5G in Canada: Policy Implications and Recommendations

Adapted from: The Socio-Economic Impacts of 5G

Deetken Insight was commissioned by TELUS to complete a comprehensive review of published research about 5G and its potential socio-economic impacts, with a particular focus on Canada. Access the full report including a bibliography here: https://deetken.com/socio-economic-impacts-of-5g/. We provide no opinion, attestation, or other form of assurance with respect to the completeness, accuracy, fair presentation, and findings from research of others that are presented in the report.

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Key Takeaways

5G connectivity will be a core enabler of digitalization as well as next-generation technologies, applications, and tools. Canada's current regulatory policies are causing significant delays in 5G deployment and hindering the realization of the socio-economic benefits of critical new technology. Canadian policymakers should collaborate across all levels of government and with 5G ecosystem participants to make current regulatory frameworks and policies more flexible, aligned with industry needs, and optimized for digitalization, harmonization, privacy and security.

This section provides detail as far as what actions each stakeholder group should ideally undertake to achieve a set of seven key **outcomes**. Additionally, a high-level framework is described for developing a 3-year **roadmap** to achieve these outcomes. Finally, a set of example metrics are provided as a foundation of a **performance measurement framework** to track and monitor deployment and adoption success.

The federal government should play a leadership role in moving these steps forward. Involvement from Canadian Radio-television and Telecommunications Commission (CRTC) and Innovation, Science and Economic Development Canada (ISED), and Statistics Canada is critical, and so too will be involvement from other departments in the federal government as well as other levels of government.

Below are the proposed key actions that need to be taken by each stakeholder group to address the current policy shortcomings and other implementation gaps. The stakeholders are categorized as:[1]

1. Government, regulators, and policy makers; referred to as "**Regulators**"
2. Enterprises, organizations, and associations; referred to as "**Industry Participants**"
3. Service Providers; referred to as "**MNOs**" and
4. Hardware, software and application providers; referred to as "**Technology Providers**":

Regulators:

i. Develop a comprehensive digital three-year roadmap including a 5G implementation plan that includes clear directions and performance management metrics for the entire 5G ecosystem.

ii. Establish 12-24-36-month national key performance indicators (KPIs) for the deployment, operational performance, customer uptake, application development and socio-economic benefits for 5G.

[1] The stakeholder groups are similar to those described in PwC work with the World Economic Forum and used in a Canada telecommunications industry report in 2020. Link to source: https://www.pwc.com/ca/en/communications/publications/761378-the-importance-of-a-healthy-telecommunications-industry-to-canadas-high-tech-success.pdf.

iii. Accelerate auctions of low and high band spectrum, ensure availability of sufficient contiguous spectrum, reduce spectrum auction reserve prices and annual fees, and avoid spectrum set-asides.

iv. Adopt a “bottom up” approach to the creation of unified national standards by promoting and supporting industry collaboration on standards, because this is the best way to ensure that technologically superior approaches prevail.

v. Provide additional government incentives in the form of: (i) accelerated capital depreciation tax policies; (ii), funding for labour reskilling support; (iii) funding for early-stage wireless research and development (R&D) programs; and (iv) target subsidies for pilot 5G-enabled use cases.

Industry Participants:

i. Ensure 5G networks are able to support cutting-edge technologies like artificial intelligence (AI), machine learning (ML), big data analytics, cloud computing and blockchain to fully realize the socio-economic benefits of these complementary technologies.

ii. Create relevant and actionable KPIs for key industry sectors to measure the operational and socio-economic impacts of 5G.

iii. Collaborate to implement proactive changes to data governance policies and support the creation of universal encryption.

MNOs:

i. Invest extensively in capacity, availability and reach of fibre backhaul and commit to resilient 5G operations.

ii. Explore new tiered service propositions for consumers and businesses and invest in and pilot viable sector-specific use cases.

iii. Establish a zero-trust security and privacy-by-design approach in 5G deployment and operations.

iv. Support government in the creation, collection and benchmarking of 5G deployment and operational metrics.

Technology Providers:

i. Orchestrate evolving technologies like AI, ML, big data analytics, anonymity-based techniques and temporary mobile subscriber identity (TMSI) to identify and mitigate cyber risks.

ii. Develop latest connected devices, software and applications in multiple forms meeting users' high-performance needs.

Globally, the deployment of 5G networks and related technologies are surfacing novel policy and regulatory opportunities and challenges around individual privacy, technological leadership, national security and economic competitiveness. Given the focus of this report on 5G networks, Deetken has targeted the policy implications discussion on this topic. The policy implications and required actions identified below have been synthesized from a rigorous systematic review of currently available literature. The literature review scope was global in nature including (as and where available) related to OECD and G7 countries. However, the policy implications are tailored for applicability within the Canadian context.

The section presents:

- **Recommended Actions** – areas of attention to address a set of recommended outcomes to support wide-scale successful and responsible adoption of 5G and related services
- **Roadmap** – a proposed framework for a 3-year integrated roadmap to achieve the outcomes
- **Performance measurement framework** – an example set of metrics to serve as a foundation for monitoring 5G deployment and adoption progress

Recommended Actions

While progress to date on 5G networks is encouraging and offers significant lessons learned, more collaboration and concrete actions are required on the part of all stakeholders to accelerate development of a healthy and strongly interlocked 5G ecosystem. The private sector will lead the 5G rollout, but governments must help. As regulators and policymakers seek to promote 5G deployment, this section outlines seven key recommended outcomes to orient policy approaches and government action. Using these key outcomes, we have identified actions to be taken by each stakeholder group. The stakeholders are categorized as:[2]

- Government, regulators, and policy makers; referred to as "**Regulators**"
- Enterprises, organizations, and associations; referred to as "**Industry Participants**"
- Service Providers; referred to as "**MNOs**" and
- Hardware, software and application providers; referred to as "**Technology Providers**":

1. **Supportive spectrum policy and timely access to spectrum across all bands:**

   Regulators should adopt national spectrum policy measures to encourage long-term heavy investment in 5G networks (e.g., long-term licenses, simple renewal process, spectrum roadmap, etc.).

