[55]

Broadcast users of the 3700-4200 MHz band also do not support reducing the amount of remaining FSS spectrum to the 4100-4200 MHz band. CBC/Radio-Canada indicates that it has already made plans with Hunter Communications and Intelsat to relocate its services into the 4000-4100 MHz band by March 2023, and that further displacement into 4100-4200 MHz could impose an additional $1 million in repointing costs that it should not be required bear.[56] CBC/Radio-Canada also note that it

[51] *See* SES Comments at 6, 32-34.
[52] Eutelsat Comments at ¶ A59.1.
[53] Intelsat Comments at ¶ 48, response to Q53.
[54] Hunter Communications Comments at 2.
[55] SSi Canada Comments at ¶ 85.
[56] CBC/Radio-Canada Comments at response to Q53 ("Dans nos négociations avec Intelsat, CBC/Radio-Canada et son partenaire d'affaires Hunter ont réussi à recevoir une nouvelle fréquence sur le même satellite à une fréquence entre 4000 et 4100 MHz. Cette transition est prévue le 31 mars 2023. […] De cette raison vient notre toute première préoccupation, rien dans la proposition de Telesat nous indique ce que serait la solution pour CBC/Radio-Canada si la bande de 4000 à 4100 devait être octroyée au 5G ? Si CBC/Radio-Canada devait changer de satellite pour poursuivre ses activités, nous évaluons le coût associé au repositionnement de nos antennes de réception à plus de 1 million $. Il est clair que nous ne pouvons pas soutenir ce fardeau financier.").

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

sources international programming from a number of C-band satellites in the 3700-4000 MHz range, not all of which will be relocated to 4000-4200 MHz as part of the U.S. relocation process.[57] The North American Broadcasters Association points to the mis-alignment with the U.S. and the cross-border coordination issues that would arise from allowing flexible use in 4000-4100 MHz.[58] It also submits that "reducing available spectrum to only 100 MHz will drive domestic C-band costs exponentially"[59] and "also threatens Canadian access to foreign satellites operating in the 4000-4100 MHz" and the international programming that is being delivered in that band.[60] Corus Entertainment agrees, noting that the Telesat proposal "has not contemplated how foreign programming and news can be accessed on foreign satellites in the 4000-4100 MHz band"[61] and that "[g]iven Canadian dependence on US program supply, 100 MHz is clearly insufficient."[62] SES agrees. SES satellites are carrying a number of U.S. and non-U.S. international video channels that appear to be intended for the Canadian market only, or which are intended for distribution in both the U.S. and Canada. Re-packing all such channels (and other Canada-only services) into 4100-4200 MHz (as opposed to 4000-4200 MHz) in order to ensure continuity of service into Canada would likely make an already challenging task virtually impossible.

In addition, the civil aviation community have raised detailed safety and technical concerns stemming from the potential for harmful interference from 5G and other flexible use transmissions into radio altimeters used in aircraft and operating in the adjacent 4200-4400 MHz band.[63] While such concerns were voiced to some extent if flexible use services are allowed up to 4000 MHz, they are heightened if flexible use transmitters were allowed to operate up to 4100 MHz.[64]

Notably, the terrestrial wireless industry, which stands to gain the most from an extra 100 MHz of flexible use spectrum, expressed mixed views on whether the 4000-4100 MHz band is desirable in terms of deployment for flexible use. Rogers, Shaw and SaskTel all question the benefits of clearing another 100 MHz, given the lack of alignment with the U.S. and the cross-border issues that this would create.[65] Shaw and SaskTel also express concerns about whether affordable equipment will be available any time soon that would enable Canada to take advantage of this additional spectrum, given that use of the 4000-4100 MHz for flexible use is the exception rather than the general rule.[66] ECOTEL, a wireless Internet service provider, also expresses doubts about the benefits to Canada of

---

[57] *Id*. at response to Q28 ("Il est important de noter que certains signaux provenant de l'international sont actuellement reçus via satellite et sont utilisés comme source d'information par CBC/Radio-Canada. Par exemple, CBC/Radio-Canada reçoit plus d'une trentaine de sources de programmation sur la plage de fréquence de 3600 à 4200 MHz. Ces source sont captées à nos centres de production de Montréal et Toronto via des antennes de réception satellite orientables […] Bien que certaines de ces sources seront relocalisés sur de nouveaux transpondeurs entre 4000 et 4200 MHz, il est possible d'autres soient brouillées dans le futur par les services d'utilisation flexible.").
[58] North American Broadcasters Association at 15.
[59] *Id*.
[60] *Id*.
[61] Corus Comments at 18.
[62] *Id*. at 19.
[63] Comments of Boeing et al. at 1, 2; Comments of Transport Canada at 3.
[64] Comments of Boeing at 3; Comments of Transport Canada at 3.
[65] Rogers Comments at ¶¶ 276, 283; Shaw Comments at ¶¶ 33, 125, 130; SaskTel Comments at ¶¶ 149-153. 177-178.
[66] Shaw Comments at ¶ 130; SaskTel Comments at ¶¶ 150, 177.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

making the 4000-4100 MHz available for flexible use services due to the lack of an equipment ecosystem.[67]

While BCE and TELUS support the Telesat proposal to free up an additional spectrum for flexible use, their support is based on deference to Telesat's assertion that 100 MHz of spectrum will be enough to accommodate all FSS users going forward.[68] However, as SES, Intelsat and Eutelsat have made clear, Telesat is not the only satellite operator in the 3700-4000 MHz range and its judgement alone is not a sufficient basis on which to make a decision on whether 100 MHz is sufficient to sustain FSS operations.[69] Some Canadian wireless Internet service providers have also made unsupported arguments that 100 MHz is "more than sufficient" to sustain the FSS.[70] Xplornet even suggests that none of the 3700-4200 MHz should be reserved for the FSS.[71] However, as noted above, Canadian FSS users have indicated clearly a continuing need for FSS in this band, and are concerned that reducing supply to just 100 MHz could result in insufficient capacity and/or price pressure.

Given the significant capacity, interference and operational concerns raised by various commentators in the Consultation, SES would urge ISED not to reduce the amount of FSS spectrum to 100 MHz, as proposed by Telesat, and to keep to its original proposal to clear only the 3700-4000 MHz band.

IV. "Satellite-Dependent Areas"

In its comments, SES took no position on whether the 3700-4000 MHz should be cleared for 5G in "satellite-dependent areas," deferring instead to the preferences of its main customer in the North, the Kativik Regional Government ("**KRG**").[72] We understand that KRG is considering its position and intends to make a submission to ISED. SES notes also that the Inuit Circumpolar Council has invited further discussions with "local Inuit communities dependent on satellite services for broadband connectivity, Internet access and telephony."[73] It is certainly conceivable that Indigenous communities in the North would prefer the option of using the 3700-4000 MHz band for 5G within the same timeframes as the rest of Canada. There are a number of population centres in ISED's "satellite-dependent areas" that may be able to economically support 5G networks backhauled using fiber or high-capacity satellite links.

[67] ECOTEL Comments at ¶ 131.
[68] BCE Comments at ¶ 23 ("As Telesat is the primary satellite provider of data connectivity in Canada, its conclusion that 100 MHz (4100-4200 MHz) provides sufficient capacity to continue FSS services in non-satellite-dependent areas should be given significant weight by the Department."); Telus Comments at ¶ 37 ("A broader mobile allocation is further supported in paragraph 57 of the Telesat proposal […], noting that the primary Canadian satellite services provider Telesat could repack FSS operations into 4100-4200 MHz").
[69] *See also* Iristel and Ice Wireless Comments at ¶ 140 ("The fact that Telesat would allocate 100 MHz more to flexible use than ISED or FCC propose to allocate does show that they believe it can be done, that satellite providers can be successfully relocated to other bands. Iristel is curious to see what SES and Intelsat have to say on the matter in their answer to this Consultation and on which system Telesat anticipates they would relocate SES and Intelsat subscribers (perhaps on Telesat's own LEO system?)").
[70] *See*, *e.g.*, Canadian Association of Wireless Internet Service Providers Comments at ¶ A59.
[71] Xplornet Comments at ¶¶ 17-25.
[72] SES Comments at 6.
[73] Inuit Circumpolar Council Comments at 2.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

However, if the 3700-4000 MHz is to be preserved for satellite-dependent areas, then ISED will need to ensure that the full 3700-4200 MHz band can continue to be used in such areas for both existing and new services. ISED's proposed half-measure, whereby the 3700-4000 MHz band can only be used with pre-existing earth stations but not new ones, impractically limits the ability of Indigenous and other communities in satellite-dependent areas to expand their satellite networks to meet their growing connectivity needs. Such a half-measure would also intensify future demand for the limited spectrum remaining in the 4000-4200 MHz band and possibly lead to increased costs or capacity shortages that effectively deprive satellite-dependent areas of C-band satellite services.

ISED would also need to ensure that both licensed and "interim-authorized" FSS earth stations in the 3700-4000 MHz band in satellite-dependent areas are properly protected from interference from flexible use transmissions. Co-channel protection and adjacent band protection measures (see Sections V. and VI., below) will be required for (1) earth stations in satellite-dependent areas that are near non-satellite dependent areas in which flexible use services are deployed, and (2) satellite gateways in non-satellite dependent areas required to maintain service in satellite-dependent areas. Significant separation distances (which could exceed 100 km, depending on geography and terrain) may be required to meet the applicable protection criteria and ensure that such earth stations can continue to operate. This in turn implies restrictions on flexible use deployments nearby, or the effective preclusion of FSS in the 3700-4000 MHz band in portions of satellite-dependent areas. This could become a significant issue to manage in locations where non-satellite-dependent and satellite-dependent communities are in fairly close proximity to one another, such as Prince George and the T-168 satellite-dependent area, and Sault Ste. Marie and the T-106 satellite-dependent area, just to name a few.

In addition, if the intention is to ensure that satellite-dependent areas have continued access to the 3700-4000 MHz band, it would not be appropriate to provide adjacent band protection for licensed but not "interim-authorized" FSS earth stations, as ISED proposes.[74] Nor is it appropriate to deny interference protection for existing FSS earth stations in the satellite-dependent areas near large or medium population centres in non-satellite-dependent areas, as Telus proposes.[75] In each case, satellite services in the 3700-4000 MHz band that are currently being enjoyed in satellite-dependent communities would be disrupted by the introduction of flexible use services. This would seem to defeat the very purpose of allowing satellite-dependent areas to continue using the 3700-4000 MHz band.

V. Co-Channel Protection for FSS Earth Stations

Most commenters supported a PFD limit for co-channel protection of FSS earth stations. SES supports a PFD level of -124 dBW/m^2/MHz for co-channel sharing (as proposed by ISED), provided it is an *aggregate* limit. As SES explained, the -124 dBW/m^2/MHz PFD level was derived by the FCC to protect FSS operations in 4000-4200 MHz against the out-of-band and spurious emissions of flexible use transmitters operating in 3700-3980 MHz, incorporating a 4 dB aggregation factor. This 4 dB may

[74] Consultation at Q36; SES Comments at 24-25 (response to Q36).
[75] Telus Comments at ¶ 115.a, ¶ 185.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

not adequately account for aggregate interference in the case of high-powered emissions from a large number of co-frequency flexible use transmitters.[76]

SES's view is consistent with the RABC's analysis, which supported the FCC-derived -124 dBW/m^2/MHz PFD limit while acknowledging that "the aggregation at similar power levels from a number of flexible use stations could necessitate a stricter PFD limit if one were to be applied to individual flexible use stations."[77] The RABC recommended further technical study during the development of the Standard Radio System Plan (SRSP) for the 3700-4000 MHz band.[78]

Intelsat provided additional analysis to show that a stricter PFD limit may also be required on account of the lower elevation angles of FSS earth stations in Canada, relative to those found in the United States, due to their higher latitudes. For Canadian earth stations operating with elevation angles as low as 6 degrees, Intelsat calculated that a PFD limit of -134 dBW/m^2/MHz would be required to ensure protection.[79]

SES also suggested that a minimum distance as a coordination trigger might be easier to administer than a PFD limit, as it would avoid having to make calculations that may be disputed after an interference outage occurs. The FCC itself adopted a minimum distance of 70 km as a trigger for co-frequency coordination between flexible use services and TT&C earth stations.[80] ISED's own studies show at least 60 km of separation might be required for protection.[81] In SES's view, the separation distance required might exceed 100 km depending on the geometry, geography and terrain.[82] While there was little support for a coordination distance, SES would recommend that the concept also be studied in the development of the SRSP for the 3700-4000 MHz band.

