

BUILDING A **SAFE** AND **RESILIENT CANADA**
Public Safety Broadband Network
Temporary National Coordination Office

Progress Report on a National Public Safety Broadband Network

Working towards the next generation of public safety communications in Canada

Emergency Management Partners in Collaboration with the Government of Canada

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Executive Summary

The Temporary National Coordination Office (TNCO) was established in July 2018 with a mandate to develop options and recommendations for a Public Safety Broadband Network (PSBN) for first responders and public safety personnel across Canada. The TNCO consulted stakeholders and field experts; examined research and literature available to date, as well as pilots and trials; and conducted analyses to develop the recommendations contained in this progress report. The TNCO will present a Policy Paper in early 2020. It should be noted that as this document serves as an indicator of progress on TNCO work, it is understood that new information gathered between this publication and the Policy Paper which bear material consideration may influence final recommendations.

PSBN Temporary National Coordination Office Composition		
Federal	**Provincial / Territorial**	**Non-Government**
Canada Border Services Agency	Government of Alberta	Canadian Association of Chiefs of Police
Canadian Security Intelligence Service	Government of British Columbia	Canadian Association of Fire Chiefs
Defence Research and Development Canada Centre for Security Science	Government of Manitoba	Federation of Canadian Municipalities
Innovation, Science and Economic Development Canada	Government of New Brunswick	Paramedic Chiefs of Canada
National Defence Canada	Government of Nova Scotia	
Public Safety Canada	Government of Ontario	
Royal Canadian Mounted Police	Government of Quebec	
	Government of Saskatchewan	
	Government of Yukon	

What is a PSBN?

The PSBN is a nationwide wireless communications network and, much like a cellular network, it is the pipe that gets user data from point A to point B during communication sessions. The PSBN is leveraged to support a wide range of related systems, applications and services in the overall public safety communications ecosystem. Unlike a commercial cellular network, the PSBN is designed to meet the distinct needs of public safety users.

What we heard

The public safety community continues to work tirelessly to improve public safety communications and ultimately the response to emergency situations and day-to-day operations. Through its outreach and engagement, the TNCO heard from first responders and the public safety community about the importance of having an interoperable and secure communications system that guarantees priority and pre-emption rights in times of need, provides adequate persistent coverage, while being sustainable and affordable for users. With the evolution of communications in the public safety space and the development of broadband wireless, a PSBN offers a high-speed wireless network that could greatly improve response effectiveness and public safety communications. The TNCO is working to develop options and recommendations that fulfill the needs and requirements of the PSBN users and stakeholders.

Principles for a PSBN

In order to meet the needs of first responders and improve their communication capabilities, the PSBN must deliver equitable service to the entire public safety community. Quality of experience is the foundation of the PSBN and reflects the universality of its service and also forms the foundation of the following nine principles:

1. Interoperability: The PSBN enables PSBN users to communicate and share information, as authorized, anytime and from anywhere it is accessible.

2. Network Access Always: Whether in their daily routine, or during major events or emergencies, PSBN users must always have immediate and uninterrupted access to the PSBN where it exists.

3. Coverage: The PSBN will, at a minimum, have equivalent to commercial broadband coverage and should establish or enhance coverage in underserved urban, rural, Indigenous and remote areas and communities.

4. Resiliency/Robustness: The PSBN must be resilient and robust to meet network access requirements.

5. Deliver Mission Critical Services: The PSBN will enable the delivery of network-hosted mission critical services to public safety users.

6. Security: The PSBN must incorporate security mechanisms meeting the trust requirements of the organizations of PSBN users and those exchanging data through it.

7. Sustainability: The PSBN must meet the needs of its first generation of stakeholders without compromising its ability to meet the needs of future stakeholders.

8. Affordability: The PSBN must be affordable to the entire community of PSBN users.

9. Use of Spectrum: The PSBN will efficiently and effectively use spectrum.

Operational delivery options

Innovation, Science and Economic Development Canada (ISED) allocated 20 MHz of the 700 MHz spectrum for public safety broadband use (hereafter known as “Band 14”). The TNCO considers that the allocated spectrum be used in a shared public safety-commercial network, which supports both public safety and commercial usage with priority access and pre-emption rights for public safety users when needed. Given that public safety traffic and commercial traffic using Band 14 spectrum will likely be directed to separate public safety and commercial core networks, concerns over security and privacy will be alleviated with respect to the protection and security of data and information being carried on the network. A shared public safety-commercial network ensures that the spectrum is used in an effective and efficient manner by permitting commercial use of excess spectrum capacity while ensuring that priority and pre-emption mechanisms are provided to public safety users. Such an approach is also consistent with the spirit of the *Radio Broadcasting Act* and the *Telecommunication Act*.

The PSBN could be delivered in many ways, each approach entailing different sets of actors, distribution of functions, risks and opportunities. The TNCO is considering four service delivery approaches for a PSBN in Canada. These approaches are notional and are not intended to affirm the ultimate service delivery approach or governance framework of the PSBN. At this juncture, based on assessment against PSBN Principles, a single public safety network deployed by either one mobile network operator (MNO) per region or a group of MNOs working together in a coordinated manner present the best opportunity for success. The feasibility of these approaches will need to be further assessed against potential governance frameworks and will be presented in the Policy Paper.

Recognizing the potential risk to communications interoperability posed by the status quo, the TNCO is committed to continuing in a leadership role to advance a national and interoperable PSBN for Canada.

Next steps

The TNCO will continue its work developing a comprehensive Policy Paper to be presented to Federal-Provincial-Territorial (FPT) Ministers responsible for emergency management. The Policy Paper will address gaps in analysis, including governance options, expand on current recommendations and findings, and propose a way forward for the establishment of a PSBN in Canada that best delivers on the PSBN Principles while balancing the diverse interests of stakeholders.

Progress Report on a National Public Safety Broadband Network

Intent

The purpose of this progress report is for the Temporary National Coordination Office (TNCO) to share information with stakeholders on the work accomplished to date towards a national Public Safety Broadband Network (PSBN) for Canada. It offers current findings and recommendations regarding options and requirements of a Canadian PSBN, while also identifying gaps in research and proposing next steps.

This progress report serves as a checkpoint. The TNCO wants to ensure that the recommended approach for a Canadian PSBN will meet the needs of the public safety community, will be viable in the long term and will appeal to all stakeholders. It should also be noted that any recommendations included herein may evolve and be refined as the TNCO pursues its work and continues to engage stakeholders.

It is equally important to clarify what content falls outside the current mandate of the TNCO and what is therefore not covered by this progress report, including network applications and architecture; costs and implementation; the development of detailed technical requirements; and the associated public safety communications ecosystem.

The TNCO acknowledges that readers of this document will have different levels of knowledge and familiarity with emergency communications and public safety broadband networks. A conscious effort was therefore made to use non-technical language and include definitions and a bibliography.

The TNCO will present a Policy Paper comprised of recommendations to support the establishment of a Canadian PSBN based on a consolidated view resulting from discussions and activities with stakeholders, field experts and the user community. In early 2020, the Policy Paper will be presented to Federal-Provincial-Territorial (FPT) Ministers responsible for emergency management. The Policy Paper will be shared with Innovation, Science and Economic

Development Canada (ISED) further to their decision paper published in June 2017. The Policy Paper will provide valuable information on how a PSBN could be established in Canada.

Context and background

Every day, Canadians count on first responders and public safety personnel to respond to routine and emergency incidents in a timely and effective manner. First responders and public safety personnel are responsible for the protection and security of over 36 million Canadians from coast to coast to coast. In addition to day-to-day use, effective response to major disasters, emergencies and planned events require reliable, interoperable voice and data communication capabilities across jurisdictions and emergency responder communities. In some cases, these incidents and events even require support from international partners. No single agency at any level of government in Canada has the authority and capacity to act unilaterally and therefore significant coordination is required to respond to these incidents.[1] There is public expectation that this coordination is achieved with all branches of government working together to ensure the safety of Canadians, including the public safety community, and the protection of property.

In order to understand the benefits and necessity of a PSBN, it is important to consider the evolution of communications, both commercially and from a public safety communications standpoint over the last several decades.

Communication evolution in the commercial space

In the commercial realm, new technologies are introduced, and over time, successful technologies are typically adopted by consumers at scale as prices decrease. Prior to the late 20th century, the primary mode of communication was the Public Switched Telephone Network (PSTN). This system allowed audio to be delivered between parties, and for over 100 years, only carried voice information. However, between 1965 and 1975, the groundwork was laid for the modern Internet.[2] This included the development of modems, which were devices that could use audio tones to establish connections between computers in physically different locations, making use of the PSTN. Between the mid-1980s and mid-1990s, the World Wide Web and the first Internet Service Providers were established. As early as 1992, the first audio and video information was distributed over the Internet and by 1993 there were a total of 600 websites worldwide!