   Regulators should accelerate auctions of low and high band spectrum. South Korea was the first country to commercialize 5G by auctioning mid- and high-band 5G spectrum in

[2] The stakeholder groups are similar to those described in PwC work with the World Economic Forum and used in a Canada telecommunications industry report in 2020. Link to source: https://www.pwc.com/ca/en/communications/publications/761378-the-importance-of-a-healthy-telecommunications-industry-to-canadas-high-tech-success.pdf.

June 2018[3], suggesting a willingness to expedite 5G rollout and desire to be a leader in 5G networks. In contrast, Canada is the last country among the G7, Australia and South Korea to issue mid-band spectrum and one of the last in the group to issue high-band spectrum. Canada's first mid-band 3500MHz spectrum auction was held in July 2021, more than four years behind leading jurisdictions.[4] The 3800MHz will be held in October 2023, while further low-band auctions are indicated to take place in 2027 after band clearing.[5] Expediting the clearing/repurposing of spectrum is critical for faster deployment of 5G.

Regulators should ensure availability of sufficient contiguous spectrum, as this is an important factor contributing to telecommunications MNOs' ability to roll out 5G networks effectively. The International Telecommunication Union (ITU) recommends that 80-100MHz of spectrum in 5G mid-band should be allocated per carrier to ensure support for high speeds and large amounts of traffic. Contrary to this guideline, the amount of spectrum made available for large MNOs in Canada thus far has been below global industry standards. "The auctions held in Canada in July 2021 assigned 200MHz of spectrum between 3.45GHz and 3.65GHz. Moreover, of this 200MHz, only 111MHz (average weighted by population) was actually up for auction, with the remaining 89MHz retained by incumbents (principally Bell Canada, Rogers and Xplornet)."[6] "In Canada, there was a more limited supply of spectrum available to national operators at the principal auction than in any of the benchmarked countries. Depending on the size of population centres, and depending on the amount of unencumbered spectrum available, 47MHz of the 3.45MHz to 3.65MHz block was set aside for facilities-based providers other than the national mobile service providers (NMSPs), defined as those mobile network operators (MNOs) with >10% national market-share."[7]

Regulators should create a timely success-based schedule for significant additional spectrum allocations and subsequent awards in both mid- and high-spectrum ranges to help 5G scale deliver widespread coverage and support a wide range of use cases. **"**Governments and regulators should support new harmonised bands on the international stage to help 5G services grow over the longer term (e.g., UHF, 3.3-4.2 GHz, 4.8 GHz and 6 GHz). This includes engaging in the WRC-23 process to ensure sufficient mid- and low-band spectrum is available."[8]

Regulators should support spectrum sharing and unlicensed spectrum that can play a complementary role. Policymakers should promote R&D of spectrum-sharing technologies to allow for more efficient use of limited spectrum available for 5G and for future generations of wireless networks. Development of sharing technologies will also be important for use in unlicensed spectrum, where multiple users are allowed to operate simultaneously. "[The] Defense Advanced Research Projects Agency's Spectrum Collaboration Challenge

[3] Link to source: https://www.pwc.com/ca/en/communications/publications/5g-the-digital-economy-and-canadas-global-competitiveness.pdf.

[4] Ibid.

[5] TELUS.

[6] Link to source: https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf.

[7] Ibid.

[8] Link to source: https://www.gsma.com/spectrum/wp-content/uploads/2021/04/5G-Spectrum-Positions.pdf.

has presented successful examples of new approaches to improve spectrum sharing, leveraging automation and artificial intelligence to improve adaptability. Future initiatives should continue to build upon its initial successes."[9]

Regulators should avoid setting spectrum aside since it could jeopardise the success of public 5G services and may waste spectrum. "Canada is the only country among the 24 [reviewed] to use set-asides regularly in spectrum auctions, and it does so in a way that makes the set-aside available for companies that are already well-established."[10]

Regulators should structure reserve prices, annual fees, spectrum supply and auction design in a manner to avoid inflating 5G spectrum prices. "The average price paid at the Canada July 2021 [3500 MHz] auction, US$1.833 per MHz/pop, was the highest price paid. It was 164% of the average price paid in the U.S., the next highest average price paid in any country. It was around 10 times higher than in France and 11 times higher than in the U.K. NMSPs paid an even higher average price, US$2.62 per MHz/pop."[11] The reserve prices, annual spectrum fees, spectrum supply and auction design are primarily the responsibility of government and regulators who should also carefully consider 5G backhaul needs, including making additional bands available and supporting wider bandwidths in existing bands. Measures should also be taken to ensure licenses are affordable and designed effectively in consultation with ecosystem participants to maximise benefits of 5G. An example of best practice is Spain, which has cut reserve prices by 12.5% to 20% for its 700 MHz band while also doubling the length of the spectrum license lease from 20 to 40 years.[12]

2. **Reinforcement of resilient network infrastructure with appropriate coverage, bandwidth, latency and reliability:**

Regulators should facilitate fewer restrictions on infrastructure planning and restrictions on permits as 5G and other wireless services have significantly higher infrastructure needs, including fibre networks and small cell deployment. New legislation should be implemented to provide a single regulatory body, such as the Canadian Radio-television and Telecommunications Commission (CRTC), with direct authority to resolve disputes, order access and establish guidelines (as appropriate) with respect to all passive infrastructure owned by utilities such as power, gas, water and local authorities. This additional authority should also be applicable to non-traditional structures for which access will be key for efficient deployment of many future technologies. This would include light poles, bridges, water towers, street furniture, and privately owned buildings such as high-rises and office towers. "5G implementation requires access to poles, buildings and trenches – passive infrastructure – since large numbers of installed antennas are required to

[9] Link to source: https://www.cnas.org/publications/reports/securing-our-5g-future.