VI. Adjacent Band Protection for FSS Earth Stations

SES commends ISED for recognizing the need to protect FSS earth stations from flexible use transmitters operating in the adjacent band. SES is concerned, however, that the adjacent band protections proposed by ISED are insufficient or incomplete in several important respects.

First, prior to the proposed FSS transition deadline (December 2023), ISED is proposing not to provide any adjacent band protection for previously licence-exempt FSS earth stations operating under a "blanket" interim authorization in 3700-4000 MHz from flexible use operations in the 3450-3700 MHz band (see Q36).[83] This contrasts starkly with ISED's proposal to provide adjacent band protection after the transition deadline for interim-authorized earth stations in 4000-4200 MHz from

[76] SES comments at 30-31.
[77] RABC Comments at ¶ 87.
[78] *Id*.
[79] Intelsat Comments at 34-35.
[80] *Expanding Flexible Use Order* at ¶ 382.
[81] Consultation at ¶ 59.
[82] *Cf.* Rogers Comments at ¶ 201 (arguing that new satellite gateway facilities in non-satellite-dependent areas "should be at least 200 km from any major urban centre to allow for population growth of the urban centres and any new suburban or ex-urban expansion"), ¶ 224 (indicating that in the absence of a common TDD framework, "large distances, in the order of 60-70 km between co-channel [flexible use] sites, will be required to achieve coexistence.").
[83] Consultation at ¶ 148, Annex G, G.5.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg
Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com
Company Register No. B 81 267
Identification No. LU18953352

flexible use services in 3700-3980 MHz, "[g]iven their importance to broadcasting."[84] In SES's view, interim-authorized earth stations in 3700-4000 MHz are just as important to broadcasting before the transition deadline as after, and providing adjacent band protection during the transition would be equally "beneficial to the content-distribution industry."[85]

As SES has explained,[86] if the adjacent 3650-3700 MHz band remained a low-powered WBS band throughout the FSS transition period, then the lack of adjacent band protection levels might be acceptable, given the lack of interference incidents to date.[87] The 50-MHz WBS band would serve as a guard band of sorts from flexible use stations operating below 3650 MHz. Even then, new filters may need to be installed. However, the introduction of high-powered flexible use services in the immediately adjacent WBS band during the transition period would present a significantly higher risk of interference that will require adjacent band protection measures similar to the ones that would be applied after the transition at the 4000 MHz band edge.[88] Such adjacent band protection levels would of course be temporary in the non-satellite-dependent areas, and would no longer be needed after the transition deadline. Without such protection measures, the prompt and orderly transition of satellite services from the 3700-4000 MHz band to the 4000-4200 MHz band will likely be disrupted.

Prior to the transition deadline, ISED is also only proposing to provide the licensed FSS earth stations in the 3700-4200 MHz band with adjacent band protection in the form of one-year advance notice of flexible use deployments within 25 km of the earth station.[89] Again, this might be acceptable if flexible use services stopped at 3650 MHz. But if flexible uses are allowed to be deployed right up to the 3700 MHz band edge during the transition period, then there is significant risk that a prompt and orderly transition of satellite services to the 4000-4200 MHz will be disrupted by the unilateral introduction of flexible use services at significantly higher power levels compared to WBS that is out of sync with FSS transition plans.[90] For this reason, and the reasons set out in its comments,[91] SES would urge the ISED to consider adjacent band protections at 3700 MHz that are similar to the ones that would be applied after the transition at the 4000 MHz band edge.[92] Again, such adjacent band protection measures would be temporary in non-satellite dependent areas and would end after the transition deadline.[93]

---

[84] Consultation at ¶ 142, Annex G, G.5 ("Earth stations authorized in accord with paragraph (b) above [i.e. interim-authorized earth stations operating in 4000-4200 MHz] are afforded adjacent band protection from flexible use stations operating in the 3700-3980 MHz band.").
[85] *Id*. at ¶ 142.
[86] SES Comments at 24-25.
[87] It should be noted that SRSP303.65 requires WBS operators to inform any satellite operator at least 6 weeks before deploying a WBS station within 25km of a licensed earth station.
[88] *See also* Corus Entertainment Comments at 12 ("the proposed conditions [on interim authorizations] must provide protection from in-band PFD emissions during the transition period and following the transition, protection from OOBE PFD emissions and front-end overload.").
[89] Consultation at ¶ 133, ¶173 Q46.
[90] In SRSP-520, flexible use stations operating in 3450-3650 MHz band must consult the satellite earth station operator when their proposed deployment is within 25 km of a licensed earth station in the 3700-4200 MHz band, and this is considering there is a 50 MHz guard band (i.e., the WBS band) separating the two services.
[91] SES Comments at 28-29.
[92] *Cf.* Corus Entertainment Comments at 13 ("5G operators should not utilize the 3650-3700 MHz band within 40 km of any FSS site until the transition deadline. We recommend this given the lack of adequate guard band during the transition period to protect sensitive equipment.").
[93] *See* SES Comments at 28.

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

Finally, as noted in Section IV. above, SES is concerned that ISED is proposing not to provide adjacent band protection for interim-authorized (previously licence-exempt) FSS earth stations in 3700-4000 MHz in satellite-dependent areas, both before and after the transition deadline.[94] While ISED's goal seems to be to allow the continued use of the 3700-4000 MHz band for FSS in satellite-dependent areas, its proposal to deny adjacent band protection from flexible use operations below 3700 MHz provides no assurance of continuity of service in that band in these areas.[95] Without adjacent band protection measures, license-exempt earth stations currently serving satellite-dependent communities in 3700-4000 MHz may be disrupted, and result in a further reduction in the C-band FSS spectrum available to serve such communities. This would seem to defeat the very purpose of preserving the 3700-4000 MHz band for satellite-dependent areas in the first place.

* * * * *

Please contact me (christophe.de_hauwer@ses.com), with copies to my colleagues, Yves Bausch (yves.bausch@ses.com) and Petra Vorwig (petra.vorwig@ses.com), if you have any questions about these reply comments.

Yours Sincerely,

/s/ Christophe de Hauwer

Christophe de Hauwer
Chief Strategy & Development Officer
SES S.A.

[94] Consultation at ¶¶ 145-146, Annex G, G.5.
[95] *See also* Intelsat Comments at 31 ("Intelsat does not agree that in satellite dependent areas earth stations should not receive protection from WBS and flexible use stations operating below 3700 MHz.").

SES société anonyme
Château de Betzdorf
L-6815 Betzdorf
Luxembourg

Tel. +352 710 725 1
Fax +352 710 725 227
christophe.de_hauwer@ses.com
www.ses.com

Company Register No. B 81 267
Identification No. LU18953352

ANNEX A

Reply Comments of SES S.A. on SLPB-002-20

The Impact of Accelerated 3800 MHz Band Repurposing on the Canadian Economy

Debra J. Aron, Ph.D.
Andy Baziliauskas, Ph.D.
Olga Ukhaneva, Ph.D.

November 30, 2020

Table of Contents

Executive Summary

We estimate the impact on Canadian GDP from an accelerated repurposing of the 3650-4200 MHz spectrum band (the "3800 MHz band") for flexible use services, including 5G. The 3800 MHz band is part of what is known as "mid-band" spectrum. Mid-band spectrum (1 GHz-6 GHz) is highly desirable for economically efficient 5G buildout because it provides a mixture of good coverage and high capacity, and this band is generally acknowledged as necessary for economic deployment of nationwide 5G networks that fully meet 5G performance requirements.

We show, applying GSMA data for an array of countries, that countries that have allocated at least 80 MHz of mid-band spectrum on average to individual mobile carriers have substantially higher actual and projected 5G penetration rates than countries that have allocated less than 80 MHz per carrier (such as Canada). Accelerated penetration of 5G drives economic benefits to a country via the extensive array of new services and industries that 5G enables via the expected improvements in capacity, speed, and latency. These benefits can be measured as increases in a country's GDP. We use these different penetration rate trajectories, combined with our estimate, based on multiple regression analysis, of the incremental impact of increased penetration of new wireless technology on GDP from a multi-country regression analysis, to estimate that accelerating the repurposing of the 3800 MHz spectrum band in Canada from December 2025 to December 2023 would increase Canadian GDP by $7.4 billion over three years, or by approximately $2.5 billion annually.

I. Introduction

These comments are provided in response to the current consultation recently released by Innovation, Science and Economic Development Canada ("ISED") "on the technical and policy framework for the 3650-4200 MHz band (referred to as the 3800 MHz band) to accommodate flexible use for fixed and mobile services."[1] The purpose of these comments is to provide our assessment of the potential benefits to the Canadian economy of accelerating the repurposing of

---

1 "Consultation on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Band," Innovation, Science and Economic Development Canada, August 2020 (hereafter, *ISED Policy Framework for the 3800 MHz Band*), ¶ 1.

portions of the 3800 MHz spectrum band. This band is currently used for fixed point-to-point wireless broadband service and the Fixed Satellite Service ("FSS") systems.[2] When released for repurposing, it is expected to be used by wireless carriers to support the implementation of 5G technologies.[3]

We estimate that if the 3800 MHz band is repurposed by December 2023 rather than by December 2025, the mandatory repurposing deadline in the U.S.,[4] the potential benefit to the Canadian economy would be $7.4 billion in 2020 dollars over the period from 2024 through 2026.[5]

II. Overview of Potential Economic Benefits of Early 5G Deployment

Leadership in a new generation of wireless technology provides substantial economic benefits to a country. Indeed, some policymakers, industry participants, and economists view the speed with which nations deploy and adopt 5G technology as a competition, or "race," in which success will have significant impact on each nation's economic development in the coming decade. There is substantial evidence that speed of deployment of new wireless technologies and the ability to outpace other countries do affect economic development.[6]

The development of the 5G ecosystem and of the extensive array of new services and industries arising from 5G will amplify GDP growth and provide substantial benefits to industry and consumers. 5G is anticipated to support 100 times more traffic than does 4G technology and

2 *ISED Policy Framework for the 3800 MHz Band,* ¶ 14.

3 *ISED Policy Framework for the 3800 MHz Band,* ¶ 13.

4 Report and Order and Order of Proposed Modification, *In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band*, Before the Federal Communications Commission, GN Docket No. 18-122, FCC 20-22 (Released: March 3, 2020) (hereafter, *03/03/2020 FCC Report and Order*), ¶ 155.