At the turn of the century, new technologies were introduced which enabled what is known as broadband connectivity.[3] These technologies allowed much higher data rates, and also allowed for connections to the Internet which no longer

[1] Public Safety Canada. January 2011. Communications Interoperability Strategy for Canada. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/ntrprblt-strtg/ntrprblt-strtg-eng.pdf

[2] For a high level view of the history of the Internet, refer to https://www.livescience.com/20727-internet-history.html (last accessed 21 March 2019)

[3] For additional information, refer to https://www.uswitch.com/broadband/guides/broadband_history/ (last accessed 21 March 2019) and https://en.wikipedia.org/wiki/Internet_access (last accessed 21 March 2019)

relied solely on the PSTN, but also allowed modern cable networks and emerging wireless networks to be used to access the Internet and World Wide Web. Broadband connectivity is what has enabled the explosive growth of the Internet, and also dramatic advances in the amount of information (including high quality video and audio information) that can be shared almost instantaneously among people throughout the world.

In parallel to developments on the Internet and PSTN side, wireless communications also experienced a revolution. Although the very first mobile telephony tests took place in 1918-1924, it wasn't until the late 1970's that true 'commercial' wireless networks began to take root.[4] As with the PSTN, the primary usage for mobile networks at their inception was to carry voice traffic. With the advent of broadband connectivity, mobile wireless networks rapidly migrated towards an environment well suited to access the Internet and World Wide Web. The first Internet service available on a wireless device was in 1999 in Japan, and from that time, the rapid evolution of technologies has increased speeds dramatically on mobile networks, making them ideally suited to access the Internet in a mobile fashion. The ubiquity of mobile wireless services is such that there are now regions that access the Internet purely using cellular networks instead of the traditional PSTN or cable networks.

Communication evolution in the public safety space

From a public safety communications perspective, the evolution of technologies has followed a slightly different trajectory. To date, the technologies relied on are not the same as commercial technologies. One reason for this may be the perceived reliability and security of commercial services.[5] However, this has been at the cost of equipping first responders with truly cutting edge capabilities.

For the most part, communications among first responders has relied on handheld radio communications and vehicle-mounted radios. As early as the 1930s, police departments introduced two-way radio communications in patrol cars.[6] As with other technologies, the focus was on voice communication. For the following decades, handheld radio usage remained largely unchanged, with their use expanding to all areas of first responders including fire fighters and paramedics. The key resource needed for mobile radios is radio frequency spectrum. One of the drawbacks of this technology, particularly in the early days, is the sub-optimal use of this spectrum, as radio transmissions between users can consume resources, which can lead to a situation where other users are unable to transmit or receive information. However, a key feature of dedicated land mobile radio (LMR) networks is the provision of highly available voice

[4] For a high-level timeline of the evolution of mobile wireless communications, refer to https://www.timetoast.com/timelines/history-of-mobile-phones-7e561d96-e442-4495-9d71-3d0789eaaab4 (last accessed 21 March 2019)
[5] PSBN Federal Task Team. October 2017-March 2018. Stakeholder engagement sessions.
[6] For a brief overview of the use of 2-way radios by emergency responders, refer to http://blog.techwholesale.com/2015/11/07/police-and-emergency-responders-two-way-radios/ (last accessed 21 March 2019)

services. These offer the ability to talk user-to-user or one user to many while not connected directly to any infrastructure (i.e. radio towers are not necessarily needed).

Over time, the LMR networks providing mission critical voice services have evolved to become more efficient in their use of spectrum (although nowhere near as efficient as cellular networks) through moving from analog to digital transmission. In addition, initiatives such as the Project 25 initiative in North America (P25), have introduced increased security features (e.g. digital encryption) as well as low bandwidth data services (e.g. simple text messages).[7] While these advancements have kept LMR systems relevant and critical for first responders, their shortcomings have led to many responders turning to commercial cellular service to supplement their mission critical voice services with high bandwidth data services offered through commercial broadband mobile services. However, these commercial offerings lack the reliability, guaranteed access and certain security features of LMR systems.

Bridging capabilities of commercial and public safety communications

With the introduction of a PSBN, first responders will have the best of both worlds. A PSBN will offer users an experience which resembles their current handheld and vehicular commercial cellular offerings, but will have enhanced functionality, security, reliability and guaranteed access closer to that of traditional LMR systems. The two systems will likely work together for many years to come, until such a time as the reliability of services offered over broadband mobile wireless networks is indistinguishable from that of LMR networks. Until then, it will be common for public safety personnel to carry both an LMR handset and a cellular device.

What is a PSBN?

Today, new technology advances the safety and security of Canadians and public safety personnel by enhancing communications capabilities to improve coordination and response for first responders and governments. One way to achieve this is through the deployment of a national, interoperable PSBN. A PSBN is a secure, high-speed, wireless communications network that can be used by responders and public safety personnel to communicate with each other and acquire and share information during emergencies, planned events and day-to-day operations. Although it may leverage the infrastructure of mobile network operators (MNOs), the PSBN is nevertheless a distinct and separate network uniquely designed to meet the specialized needs of responders.

A PSBN will be a key part of a larger public safety communications ecosystem. As the backbone of the ecosystem, it will be leveraged to support a wide range of related public safety systems, applications and services. It will improve the effectiveness and safety of first responders and the public safety community by enabling a range of wireless communications capabilities to enhance coordination, response and situational awareness.

[7] For more information on P25, refer to http://www.project25.org/index.php/technology/p25-history (last accessed 21 March 2019)

Current commercial networks, while offering wireless services, may not meet the security, reliability and quality of service standards that are expected by potential end users of a PSBN. A PSBN will be distinguished from currently available commercial service by enabling the development and use of information rich-applications supporting service delivery by responders, not seen today in Canada. A PSBN will primarily be a secure layer on existing infrastructure, which will enable a range of mobile wireless broadband services to be delivered and used by public safety users. It is worth noting that users could include autonomous machines as well as people. An example highlighting this would be the use of the Internet of Things (IoT) and the Internet of Life-Saving Things (IoLST) devices and sensors to also communicate and share information through the PSBN. For example, devices could include cameras, alarms, and various environmental sensors. The move towards 'smart cities' will result in thousands of such devices within every community.[8] This trend is another reason to ensure there will be infrastructure in place to support the secure and reliable transmission of data over networks not purely intended for commercial users.

A PSBN is different from Wireless Priority Service, which is a subscriber-based voice service offered to authorized essential personnel with access to the next available wireless radio channel while minimizing the impact on consumer access to the same wireless infrastructure.[9]

The maroon block in *Figure 1* below depicts the components that are considered to be part of the PSBN. The remainder of the components in the white coloured block of this figure illustrate the external networks, systems, services and applications that a PSBN would enable. This diagram is extracted from the Defence Research and Development Canada's (DRDC) Centre for Security Science (CSS) report on a PSBN Network Architecture Description (NAD).[10] That report describes, at a technical level, how the PSBN could interface with many of these external components.

[8] For a brief article on smart cities and the Internet of Things, refer to https://www.information-age.com/smart-city-technology-123473905/ (last accessed 21 March 2019)
[9] Innovation, Science and Economic Development Canada. August 2011. Wireless Priority Service (WPS). http://www.ic.gc.ca/eic/site/et-tdu.nsf/eng/h_wj00016.html
[10] Fournier, J., Lucente, C., Skidmore, D., and Samson, L. January 2019. Scientific Report DRDC-RDDC-2018-R236: Public Safety Broadband Network (PSBN) Network architecture description. DRDC – Centre for Security Science.