[10] Link to source: https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf.

[11] Ibid.

[12] Link to source: https://www.pwc.com/ca/en/communications/publications/5g-the-digital-economy-and-canadas-global-competitiveness.pdf.

compensate for short range of signal when communicating at very high speed."[13] Proactive amendments to the Telecommunications Act are required to ensure that public access rights for MNOs apply to the construction of "transmission facilities" instead of "transmission lines" to enable faster deployment of network infrastructure. Changes are also required to the Radiocommunication Act to accelerate the deployment of wireless network facilities by eliminating some site approval requirements and providing for access (as well as procedures that govern said access) to supporting structures owned and operated by third parties. Infocomm Media Development Authority in Singapore has required that "mobile installation spaces" – typically rooftop spaces reserved for telecommunication equipment – be provided to MNOs by building developers and owners free of charge.[14] In Japan, MNOs can install 5G base stations on roughly 200,000 traffic lights across the country. Moreover, the Japanese government has proposed that costs of using traffic lights for 5G deployments be shared between MNOs and local governments.[15] In 2018, the U.S. Federal Communications Commission issued infrastructure rules aimed at streamlining and removing barriers at federal, state and city levels. These include establishment of two new "shot clocks" to review small wireless facilities deployments: 60 days for collocation on pre-existing structures and 90 days for new construction.[16] Similarly, the EU has launched a consultation on light deployment regime for small cells, which will likely lead to regulation updates in the intermediate term.[17] The Danish Energy Agency is exploring guidelines (including best practice examples) for public authorities on how to deal with applications for permission to set up telecommunications infrastructure.[18]

Regulators and MNOs should promote extensive capacity, availability and reach of fibre backhaul. The Canadian government launched the CA$2.75 billion Universal Broadband Fund to support high-speed internet projects across the country. These projects will bring the internet at speeds of 50/10 Megabits per second (Mbps) to rural and remote communities by 2030.[19] Some of the currently allocated broadband funds may be used to expand 4G wireless coverage on roads. This is a good start, but it should also be expanded to encourage 5G access, including selective funding of fibre backhaul, cell towers or other network investments needed to expedite rural/remote 5G rollout, in rural and remote communities where market-based service economics are insufficient.

5G coverage and service obligations should be imposed by Regulators, but they should be reasonable, with financial incentives if considered. Coverage and service obligations directly impact the cost of network deployment. MNOs will deploy and create

[13] Link to source: https://ppforum.ca/wp-content/uploads/2021/09/FutureProof-ConnectingPost-PandemicCanada-OCT2021-PPF-EN.pdf

[14] Link to source: https://www.imda.gov.sg/-/media/Imda/Files/Regulation-Licensing-and-Consultations/Consultations/completed-consultations/consultation-papers/12/COPIF-2018-Industry-briefing-on-7Dec2018-cleanpptx.pdf?la=en.

[15] Link to source: https://resources.realestate.co.jp/living/5g-in-japan-govt-to-allow-5g-base-stations-to-be-installed-on-200000-traffic-lights-nationwide/.

[16] Link to source: https://docs.fcc.gov/public/attachments/FCC-18-133A1_Rcd.pdf.

[17] Link to source: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/1981-Light-deployment-regime-for-small-area-wireless-access-points_en.

[18] Link to source: https://ens.dk/sites/ens.dk/files/Tele/5g_action_plan_for_denmark.pdf.

[19] Link to source: https://ised-isde.canada.ca/site/high-speed-internet-canada/en/universal-broadband-fund.

service levels for networks based on the marginal return of building and servicing a new site. If regulators impose onerous coverage and service obligations that are not commercially feasible, this will negatively impact return on investment for MNOs and delay deployment and innovation.[20] However, reasonable time limits should be placed on the deployment of the spectrum so that MNOs are incentivized to deploy the acquired spectrum in a cost effective and timely manner, thereby avoiding having to surrender the spectrum back to the government for auction to other players.

MNOs should commit to sustainable operations including softwarization and virtualization, flexibility and adaptation to diverse (and changing) requirements of applications with maximum reusability of common network infrastructure capabilities. Efficiency and open integration between application and 5G ecosystem will be critical, as will scalability, energy efficiency and customisation (i.e., modularization of functions, separation between control plane and user plane, network slicing, flexible user plane and fixed mobile convergence).

3. **Investment in latest connected devices, software and applications in multiple forms meeting users' high-performance needs:**

Regulators, MNOs, Technology Providers and Industry Participants should develop a comprehensive digital three-year roadmap, including a 5G implementation plan that includes clear directions and performance management metrics for infrastructure and device vendors, software and applications providers, service providers and other industry sector associations. This will ensure the availability of devices, software and applications that are compatible with local spectrum allocation and in line with harmonized global standards.

Regulators and MNOs should ensure supply chain trust. According to a U.S. April 2019 Defense Innovation Board report, "the compromised supply chain issue poses a serious threat to national security by introducing vulnerabilities into networks and systems."[21] Moreover, supply chains for 5G wireless telecommunications will expand on existing global supply chains for wireless technology and be highly complex. Another report states that "the two keys to supply chain trust are promoting supplier diversity and creating risk management strategies for technology acquirers."[22]

MNOs, Technology Providers and Industry Participants should integrate 5G networks with cutting-edge technologies like AI, big data, cloud computing and block chain to fully realize the socio-economic benefits of 5G.

Regulators should engage and collaborate with all ecosystem participants to crystalize priorities, cut red tape and cultivate a spirit of innovation. This will help businesses tap into 5G in scalable ways. The right regulatory environment will cultivate the right innovation environment. Federal, provincial, and municipal governments need to align on the 5G services and outcomes they expect to deliver to their citizens and businesses.

[20] Link to source: http://www.coleago.com/app/uploads/2020/10/Regulatory-Policy-and-Assignment-to-Support-5G1.pdf.