5 Unless noted otherwise, all currency amounts in this report are in Canadian dollars.

6 See, for example, "How America's 4G Leadership Propelled the U.S. Economy," Recon Analytics, April 16, 2018; "5G: The chance to lead for a decade," Deloitte, 2018; Jeffrey A. Eisenach and Robert Kulick, "Economic impacts of mobile broadband innovation: Evidence from the transition to 4G," American Enterprise Institute Economics Working Paper, May 2020, https://www.aei.org/wp-content/uploads/2020/06/Eisenach-Kulick-Mobile-Broadband-Innovation-WP.pdf; Harald Gruber *et al.*, "Mobile telecommunications and the impact on economic development," *Economic Policy* 26, no. 67 (July 2011) (hereafter, *2011 Gruber et al.*), p. 390, https://www.jstor.org/stable/41261993?seq=1#metadata_info_tab_contents; Timothy F. Bresnahan and Manuel Trajtenberg, "General purpose technologies 'Engines of growth'?" *Journal of Econometrics* 65, no. 1 (1995), p. 84.

will increase peak speeds from 1 gigabit per second ("Gbps") to 20 Gbps.[7] Capacity improvements will enable the network to carry massive numbers of connections simultaneously and will also help support ever-increasing data usage.[8] 5G is also predicted to lower the cost per gigabyte ("GB") of data substantially.[9]

In addition, 5G will allow devices to communicate in almost real time, with latency expected to be as low as one tenth that of 4G. Higher speeds and lower latency will improve customers' experiences with current applications and uses, such as watching videos, surfing the internet, and engaging with social media. Because of the order-of-magnitude improvements in speed and latency, 5G is anticipated to enable innovation in transport, logistics, internet of things ("IoT"), electricity distribution, public safety, manufacturing, energy, and health and wellness. Higher speeds and lower latency will also undoubtedly engender newer technologies like augmented and virtual reality, 8K (ultra-high definition) video, new forms of social media,[10] and other applications and technologies that are not yet anticipated.

An Accenture study on 5G deployment found that adoption of 5G (as compared to no 5G adoption at all) in Canada would increase Canadian GDP by $40 billion annually by 2026.[11] Accenture's estimated benefit represents an increase in GDP from 5G adoption by 2026 of about 2 percent annually based on current GDP.[12] The GSMA, an organization that collects data and

---

7 "IMT Vision—Framework and overall objectives of the future development of IMT for 2020 and beyond," International Telecommunication Union, Recommendation ITU-R M.2083-0, September 2015, pp. 11, 13-14.

8 Mark Collins *et al.*, "Are you ready for 5G?" *McKinsey & Company*, February 2018, https://www.mckinsey.com/industries/telecommunications/our-insights/are-you-ready-for-5g.

9 "The 5G Consumer Business Case: An economic study of enhanced mobile broadband," Ericsson, 2018, pp. 2, 7, https://www.ericsson.com/assets/local/networks/documents/the-5g-consumer-business-case.pdf.

10 "5G Top 10 Use Cases," Huawei Technologies Inc., https://www.huawei.com/us/industry-insights/outlook/mobile-broadband/xlabs/use-cases/5g-top-10-use-case; Geoffrey Morrison, "TV resolution confusion: 1080p, 2K, UHD, 4K, 8K, and what they all mean," *CNET*, February 7, 2019, https://www.cnet.com/news/4k-1080p-2k-uhd-8k-tv-resolutions-explained/.

11 "Fuel for Innovation: Canada's Path in the Race to 5G," Accenture, 2018, p. 2, https://www.5gcc.ca/wp-content/uploads/2018/06/CWTA-Accenture-Whitepaper-5G-Economic-Impact_Updates_WEB_06-19-2018.pdf.

12 Canada's GDP is approximately $1,849 billion (see "Gross domestic product (GDP) at basic prices, by industry, monthly, growth rates (x 1,000,000)," Statistics Canada, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610043402). A $40 billion increase therefore represents a growth of 2.2 percent. Canada's GDP is estimated as the average over the period from January 2020 through August 2020 (the most recent data available).

issues analyst reports on the mobile telecommunications industry,[13] also conducted a study of the effect of 5G networks on Canadian GDP. GSMA's timeframe of analysis and methodology were substantially different from those of Accenture, but the GSMA also found that the Canadian economy would benefit substantially from deployment of 5G networks. Specifically, the GSMA estimates that the total impact on Canadian GDP of 5G networks will be $150 billion USD for the entire period between 2020 and 2040, or $7.5 billion USD annually.[14]

III. THE ROLE OF THE 3800 MHZ BAND IN 5G ADOPTION AND PENETRATION IN CANADA

In 2018, ISED, at the behest of the Minister of Innovation, Science and Economic Development, outlined its plan for the release of spectrum for 5G and other applications for the period from 2018 to 2022.[15] The auction for 600 MHz (low-band) spectrum repurposed for flexible use, including 5G, concluded in April 2019, and resulted in payments by licensees of $3.47 billion.[16] In addition, up to 200 MHz of 3500 MHz (mid-band) spectrum will be allocated for flexible use,[17] with auctions for the spectrum in this band that is not already assigned scheduled to begin in June 2021.[18] The technical and policy framework for allocation and use of a large quantity

13 "About Us," GSMA, https://www.gsma.com/aboutus/; "Definitive Data and Analysis for the Mobile Industry," GSMA Intelligence, https://www.gsmaintelligence.com/.

14 "5G and economic growth: An assessment of GDP impacts in Canada," GSMA Intelligence, November 2020 (hereafter, *2020 GSMA – 5G and Economic Growth*), p. 2, https://data.gsmaintelligence.com/research/research/research-2020/5g-and-economic-growth-an-assessment-of-gdp-impacts-in-canada.

15 "Spectrum Outlook 2018 to 2022," ISED, June 6, 2018, ¶ 1, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html.

16 "600 MHz Spectrum Auction – Process and Results," Innovation, Science and Economic Development Canada, Modified April 10, 2019,https://www.canada.ca/en/innovation-science-economic-development/news/2019/04/600-mhz-spectrum-auction--process-and-results.html; "Technical, Policy and Licensing Framework for Spectrum in the 600 MHz Band," Innovation, Science and Economic Development Canada, March 28, 2018, http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11374.html.

17 "Flexible use" of spectrum, according to ISED, means that licensees can choose the services and technologies to employ in the spectrum bands they hold with minimum limitations on spectrum use. The limitations imposed on flexible use spectrum include those required for interference management purposes, terms of international agreements to which Canada is a party, and the provisions of the International Telecommunications Union's Radio Regulations. See "Framework for Spectrum Auctions in Canada," Government of Canada, March 2011, Sec. 3.3, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01626.html#section33.

18 "Table of Key Dates - Policy and Licensing Framework for Spectrum in the 3500 MHz Band," Government of Canada, Updated June 5, 2020, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11586.html.

of 3800 MHz (also mid-band) spectrum, as well as proposed changes to the allocation of the 3500-3650 MHz band, are the subjects of the current consultation.

Spectrum in each of the low-, mid-, and high-bands has different attributes that support the deployment of 5G technologies in complementary ways.[19] The low-band spectrum (frequencies below 1 GHz) can be used to cover large areas and to penetrate walls and other obstacles, making it economically suitable for providing coverage in rural areas and inside buildings. Low-band spectrum can also be used for 5G deployment in urban areas, but it does not offer the same high speeds that can be achieved with 5G deployment in mid-band and high-band spectrum. There are two reasons. First, the speeds available in 5G depend on the width of the available spectrum, and available bandwidths in low-band spectrum are relatively narrow.[20] Second, Massive MIMO technology, a key component of the 5G radio access network ("RAN") that increases its speed and efficiency, is not currently feasible in low-band spectrum. Massive MIMO is a technology that permits a large number of antennas, each with a focused geographic target, to be deployed at a single tower site. Massive MIMO is not currently available for low frequency spectrum because the long wavelengths of low-band spectrum require antennas that are too large to fit into Massive MIMO arrays.[21]

High-band spectrum (frequencies above 24 GHz), also known as millimeter wave ("mmW") spectrum, offers very wide bandwidths but short ranges and poor building penetration. The costs of deploying 5G in millimeter wave spectrum tend to be relatively high because the limited range of spectrum in this band requires many more base stations to cover a given area

---

19 Debra Aron, Chloe Sun, and Olga Ukhaneva, "The economics of 5G deployment in the "race" to 5G: The role of mid-band spectrum," *CRA Insights: The Economics of 5G*, July 2020, http://www.crai.com/sites/default/files/publications/Insights-The-Economics-of-5G_Deployment--Mid-band-spectrum-July2020_0.pdf.

20 Ian Fogg, "Why US carriers have an insatiable appetite for new spectrum," *Opensignal*, December 6, 2019, https://www.opensignal.com/2019/12/06/why-us-carriers-have-an-insatiable-appetite-for-new-spectrum; "5G Spectrum Vision," 5G Americas Whitepaper, February 2019, p. 17, https://www.5gamericas.org/wp-content/uploads/2019/07/5G_Americas_5G_Spectrum_Vision_Whitepaper-1.pdf.

21 "Professor Rappaport Explains Why T-Mobile 5G 600 MHz Ultimately Doesn't Make It," *Wireless One*, May 3, 2018, http://wirelessone.news/10-r/1037-professor-rappaport-explains-why-t-mobile-5g-600-mhz-are-a-dud; Matti Passoja, "5G NR: Massive MIMO and Beamforming – What does it mean and how can I measure it in the field?," *RCR Wireless News*, September 12, 2018, https://www.rcrwireless.com/20180912/5g/5g-nr-massive-mimo-and-beamforming-what-does-it-mean-and-how-can-i-measure-it-in-the-field; Melanie Smith, "5G FAQ series: What is massive MIMO?" RootMetrics by IHS Markit, February 10, 2020, https://www.rootmetrics.com/en-US/content/5g-faq-series-what-is-massive-mimo.

compared to sub-6 MHz spectrum. Millimeter wave spectrum is thought to be ideal for extremely dense areas such as athletic stadiums, concert venues, and, for industrial applications, factory settings, but is not well-suited for 5G deployments in rural areas, small towns, and less densely populated urban areas.[22]

Mid-band spectrum (frequencies between 1 GHz and 6 GHz) provides a mixture of good coverage and high capacity and, due to its favourable attributes, is highly desirable for the economically efficient buildout of 5G networks in suburban and all but the densest urban locations. As a result, it is generally acknowledged that mid-band spectrum is necessary for economic deployment of nationwide 5G networks. Indeed, mid-band spectrum was characterized by the U.S. Federal Communications Commission ("FCC") as "essential for 5G buildout due to its desirable coverage, capacity, and propagation characteristics."[23] ISED also noted that "[t]he 3500 MHz and 3800 MHz bands are viewed as key spectrum to support 5G technologies, and many countries have begun work to make this spectrum available for this purpose."[24] Consistent with these perceptions, most countries worldwide that have launched 5G networks have made their initial launches in mid-band spectrum. According to S&P Global Market Intelligence, a market research firm, as of February 2020, 56 out of 62 commercial 5G networks worldwide used mid-band spectrum.[25]

The subject of the instant consultation, the 3800 MHz spectrum band, is part of the mid-band. Specifically, ISED has proposed to repurpose 280 MHz of spectrum in the 3700-3980 MHz band for flexible use in its current consultation.[26]

---

22 Ferry Grijpink *et al.*," Connected world: An evolution in connectivity beyond the 5G revolution," McKinsey Global Institute, February 20, 2020, p. 12, https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/connected-world-an-evolution-in-connectivity-beyond-the-5g-revolution; "5G Spectrum Vision," 5G Americas Whitepaper, February 2019, p. 15, https://www.5gamericas.org/wp-content/uploads/2019/07/5G_Americas_5G_Spectrum_Vision_Whitepaper-1.pdf.

23 *03/03/2020 FCC Report and Order*, ¶ 3.

24 "Spectrum Outlook 2018 to 2022," ISED, June 6, 2018, ¶ 162, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html.

25 Julber Osio and Erik Keith, "33 markets worldwide have commercial 5G services," S&P Global Market Intelligence, February 14, 2020.