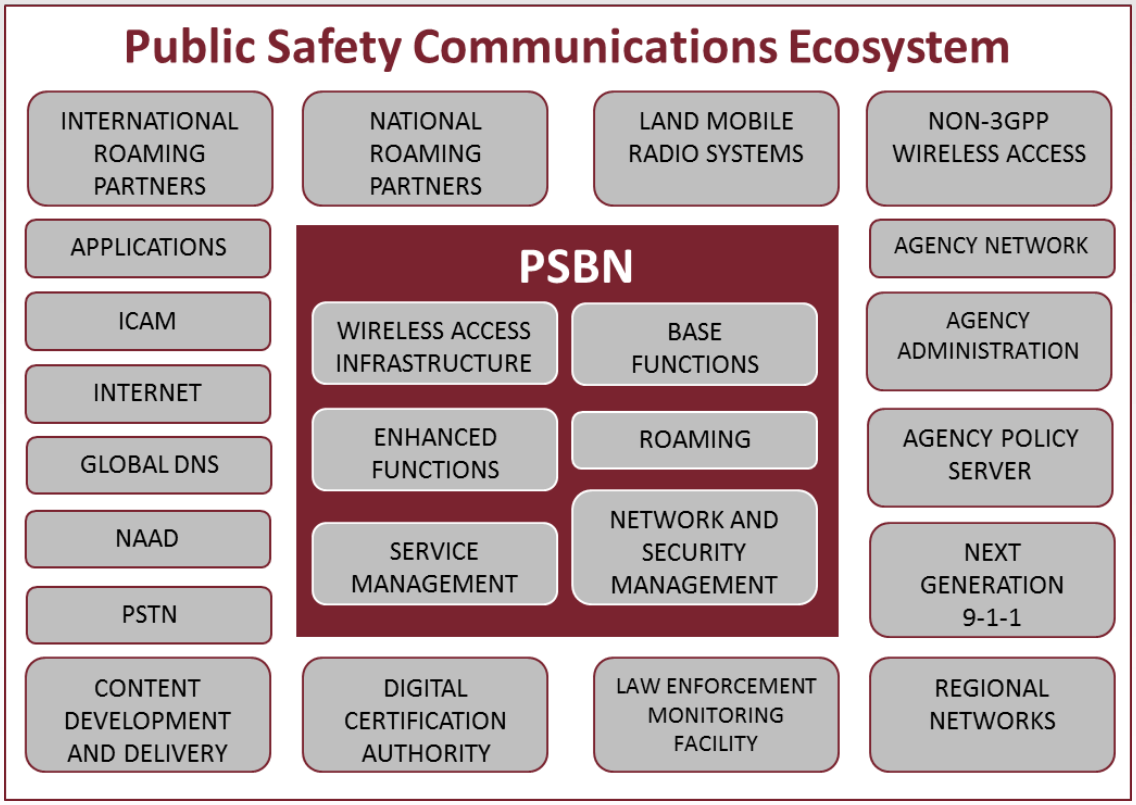

Figure 1 - Public Safety Communications Ecosystem (source: DRDC NAD Document)

By examining *Figure 1*, we see that the PSBN is comprised of the basic building blocks of offering a mobile wireless broadband service. Namely, the infrastructure, base and enhanced functions and service management (e.g. subscriber management, billing, etc.), as well as roaming and network and security management. Agency systems and information do NOT form part of the actual PSBN. Rather, the PSBN becomes the conduit through which users of the PSBN can access the information from their individual agencies that they are authorized to access. In this regard, the PSBN becomes an environment and an enabler for public safety agencies to use new applications and services, and to interoperate with one another.

Why Canada needs a PSBN

Canadians increasingly rely on wireless services in their daily lives for things such as connecting with family, streaming online content or working while on the move. The consumption of data continues to grow and this growth will continue for the foreseeable future with the arrival of 5G, the increase in the number of users, the bandwidth demand of

applications, device types, smart cities and the expansion of the IoT.[11] First responders and public safety personnel play a crucial role in protecting Canadians every day and they should have the best available technology to enhance and improve their response.

Today, Canadian first responders and public safety personnel rely predominantly on LMR using handheld and in-vehicle radios to communicate during both day-to-day and emergency operations. There are multiple dedicated LMR systems in Canada using narrowband spectrum, most of which are limited to voice communications while some are capable of low bandwidth data applications. LMR systems are not capable of transmitting the larger volumes of data increasingly needed by first responders to support current and evolving needs.

Additionally, LMR systems have evolved over time at the municipal and provincial levels, and were deployed without considering national interoperability requirements. With some provincial and regional exceptions, the result is considerable fragmentation at various levels in Canada. Considered nationally, and even within the same jurisdictions, public safety agencies using different systems operating in different parts of the radio spectrum are not able to communicate with each other, unless by means of physically sharing devices. This effectively creates non-interoperable communication silos. As a result, in some jurisdictions, exercises and after-action reports point to significant challenges with non-interoperable communications systems. In the National Capital Region (NCR), for example, law enforcement agencies, tri-services personnel, and transit authorities representing multiple levels of jurisdictions all operate within the parliamentary precinct and wider NCR without fully interoperable communications.

The PSBN would act as a complementary technology to LMR over the medium term (10-15 years),[12] enabling more data intensive applications and nationally interoperable voice communications. The eventual goal is for the PSBN to mature and become the primary communications platform for responders.

Currently, responders use commercial networks to address their mobile data needs. The agencies using commercial mobile networks today configure their systems for access by their members only and use proprietary applications or configured applications that restrict access to authorized users only. As a result, agencies have effectively isolated themselves into virtual silos. In addition, commercial networks are not necessarily built to meet public safety requirements. For instance, commercial providers routinely augment their coverage in times of anticipated network congestion, such as during sporting events or concerts. However, unanticipated congestion on commercial wireless networks during unplanned events can result in degradation of service, thereby impeding responders' communications capabilities during critical times. Current commercial networks, therefore, may have limited ability to support broadband

[11] Canadian Radio-television and Telecommunications Commission. 2018. Communications Monitoring Report. https://crtc.gc.ca/eng/publications/reports/policymonitoring/2018/index.htm.
[12] FPT Ministers responsible for emergency management. May 2018. Endorsed guiding considerations.

data for current and emerging applications required by PSBN users. Such an inability of public safety users to effectively communicate, particularly across jurisdictions, disciplines and levels of government, threatens the safety and security of first responders as well as Canadians.[13]

The PSBN will enable a public safety applications ecosystem that can address this issue of non-interoperability. A PSBN seeks to dismantle data communication silos from a technology perspective by establishing a secure and highly-available network for all first responders and public safety personnel in Canada. Though it may leverage the infrastructure of many mobile networks, it will be a single network, in order to most effectively address responder requirements and the PSBN Principles (discussed below).

A PSBN would align with the *Communications Interoperability Strategy for Canada* (CISC) which, through its *Action Plan*, is intended to strengthen and improve voice and data communications interoperability.[14] The CISC was endorsed by all levels of government and emergency management responder associations in January 2011, along with its accompanying *Action Plan* published in March 2013.

A PSBN will provide a venue for the willing and innovative to interoperate and share information for the public good. On its own, the establishment of the PSBN will not advance all five pillars of the Canadian Communications Interoperability Continuum found in the CISC. A high degree of leadership, planning and collaboration will still be required.[15]

Other public safety communications initiatives such as Next Generation 9-1-1 (NG9-1-1) and the National Public Alerting System (NPAS) complement a PSBN. Both of these initiatives are intended to improve emergency management and communications for Canadians across the country.

In June 2017, the Canadian Radio-television and Telecommunications Commission (CRTC) directed all telephone and mobile wireless companies to update their networks in order to be ready to provide NG9-1-1 voice services by June 2020 and text messaging services by December 2020. With NG9-1-1 services, Canadians could eventually stream video from an emergency incident, send photos of accident damage or a fleeing suspect, and send personal medical information, including accessibility needs, which could greatly aid the emergency response.[16] The NPAS, known as Alert Ready, provides emergency management organizations throughout Canada with a standard alerting capability to send life-saving

[13] Public Safety Canada. January 2011. Communications Interoperability Strategy for Canada. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/ntrprblt-strtg/ntrprblt-strtg-eng.pdf
[14] Ibid.
[15] Ibid.
[16] Canadian Radio-television and Telecommunications Commission. June 2017. The CRTC is creating a safer environment for Canadians by enabling access to enhanced and innovative 9-1-1 services. https://www.canada.ca/en/radio-television-telecommunications/news/2017/06/the_crtc_is_creatingasaferenvironmentforcanadiansbyenablingacces.html

emergency alerts directly to television, radio and compatible wireless devices (e.g. LTE smartphones). Alert Ready has the capability to rapidly warn the public of imminent or unfolding hazards to life and property, such as fire, natural, biological, hazardous, environmental, terrorist, civil events and Amber Alerts. These capabilities could result in large amounts of data that needs to be shared with responders through the PSBN.

A PSBN can also enhance preparedness, response and recovery from an incident. For example, a PSBN could enable a suite of mapping and notification tools during a large tornado to share alerts, warnings and notifications among public safety agencies to support effective decision-making. This supports Priority 4 of the *Emergency Management Strategy for Canada: Toward a Resilient 2030*, which was endorsed in January 2019 by Federal, Provincial and Territorial (FPT) Ministers responsible for emergency management. Priority 4 of the Strategy seeks to enhance disaster response capacity and coordination and foster the development of new capabilities by encouraging FPT governments to work with their respective emergency management partners to develop interoperable public safety communication systems.[17]

In addition, through a use-case (a simulated wildland-urban interface fire), it was demonstrated that the PSBN has the "ability to deliver broadband communications services to first responders intelligently, and in adverse conditions, where other systems that are based on similar technology would fail under those conditions."[18] In the use-case, the PSBN increased situational awareness, which resulted in improved incident response, fewer casualties, and more efficient use of human and material resources.