[21] Link to source: https://media.defense.gov/2019/Apr/03/2002109302/-1/-1/0/DIB_5G_STUDY_04.03.19.PDF.

[22] Link to source: https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210301_Lewis_Accelerating_5G_0.pdf.

4. **Development of competitive and targeted services provided by MNOs for different market segments and key sectors through right partnership models:**

Regulators should provide additional government incentives in the form of targeted subsidies and accelerated capital depreciation tax policies to incent investment from various ecosystem participants. Many nations already offer a range of tax grants, holidays and related benefits. To unlock the full value of 5G for the entire country, governments should consider providing financial support to achieve the widest coverage. Several financial incentive models are taking shape. In the U.K., for example, MNOs agreed with the government to build a shared rural network with financial contributions from both industry and government.[23] Not all subsidies are for rural deployment. Another example is Japan, which has introduced tax measures that allow MNOs to use either a 30% special depreciation rate or a 15% tax credit for their 5G network investments.[24]

Regulators should increase funding for early-stage wireless research and development (R&D) and pilot programs to identify and overcome challenges with the ongoing transition to virtualized network functions, enable more software running on generic hardware infrastructure in wireless networks and protect innovators' intellectual property rights.[25]

MNOs and Regulators should generate and align incentives for cross-sector collaboration by ensuring that entities that bear the cost and risk of investment participate proportionately in the resulting value. There are many reasons to believe that much of the new 5G value will be generated in business-to-business applications. In Japan, NTT DOCOMO and an international group of other leading firms jointly announced in early 2021 that they "have signed a basic agreement to establish a consortium to provide 5G solutions, first in Thailand and later in other Asia Pacific countries with possible inclusion of additional partners."[26]

Regulators and MNOs should invest in and pilot viable sector-specific use cases that help unleash the power of evolving technologies (e.g., Internet of Everything, AI, big data analytics, etc.). Currently, value potential is fragmented across hundreds of use cases and different domains without a single source of significant demand. Direct investments and incentives related to specific 5G implementations are required across industry verticals to accelerate nationwide 5G deployment and to support Canadian manufacturing, agriculture, community anchor institutions, remote education, remote work and telemedicine. The supply-side dimension must be complemented with initiatives to strengthen demand for innovative applications of 5G from industry, institutional and public sectors. One laudable step was the $400 million investment by the governments of Canada, Ontario and Quebec to create a 5G test bed, ENCQOR, which has enabled hundreds of smaller developers of 5G technology and applications to build and test their 5G-enabled technology. To finance the cost of

[23] Link to source: https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf.

[24] Link to source: https://www.pwc.com/ca/en/communications/publications/5g-the-digital-economy-and-canadas-global-competitiveness.pdf.

[25] Link to source: https://itif.org/publications/2020/04/27/us-national-strategy-5g-and-future-wireless-innovation.

[26] Link to source: https://www.ntt.com/en/about-us/press-releases/news/article/2021/0203.html.

extending the ENCQOR model and the Centre of Excellence for Next Generation Networks (CENGN), at least 5% of the recent 5G spectrum auction windfall of CDN$8.9 billion should be earmarked to support demand-side experimentation and testing of new 5G-enabled technologies. This would require an investment of $450 million by the federal government.[27] This, and similar cooperative models, need to be well-funded and replicated across Canada.

MNOs should explore new tiered service propositions for consumers and businesses, while Regulators should consider some form of compromise to aspects of Net Neutrality to promote investment. Regulatory authorities should acknowledge the dynamic nature of 5G networks and services and that optimised connectivity built on network slicing is compatible with the open internet principle. Network slicing will enable MNOs to create products for different verticals that can be customized for enterprises. Customizable network capabilities include data throughput, latency, reliability, security and service optimization. Currently, the CRTC defines net neutrality as "the concept that all traffic on the Internet should be given equal treatment by Internet providers with little to no manipulation, interference, prioritization, discrimination or preference given."[28] However, 5G will use advanced structures, devices, systems, and processes to manage various types of traffic thereby allowing 5G to provide a broader array of use cases than previous mobile technologies, such as 3G and 4G. Several of the applications envisaged for 5G will be of a control nature, requiring infinitesimal delay and high consistency and dependability. These applications will necessitate traffic prioritization – a capability currently restricted by current CRTC net neutrality rules. 5G networks face the obstacle of being built in an environment of high ambiguity, where most of the services that support 5G business models seem to be in direct contravention of the current CRTC rules pertaining to net neutrality. It is critical to immediately begin collaborative discussions among the 5G ecosystem participants to address this challenge and promote 5G functionality and modernization. While controversial, regulators should collaborate with MNOs to formulate some form of compromise where "a minimum level of performance is guaranteed for all Internet users, but operators can provide a differentiated service for speeds above the minimum."[29]

Regulators, MNOs, Technology Providers and Industry Participants should work to mitigate the current shortage of technical skills across the ecosystem by launching upskilling or reskilling initiatives among current workers, reimagining training for tech talent by promoting apprenticeship programs, turning to the global freelance economy, and reshaping national immigration policy. According to a 2021 survey by Gartner, businesses think that talent shortage is the biggest barrier to adoption of 64% of new technologies, compared to just 4% in 2020. This means that in most cases, IT leaders who want to deploy a new tool to boost business outcomes anticipate that a lack of suitable workers to implement the technology will be problematic at some point. Talent availability even overtook implementation costs (29%) or security risks (7%) as a top barrier to deploying a new technology. This issue is particularly prevalent when it comes to adopting IT automation

[27] Link to source: https://ppforum.ca/wp-content/uploads/2021/09/FutureProof-ConnectingPost-PandemicCanada-OCT2021-PPF-EN.pdf.
[28] Link to source: https://crtc.gc.ca/eng/internet/diff.htm.
[29] Link to source: http://www.coleago.com/app/uploads/2020/10/Regulatory-Policy-and-Assignment-to-Support-5G1.pdf.