26 See *ISED Policy Framework for the 3800 MHz Band*, Figure 5, ¶ 65. ISED proposes that 20 MHz in the 3980-4000 MHz band be reserved as a "guard" band to protect the adjacent 4000-4200 MHz band that will continue to be used for FSS). See *ISED Policy Framework for the 3800 MHz Band,* ¶¶ 66-68. ISED is proposing to additionally repurpose the 3650-3700 MHz band to flexible use services or alternatively ISED proposes that

While access to the 3800 MHz band is not strictly necessary as a technical matter for deployment of 5G services by wireless carriers, it is necessary for wireless carriers to have access to a sufficient amount of (preferably contiguous) mid-band spectrum to provide high-quality 5G services at reasonable cost, which will drive adoption of 5G wireless service by businesses and consumers.

The amount of spectrum available to carriers affects the speed of their 5G networks.[27] For example, according to the GSMA, both peak and average speeds more than double when the spectrum band available to a carrier increases from 40 MHz to 100 MHz.[28] The cost of network infrastructure also depends materially on the amount of spectrum available to a carrier. For example, decreasing the amount of spectrum available to a carrier from 100 MHz to 60 MHz increases the number of cell sites necessary to carry the same amount of traffic in the same geographic area by 64 percent.[29] Because a significant driver of network infrastructure cost is the number of cell sites necessary to cover a given area, reducing the number of required cell sites allows for substantial economies in deployment.

The GSMA noted in a recent report the importance of sufficient spectrum in low-, mid-, and high-spectrum bands to "to deliver 5G services that provide widespread coverage and support all potential 5G use cases."[30] Specifically, it stated that:

> 5G needs a significant amount of new harmonised mobile spectrum, so defragmenting and clearing key spectrum bands should be prioritised. . . Regulators should aim to make available at least 80–100 MHz of contiguous spectrum per operator in prime mid-bands (e.g. 3.5 GHz) and around 1 GHz per operator in high-bands (e.g. mmWave spectrum).[31]

---

wireless broadband service ("WBS") licensees remain in the 3650-7000 MHz band. Therefore, it is unclear whether this band will be reallocated to flexible use services and will be available for deployment of 5G services in the future. See *ISED Policy Framework for the 3800 MHz Band*, ¶¶ 87-94.

27 "5G Spectrum: GSMA Public Policy Position," GSMA, March 2020, Figures 1 and 2, https://www.gsma.com/spectrum/wp-content/uploads/2020/03/5G-Spectrum-Positions.pdf.

28 *2020 GSMA – 5G and Economic Growth*, Figure 17 and p. 32.

29 *2020 GSMA – 5G and Economic Growth*, Figure 17 and p. 32. The GSMA noted at p. 30 of the same report that "in order to deliver high-quality 5G services it is recommended that operators have contiguous spectrum."

30 *2020 GSMA – 5G and Economic Growth,* p. 28.

31 *2020 GSMA – 5G and Economic Growth,* p. 29.

CTIA, a U.S.-based association of wireless industry participants, also emphasizes the importance of adequate spectrum in the mid band (and high band) for "achieving the faster connections and lower latency that 5G promises."[32] According to CTIA,

> it is important that licensees have the opportunity to assemble 100- megahertz bandwidth spectrum blocks.[footnote omitted] While the FCC may not be able to immediately allocate 100-megahertz channels in all instances, mid-band and high-band spectrum blocks for 5G should have 100-megahertz channel sizes as a minimum goal whenever practical. Other countries have recognized this physical and technological reality and are focusing on the availability of 100-megahertz channels for 5G.[footnote omitted][33]

Consistent with CTIA and the GSMA, Analysys Mason, a global telecoms consultancy, opined that allocating at least 80-100 MHz of contiguous mid-band spectrum per carrier is required for high quality 5G service.[34]

A. Mid-Band Spectrum Currently Available or Scheduled to Be Allocated to Wireless Carriers in Canada

All three major Canadian wireless telecommunications carriers have launched 5G commercial mobile networks.

Rogers Communications, Inc. ("Rogers") launched a 5G commercial network in January 2020.[35] As of October 2020, Rogers's 5G network reached 130 towns and cities across Canada.[36]

32 "Spectrum Consideration for 5G," CTIA, p. 10, https://api.ctia.org/wp-content/uploads/2019/03/Spectrum-Considerations-for-5G.pdf. Like the GSMA, CTIA also concluded that contiguous spectrum provides more benefits than non-contiguous spectrum: "[c]ontiguous spectrum is the most efficient way to enhance performance," and to allow for "most efficient deployments with the best spectral efficiencies and highest data rates" policymakers should prioritize allocation of contiguous spectrum to the extent possible. That is because carrier aggregation technology that allows for the aggregation of non-contiguous spectrum results in latency and signaling overhead. "Spectrum Consideration for 5G," CTIA, p. 10, https://api.ctia.org/wp-content/uploads/2019/03/Spectrum-Considerations-for-5G.pdf.

33 "Spectrum Consideration for 5G," CTIA, p. 10, https://api.ctia.org/wp-content/uploads/2019/03/Spectrum-Considerations-for-5G.pdf, citing to comments from Ericsson and Nokia.

34 Stein Gudbjørgsrud, "Mid-band spectrum is important for 5G networks," Analysys Mason, June 25, 2020, p. 1, https://www.analysysmason.com/research/content/comments/midband-5g-spectrum-rdts0/.

35 "We are leading the way with 5G, the next generation technology that will transform our lives," Rogers Communications, Inc., https://about.rogers.com/stories/5g-is-the-next-generation-in-network-technology-that-will-transform-our-lives/; "Rogers Doubles the Size of Canada's First and Largest 5G Network to Connect 130 Towns and Cities," Rogers Communications, Inc. Press Release, October 13, 2020 (hereafter, *10/13/2020 Rogers Press Release*), https://www.globenewswire.com/news-release/2020/10/13/2107398/0/en/Rogers-Doubles-the-Size-of-Canada-s-First-and-Largest-5G-Network-to-Connect-130-Towns-and-Cities.html.

36 *10/13/2020 Rogers Press Release*.

Rogers's 5G network is deployed in the 2500 MHz (mid-band) spectrum, AWS spectrum (mid-band spectrum in the 1700 MHz band), and 600 MHz spectrum (low-band). Rogers's 600 MHz and AWS spectrum is shared between its 4G and 5G networks.[37]

Bell Canada ("Bell") launched its first 5G commercial mobile network in June 2020. As of that date, Bell's network covered Montreal, the Greater Toronto Area (the "GTA"), Calgary, Edmonton, and Vancouver.[38] Bell's 5G deployment uses spectrum known asAWS-3 with frequency that ranges from 1755 to 1780 MHz (uplink) and from 2155 to 2180 MHz (downlink).[39] Bell has also announced that it will be expanding its 5G services into 28 additional markets by the end of 2020.[40]

TELUS launched its 5G network in Vancouver, Montreal, Calgary, Edmonton, and the GTA in June 2020,[41] and announced that it will expand its 5G network into 26 additional markets across Canada by the end of 2020.[42] TELUS is also using the AWS-3 spectrum band.[43]

---

37 *10/13/2020 Rogers Press Release*; "Rogers doubles 5G cities/towns to 130; launches Dynamic Spectrum Sharing," Comms Update, October 14, 2020, https://www.commsupdate.com/articles/2020/10/14/rogers-doubles-5g-citiestowns-to-130-launches-dynamic-spectrum-sharing/.

38 "Bell launches Canada's largest 5G wireless network," Bell Canada Press Release, June 11, 2020, https://www.bce.ca/news-and-media/releases/show/Bell-launches-Canada-s-largest-5G-wireless-network-1?page=1&month=&year=&perpage=25.

39 Sasha Segan, "Bell Launches 5G in Canada: Exclusive Tech Details," *PC Mag*, June 12, 2020, https://www.pcmag.com/news/bell-launches-5g-in-canada-exclusive-tech-details; "AWS-3 — Band Plan," Government of Canada, Updated September 21, 2015, at https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10957.html; "n66 (2100 MHz)," Halberd Bastion, https://halberdbastion.com/technology/cellular/5g-nr/5g-frequency-bands/n66-2100-mhz.

40 Juan Pedro Tomás, "Bell Canada to launch 5G in 28 additional markets this year: CEO," *RCR Wireless News*, August 7, 2020, https://www.rcrwireless.com/20200807/5g/bell-canada-launch-5g-28-additional-markets-this-year-ceo.

41 "TELUS launches first wave of its 5G network to bolster Canada's economic productivity, improve virtual healthcare, and support digital education," TELUS Communications Inc. Press Release, June 18, 2020 (hereafter, *6/18/2020 TELUS Press Release*), https://www.globenewswire.com/news-release/2020/06/18/2050450/0/en/TELUS-launches-first-wave-of-its-5G-network-to-bolster-Canada-s-economic-productivity-improve-virtual-healthcare-and-support-digital-education.html; "TELUS 5G is connecting Canadians for good," TELUS Communications Inc., https://www.telus.com/en/about/5g?INTCMP=tcom_network_ban_more_about_5g_to_5g_about_july102020&linktype=hero_banner.

42 *6/18/2020 TELUS Press Release.*

43 Mike Dano, "Telus will require vendors to support open RAN," *Light Reading*, September 24, 2020, https://www.lightreading.com/open-ran/telus-will-require-vendors-to-support-open-ran-/d/d-id/764191; Julber Osio and Erik Keith, "33 markets worldwide have commercial 5G services," S&P Global Market Intelligence, February 14, 2020, SP Global Market Intelligence Global Tech Media Workbook.

At least Bell and Rogers have relied in their initial 5G deployments on spectrum bands that they currently also use for 4G, utilizing dynamic spectrum sharing between 4G and 5G, and all three national carriers rely on narrow slices of mid-band spectrum available to them that are dedicated entirely to 5G. For example, Bell has 10 MHz in the n66 band dedicated entirely to 5G;[44] Rogers has 20 MHz in the 2.5 GHz band dedicated to 5G;[45] and TELUS has 10-20 MHz of spectrum in the n66 band dedicated to 5G.[46] The unencumbered mid-band spectrum currently held by carriers that can be dedicated to 5G is therefore far below the 80-100 MHz recommended by the GSMA and CTIA for efficient 5G deployment of high-performing networks, while still supporting the carriers' 4G services.

The mid-band spectrum in the 3500 MHz band that is scheduled to be auctioned in June 2021 will not provide sufficient additional bandwidth for each of the three wireless carriers in Canada to reach the 80-100 MHz considered necessary for high-quality 5G service. As noted above, no more than 200 MHz of spectrum in the 3500 MHz band will be converted to flexible use to accommodate fixed and mobile 5G wireless service. Moreover, some of this spectrum is encumbered and, in addition, up to 50 MHz is reserved as set-asides for smaller (non-incumbent) wireless carriers to support competition in wireless services.[47] This means that in most service areas at most 150 MHz of 3500 MHz band spectrum will be available for the three major wireless carriers, so that on average at most 50 MHz of spectrum will be allocated to each carrier.

Because the 3500 MHz band spectrum to be allocated in Canada will not fully supply adequate bandwidth in the mid-band necessary for each of the three major wireless carriers to deploy 5G nationwide that fully meets the performance expectations of 5G, even considering current mid-band spectrum holdings, deployment of 5G networks that supply the full benefits of 5G service will necessarily require the allocation of the 3800 MHz band. Accelerated repurposing

44 Sasha Segan, "Bell Launches 5G in Canada: Exclusive Tech Details," *PC Mag*, June 12, 2020, https://www.pcmag.com/news/bell-launches-5g-in-canada-exclusive-tech-details.

45 "Rogers Wireless," Halberd Bastion, https://halberdbastion.com/intelligence/mobile-networks/rogers-wireless; "Rogers (CAN) 5G Spectrum and Roll out," Allnet Insights & Analytics, January 16, 2020, at https://www.allnetinsights.com/blogs/news/rogers-can-5g-spectrum-and-roll-out.