Allocation of 700 MHz spectrum for public safety use

Recent spectrum allocation activities have created a vehicle to allow the use of 20 MHz of 700 MHz spectrum for public safety communications (hereinafter "Band 14," designated in Canada as the "700 MHz public safety broadband spectrum"[19]). In March 2012, ISED (then Industry Canada) designated 5+5 MHz block of the highly valued spectrum in the 700 MHz band for public safety broadband communications.[20] Policy consultations ensued to seek comments on the designation of use of an additional 5+5 MHz of spectrum known as the D block. In Budget 2015, the Government of Canada (GoC) announced that this additional 10 MHz of 700 MHz spectrum would also be designated for public safety

[17] Public Safety Canada. January 2019. Emergency Management Strategy for Canada: Toward a Resilient 2030. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/mrgncy-mngmnt-strtgy/index-en.aspx.
[18] Fournier, J. and Lucente, C. 2017. Scientific Report DRDC-RDDC-2017-R116: Public safety broadband network use-case – wildland-urban interface fire. DRDC – Centre for Security Science.
[19] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).
[20] Innovation, Science and Economic Development Canada. August 2012. Consultation on a Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).

broadband use.[21] The government also provided $3 million over two years, starting in 2016-17, to take initial steps to enable the establishment of a PSBN.

In June 2017, ISED published a decision paper confirming the allocation of 20 MHz of the 700 MHz spectrum for public safety broadband use.[22] The decision also stated the following:

- Spectrum will not be auctioned;
- Commercial use of excess capacity will be allowed, provided that public safety users will have priority and pre-emptive rights over any form of commercial usage;
- Spectrum licenses will be issued either directly to a single public safety network entity (PSNE) or multiple PSNEs; and
- Specific technologies will not be mandated, but any technology employed using this spectrum must ensure national and cross-border interoperability, and ensure priority and pre-emption capability for public safety services.

Subsequent to that confirmation, as part of the PSBN Federal Task Team, ISED led a Request for Information (RFI) in November 2017 which sought information and communications technology/telecom industry perspectives on the following topics: a viable business model; governance model; and ecosystem of applications, services and devices to inform the GoC's approach to a PSBN for Canada.[23] Through its collaboration with ISED, the TNCO reviewed responses submitted by telecommunication industry stakeholders. The responses were useful to gain a deeper understanding of their perspectives and positions and inform the development of a PSBN for Canada.[24]

Temporary National Coordination Office

In May 2018, FPT Ministers Responsible for emergency management collectively acknowledged the benefits of a PSBN and endorsed the establishment of a Temporary National Coordination Office (TNCO)[25] to advance the work towards a secure and interoperable wireless data communications network.[26] FPT Ministers also endorsed a set of guiding

[21] Government of Canada. April 2015. Budget 2015. https://www.budget.gc.ca/2015/docs/plan/toc-tdm-eng.html
[22] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).
[23] Innovation, Science and Economic Development Canada. 2017. Public Safety Broadband Network Request for Information.
[24] PSBN RFI Review (28 May 2018) Gartner.
[25] Public Safety Canada. February 2019. Temporary National Coordination Office. https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/tnco-en.aspx
[26] Canadian Intergovernmental Conference Secretariat. May 2018. NEWS RELEASE: Federal/Provincial/Territorial Ministers met to Discuss Emergency Management. http://www.scics.ca/en/product-produit/news-release-federal-provincial-territorial-ministers-met-to-discuss-emergency-management/

considerations for PSBN implementation which was collaboratively developed by FPT officials, municipalities, and tri-services:

- Best practices and lessons learned from pilots and trials would be leveraged to inform PSBN deployment;
- Deployment timelines would differ across Canada according to each jurisdiction's priorities and capabilities;
- LMR networks would likely co-exist with a PSBN over the medium-term (10-15 years);
- The short-term focus of the PSBN would be to provide secure, interoperable wireless data communication services;
- Existing wireless infrastructure would be leveraged as much as possible to reduce costs;
- Linkages should be built with other public safety communications initiatives (e.g., NPAS and NG9-1-1) and governance mechanisms; and
- Funding programs at all levels of government should be leveraged to address coverage and capacity challenges.

Keeping these guiding considerations in mind, the mandate of the TNCO is to provide a consolidated policy position on a framework, with considerations on technical requirements, governance and business models, for the future of a Canadian PSBN. The TNCO is aiming to present a Policy Paper to FPT Ministers responsible for emergency management in early 2020 which will also address questions posed by ISED in their June 2017 decision on the designation of spectrum for public safety broadband use.

The TNCO recognizes that the implementation of a PSBN in Canada will require close collaboration between governments, industry, and end-users of the network. As a result, the office is comprised of representatives from the following jurisdictions, associations and departments (in alphabetical order):

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Canadian Security Intelligence Service	Government of British Columbia	Canadian Association of Fire Chiefs
Defence Research and Development Canada Centre for Security Science	Government of Manitoba	Federation of Canadian Municipalities
Innovation, Science and Economic Development Canada	Government of New Brunswick	Paramedic Chiefs of Canada
National Defence Canada	Government of Nova Scotia	
Public Safety Canada	Government of Ontario	
Royal Canadian Mounted Police	Government of Quebec	
	Government of Saskatchewan	
	Government of Yukon	

These members wear dual hats because while they are members of the TNCO, they also represent the interests and convey the considerations of their own organization which further contributes to inform the recommendations contained in this progress report and the forthcoming Policy Paper. They are engaged continuously throughout the development process.

Outreach and stakeholder engagement

The TNCO recognizes the essential role of stakeholders in the development of a PSBN that is successful and efficient in the Canadian context. That is why the TNCO has engaged and gathered the views of various stakeholders in different fora, including the private sector, academic, tri-services, FPT jurisdictions, critical infrastructure operators, and municipalities. Stakeholder engagement will continue until the delivery of the Policy Paper in early 2020, and possibly beyond.

In 2017-2018, prior to the establishment of the TNCO, a federal PSBN Task Team[27] established by the FPT Interoperability Working Group (IWG) undertook a series of stakeholder workshops in six cities across the country, as well as one engagement session online. More than 200 stakeholders participated in the workshops covering many jurisdictions, including: Yukon, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador. Public Safety Canada also worked separately through the IWG and other FPT fora to engage stakeholders in the Northwest Territories and Nunavut. The PSBN Task

[27] The Federal PSBN Task Team was comprised of representatives from Public Safety Canada (PS), Innovation, Science and Economic Development Canada (ISED) and Defence Research and Development Canada's Centre for Security Science (DRDC CSS).

Team consulted provincial, territorial and municipal governments, first responders, the private sector, and various other stakeholders on implementation models for a PSBN in Canada. They found that some of the most frequently discussed challenges facing current emergency communications include: coordination of a potential PSBN; coverage in rural, remote and Northern areas; costs and potential implementation timelines; interoperability between Canada and the United States; capacity in small communities and volunteer organizations; and the relationship between a potential PSBN and existing land mobile radio networks. These concerns were also heard by the TNCO during its engagement with stakeholders, as detailed below.

From June 2017 to January 2018, DRDC CSS, on behalf of the PSBN Task Team, held eight workshops across the country with the aim of validating PSBN use-cases to better understand the user requirements of the public safety community in the context of public safety communications. Attendance at these sessions totalled 131 participants, including representatives from the first responder community, academia, information technology, telecommunications sector, and municipal and provincial jurisdictions. In addition to the workshops, the Royal Canadian Mounted Police (RCMP) also provided consolidated input to the 31 use-cases reviewed. Information collected in addition to the feedback on the PSBN use-cases has allowed for stronger analysis of public safety community requirements. This work resulted in the finalization of the DRDC CSS PSBN *Use-Cases and User Requirements* document.[28] Additionally, the work was used as a guiding document in the creation of other scientific documents regarding technical considerations for a PSBN in Canada.

The TNCO acknowledges the valuable work and contribution of other government departments, provinces, territories, municipalities and tri-services associations. Whether speaking at conferences, briefing industry stakeholders or hosting stakeholder meetings with users, the outreach and engagement within their respective jurisdictions is crucial to the development of meaningful and evidence-based recommendations regarding the implementation of a PSBN in Canada.

What we heard

The feedback received is positive as stakeholders are pleased to see development and leadership on this initiative. They also appreciate being briefed on current work and expressed interest in remaining abreast of further developments. Stakeholders are eager to be a part of this initiative and offered to assist the TNCO.

Throughout this engagement, there were common issues arising from stakeholders including the timeline for the establishment of a PSBN and the budget cycles at the federal, provincial and municipal levels, especially since the spectrum was allocated by ISED in 2017. For some jurisdictions, aging communications infrastructure and the need for additional investment in the very near future are reasons to accelerate the launch of a PSBN.

[28] DRDC Centre for Security Science (CSS). Unpublished. PSBN Use-Cases and User Requirements.

Interoperability at the national and agency level, including between applications, was raised as an important consideration for PSBN users, along with resiliency of the network. Coverage challenges were a significant consideration, particularly in rural, remote and Northern communities. Questions were also raised on the allocation of licenses, experimental use of Band 14, and the commercial usage of excess capacity.

In December 2018, the TNCO held an engagement session in Toronto with stakeholders from the private sector. During this event and subsequent bilateral discussions, the TNCO communicated work updates, answered questions from participants and sought feedback on proposed approaches and potential implications for stakeholders. The level of attendance demonstrated that there is an interest from the private industry to be involved in the PSBN. Participants were interested to learn about the ISED public consultations, the attribution of Band 14 licenses, non-standard licenses and the transition process. The prospect of aligning with planned commercial investments was also raised as a potential efficiency in the deployment of a PSBN.