technologies: in 75% of cases, leaders cited talent availability as the main adoption risk factor. There is a similar talent shortage for computer infrastructure, platform services, network security, digital workplace, and storage and database.[30] Canada faces these challenges as well. According to a report by the Business Development Bank of Canada, at least 55% of Canadian tech entrepreneurs are having difficulty hiring the employees they need.[31]

5. **Creation of unified national standards that are strongly interlocked with global standards to support the timely and responsible deployment and adoption of 5G:**

Regulators, MNOs, Technology Providers and Industry Participants should participate nationally in international standards-setting bodies, specifically the International Telecommunication Union (ITU), 3rd Generation Partnership Project (3GPP), Global System for Mobile Communications (GSMA), O-RAN Alliance, Internet Engineering Task Force (IET), Institute for Electrical and Electronics Engineers (IEEE), International Standards Organization (ISO), and International Electrotechnical Commission (IEC) that are defining the building blocks for 5G. "Standards bodies are not all the same. In order to assess the proper role of government in global standards setting organizations, and to avoid unintended consequences, policymakers need to account for the different goals and roles of standards bodies, their historical roles and responsibilities, and the positive benefits they have achieved."[32]

Regulators, MNOs, Technology Providers and Industry Participants should conduct research and develop national technical standards based on consensus global technical direction while maximizing technology compatibility, configurability, interoperability, portability, security, repeatability, energy efficiency, and quality, thereby avoiding unnecessary duplication of effort in terms of network and device upgrades. These stakeholders should also demonstrate leadership in the ongoing modernization and streamlining of regulation that is supportive of standards for network infrastructure, spectrum, devices and applications.

Regulators, MNOs, Technology Providers and Industry Participants should adopt a "bottom up" approach to global standards by promoting and supporting industry collaboration on standards, because this is the best way to ensure that technologically superior approaches prevail. "Rather than taking a direct role in standards setting organizations where the private sector has typically led, the government should instead prioritize support for private efforts in standards bodies, encouraging and facilitating broader private participation."[33]

Regulators, MNOs, Technology Providers and Industry Participants should support research and other initiatives to ensure the responsible adoption of 5G and related

[30] Link to source: https://www.marketscreener.com/quote/stock/GARTNER-INC-40311131/news/Gartner-Survey-Reveals-Talent-Shortages-as-Biggest-Barrier-to-Emerging-Technologies-Adoption-36410808/.
[31] Link to source: https://www.bdc.ca/en/about/analysis-research/tech-industry-outlook.
[32] Link to source: https://www.wiley.law/assets/htmldocuments/Tech-Standards.pdf.
[33] Ibid.

services. Stakeholders should monitor for and address unintended consequences of 5G such as the potential proliferation of e-waste related to expired or faulty devices and sensors.

6. **A uniform approach or minimum requirements to data governance and security at the underlying network level:**

Regulators, MNOs and Technology Providers should establish a zero-trust security-by-design approach from end to end for all devices and software on the 5G network. "Each device and application must be assessed for cyber risk and allowed access to network resources only if they meet high security standards. Also, all software must be constantly checked for vulnerabilities and malware."[34]

Regulators, MNOs and Technology Providers should adopt uniform privacy-by-design practices that help enhance protection of consumers' personal information. "These practices would address (1) the collection, storage, and use of 5G user data and (2) uniform practices for informing users and obtaining their consent for collection, storage and use of such data. Policymakers could also choose to apply practices to ensure the policy framework addresses other new technologies, such as biometric data collection. Uniform practices could help consumers better understand the privacy of their data and inform their decisions on what information to provide. Such practices could help overcome the privacy concerns exacerbated by 5G networks and applications because they could reduce consumer uncertainty about data collection, use and storage."[35]

Regulators, MNOs, Technology Providers and Industry Participants should create universal encryption to minimize the risk of data being compromised or corrupted. MNOs and other 5G participants will need to adopt strong encryption methods for traffic between end points and services. These methods will need to be flexible and scalable enough to be strengthened progressively over time as standards and risks evolve. They should also be sufficiently agile to thwart middleware attacks, in which hackers eavesdrop on communications between two network participants.

MNOs and Technology Providers should orchestrate evolving technologies like artificial intelligence (AI), machine learning (ML), big data analytics (BDA), anonymity-based techniques and temporary mobile subscriber identity (TMSI) to identify and mitigate mutable cyber risks, provide high levels of automated intelligence to manage and eliminate security intrusions across hyper-dense communications and ultra-low latency applications, and increase the difficulty of identifying mobile devices and subscribers. These technologies will be used for traffic analysis, network packet inspections, threat identification, infection isolation and location, and identity tagging.

Regulators, MNOs, Technology Providers and Industry Participants should collaborate to implement proactive changes to data governance policies that could abate the strain of increased mobile capacities, such as ensuring data singularity, reducing existing data "Redundancy, Obsolescence, Triviality" (ROT), prioritizing important data in

[34] Link to source: https://www.pwc.com/gx/en/industries/tmt/5g/pwc-5g-in-healthcare.pdf.

[35] Link to source: https://www.gao.gov/assets/gao-21-26sp.pdf.

ingestion, virtually merging “silo-ed” information, and ensuring all data management policies are uniform across platforms.