46 "Telus switches on 5G in five cities; adds Samsung to 5G vendor roster," Comms Update, June 19, 2020, https://www.commsupdate.com/articles/2020/06/19/telus-switches-on-5g-in-five-cities-adds-samsung-to-5g-vendor-roster/.

47 "Policy and Licensing Framework for Spectrum in the 3500 MHz Band," ISED, March 2020, p. 14.

of the 3800 MHz spectrum will, therefore, substantially accelerate the delivery of the economic benefits of 5G to Canadians. Four wireless carriers—that is, three national carriers and a regional carrier or a smaller carrier in each region—could each acquire up to 70 MHz of spectrum through the 3800 MHz auction. Acquiring 70 MHz of 3800 spectrum would be sufficient for each carrier to reach the 80-100 MHz of mid-band spectrum that is required, according to CTIA, the GSMA, and others, for successful deployment of 5G services. The prompt repurposing of the 3800 MHz band is therefore expected to facilitate deployment of quality 5G wireless service and drive 5G adoption.

B. Existing Economics Studies Indicate That Accelerated Reallocation of Spectrum to New Services Creates Substantial Benefits

The FCC's findings in relation to the impacts of accelerated reallocation of the 3700-4200 MHz spectrum provide a useful benchmark for assessing the economic effects of accelerating mid-band spectrum repurposing in Canada. The FCC noted that "we agree that delaying the transition of this spectrum longer than necessary will have significant negative effects for the American consumer and American leadership in 5G."[48] It also noted "the significant benefits of accelerating a transition of this spectrum. Studies in the record indicate that licensing mid-band spectrum will lead to substantial economic gains,"[49] citing economic evidence from economist Jeffrey Eisenach that the annual increase in consumer surplus that would result from licensing of mid-band spectrum is approximately equal to the total amount paid by purchasers for the spectrum.[50]

The FCC also cited an estimate by economist Coleman Bazelon to the effect that one year of delay in transitioning the 3700-4200 MHz (also known as the "lower C-band") spectrum would reduce the value of re-purposing it by between 7 percent and 11 percent.[51] The FCC concluded that "(t)hese studies underscore the importance of incentivizing incumbents to clear the band for 5G use as quickly as possible."[52] In addition, the FCC cited a 2019 study by economists David

48 *03/03/2020 FCC Report and Order*, ¶162.

49 *03/03/2020 FCC Report and Order*, ¶185.

50 *03/03/2020 FCC Report and Order*, ¶185. The cited Eisenach evidence references a study by Thomas W. Hazlett and Roberto E. Muñoz, "A Welfare Analysis of Spectrum Allocation Policies," RAND Journal of Economics 40; 3 (2009) 424-454.

51 *03/03/2020 FCC Report and Order*, ¶185.

52 *03/03/2020 FCC Report and Order*, ¶185.

Sosa and Greg Rafert that quantified the effect on the U.S. economy of re-allocating 400 MHz of C-band spectrum for 5G networks. Sosa and Rafert quantified the effect at $274 billion USD in additional GDP over a 7-year period between 2019 and 2025, or $39 billion USD annually, plus 1.3 million new jobs created over 7 years.[53]

Consistent with these studies, a recent study by the GSMA estimates that the GDP impact of increasing the bandwidth of mid-band spectrum available to Canadian carriers to 100 MHz per carrier on average in the 3.5 GHz band and accelerating mass network rollout by 2 years would increase Canada's GDP by at least $30 billion USD between 2020 and 2040, implying an estimated annual impact over the 20-year period of at least $1.5 billion USD.[54] The GSMA also estimates that the total impact on Canadian GDP of 5G networks between 2020 and 2040 will be $150 billion USD, or $7.5 billion USD annually.[55]

The following table provides a summary of studies of the economic impacts of 5G adoption and delayed adoption.

53 David W. Sosa, Ph.D. and Greg Rafert, Ph.D., "The Economic Impacts of Reallocating Mid-Band Spectrum to 5G in the United States," Analysis Group, February 2019, pp. 1, 13, https://www.analysisgroup.com/globalassets/uploadedfiles/content/news_and_events/news/sosa-rafert-economic-impacts-of-reallocating-mid-band-spectrum-to-5g-1.pdf.

54 *2020 GSMA – 5G and Economic Growth*, pp. 35-37.

55 *2020 GSMA – 5G and Economic Growth*, p. 3.

Table 1
Summary of Estimates of Economic Impacts of 5G Deployment

Authors (Country Analyzed)	Impact Variable	Impact Estimates
David Safer, Mourad Soliman, and Alex Alexa, Accenture (Canada)[56]	Adoption of 5G in Canada	$40 billion annual GDP increase and 250k permanent jobs by 2026
Pau Castells, Stefano Suardi, Dennisa Nichiforov-Chuang, and David George, GSMA (Canada)[57]	Bringing 5G spectrum policies in line with "international best practice": increase mid-band spectrum bandwidth to an average of 100 MHz in the 3.5 GHz band per carrier and bring mass rollout of 5G forward by 2 years	$30 billion USD ($39 billion) GDP increase over 20 years (2020-2040)/$1.5 billion USD ($2 billion) annually
Pau Castells, Stefano Suardi, Dennisa Nichiforov-Chuang, and David George, GSMA (Canada)[58]	Total impact of 5G on Canadian economy	$150 billion USD ($195 billion) GDP increase over 20 years (2020-2040)/$7.5 billion USD ($9.8 billion) annually
David W. Sosa and Greg Rafert, Analysis Group (U.S.)[59]	400 MHz of mid-band spectrum between 3.45-4.2 GHz licensed to U.S. wireless providers	$274 billion USD ($356 billion) increase in GDP over seven years (2019-2025)/$39 billion USD ($51 billion) annual increase; creation of 1.3 million job-years/190,000 jobs annually
Coleman Bazelon, The Brattle Group (U.S.)[60]	Delay in transitioning C-band spectrum	One year of delay reduces social value of spectrum by 7% - 11%
Jeffrey Eisenach, NERA Economic Consulting (U.S.)[61]	Acceleration in transitioning C-band spectrum	Annual increase in consumer surplus from licensing of mid-band spectrum is equal to the total amount paid for the spectrum.

56 "Fuel for Innovation: Canada's Path in the Race to 5G," Accenture, June 19, 2018, https://www.5gcc.ca/wp-content/uploads/2018/06/CWTA-Accenture-Whitepaper-5G-Economic-Impact_Updates_WEB_06-19-2018.pdf.

57 *2020 GSMA – 5G and Economic Growth*, pp. 35-37.

58 *2020 GSMA – 5G and Economic Growth*, p. 3.

59 David W. Sosa, Ph.D. and Greg Rafert, Ph.D., "The Economic Impacts of Reallocating Mid-Band Spectrum to 5G in the United States," Analysis Group, February 2019, pp. 1, 13, https://www.analysisgroup.com/globalassets/uploadedfiles/content/news_and_events/news/sosa-rafert-economic-impacts-of-reallocating-mid-band-spectrum-to-5g-1.pdf.

60 Coleman Bazelon, "Maximizing the Value of the C-Band: Comments on the FCC's NPRM to Transition C-Band Spectrum to Terrestrial Uses," The Brattle Group, October 29, 2018, p. 27.

IV. Quantifying the Economic Impact of Accelerated Adoption of 5G

A. The Importance of Mid-Band Spectrum for 5G Deployment and Adoption: The Effect of Larger Bandwidth Availability

We use data provided by the GSMA for twelve countries to plot the current and projected trajectories of 5G penetration rates for a group of countries that, to date, have allocated an average of more than 80 MHz of mid-band spectrum per major carrier, and for a group of countries that allocated an average of less than 80 MHz of mid-band spectrum per major carrier.[62] Penetration of 5G service is defined as the number of 5G-capable mobile devices in a country divided by the population.[63]

We consider only spectrum allocated in the recent spectrum auctions (since 2018) that carriers can dedicate to 5G services. Figure 1 shows the average amount of mid-band spectrum allocated per major carrier in the twelve countries in our data. The countries that on average allocated more than 80 MHz of mid-band spectrum to each of their major carriers include China, Switzerland, Germany, Kuwait, Saudi Arabia, and South Korea; the countries that on average allocated less than 80 MHz of mid-band spectrum to each of their major carriers include Spain, the U.S., Australia, Italy, Thailand, and the U.K.

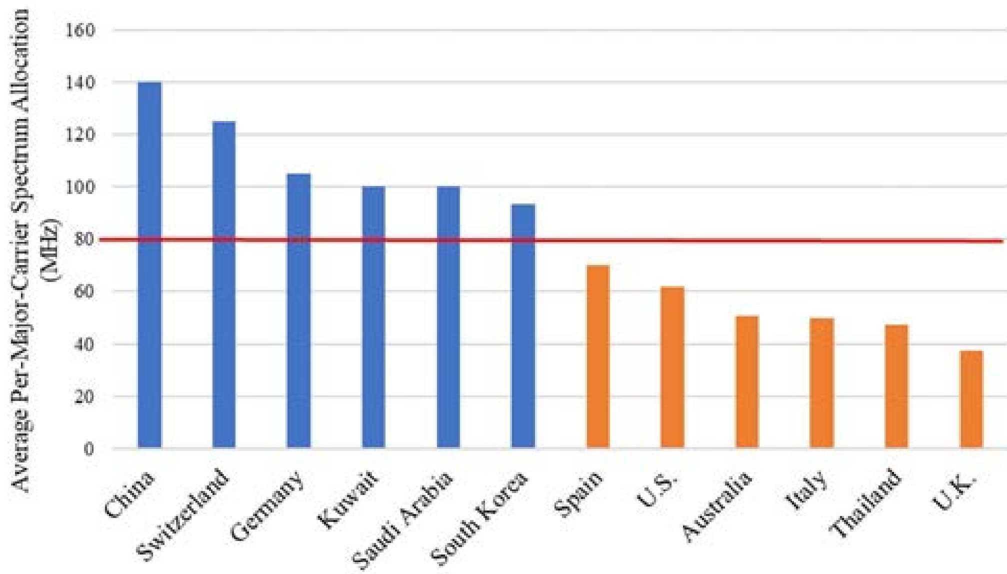
---

61 Reply Declaration of Jeffrey A. Eisenach, Ph.D., *In the Matter of Expanding Flexible Use of the 3.7-4.2 GHz Band, et al.*, Before the Federal Communications Commission, GN Docket No. 18-122, *et al.* (December 7, 2018).

62 These twelve countries are Australia, China, Germany, Italy, Kuwait, Saudi Arabia, South Korea, Spain, Switzerland, Thailand, the U.K., and the U.S. We chose these countries because all of them except China were reported as 5G leaders by Opensignal, an analytics firm that conducts independent worldwide studies of the state of mobile networks. See Ian Fogg, "Benchmarking the global 5G user experience – October update," *Opensignal*, October 13, 2020, https://www.opensignal.com/2020/10/13/benchmarking-the-global-5g-user-experience-october-update; "About us," *Opensignal*, https://www.opensignal.com/about-us. We included China because China was reported by other sources as a 5G leader. See, for example, "Global Telecoms Sector: 5G: Huawei uncertainty triggers capex cuts," Credit Suisse, October 12, 2020, p. 3. Opensignal also included Canada, Netherlands, Taiwan in the list of countries that it identified as 5G leaders. We did not include these countries in our analysis because GSMA Intelligence data reported very few quarters (1 or 2) of actual data for these three countries.