TNCO also heard from transportation and utilities providers who expressed interest in participating in and contributing to a PSBN. Powertech Labs is partnering with multiple stakeholders to undertake a trial which will, *inter alia*, demonstrate, test and validate the value of a PSBN to utility and transportation operations. These organizations already have considerable infrastructure, which is especially important in underserved rural and remote areas.

The TNCO also regularly engaged counterparts from the United States' First Responder Network Authority, who is responsible for the delivery of the FirstNet network in the United States and, as such, is an important international stakeholder. FirstNet was created in 2012 and allocated the same 20 MHz of spectrum that was allocated in Canada. The First Responder Network Authority was provided with $7 billion to establish a nationwide, interoperable public safety broadband network and was mandated to build, operate, and maintain that network.[29]

Meetings with the First Responder Network Authority have provided the TNCO with valuable insights and lessons learned from their experience deploying and implementing a nationwide PSBN. Bilateral discussions have strengthened the TNCO's understanding of important risks and opportunities concerning items including but not limited to Canada-United States PSBN interoperability, network security, public safety user needs, evolution of technologies, as well as business and governance considerations. Engagement with the First Responder Network Authority will be ongoing as the TNCO develops recommendations for a nationwide PSBN in Canada.

Regardless of how a PSBN is ultimately implemented, the public safety community wants to ensure that the spectrum serves the public interest. Similarly, the TNCO wants to ensure that a PSBN is used by the public safety community and

[29] First Responder Network Authority. 2019. FirstNet: The History of our Nation's Public Safety Network. https://firstnet.gov/about/history

that it becomes as indispensable as the LMR systems currently used by the majority of first responders and public safety personnel. Other important considerations are affordability, resiliency, and interoperability.

At this juncture, the TNCO is in a position to provide preliminary analysis and recommendations to stakeholders for consideration. It is important to emphasize that the TNCO's proposals are focused on the minimum requirements for an interoperable PSBN for Canada. This allows public safety entities to customize or use available network capacity to meet their diverse needs.

PSBN projects, pilots and experiments

With a view to providing evidence-based analysis and informed recommendations, the TNCO has been compiling and reviewing literature and research pertaining to PSBN developments in Canada and internationally. Where possible, the TNCO has also been engaging individuals and organizations directly for information and feedback. The experience, expertise and body of research available enable the TNCO to draw lessons in the context of governance, service delivery, economics, and available and emerging technologies. In order to best meet the needs of the public safety user community in Canada, ensuring that TNCO conclusions and recommendations are supported by tangible 'real-world' findings is central to the work being undertaken. Broadly speaking, the themes of the research include current international PSBN undertakings and examples; PSBN pilots and projects; and experiments pertaining to PSBN-related technologies.

Canada holds a leadership position internationally in the research of PSBN technologies and in the development of innovative solutions. As countries around the world explore their own PSBN considerations, Canada can also learn from both their experiences and challenges related to public safety broadband. While potential Canadian approaches must be considered in respect to our own geographic, economic, demographic and political realities, comparison with other national PSBN projects offer the opportunity to consider an array of lessons learned. At the time of writing, countries including (but not limited to) the United States, United Kingdom, Australia, France, Finland, Qatar and the Republic of Korea have, to varying stages, undertaken national PSBN projects. Due to its proximity and its inclusion in the PSBN Principle of interoperability, it should be no surprise that the experience of FirstNet in the United States is of particular interest to the TNCO at this time. As these international markets develop and new ones emerge, the TNCO will continue to monitor and incorporate analysis into its conclusions.

In respect to PSBN pilots, tests and evaluation initiatives, the TNCO has been keeping abreast of both Canadian and American examples with a view to examining the proofs of concepts presented in each. Several Canadian pilots have been operating on temporary experimental Band 14 spectrum licenses, many of which center on practical research in either event-driven or event-simulated environments. Other examples were designed to be geographically limited and to operate according to their specific local needs. Examples include the NCR LTE trial network, the Halton Regional Police

Service LTE Project, the Toronto Police Service mobile broadband trial, the Calgary Police Services LTE trial, the LA-RICS LTE project, the Adams County (Colorado) LTE trials, Harris County (Texas) LTE PSBN, New Jersey's *JerseyNet*, the New Mexico Public Safety LTE network, the Ottawa Fire hazmat experiment, the Ottawa Paramedics airport communications experiment, and the Canada-US enhanced resiliency experiments (CAUSE) series.

Technological considerations have also been an important aspect of the TNCO's work, particularly as they concern current and anticipated broadband network capabilities and limitations. The assumption has been that the PSBN would use open standards to the extent possible, with specific reference to those articulated by the 3GPP (and by other key standard setting bodies where appropriate). As such, the TNCO has been following experiments and findings published by key organizations, institutions and agencies, including DRDC CSS, ISED's Communication Research Centre, University of Regina's Bridging Research and Interoperability Collaboration (BRiC), Simon Fraser University Telematics Research Lab, Department of Homeland Security Office of Emergency Communications and the Office for Interoperability and Compatibility, National Institute of Standards and Technology Communications Technology Laboratory, Texas A&M University Internet2 Technology Evaluation Centre, and the European Telecommunications Standards Institute's Centre for Testing and Interoperability.

While this section does not provide an exhaustive list of referenced materials, it aims to provide a sense of the depth and breadth of research being considered when developing recommendations and drawing conclusions.

Principles for a PSBN

The TNCO recognizes that discussions surrounding a PSBN for Canada have been ongoing for quite some time. It has been established that the use of broadband network in the context of public safety offers considerable advantages and ultimately can improve the effectiveness of response efforts. The creation of a national PSBN would help address current emergency communications challenges by providing responders with prioritized access to communications networks, a high degree of interoperability with other jurisdictions, as well as secure use of high-speed wireless data and applications. However, some important considerations need to be taken into account to meet the needs of the public safety community in the elaboration of this network. These considerations are described below and are essential in the success of a Canadian PSBN.

Principles are fundamental norms, rules, or values that should represent what is desirable and positive for a person, group, organization, or community, and help it in determining the rightfulness or wrongfulness of its actions. They are more basic than policy and objectives - they are meant to both govern and inform the community as a whole.

PSBN Principles flow from user requirements identified through the analysis of PSBN use-cases gathered through consultation with potential PSBN users, domestic pilots and trials, and international case studies. They flow from the public safety and network configuration knowledge, research and experience, and from the shared norms, ethical practices and cultural experiences of the TNCO's national membership.

The PSBN must deliver equitable service to the entire public safety community. Quality of experience is the foundation of the PSBN and reflects the universality of its service. It provides a framework for the PSBN Principles and also forms the foundations of those principles as they are practiced.

"PSBN users" is used rather than "public safety users." "PSBN users" does not include commercial users who stay outside the PSBN security envelope but may consume PSBN spectrum capacity while it is unencumbered by PSBN users.

The following are principles of a Canadian PSBN:

Interoperability

Principle: *The PSBN enables PSBN users to communicate and share information, as authorized, any time and from anywhere it is accessible.*

Users on commercial LTE networks are inherently able to communicate with each other anytime and anywhere there is coverage as the result of technology implementations and roaming agreements between MNOs.

The PSBN Principle on Interoperability requires network services and agreements necessary to ensure PSBN users can access PSBN services and other users from any point within the PSBN at any time.

Subject to agreement with FirstNet, additional network services and agreements are necessary to ensure PSBN users and FirstNet users can access services and other users necessary for them to perform their duties, from any point within either the PSBN or FirstNet at any time. As reflected in the CISC's Action Plan and accompanying Canada/United States (CANUS) Interoperability Working Group (IWG), communications interoperability between a Canadian PSBN authority and FirstNet are integral to sharing strategic and technical information across the border.[30]

[30] Public Safety Canada. January 2018. Communications Interoperability Strategy for Canada. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/ntrprblt-strtg/index-en.aspx#cisc-C

The PSBN must adopt common standards to ensure applications adopted in any region of Canada will function properly in the other regions of Canada, to ensure mission critical applications are fully interoperable and to ensure the common experience of PSBN users.

It is foundational to the vision for a PSBN that it facilitates information access and sharing. The access to, or sharing of, information may be initiated or completed in the wireless environment of a PSBN but takes place through interaction between the applications, data and servers of the initiator and recipient. Existing statutes, regulations, policies and agreements will influence the availability of such transactions and may require well considered change to facilitate them. The PSBN will require access and sharing rules.

Network Access Always

Principle: *Whether in their daily routine, or during major events or emergencies, PSBN users must always have immediate and uninterrupted access to the PSBN where it exists.*

Quality of Service, Priority, and Pre-emption (QPP) enabling mechanisms within the PSBN are required to provide network access to PSBN users. PSBN users must always have priority over commercial users and may pre-empt them under specific circumstances. Within the PSBN, there must be a means of establishing priority but there must be enough control of PSBN resources to provide the local command hierarchy with the capability to dynamically change the QPP of users and applications where their role in an event is sufficiently important.