7. **Need for a comprehensive set of operational and sector specific Key Performance Indicators (KPIs) to track the performance and socio-economic contributions of 5G:**

Regulators, MNOs and Industry Participants should work together to set 12-24-36-month national KPIs for the deployment, customer uptake and application development for 5G. China’s Ministry of Industry and Information Technology recently released a draft of the 2021-2023 Action Plan for 5G Applications, putting forward seven key performance indicators (KPIs) and three initiatives on the application and development of 5G. The action plan sets a goal to greatly improve the application and development of 5G and the overall strengths in 5G by 2023. Specifically, a new ecosystem featuring deep integration of IT (information technology), CT (communication technology) and OT (operational technology) will be developed; breakthroughs in 5G applications in key fields will be achieved; the dual pillars of the technology industry and standard system will be built; fundamental capabilities in terms of network, platform, security and other fields will be further improved; and a pattern of a wide range of 5G applications will basically take shape. Seven key performance indicators are set for the application and development of 5G, namely a 5G penetration rate of 40% among individual users; 50% of access traffic with 5G networks; a 5G penetration rate of 35% in large industrial enterprises; a 200% average annual growth rate of 5G-powered IoT end users; 18 5G base stations per 10,000 people; 3,000 5G-empowered industry-specific virtual private networks; and 100 5G applications in each key industry.[36]

Regulators, MNOs and Industry Participants should create relevant and actionable KPIs for both MNOs and key industry sectors to measure the operational performance and socio-economic impacts of 5G. 3rd Generation Partnership Project **(**3GPP) is still in the process of completing 5G KPIs. These KPIs are driven from ITM-2020 and mainly consider three broad categories: (1) Enhanced Mobile Broadband (eMBB), (2) Mission Critical Control (MCC) and (3) Massive Internet of Things (mIoT). These KPIs should be tracked and reported to Canadian Radio-television and Telecommunications Commission (CRTC) and Statistics Canada by each MNO across province/territory, and population centers. The key operational and customer centric KPIs are discussed further below in this section and in Section 3. Metrics should dovetail with sector strategies, for example, creating a national virtual care strategy to ensure universal access to virtual care, especially for patients in underserved communities that cannot access physical clinics.

Regulators, MNOs and Industry Participants should collect, audit and publish the socio-economic benefits that are being driven by the deployment and adoption of 5G services and applications by province/territory, population centers and nationally. These metrics should be defined jointly by CRTC and Statistics Canada and measured and gathered by the various industry associations and provided to both CRTC and Statistics Canada for the purposes of reporting and publishing. The CRTC and Statistics Canada

[36] Link to source: https://cset.georgetown.edu/wp-content/uploads/t0339_5G_action_plan_draft_EN.pdf.

should also ensure the integrity and accuracy of the data submitted via random audits. The data should be made available to the public via open government concept so that it may be leveraged by MNOs, researchers and other consultancy firms for big data analytics to provide key insights on future policy decisions.

Roadmap

As demonstrated above, 5G will present a high degree of complexity for policymakers and regulators as these new technologies and business models replace the current system. For Canada to capitalize on the extensive environmental, social and economic benefits of 5G technology, policy and regulatory modernization will be required for infrastructure and spectrum, public safety, cybersecurity, privacy, healthcare and training standards. Regulators and policymakers are under increasing pressure to connect with peers across all economic sectors to leverage digital transformation as an engine for the achievement of the United Nations Sustainable Development Goals (SDGs). They will need to engage with all their 5G ecosystem partners to define initiatives that help clear the path for 5G by future-proofing access to connectivity and encouraging early adoption of 5G and digitalization. Regulatory reform is critical for the future success of 5G. Finding the right balance that serves the interests of diverse stakeholders is key to that success.

The current Canadian government regulatory frameworks and policies do not fully embrace the new shift in regulatory perspectives mentioned above. By focusing on the affordability of mobility services, the government risks overlooking other factors that play an important role in the promotion of a healthy telecommunications ecosystem. The marginalization of these other key factors will have severe negative long-term impacts not only on the Canadian telecommunications industry, but on the national socio-economic objectives and global competitiveness goals of the current administration, such as addressing regional inequalities, achieving GHG emissions targets and climate change objectives and other ESG goals.

The creation of a **three-year digital roadmap** is recommended to achieve these outcomes. The creation of this roadmap should be led by the federal government, as seen in the case of China,[37] United Kingdom,[38] and Finland,[39] in active collaboration with the provincial and municipal governments, regulatory bodies and agencies such as Canadian Radio-television and Telecommunications Commission (CRTC) and Innovation, Science and Economic Development Canada (ISED), MNOs and other 5G ecosystem participants. Below is a proposed framework for the creation of a well articulated evergreen national Digital Roadmap including 5G enablement.

TABLE 6.1: 5G ROADMAP FRAMEWORK

Phases	Roadmap Components

[37] Link to source: https://english.www.gov.cn/policies/latestreleases/202201/12/content_WS61de9a35c6d09c94e48a385f.html.

[38] Link to source: https://www.gov.uk/government/publications/roadmap-for-digital-and-data-2022-to-2025/transforming-for-a-digital-future-2022-to-2025-roadmap-for-digital-and-data.

[39] Link to source: https://valtioneuvosto.fi/en/-//10623/ministerial-working-group-sets-finland-s-digital-vision-and-targets-for-2030.