63 GSMA Intelligence database.

Figure 1
Average Per-Major-Carrier Mid-Band Spectrum Allocation by Country (in MHz)[64]



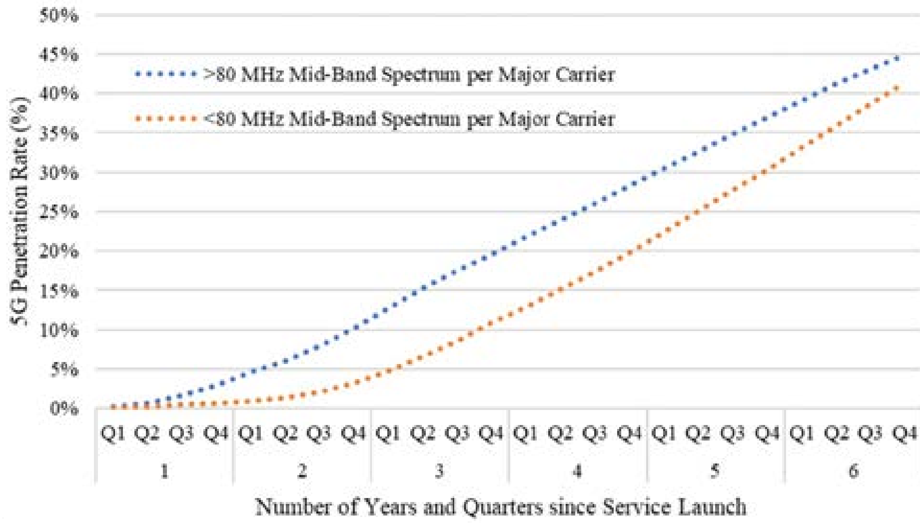
64 China: Sarah Barry James, "Spectrum, infrastructure expected to give China early lead in 5G race," S&P Global Market Intelligence, March 14, 2019, https://www.spglobal.com/marketintelligence/en/news-insights/trending/iNvEvaUqDqvKw85gUljTdw2; Janette Stewart, Chris Nickerson, Tamlyn Lewis, "5G Mid-Band Spectrum Global Update," *Analysys Mason*, March 2020, p. 3, https://api.ctia.org/wp-content/uploads/2020/03/5G-mid-band-spectrum-global-update-march-2020.pdf; Juan Pedro Tomás, "China Mobile, China Broadcasting Network ink 5G network sharing deal," *RCR Wireless*, May 22, 2020, https://www.rcrwireless.com/20200522/5g/china-mobile-china-broadcasting-network-ink-5g-network-sharing-deal; Switzerland: Sean Kinney, "5G in Switzerland: Country is 'massively in the lead,'" *RCR Wireless*, August 20, 2019, https://www.rcrwireless.com/20190820/5g/5g-in-switzerland; Germany: Jochen Homann, "Spectrum auction comes to an end," Bundesnetzagentur, June 12, 2019, https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2019/20190612_spectrumauctionends.htmlJun-19; Kuwait and Saudi Arabia: *2020 GSMA – 5G and Economic Growth*, Figure ii; South Korea: Janette Stewart, Chris Nickerson, Tamlyn Lewis, "5G Mid-Band Spectrum Global Update," *Analysys Mason*, March 2020, p. 4, https://api.ctia.org/wp-content/uploads/2020/03/5G-mid-band-spectrum-global-update-march-2020.pdf; Spain: Janette Stewart, Chris Nickerson, and Tamlyn Lewis, "5G Mid-Band Spectrum Global Update," *Analysys Mason,* March 2020, p. 4, https://mma.prnewswire.com/media/1136543/5G_Mid_Band_Spectrum_Global_Update.pdf; Frédéric Pujol, Carole Manero, Basile Carle And Santiago Remis, "5G Observatory, Quarterly Report 9, Up to September 2020," European Commission, October 2020, p. 106, http://5gobservatory.eu/wp-content/uploads/2020/10/90013-5G-Observatory-Quarterly-report-9-V2.pdf; U.S.: Milan Milanović, "How T-Mobile's Merger with Sprint is Changing the Game for 5G," Speedtest, May 28, 2020, https://www.speedtest.net/insights/blog/t-mobile-merger-sprint-changing-5g/; "CBRS Auction 105: MNO Results and The Changing Landscape," Digital Twin SIM, https://www.digitaltwinsim.com/cbrs-auction; Australia: "Vodafone Australia," Halbert Bastion, https://halberdbastion.com/intelligence/mobile-networks/vodafone-australia; "Optus," Halbert Bastion, https://halberdbastion.com/intelligence/mobile-networks/optus; Andrew Penn,
"Telstra invests $386m to secure 30-80MHz nationwide in 5G spectrum auction," Testra Exchange, December

Figure 2 demonstrates that, according to the GSMA data, countries that have allocated on average more than 80 MHz of mid-band spectrum per major carrier have and are projected to have higher 5G penetration rates for at least the first six years after the launch of 5G mobile service than countries that have allocated less than 80 MHz of mid-band spectrum per major carrier.[65]

10, 2018, https://exchange.telstra.com.au/telstra-invests-386m-to-secure-30-80-mhz-nationwide-in-5g-spectrum-auction/; Italy: "The auction on 21 September raised 4.42 billion EUR, of which 2.2 billion EUR for mid-range frequencies," 5G Observatory, October 15, 2018, https://5gobservatory.eu/italian-5g-spectrum-auction-2/; Thailand: Patpicha Tanakasempipat, "Thailand raises $3.2 billion at 5G license auctions," *Reuters*, February 16, 2020, https://www.reuters.com/article/us-thailand-telecoms/thailand-raises-3-2-billion-at-5g-license-auctions-idUSKBN20A0DC; U.K.: Sacha Kavanagh, "5G UK auction," 5G UK Limited, March 13, 2020, https://5g.co.uk/guides/5g-uk-auction/.

65 We are not able to disentangle the effect of allocating sufficient amount of mid-band spectrum from the effect of allocating a sufficient amount of *contiguous* mid-band spectrum, due to the limited number of countries in our analysis. We note, however, that among countries that allocated an average of more than 80 MHz of mid-band spectrum per major carrier, at least China, Switzerland, Saudi Arabia, and South Korea allocated on average more than 80 MHz of contiguous mid-band spectrum. Germany allocated on average less than 80 MHz of contiguous mid-band spectrum. We were not able to find information on mid-band spectrum allocations for each major carrier in Kuwait.

Figure 2
5G Penetration Rate (Actual and Projected) by Average Spectrum Allocation to Major Carriers



Notes:
[1] The penetration rate for countries with less than 80 MHz of spectrum was calculated by averaging the 5G penetration rates of Australia, Spain, the U.K., Italy, Thailand, and the U.S. The penetration rate for countries with more than 80 MHz of spectrum was calculated by averaging the 5G penetration rates of Switzerland, China, Germany, South Korea, Kuwait, and Saudi Arabia.
[2] The average penetration rates for the two groups of countries were calculated using the actual 5G penetration rates for the period from Q4 2018 through Q3 2020 and the projected 5G penetration rates for the period from Q4 2020 through Q4 2025. Projections of 5G penetration rates were made by the GSMA.

Source: GSMA Intelligence database

The impact of mid-band spectrum availability on 5G penetration rates is illustrated by the contrast between the development of 5G in the U.S. and South Korea. The U.S. and South Korea were the first two countries to launch 5G mobile service, launching service simultaneously on April 3, 2019.[66] Carriers in South Korea launched their 5G networks using spectrum in the 3420-3700 MHz band,[67] with each of three mobile wireless providers having access to at least 80 MHz

[66] Tim Fischer, "When Is 5G Coming to South Korea? (Updated for 2020)," *Lifewire*, March 1, 2020, https://www.lifewire.com/5g-south-korea-4583813; Nidhi Singh, "Here's the World's First Country to Launch 5G Services," *Entrepreneur Asia Pacific*, April 5, 2019, https://www.entrepreneur.com/article/331801; Ed Adamczyk, "Verizon becomes first in the world to activate 5G network," *UPI*, April 3, 2019, https://www.upi.com/Top_News/US/2019/04/03/Verizon-becomes-first-in-the-world-to-activate-5G-network/1901554310388/.

[67] Janette Stewart, Chris Nickerson, Tamlyn Lewis, "5G Mid-Band Spectrum Global Update," Analysys Mason, Final Report for CTIA, March 2020, pp. A-21 and A-22.

of spectrum in June 2018.[68] Unlike carriers in South Korea, U.S. carriers launched 5G in April 2019 without significant quantities of mid-band spectrum,[69] because much of the 3400-4200 MHz band was being extensively used for other services in the U.S., including the satellite delivery of video programming content to cable operators serving nearly 120 million American homes.[70] The FCC held its first auction for 3.5 GHz mid-band spectrum in July 2020.[71] Despite the simultaneous service launch, the penetration rate in the U.S. had reached only 1.6 percent as of 2020 Q3, whereas the 5G penetration rate in South Korea had reached 17 percent in the same quarter. See Figure 3. This difference in early adoption rates, while undoubtedly not due entirely to differences in the timing of mid-band spectrum allocation, is nevertheless indicative of the implications of delayed availability of mid-band spectrum.

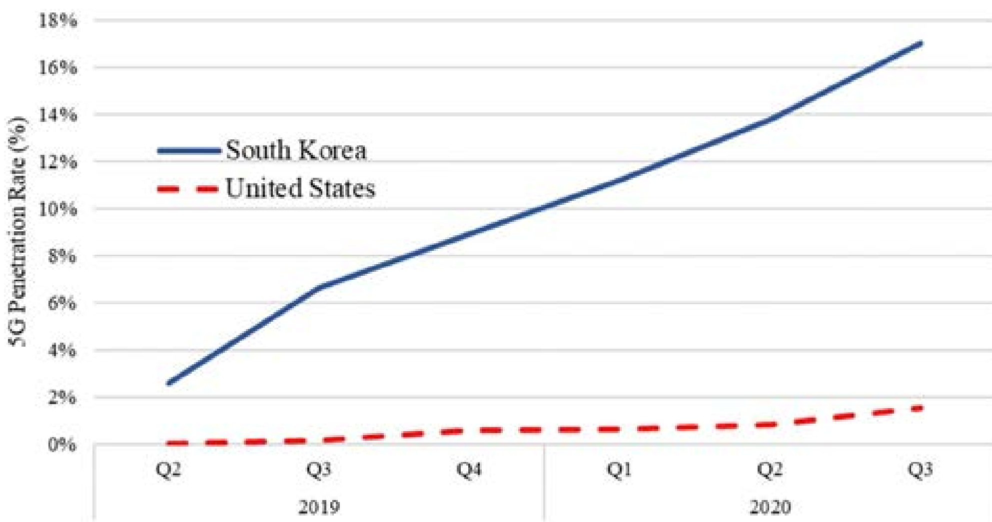
68 Iain Morris, "South Korea's 5G Auction Raises $3.3B," *Light Reading*, June 19, 2018, https://www.lightreading.com/mobile/spectrum/south-koreas-5g-auction-raises-$33b/d/d-id/744066.