Users roaming from one means of service delivery to another – one MNO to another, fixed site to deployable – must not experience interruption in sessions and must experience the same QPP regardless of how they are connected to the PSBN. Furthermore, sessions should not be interrupted between the PSBN and FirstNet.

Coverage

Principle: *The PSBN will, at a minimum, have equivalent to commercial broadband coverage and should establish or enhance coverage, in underserved urban, rural, Indigenous and remote areas and communities.*

The daily, major and emergency events PSBN users respond to know no geographical or durational boundaries, and often occur unplanned in indoor, rural, remote, northern and Indigenous communities where the current business case for commercial coverage is thin. Persistent coverage must exist where the business of PSBN users frequently/normally takes place and must be supplemented by deployable coverage elsewhere. Coverage can be no less than what is available to commercial users and should over time, be greater.

Resiliency/Robustness

Principle: *The PSBN must be resilient and robust to meet network access requirements.*

The services provided by the PSBN to its users, especially those deemed mission critical, are important in day-to-day operations and particularly important during major events and emergencies – the times when they are most likely to be stressed by the conditions of their environment or come under attack. The PSBN must be capable of performing without failure under a wide range of conditions, be able to recover from setbacks (or "a setback") and adapt well to change. Radio Access Network (RAN) sites may require hardening to a greater degree than commercial sites, particularly with respect to power, in order to survive worst case scenarios.[31]

Deliver Mission Critical Services

Principle: *The PSBN will enable the delivery of network-hosted mission critical services to public safety users.*

It is widely accepted that failure or disruption of public safety push-to-talk voice communication, at any time, will result in the severe degradation of its operations. It is an essential communication and safety element of public safety operations. As the PSBN develops and is embraced, open standards such as Mission Critical Push to Talk (MCPTT) will be joined by Mission Critical Data (MCData) and Mission Critical Video (MCVideo) as basic and essential communication and safety elements. As opposed to applications chosen by individual user agencies, these network-hosted mission critical services will be integral parts of the PSBN, enhancing nationwide interoperability.

Security

Principle: *The PSBN must incorporate and enable security mechanisms meeting the trust requirements of the organizations of PSBN users and those exchanging data through it.*

Risk assessments evaluate the probability and impact of potential threats. Security is built in layers to mitigate the impact of potential threats. Potential threats to the PSBN must be identified, evaluated and mitigated by a security posture sufficiently strong to ensure continued network access, and the trust of PSBN users and those willing to exchange their data through it.

[31] For an example of hardening guidelines, please see the 2014 NPSTC Public Safety Communications Report, *Defining Public Safety Grade Systems and Facilities*.
http://www.npstc.org/download.jsp?tableId=37&column=217&id=3066&file=Public_Safety_Grade_Report_140522.pdf

Sustainability

Principle: *The PSBN must meet the needs of its first generation of stakeholders without compromising its ability to meet the needs of future stakeholders.*

The three pillars of sustainability are environmental, economic and social. The PSBN must be delivered by means that ensure ecological integrity is maintained, resources required to maintain its future integrity are available and the future needs of stakeholders are attainable, served and respected. Intrinsic in this are the needs for ongoing maintenance, to evolve, staying current with changing technology and standards, and the need for suppliers of goods and services to the PSBN to be sustainable well into the future.

Affordability

Principle: *The PSBN must be affordable to the entire community of PSBN Users.*

Affordability is measured by cost relative to the amount a purchaser can pay. Interoperability cannot be allowed to fail due to the inability of members of the PSBN user community to afford PSBN services. Affordability will compete with other PSBN priorities for scarce funding.

Should the cost of acquiring PSBN services be prohibitive for some subscribers, an alternative is for their rates to be subsidized. For example, such subsidies could come from revenue generated through the commercial use of excess PSBN spectrum capacity or by a surcharge similar to that currently on commercial telephone service in some Canadian jurisdictions.

Use of Spectrum

Principle: *The PSBN will efficiently and effectively use spectrum.*

Whether through the support of PSBN users in their daily work and during major events or emergencies, or to generate revenue in support of other PSBN Principles, PSBN spectrum must be used as efficiently and effectively as possible.

The PSBN spectrum must always be available to PSBN users, who must have priority over and the ability to pre-empt commercial users. Though PSBN user requirements may at times exceed capacity provided by the spectrum, at most times, it is expected that PSBN allocated spectrum will have surplus capacity.

Leverage of unused spectrum through commercial use, outside of the PSBN security envelope, holds the promise of generating revenue to offset the costs of the PSBN.

Operational delivery options

Research methodologies and approach

Study design

The TNCO conducted comparative analyses to develop and inform the assessment of spectrum utilization, service delivery, and licensing structure options for the PSBN.

Selection criteria and methods

For the purpose of analysis, a range of possible models were selected and assessed against their ability to fulfill the fundamental principles of a PSBN described above. Models were selected in consultation with diverse stakeholders and technical experts, including DRDC CSS, and reflect a reasonable range of possibilities. Where applicable, the TNCO also drew on international case studies and early adopters of public safety broadband to support comparative analysis and inform recommendations. For example, lessons learned from the United States, United Kingdom, Republic of Korea and Australia were used to demonstrate the benefits, challenges and limitations associated with various models.

Data analysis

The TNCO assigned ratings to each PSBN Principle by drawing on the key insights and findings of case studies, research and consultation with technical experts. Ratings have been assigned using the following categories:

- Green - High likelihood of success in meeting principle (H)
- Orange - Moderate likelihood of success (M)
- Red - Little likelihood of success (L)

Each rating was provided on a relative basis and intended to indicate differences between the models. It is important to note that the magnitude of differences may not be uniform. For example, the difference between red and orange may not be the same as the difference between orange and green. At this juncture, no attempt has been made to determine if some requirements are more or less important than others, and therefore should not be compared against one another. The TNCO also acknowledges the importance of flexibility with regards to operational delivery options and makes every attempt to highlight additional opportunities that may fall outside the scope of a given analysis.

Analysis

Spectrum utilization models

Context

As part of Budget 2015, the GoC acknowledged that the creation of a PSBN using Band 14 would be an essential step towards improving "…collaboration among public safety agencies to help save lives and keep our communities safe."[32] As advocated by the public safety community, this designation of spectrum is a necessity to meet first responders' current and long-term demand for mobile data communications.[33]

With these decisions in mind, it is anticipated that a PSBN would, at the outset, be a fourth generation (4G) broadband cellular network similar to the commercial networks that currently serve the smart devices used by the general public.[34] As decided by ISED, it would make use of Band 14 and allow first responders and other public safety users to communicate and share content-rich information with one another during day-to-day operations, major events and incidents.[35]

While there are many possible ways of implementing a nationwide PSBN, the approach to how Band 14 spectrum is utilized can vary significantly and bring with it different costs and risks.[36] In order to propose recommendations for the implementation of a PSBN in Canada, the TNCO considered three broad models of spectrum utilization that are consistent with the current focus and functional requirements of the Canadian public safety community. The models are defined in *Table 1* below:

[32] Government of Canada. 2015. Budget 2015. Chapter 4.3, Subsection on *Improving Public Safety Communications:* http://www.budget.gc.ca/2015/docs/plan/toc-tdm-eng.html

[33] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).

[34] Defence Research and Development Canada. April 2017. Scientific Letter DRDC-RDDC-2017-L121: Implementation models for a public safety broadband network.

[35] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).

[36] Defence Research and Development Canada. April 2017. Scientific Letter DRDC-RDDC-2017-L121: Implementation models for a public safety broadband network.

Table 1: Spectrum Utilization Models

Spectrum Utilization Models		
Model One **Public Safety Exclusive Dedicated Network** (Dedicated Network)	Model Two **Shared Public Safety-Commercial Network** (Shared Network)	Model Three **Commercial Network** (Commercial Network)
A dedicated public safety network, with spectrum used exclusively by public safety users (using the 700 MHz Public Safety Broadband (PSBB) and D Blocks) (e.g. South Korea - SafeNet)	A network that supports both public safety and commercial usage (with distinct public safety and commercial network cores), with priority access and pre-emption rights for public safety use during emergencies and other times of need (e.g. United States - FirstNet)	The public safety community obtains services from one or multiple commercial carrier(s) using that carrier's existing network spectrum and/or acquired Band 14 spectrum (e.g. United Kingdom)

While three distinct models have been presented for consideration, it should be noted that given ISED's *Decision on Policy, technical and Licensing Framework for the Use of Public Safety Broadband Spectrum* (June 2017), Model Three – commercial network – is no longer viable for consideration. Through this decision, as previously mentioned, ISED allocated 20 MHz of spectrum for a national PSBN. As such, Model Three, where the national PSBN would obtain services from commercial carriers using carriers' existing or newly acquired commercial spectrum, is no longer being considered given the fact that the national PSBN would not be serviced solely through existing commercial networks.