1. Identify strategic context and foundational elements	1. Identify Canadian long-term digital objectives including 5G enablement. 2. Ascertain roles and responsibilities of the key players (e.g., government, regulatory bodies and other agencies, enterprises, organizations, and associations of industry verticals; MNOs; and hardware, software, and application providers) in the development of the digital roadmap including the deployment, implementation and operations of 5G networks and complementary technologies. 3. Conduct an environmental scan on digital frameworks, 5G networks and complementary technologies with targeted and coordinated research and analysis of (e.g., spectrum and technology; competitors; customer and industry vertical needs assessment; regulatory environment; and core competencies) to assess Canadian strengths/weaknesses versus other countries.
2. Define policy and ecosystem development guidelines to facilitate 5G build out	1. Shortlist suppliers/partners and evaluate their global competitiveness and risk (e.g., threats, vulnerabilities, and risks to 5G infrastructure). 2. Develop an on-going partner engagement and collaboration model. 3. Create a list of different capabilities and business models by industry vertical that 5G digital solutions and complementary technologies could potentially enable as well as corresponding governance models. 4. Establish a spectrum allocation, sharing, pricing, and licensing framework as well as a standards policy framework. 5. Identify and establish additional legal and policy frameworks pertaining to infrastructure support, development of 5G sites, cross border issues, industry verticals applications, coordination, and harmonization of 5G across different levels of government and different regions. 6. Define security principles for 5G infrastructure, software, applications, and complementary technologies and devices. Establish potential policies and incentives to address any challenges. 7. Identify other potential incentives and options for ecosystem partners to ensure Canada's telecommunication, technology and industrial base are economically viable in the long-term including tax system revisions, R&D and use case subsidization, and dedicated funds for remote/rural buildout. 8. Create a list of potential "workforce of the future" skill gaps and develop potential incentives and options for "workforce of the future" training and development programs. 9. Determine 5G awareness and education plan and roles of different partners.
3. Monitor and report 5G deployment, new service and device introductions and realization of economic and ESG benefits	1. Construct detailed deployment, operational and customer satisfaction KPIs/metrics along with descriptions and calculation methodology, scope, limitations, and frequency of reporting. 2. Ascertain roles and responsibilities of ecosystem partners and government agencies such as ISED, CRTC and Statistics Canada in gathering, verifying, benchmarking and publishing these metrics to ensure a "Single Version of the Truth".

Performance Measurement Framework

While a strong metric-based deployment and operations framework is critical to measuring the performance of 5G rollout, it is only a component of a holistic 5G value creation framework. To realize the full spectrum of 5G benefits, the 5G ecosystem partners need to develop a performance measurement framework which includes other facets such as consumer and business adoption; cybersecurity, privacy and resilience of the network and applications; proliferation of uses cases; improved productivity, cost and quality competitiveness for Canadian industries; improved health and safety for Canadian citizens; and the closing of the digital divide in Canada. The ultimate measure of success will be in how efficiently and effectively 5G is deployed, operated, and used to create revenue and growth and/or reduce costs and/or deliver environmental and social value. The next few years are crucial for the expansion of a 5G ecosystem in Canada. If this expansion is executed well, it will help sustain and potentially grow Canada's competitive advantage in key industries while simultaneously facilitating the achievement of key government policy objectives in the areas of environmental and social sustainability.

The creation of simple, measurable, and actionable metrics will be important to measure the operational performance and subsequent socio-economic impacts of 5G. Additional consumer metrics that measure the uptake and "experience" of 5G services and applications for end-users will be equally important. Operational KPIs are driven from ITM-2020 and mainly consider three broad categories: (1) Enhanced Mobile Broadband (eMBB), (2) Ultra Reliable Low Latency Communication (URLLC), and (3) Massive Internet of Things (mIoT). These KPIs should be tracked and reported to Canadian Radio-television and Telecommunications Commission (CRTC) and Statistics Canada by each MNO across province/territory, and population centers.

In addition to the operational metrics described above, regulators, service providers, and industry participants should collect, audit, and publish the socio-economic benefits that are being driven by deployment and adoption of 5G services and applications by province/territory, population centers, and nationally. These "consumer metrics" should be completed by the various industry associations and provided to both CRTC and Statistics Canada. The data should be leveraged for big data analytics to provide key insights on future policy decisions.

An example set of operational and consumer related metrics are listed below.

TABLE 6.2: EXAMPLE PERFORMANCE MANAGEMENT FRAMEWORK METRICS[40]

Metric	Definition	Example 5G Performance Requirements	Category
Operational Metrics			

[40] The following sources were used to inform the contents of this table: 1) https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2083-0-201509-I!!PDF-E.pdf; 2) https://www.opensignal.com/reports/2021/04/canada/mobile-network-experience-5g; and 3) https://telcomatraining.com/5g-kpis-key-performance-indicators-2/.

Metric	Definition	Example 5G Performance Requirements	Category
Peak data rate	The highest theoretical data rate, which is the received data bits assuming error-free conditions, assignable to a single mobile station when all assignable radio resources for the corresponding link direction are utilised (i.e., excluding radio resources that are used for physical layer synchronisation, reference signals or pilots, guard bands and guard times).	The target for peak data rates should be 20Gbps for downlink and 10Gbps for uplink.	eMBB
Peak spectral efficiency	The maximum achievable data rate under ideal conditions, usually measured in gigabits per second (Gbps), that can be transmitted over a given bandwidth in a specific communication system. It is a measure of how efficiently a limited frequency spectrum is utilized by the physical layer protocol, and sometimes by the medium access control (the channel access protocol).	The target for peak spectral efficiency should be 30bps/Hz for downlink and 15bps/Hz for uplink.	eMBB
User experienced data rate	The 5% point of the cumulative distribution function (CDF) of the user throughput. User throughput (during active time) is defined as the number of correctly received bits, i.e., the number of bits contained in the service data units delivered to Layer 3, over a certain period of time.	The target values for the user experienced data rate are as follows in the Dense Urban – eMBB test environment: (1) Downlink user experienced data rate is 100Mbps; (2) Uplink user experienced data rate is 50Mbps.	eMBB
System bandwidth	The maximum aggregated system bandwidth. The bandwidth may be supported by single or multiple radio frequency carriers.	The requirement for bandwidth is at least 100 MHz, up to 1 GHz for operation in high-frequency bands above 6 GHz.	eMBB URLLC mIoT
Control plane latency	Refers to the transition time from a most “battery efficient” state (e.g., Idle state) to the start of continuous data transfer (e.g., Active state).	The target for control plane latency should be 10ms.	eMBB
User plane latency	Also known as the radio segment latency. It is the one-way latency for successful reception of a packet and includes the time for one or more retransmissions if packet reception fails. Furthermore, if possible, the latency should also be low enough to support the use of the next generation access technologies as a wireless transport technology that can be used within the next generation access architecture.	The target for user plane latency should be 0.5ms for downlink and uplink. For eMBB specifically, the target for user plane latency should be 4ms for downlink and uplink.	eMBB URLLC
Area traffic capacity	Refers to the total traffic throughput served per geographic area, measured as data rate per unit area. Area traffic capacity increases	The target for area traffic capacity should be 10Mbps/m^2.	mIoT