69 Before July 2020, major U.S. carriers had access only to low-band spectrum (600 MHz) and mmW spectrum (24 GHz, 28 GHz, 37 GHz, 39 GHz, and 47 GHz); with the exception of Sprint (now, T-Mobile), which had access to the 2.5 GHz band via its historical spectrum holdings. See "Spectrum analysis: Why Sprint's 2.5 GHz spectrum is key to T-Mobile's future," Tutela, December 2018, https://www.tutela.com/blog/spectrum-analysis-merging-t-mobile-and-sprint-will-create-a-formidable-competitor; Mike Dano, "Here Are the Big Winners in the FCC's 24GHz & 28GHz 5G Auctions," *Light Reading*, June 3, 2019, https://www.lightreading.com/mobile/5g/here-are-the-big-winners-in-the-fccs-24ghz-and-28ghz-5g-auctions/d/d-id/751903; "Incentive Auction Task Force and Wireless Telecommunications Bureau Grant 600 MHz Licenses," Federal Communications Commission, Public Notice, DA 18-66, January 30, 2018, https://www.fcc.gov/document/auction-1002-long-form-applications-granted-3; Dan Meyer, "T-Mobile US, Dish, Comcast dominate 600 MHz incentive auction, Verizon a no-show," *RCR Wireless News*, April 13, 2017, https://www.rcrwireless.com/20170413/policy/t-mobile-us-dish-comcast-dominate-600-mhz-incentive-auction-verizon-no-show; Mike Dano, "Shocker! Verizon was the big spender in FCC's 5G mmWave auction," *Light Reading*, March 12, 2020, at https://www.lightreading.com/5g/shocker!-verizon-was-the-big-spender-in-fccs-5g-mmwave-auction/d/d-id/758171.

70 Comments of the Content Companies, *In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band,* Before the Federal Communications Commission, GN Docket No. 18-122, p. i.

71 The first mid-band spectrum auction in the U.S. for 70 MHz of spectrum in the 3.5 GHz band was held in July 2020. See "FCC Starts First 5G Mid-Band Spectrum Auction Today: 3.5 GHz Spectrum Will Promote Innovation and Advance U.S. Leadership in 5G," Federal Communications Commission News Release, July 23, 2020, https://docs.fcc.gov/public/attachments/DOC-365702A1.pdf; "Auction of Priority Access Licenses for the 3550-3650 MHz Band. 271 Applicants Qualified to Bid in Auction 105," FCC, July 1, 2020, at https://docs.fcc.gov/public/attachments/DA-20-695A1.pdf; "FCC Concludes First 5G Mid-Band Spectrum Auction," FCC, August 25, 2020, at https://docs.fcc.gov/public/attachments/DOC-366396A1.pdf.

Figure 3
5G Penetration Rate: United States and South Korea, 2019 Q2 – 2020 Q3



Source: GSMA Intelligence database.

B. The Impact of Accelerated 5G Deployment on Canadian GDP

We estimate the effect on GDP in Canada of repurposing of the 3800 MHz band before December 2023 rather than December 2025.[72] To estimate this effect, we first project what the 5G penetration rate in Canada would be between 2021 and 2026 if the 3800 MHz spectrum is repurposed by December 2023, and, alternatively, what it would be if the 3800 MHz spectrum is repurposed by December 2025.

Because, as explained in Section III, prior to the repurposing of the 3800 MHz band Canada would have on average less than 80 MHz of mid-band spectrum per major carrier, we assume that its 5G penetration rate would follow the average penetration rate trajectory of the group of countries with average mid-band spectrum per major carrier of less than 80 MHz (the orange dotted line in Figure 2). After the 3800 MHz band is repurposed for flexible use, we assume that wireless carriers in Canada would acquire enough 3800 MHz spectrum to have, in combination

---

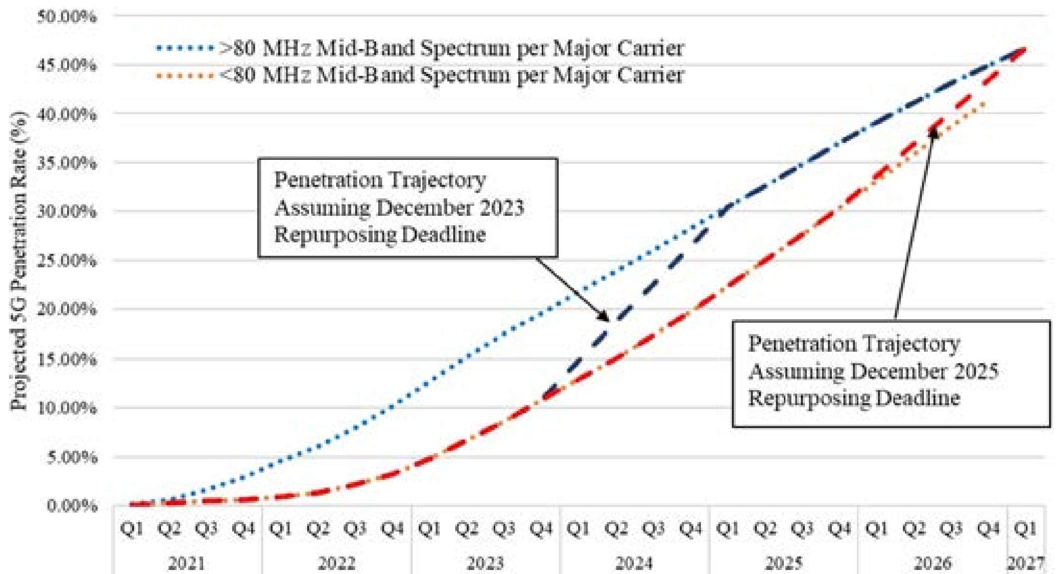
72 The FCC established a deadline of December 5, 2025 for clearing the 3700-4000 MHz band to make it available for flexible use. The FCC also ordered that the licensees that currently operate in the 3700-4000 MHz band and that elect to clear the band by December 5, 2023 will be eligible to apply for accelerated relocation payments (in addition to the reimbursement of their relocation costs). We understand that ISED proposes to synchronize the reallocation of 3800 MHz band in Canada with the reallocation of C-band in the U.S. *ISED Policy Framework for the 3800 MHz Band*, pp. 8-9, 36-37.

with the spectrum they acquire in the 3500 MHz auction plus current holdings of mid-band spectrum, access to more than 80 MHz of mid-band spectrum on average per carrier and that the 5G penetration rate trajectory would transition to the trajectory of the group of countries where major carriers have access to more than 80 MHz of mid-band spectrum on average (the blue dotted line in Figure 2).

We assume that the 5G penetration rate will glide from the trajectory with less than 80 MHz of spectrum to the trajectory with more than 80 MHz of spectrum by each carrier over the course of the year after the 3800 MHz band is repurposed, as Figure 4 illustrates.[73]

[73] The transition from one penetration rate trajectory to the other trajectory may be shorter or longer than a year. Assuming an immediate transition, i.e., in the next quarter after the 3800 spectrum is repurposed, rather than a year-long transition, results in a higher estimate of benefit to the Canadian economy. We believe a year-long transition is more reasonable as compared to an immediate transition because we expect that it will take more than one quarter for carriers to implement the use of their spectrum and for consumers to respond to the increased speed and availability of service. We note that data limitations prevent us from estimating longer transition periods. Figure 2 suggests, however, that consumers respond within a year to the greater speed of service and other attributes associated with service provided over more than 80 MHz of mid-band spectrum. We note also that by construction of our model, limiting the transition period to one year limits the length of time during which effects of the delayed transition reverberate in the economy.

Figure 4
Projected 5G Penetration Rate under December 2023 Deadline and December 2025 Deadline for Repurposing of the 3800 MHz Band



Sources: GSMA Intelligence database and Figure 2

To estimate the effect of accelerated 5G penetration on GDP, we first apply regression analysis over a panel of data covering a variety of countries to estimate the effect of 4G penetration on GDP. Specifically, we apply data from GSMA Intelligence on 4G penetration rates and total mobile penetration rates in Australia, Canada, Germany, Japan, South Korea, the United States, and the United Kingdom over the years 2012 to 2017.[74] To isolate the effect of 4G wireless penetration on GDP we control for other factors, including the country's overall wireless penetration rate, country-level net investment in nonfinancial assets, total country-level supply of labor, and volume of trade measured as the sum of imports and exports. This specification follows previous research on the effects of new wireless technology on a country's GDP.[75] These

[74] We used data available to us for this analysis. We note that these countries are considered to be leaders in one of previous generations of wireless technology (i.e., 2G, 3G, 4G) or are considered to be leaders in 5G. See "How America's 4G Leadership Propelled the U.S. Economy," Recon Analytics, April 16, 2018; See Ian Fogg, "Benchmarking the global 5G user experience – October update," *Opensignal*, October 13, 2020, https://www.opensignal.com/2020/10/13/benchmarking-the-global-5g-user-experience-october-update.

[75] See "What is the impact of mobile telephony on economic growth? A Report for the GSM Association," Deloitte, GSMA, Cisco, November 2012, pp. 13-14.

variables, as well as data on GDP per capita, are taken from the World Bank's World Development Indicators ("WDI") database.[76]

We find that a one percentage point increase in the 4G penetration rate increased GDP per capita by 0.035 percent all else equal on average over the countries studied. This result is statistically significant and robust to modifications in the model specification. Details of this estimation are provided in the Appendix.

We apply the results of the regression analysis to estimate the difference between the effects on GDP in Canada of repurposing the 3800 MHz spectrum band in December 2023 instead of in December 2025. We believe that applying the estimated effect of 4G penetration on economic activity is a sound, if conservative, benchmark for the effect of 5G penetration on economic activity. The effect on GDP per capita of the transition from 4G to 5G will be at least as great as, and likely greater than, the impact on GDP per capita of the transition from 3G to 4G because of the substantial network effects that are predicted to be generated by billions of devices connected to 5G networks, as well as the virtuous cycle generated by the numerous new and novel anticipated applications of 5G for manufacturing, logistics, transport, and other infrastructure. Because we assume that the impact of the 5G penetration rate on GDP is the same as the estimated impact that 4G penetration has had on GDP across countries, our estimates likely understate the true impact of accelerated repurposing of the 3800 MHz band on Canadian GDP.

We calculate the difference in the projected 5G penetration rates assuming repurposing in December 2023 and repurposing in December 2025 for each year from 2021 through 2026 and apply the estimated regression coefficient quantifying the effect of increased penetration of new technology to this difference to quantify the effect of accelerating the availability of the 3800 MHz spectrum on GDP per capita in Canada. We then multiply the effect on GDP per capita by the projected population in Canada in each year from 2021 through 2026 to arrive at the estimated total GDP effect of accelerated deployment of the 3800 MHz band.

Table 2 shows the estimate of the effect of accelerating the repurposing of the 3800 MHz band by two years, from December 2025 to December 2023, on Canadian GDP, in discounted

[76] See "Databank: World Development Indicators," World Bank, https://databank.worldbank.org/data/source/world-development-indicators.

present value. **The estimated discounted present value of the effect on GDP in Canada is approximately $7.4 billion in 2020 dollars over the period from 2024 through 2026.** Our estimate demonstrates that there are substantial benefits to the Canadian economy of accelerating the repurposing of the 3800 MHz spectrum that is essential for successful deployment of full-specification 5G technology.