In the same decision, ISED took the position that commercial use of excess capacity would be allowed provided that public safety users have priority and pre-emptive rights over any form of commercial usage.[37] ISED encouraged continued discussion surrounding this and other issues in order to establish informed recommendations based on a consolidated view.

[37] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).

Considerations

The TNCO applied the assumptions in *Table 2* below to its analysis in order to establish recommendations with regards to the utilization of spectrum for a PSBN in Canada. Changes to any of the fundamental assumptions stated below may impact analysis and the resulting recommendations.

Table 2: Spectrum Utilization Assumptions

Legend	Yes (Y)	No (N)

Spectrum Utilization Assumptions		
Assumptions	**Dedicated**	**Shared**
A PSBN would be implemented by leveraging physical infrastructure, such as cell sites, of commercial MNOs and government and public safety owned communications infrastructure to the greatest extent possible.	Y	Y
Quality of Service, Priority and Pre-emption (QPP) would be implemented, as this is a highly valued criterion for users.	Y	Y
A public safety network core would be separate from the commercial core.	Y	Y
Public safety organizations would not be obligated to join the PSBN.	Y	Y
There is allocated public safety spectrum.	Y	Y

Analysis, Risks and Opportunities

With the above assumptions in mind, the TNCO qualitatively assessed each of the considered spectrum utilization models against their ability to fulfill the PSBN Principles, using a rating of low, moderate or high likelihood of success.

The opportunities and challenges identified within each model are summarized in *Table 3: Summary of Spectrum Utilization Models Analysis* and examined below.

Table 3: Summary of Spectrum Utilization Models Analysis

Legend	High likelihood of success (H)	Moderate likelihood of success (M)	Little likelihood of success (L)

Spectrum Utilization Models Analysis		
PSBN Principles for Assessment	**Dedicated Network**	**Shared Network**
Interoperability	M	M
Network Access Always	H	H
Coverage	L	H
Resiliency/Robustness	M	H
Deliver Mission Critical Services	H	H
Security	H	H
Sustainability	L	H
Affordability	L	H
Use of Spectrum	L	H

Interoperability: In each of the models examined, interoperability is facilitated by central coordination of network operations policies, adherence to nationwide interoperability standards and a robust monitoring and compliance enforcement regimen for those policies and standards.

The Dedicated and Shared Network models are assessed as having a moderate likelihood of achieving interoperability. The main risk to interoperability on a Dedicated or Shared Network rests on the assumption that public safety organizations would not be obligated to join the PSBN. As a result, some public safety users may not migrate from their

current commercial services, and as such, would not be interoperable with PSBN users accessing PSBN network-hosted services and applications.

Network Access Always: The two models are assessed as having a high likelihood of providing network access always. A Dedicated Network could have relatively few users – public safety only – and therefore have excess bandwidth such that priority and pre-emption may rarely be needed. A Shared Network would ensure network access for public safety users over commercial users through priority and pre-emption.

Coverage: A Shared Network is assessed as having the highest likelihood of achieving the coverage principle. As with multiple LMR systems across Canada,[38] this model can leverage a range of resources in order to extend network coverage beyond existing commercial network coverage into rural, remote and otherwise underserved areas. It would also be able to provide roaming coverage onto existing commercial networks and leverage existing relationships with public sector organizations and critical infrastructure to promote the sharing of infrastructure and further expansion in coverage.

A Dedicated Network is assessed as having low likelihood of fulfilling the coverage principle due to the risks associated with the need to leverage existing and/or establish new infrastructure. While a Dedicated Network may be able to leverage existing commercial network infrastructure (such as mobile sites and backhaul transmission), it could have difficulty leveraging other public sector and critical infrastructure. Achieving network coverage objectives, particularly to underserved areas, will require significant new capital expenditure that would be borne solely by the public safety user base. Such additional costs are reflected in affordability and/or sustainability considerations of a PSBN.

Resiliency/Robustness: Each spectrum utilization model will require varying degrees of investment in infrastructure (e.g. adding back-up power, backhaul route redundancy) to meet the resiliency and robustness requirements of a PSBN. A Shared Network is assessed as having a high likelihood of achieving resiliency and robustness as the MNO would be able to leverage resiliency/robustness investments to concurrently enhance the resiliency of their commercial networks.

Deliver Mission Critical Services: Because all models would likely be based on similar technologies and architectures, they will all have a similar ability to deliver network-hosted applications and services such as MC Services. Either of the two models would have a high likelihood of success in delivering such services.

Security: It is assumed that both models have a dedicated public safety core with ingress and egress traffic to the network potentially going through the Internet. As such, physical security will be similar for all models as varying amounts of

[38] Nova Scotia. 2019. Network Information: Trunked Mobile Radio Service. https://novascotia.ca/is/programs-and-services/psfc/network-information.asp

commercial infrastructure and/or public safety LMR infrastructure will likely be leveraged. Both a Dedicated Network and Shared Network will be able to ensure over-the-air encryption of user plane traffic.

Sustainability: The sustainability of the PSBN is characterized by the network's ability to support a sound ongoing business model, to maintain a sufficient subscriber base, to stay current with evolving technology and standards, and to ensure continuous, long-term access to necessary network equipment and services. Ultimately, the sustainability of a PSBN will depend largely on whether it can meet the needs of public safety users over a long period of time and whether it can do so at acceptable economic, social and environmental costs. A flexible approach that allows changes to be made quickly when new information and/or technology becomes available, or when market conditions change, will lead to more sustainable solutions for PSBN users.

A Shared Network is therefore assessed as the most sustainable implementation model if spectrum is provided at negligible cost, which is a formidable cost savings in MNO(s) business models.[39] The MNO(s) would be able to generate revenue from not only public safety users, but also commercial users of the Band 14 spectrum. Such savings could be applied to lower public safety user fees, make investments in QPP, coverage, robustness, research and development, or a combination thereof. A Shared Network may also take advantage of economies of scope and partnerships to reduce the financial and environmental costs of unnecessary duplication of infrastructure such as towers and backhaul.

A Dedicated Network is the least sustainable as it would require new investment to achieve the same effect, without the ability to generate revenue from commercial uses. In 2013 this level of capital investment was estimated between $4 and $7 billion.[40] Furthermore, a revenue stream would be required to cover operational expenditures leaving little for re-investment. A Dedicated Network would also be competing with commercial providers.

Affordability: The affordability of the PSBN is defined as the network's ability to establish a supportable cost structure for all PSBN users, enabling maximum user uptake while satisfying a sustainable business model.

A Shared Network is assessed as the most affordable spectrum utilization model as it may leverage the excess spectrum's commercial value for investment(s), maximize the use of existing infrastructure and allow for flexible and efficient use of the spectrum. These factors result in lower user costs for public safety users compared to a Dedicated model.

[39] Innovation, Science and Economic Development Canada. 2014. 700 MHz Auction. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf10598.html
[40] KPMG/RedMobile. 2013.

A Dedicated Network is assessed as the least affordable as operating costs would be funded only by the PSBN user base, estimated at approximately 350,000 users.[41] As mentioned, a Dedicated Network may not be able to leverage existing commercial infrastructure as readily as a Shared Network, and this could also result in high user fees and/or a need for subsidies.

Use of Spectrum: A Shared Network is assessed as having a high likelihood of success with regards to efficient use of spectrum as it allows use by commercial users in addition to public safety users. As previously noted, such shared use of unused capacity with commercial users is in alignment with ISED's 2017 decision.[42]

A Dedicated Network is assessed as having little likelihood of achieving efficient use of spectrum. Wells Fargo previously estimated that in the U.S. context, first responders are likely to utilize less than 1% of the 20 MHz of spectrum available.[43] Similarly, DRDC estimates that public safety users occupy less than 10% of the spectrum on a daily basis[44] leaving considerable spectrum available for commercial uses.

Spectrum utilization recommendation(s)

While it is technically feasible to implement a PSBN under a Dedicated or Shared approach, comparative analysis demonstrates significantly different risks and opportunities associated with each model. After taking these risks and opportunities into consideration, the TNCO recommends that a future PSBN be implemented using a Shared Network approach.

Based on comparative analysis, a Shared Network has the highest likelihood of satisfying the fundamental PSBN Principles, largely due to its ability to leverage the value of Band 14 spectrum. This value could drive investments in coverage and resiliency/robustness, while maintaining affordability and sustainability of the network over time. Additionally, a Shared Network model will be best able to ensure the efficient use of spectrum by making best commercial use of Band 14 while ensuring priority and pre-emption for public safety users when and where required.