Metric	Definition	Example 5G Performance Requirements	Category
	will enable better network performance in densely populated areas.		
Connection density	The total number of connected and/or accessible devices that can be accommodated, measured in devices per unit area. Increased connection density will support customer use where there are a tremendous number of devices, such as in stadiums and warehouses.	The target for connection density should be 1,000,000 devices/km^2.	mIoT
Energy efficiency	On the device side, the number of bits transmitted or received per unit of energy consumption. On the network side, energy efficiency refers to the quantity of information bits transmitted to or received from users, per unit of energy consumption of the radio access network, measured in bits per joule. Energy efficiency improvements are critical due to the expected massive increase in data use over time.	Targeted energy efficiency should be 90% reduction in energy usage.	mIoT
Mobility	The maximum speed a device can be traveling and still experience a defined quality of service. Mobility is important for applications that require reliable connection when moving, such as in transportation safety.	The target for mobility should be up to 500km/h.	eMBB
Mobility interruption	The shortest time duration supported by the system during which a user terminal cannot exchange user plane packets with any base station during transitions. This KPI is for both intra-frequency and inter-frequency mobility for intra-New Radio mobility.	The target for mobility interruption time should be 0ms.	URLLC
Coverage	The uplink and downlink between device and Base Station site (antenna connector(s)) for a data rate of 160bps, where the data rate is observed at the egress/ingress point of the radio protocol stack in uplink and downlink. Link budget and/or link level analysis are used as the evaluation methodology.	The target for coverage should be 164dB.	mIoT
User equipment (UE) battery life	The battery life of the UE without recharge. For mIoT, UE battery life in extreme coverage shall be based on the activity of mobile originated data transfer consisting of 200bytes uplink per day followed by 20bytes downlink from MaxCL of 164dB, assuming a stored energy capacity of 5Wh.	The target for mIoT device battery life should be 15 years.	mIoT

Metric	Definition	Example 5G Performance Requirements	Category
UE energy efficiency	The capability of a UE to sustain much better mobile broadband data rate while minimizing the UE modem energy consumption.	Example not found. Target to be determined by stakeholders.	mIoT
Network energy efficiency	The capability of a network to minimize the RAN energy consumption while providing a much better area traffic capacity. Both qualitative and quantitative KPIs are proposed. Network energy efficiency shall be considered as a basic principle in the New Radio design. The target is a design with: (1) the ability to efficiently deliver data; (2) the ability to provide sufficiently granular network discontinuous transmission when there is no data to transmit and network availability is maintained; (3) the ability to provide operator flexibility to adapt sleep durations of base stations depending on load, services, and area.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
Spectrum and bandwidth flexibility	The flexibility of the network design to handle 5G Wireless different scenarios, such as the capability to operate at different frequency ranges.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
Reliability	The capability to provide a given service with a very high level of availability. Reliability is compromised if too much data is lost, late, or has errors. Improving the reliability of the network is critical for time-sensitive, mission-critical applications like automation and healthcare.	The target for reliability should be 1 x 10^{-5} probability of transmitting layer-2 PDU of 32 bytes in size within 1ms, in channel quality of coverage edge for Urban Macro-URLLC test environment.	URLLC
Resilience	The ability of the network to continue operating correctly during and after a natural or man-made disturbance, such as the loss of power.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
Security and privacy	The ability to encrypt and protect user data and signaling, and enhance network security against cyberattacks, such as unauthorized user tracking, hacking, fraud, sabotaging, and denial of service, which can be detrimental to national security and the safeguarding and privacy of users' data.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
Operational lifetime	Operation time per stored energy capacity, which is particularly important for IoT devices requiring a very long battery life whose regular maintenance is difficult for physical or economic reasons.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT

Metric	Definition	Example 5G Performance Requirements	Category
Consumer Metrics			
5G spectrum owned	The type and quantity of spectrum held by an MNO.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
5G spectrum deployed	The type and quantity of spectrum put in use by the MNO.	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
5G coverage	The geographic extent of an MNO's network	Example not found. Target to be determined by stakeholders.	eMBB URLLC mIoT
5G availability	The proportion of time users with a 5G device have a 5G connection. It is not a measure of coverage or the geographic extent of a network.	Example not found. Target to be determined by stakeholders.	eMBB
5G reach	Measures how users experience the geographical extent of an MNO's 5G network. It analyzes the average proportion of locations where users were connected to a 5G network out of all locations those users have visited. In simple terms, 5G reach measures the 5G mobile experience in all locations that matter most to everyday users - i.e., all places where they live, work and travel.	Example not found. Target to be determined by stakeholders.	eMBB
5G video experience	Quantifies the quality of mobile video experienced by users on real-world video streams. It is calculated by measuring video streams from end-user devices using an ITU-based approach to quantify factors such as load times, stalling and video resolution over an MNO's 5G networks.	Example not found. Target to be determined by stakeholders.	eMBB
5G games experience	A measure of how mobile users experience real-time multiplayer mobile gaming on an MNO's 5G network. It analyzes how the multiplayer mobile games experience is affected by mobile network conditions including latency, packet loss, and jitter to determine impact on gameplay and overall multiplayer 5G Games Experience.	Example not found. Target to be determined by stakeholders.	eMBB
5G voice app experience	Quantifies the quality of experience over mobile voice services for each operator on 5G connections.	Example not found. Target to be determined by stakeholders.	eMBB

Metric	Definition	Example 5G Performance Requirements	Category
5G download and upload speed	The average download and upload speed experienced by users across an MNO's 5G network.	Example not found. Target to be determined by stakeholders.	eMBB