Table 2
Benefits to the Canadian Economy of Accelerating the Repurposing of the 3800 MHz Band from December 2025 to December 2023

Year	5G Penetration Rate with if the 3800 MHz Band Is Repurposed in 2023	5G Penetration Rate with if the 3800 MHz Band Is Repurposed in 2025	GDP per Capita	Increase in GDP per Capita Because of Accelerated Repurposing of the 3800 Band	Canadian Population Estimate	Increase in Total Annual Real GDP Because of Accelerated Repurposing of the 3800 MHz Band
[A]	[B]	[C]	[D]	[E]=0.035* ([C]-[B])*[D]	[F]	[G]=[E]*[F]
2021	0.38%	0.38%	$ 48,962	$ -	38,435,380	$ -
2022	1.91%	1.91%	$ 49,209	$ -	38,915,220	$ -
2023	7.73%	7.73%	$ 49,457	$ -	39,401,051	$ -
2024	20.66%	16.30%	$ 49,707	$ 75.89	39,892,947	$ 3,027,331,187
2025	33.74%	26.38%	$ 50,034	$ 128.81	40,390,984	$ 5,202,873,852
2026	42.09%	38.55%	$ 50,416	$ 62.43	40,895,239	$ 2,553,125,006
Discounted Present Value of Total Decline in GDP (in 2020 Dollars)						**$ 7,375,069,149**

Notes:
[1] In this scenario, in column [B] we assume that the 3800 MHz band is repurposed in December 2023, and thus the penetration transitions from the penetration rate trajectory for countries with less than 80 MHz spectrum to the 5G penetration rate trajectory for countries with more than 80 MHz in 2024.
[2] In this scenario, in column [C] we assume that the 3800 MHz band is repurposed in December 2025, and thus the penetration transitions from the penetration rate trajectory for countries with less than 80 MHz spectrum to the 5G penetration rate trajectory for countries with more than 80 MHz in 2026.
[3] Real GDP per capita in [D] is assumed to grow at the rate of 0.5 percent per year. This growth rate is calculated as the compounded growth rate of annual real GDP per capita between 2014 and 2019 (6-year period), i.e., real GDP per capita growth rate = (real GDP per capita2019/real GDP per capita2014)(1/5)-1.
[4] We assume that a 1 percentage point decline in the 5G penetration rate would result in a 0.035 percent decline in GDP per capita. This assumption is based on the regression estimates reported in Table A.1.
[5] The Canadian population in [F] is assumed to grow at the rate of 1.25 percent per year. This growth rate is calculated as the compounded growth rate of the Canadian population between 2015 and 2020, i.e., the population growth rate = (Canadian population$_{2020}$/Canadian population$_{2015}$)(1/5)-1.
[6] The discounted present value of total decline in real GDP is calculated according to the following formula Σt = 2021,...2026 Real GDP$_t$/(1+0.08)(t-2020), where 8 percent is the annual social discount rate from "Canadian Cost-Benefit Analysis Guide," Treasury Board of Canada Secretariat, p. 37.

Sources:
[1] Statistics Canada. Table 36-10-0434-03 Gross domestic product (GDP) at basic prices, by industry, annual average (x 1,000,000)
[2] World Bank, Constant GDP per capita for Canada [NYGDPPCAPKDCAN], retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/NYGDPPCAPKDCAN, October 23, 2020.
[3] Statistics Canada. Table 17-10-0009-01 Population estimates, quarterly, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000901&cubeTimeFrame.startMonth=01&cubeTimeFrame.startYear=2012&cubeTimeFrame.endMonth=07&cubeTimeFrame.endYear=2020&referencePeriods=20120101%2C20200701.
[4] "Canadian Cost-Benefit Analysis Guide," Treasury Board of Canada Secretariat, p. 37, https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf.
[5] Table A.1
[6] Figure 4

V. BENCHMARKING OUR RESULTS

As a check of our results, we compared them to results of other analyses of the effects of 5G deployment on economic activity. We note that our analysis addresses a somewhat different question than those addressed by several other studies, because we consider the incremental effects of accelerated deployment of the 3800 MHz band assuming that some mid-band spectrum, particularly the 3500 MHz spectrum, will already have been allocated. In contrast, Accenture's estimate of a $40 billion increase in annual GDP by 2026 is based on a comparison of Canadian GDP with and without 5G deployment across all bands and across all uses. The GSMA's estimate of a $195 billion increase in Canadian GDP as a result of 5G deployment between 2020 and 2040 (for an average of a $9.8 billion increase in annual GDP over this 20-year period) similarly considers the impact of 5G deployment across all bands and all uses.

The Sosa and Rafert estimate of a $51 billion annual increase in U.S. GDP over the seven years from 2019 to 2025 as a result of licensing 400 MHz of 3.45-4.2 GHz mid-band spectrum to U.S. wireless providers (and not the incremental impact of licensing 3800 MHz spectrum when the 3500 MHz band has already been licensed) is roughly $5 billion in Canada after adjusting for the relative sizes of the U.S. and Canadian economies. This is in the same range as our estimate of annual GDP impact of $2.5 billion over three years from 2024 through 2026, although Sosa and Rafert estimate that the impact will be longer lasting.

The GSMA's estimate of a $39-billion impact on Canadian GDP over the period between 2020 and 2040 from bringing 5G spectrum policies in Canada into line with international best practice is similar in spirit to our analysis in that it also considers the incremental impact of a change in spectrum policy on economic outcomes. The parameters of the GSMA's estimate are not clear, so we cannot determine how closely our methodology matches with the GSMA's. We note that the GSMA estimates that the effects of changes in spectrum policy would be much longer lasting than the duration of impacts in our analysis, but our annual estimated impact of $2.5 billion over three years is larger than the GSMA's average annual impact of $2 billion. We conclude that our results are reasonable in the context of other estimates of the effects of 5G on economic activity.

APPENDIX

To quantify the impact of the penetration rate of new wireless technology generation on GDP per capita we estimate the following regression model:

$$\ln(GDP\ per\ Capita_{it}) = \alpha_0 + \alpha_1 * \ln(GDP\ per\ Capita_{it-1}) + \alpha_2 * \ln(GDP\ per\ Capita_{it-2}) + \alpha_3 * \ 4G\ Penetration\ Rate_{it} + \alpha_4 * Mobile\ Penetration\ \mathrm{R}ate_{it} + \alpha_5 * Trade\ (\%\ of\ GDP)_{it} + \alpha_6 * Investment\ (\%\ of\ GDP)_{it} + \alpha_7 * \ln\ (Labor_{it}) + \epsilon_{it} \quad (1)$$

where $GDP\ per\ Capita_{it}$ is GDP per capita in 2010 USD at time t in country i; $4G\ Penetration\ Rate_{it}$ is the penetration rate of 4G in country i at time t;[77] $Mobile\ Penetration\ Rate_{it}$ is the overall penetration rate of mobile phones (of any technology) in country i at time t; $Trade\ (\%\ of\ GDP)_{it}$ is the sum of exports and imports of goods and services as a share of GDP in country i at time t; $Investment\ (\%\ of\ GDP)_{it}$ is the net investment in nonfinancial assets measured as a share of GDP in country i at time t; $Labor_{it}$ is the total supply of labor in country i at time t; $\alpha_0, \ldots, \alpha_7$ are the regression coefficients to be estimated; and ϵ_{it} is the regression error term that captures idiosyncratic factors in country i at time t that are not captured by the explanatory variables in the regression.

The coefficient of interest is α_3. A positive and significant estimate of α_3 is consistent with the conclusion that a higher 4G penetration rate results in a higher GDP per capita. The estimated coefficient is the estimated percentage effect on GDP per capita of an increase in the 4G penetration rate of one percentage point.

We examine data from GSMA Intelligence on 4G penetration rates and mobile penetration rates in Australia, Canada, Germany, Japan, South Korea, the United States, and the United

77 The 4G penetration rate in a country is calculated as the number of 4G-capable mobile devices in a country divided by the total population of that country.

Kingdom. Data on GDP per capita, investment, labor force, and trade are taken from the World Bank's World Development Indicators ("WDI") database.[78]

The regression equation (1) might suffer from endogeneity. Endogeneity arises when there is a reverse causality issue or omitted variable bias. A reverse causality issue arises when there is a causal relationship between the outcome variable (e.g., GDP per capita) and an independent variable (e.g., the 4G penetration rate) in both directions. An omitted variable bias exists when there is a variable that is not included in the regression model but that affects both the outcome variable and one or several independent variables. For example, if certain government regulations have an effect on both GDP per capita and the 4G penetration rate, then the estimated effect of the 4G penetration rate on GDP per capita may be biased.

Our regression equation follows the regression specification estimated by Deloitte in a 2012 report on the effect of mobile telephony on economic activity.[79] Similar to the estimation strategy in Deloitte's report, we use the Arellano-Bond estimator to account for both types of endogeneity.[80] We apply the one-step Arellano-Bond estimator with 4G penetration rate and mobile penetration rate as contemporaneously endogenous variables and labor, investment, and trade as predetermined variables.[81] Table A.1 shows the results.

---

78 See "Databank: World Development Indicators," the World Bank, at https://databank.worldbank.org/data/source/world-development-indicators.

79 "What is the impact of mobile telephony on economic growth? A Report for the GSM Association." Deloitte, November 2012, pp. 13-14. Unlike the Deloitte study, I do not include government expenditures in my model because including this variable results in the violation of the critical assumption for Arellano-Bond estimator that the regression error terms are serially uncorrelated. See A. Colin Cameron and Pravin K. Trivedi, MICROECONOMETRICS USING STATA, Revised ed. (College Station, TX: StataCorp LP, 2010), p. 300.

80 A. Colin Cameron and Pravin K. Trivedi, MICROECONOMETRICS USING STATA, Revised ed. (College Station, TX: StataCorp LP, 2010), pp. 293-301.

81 Predetermined regressors are regressors that are correlated with past errors and are uncorrelated with present or future errors. Contemporaneously endogenous regressors are regressors that are correlated with past and present errors and are uncorrelated with future errors. See A. Colin Cameron and Pravin K. Trivedi, MICROECONOMETRICS USING STATA, Revised ed. (College Station, TX: StataCorp LP, 2010), p. 295.

Table A.1
Regression Results for the Estimate of the Impact of the 4G Penetration Rate on GDP per Capita. Arellano-Bond Estimator, 2012-2017

	(1) ln(GDP per Capita$_t$)	(2) ln(GDP per Capita$_t$)
ln(GDP per Capita)$_{t-1}$	0.207	0.503**
	(0.132)	(0.213)
ln(GDP per Capita)$_{t-2}$	0.073	0.022
	(0.059)	(0.081)
Investment (% of GDP)$_t$	−0.013**	
	(0.006)	
Trade (% of GDP)$_t$	−0.001***	−0.001***
	(0.000)	(0.000)
ln(Labor)$_t$	0.182**	0.031
	(0.083)	(0.144)
4G Penetration Rate$_t$	0.043***	0.035**
	(0.014)	(0.017)
Mobile Penetration Rate$_t$	0.030*	0.021
	(0.018)	(0.015)
Observations	36	42

Notes:
[1] Models (1) and (2) are estimated using one-step Arellano-Bond estimator. 4G penetration rate and mobile penetration rate are assumed to be contemporaneously endogenous; trade, investment, and labor are assumed to be pre-determined.
[2] Robust standard errors are in parentheses.
[3] *significant at 90% level; **significant at 95% level; and ***significant at 99% level.

Sources:
[1] "DataBank. World Development Indicators," The World Bank, Series "GDP per capita (constant 2010 US$)," "Trade (% of GDP)," "Net investment in nonfinancial assets (% of GDP)," "Labor force, total," at https://databank.worldbank.org/data/source/world-development-indicators.
[2] GSMA Intelligence 2019 mobile subscriptions and statistics reports for Australia, Canada, Germany, Japan, South Korea, the U.K., and the U.S.

We run two regression models: Model (1) uses all variables from equation (1); Model (2) uses all variables from equation (1) but excludes net investment as a share of GDP, because this variable is missing for all counties in 2017, except for Canada. The results of the two models are similar. Model (1) indicates that when the 4G penetration rate increases by 1 percentage point, GDP per capita increases by 0.043 percent. Model (2) indicates that when the 4G penetration rate increases by 1 percentage point, GDP per capita increases by 0.035 percent. In our estimate of the impact of 5G adoption delay, we use the more conservative result of Model (2).

To ensure the validity of my estimates, we perform two specification tests of our estimator. We run the Arellano-Bond test for zero autocorrelation (i.e., no serial correlation in an error term is a key assumption of the Arellano-Bond estimator). We also run the Sargan test for overidentifying restrictions.[82] Both tests do not reject the null hypothesis at a 95 percent confidence level that the model assumptions are met.

[82] A. Colin Cameron and Pravin K. Trivedi, MICROECONOMETRICS USING STATA, Revised ed. (College Station, TX: StataCorp LP, 2010), pp. 300-301.