A Dedicated Network is not preferred due to the low likelihood of satisfying the principles of coverage, sustainability, affordability, and efficient use of spectrum. A Dedicated Network would require a combination of significant new capital

[41] Innovation, Science and Economic Development Canada. 2017. Public Safety Broadband Network Request for Information.
[42] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).
[43] Forbes. 2017. How Much Does AT&T Stand To Gain From FirstNet? https://www.forbes.com/sites/greatspeculations/2017/12/12/how-much-does-att-stand-to-gain-from-firstnet/#164ddf672997
[44] Defence Research and Development Canada. May 2017. Bandwidth Requirements for Day-to-Day Operations on Canada's 700 MHz Public Safety Broadband. P. 7. http://cradpdf.drdc-rddc.gc.ca/PDFS/unc273/p805324_A1b.pdf

and ongoing operational expenditures and would depend solely on user fees from PSBN users, which would not be complemented by a much more significant base of commercial user fees. As public safety organizations will not be obligated to adopt the PSBN, costs to public safety organizations would likely be high and could require subsidization of user fees to migrate users from existing networks. Low PSBN uptake would ultimately hinder interoperability, the primary objective of a future PSBN. Moreover, a Dedicated Network would have the least efficient use of spectrum with 90-95% of the spectrum unused daily outside of major emergencies and events.[45]

While the TNCO's recommendation to implement a Shared Network is consistent with similar work completed by the public safety community, it may be useful to explore the implications of regions adopting different spectrum utilization approaches.[46] As a next step, further analysis has begun to determine if a combination of approaches would ensure adherence to PSBN Principles, and the delivery of equivalent levels of service and quality of user experience to all PSBN users. If such an approach created inequities, it is possible that it could put the nationwide implementation of a PSBN at risk.

Service delivery models

Context

There are many ways to deliver the PSBN, each approach entailing different sets of actors and distribution of functions among them. The TNCO considered four service delivery approaches for a PSBN in Canada, comparing them against their ability to fulfill the PSBN Principles. The following approaches are notional and are not intended to affirm the ultimate service delivery approach or governance framework of the PSBN. The hypothetical models were originally developed by DRDC CSS and have been utilized to represent a wide breadth of possible service delivery options.

Each model assumes a single national entity and/or several regional entities. For the purposes of this report, network entities perform certain operational network functions and could perform governance functions. Although each model specifies where network functions may reside, it makes no recommendations regarding the composition or structure of any network entities. Furthermore, these entities may perform various network functions in any of the models; this does not restrict their operations from being contracted to third parties.

[45] Ibid.

[46] Defence Research and Development Canada, "Implementation models for a public safety broadband network," April 2017; TETRA and Critical Communications Association, "A discussion on the use of commercial and dedicated networks for delivering Mission Critical Mobile Broadband Services," February 2017; TETRA and Critical Communications Association, "Mobile Broadband for Critical Communications Users – A review of options for delivering Mission Critical solutions," December 2013.

For a more detailed description of each service delivery model, please see *Figure 2: Service Delivery Model Options* below and/or the Scientific Report *Implications of Service Delivery Model Options on Interoperability and Operational Efficiency in a Public Safety Mobile Broadband Network* developed by DRDC CSS.[47]

Model A: One Public Safety Network/One National MNO

(Hereinafter referred to as "Model A"): One national network would operate throughout Canada (one Public Land Mobile Network Identification Number (PLMN ID)[48]) that would serve all PSBN users. The national MNO could be a single MNO with nationwide coverage, or a single MNO leveraging other MNOs radio access network (RAN) infrastructure to achieve nationwide coverage. The latter would require an agreement on the part of MNOs across the country on how to work together to work as a single network that can provide seamless nationwide coverage. The national network operator would interface with all external networks and roaming partner networks. It would be responsible to comply with ISED Conditions of License (CoL), network standards, and PSBN Principles.

Model B: Multiple Regional Public Safety Networks/Multiple Regional MNOs

(Hereinafter referred to as "Model B"): Regional entities would be allocated spectrum in specific geographic boundaries, each with their own PLMN ID. Each regional entity would be responsible for interfacing with external networks, national and international roaming agreements, and complying with CoL. Standards would have to be in place initially but there is no central body to manage them as they evolve or ensure uniform application and compliance. Each regional entity would be required to perform all network functions.

Model C: Single Public Safety Network/Multiple Regional MNOs

(Hereinafter referred to as "Model C"): Each regional entity would be allocated spectrum with one PLMN ID shared among them. A national coordinating entity would be the applicant for the PLMN ID. As in Model B, the regional entities are responsible for interfacing with external networks, roaming agreements, and complying with CoL and network standards. The national coordination entity would need to manage standards as they evolve. Each regional entity would be required to perform most, if not all, network functions.

Model D: Single Public Safety Network/Multiple Regional MNOs (with centralized national functions)

(Hereinafter referred to as "Model D"): A national entity would be responsible for network standards, connections with

[47] Defence Research and Development Canada. March 2017. Scientific Report DRDC-RDDC-2017-R038: Implications of Service Delivery Model Options on Interoperability and Operational Efficiency in a PSBN.

[48] The PLMN ID is a globally unique 6-digit number used to distinguish one public mobile network from any other public mobile network in the world. The PLMN ID comprises a 3-digit Mobile Country Code (MCC) and a 3-digit Mobile Network Code (MNC). In Canada, the MNC is administered by the Canadian Numbering Administrator (CNA) by authority of the CRTC. At the time of writing, it is unknown whether the CNA would issue multiple PLMN IDs to REs. (European Telecommunications Standards Institute (*ETSI*) Technical Specification 122-101 v15.6.0 (2018 -10)

external networks and roaming agreements and certain operational network functionality. Network functions could be consolidated for efficiency in the national entity. The spectrum could be allocated to the national entity or to the regional entities.

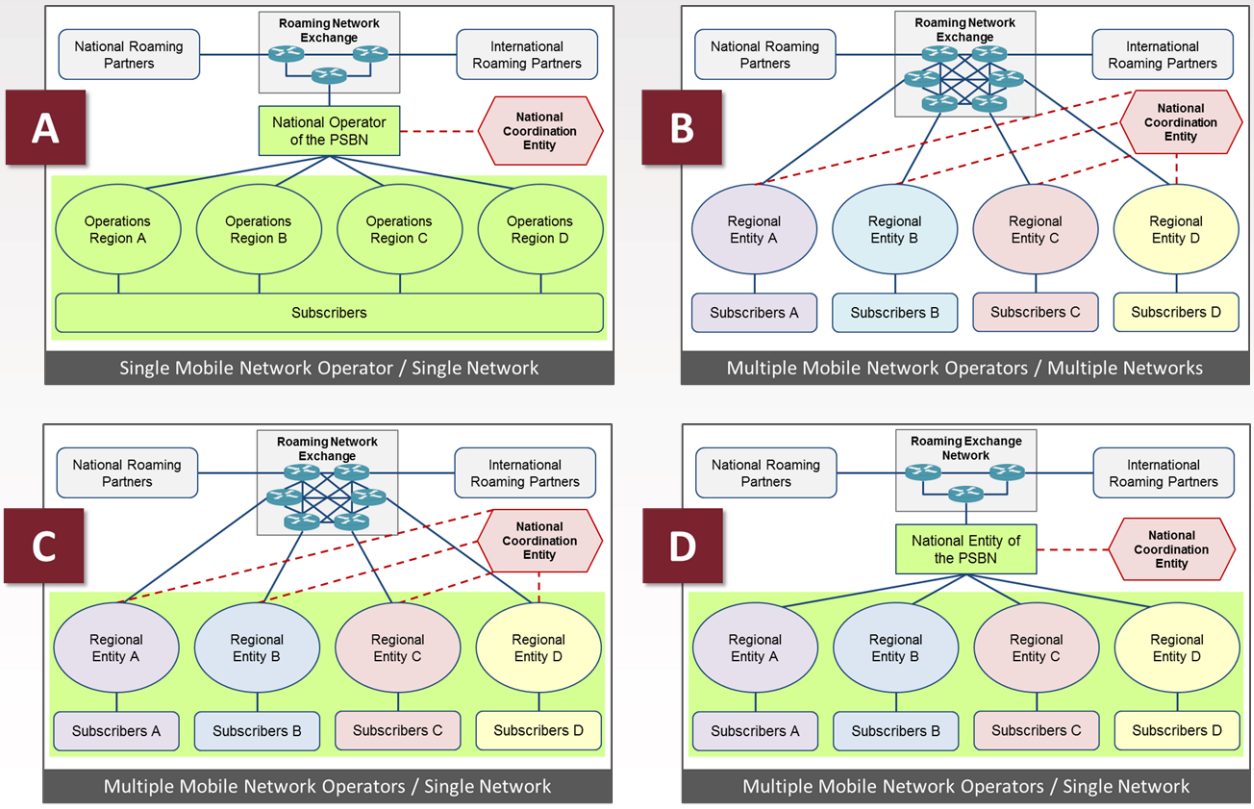

Figure 2: Service Delivery Model Options[49]

Considerations

Models A to D were developed by DRDC CSS and assessed in their 2017 report,[50] based on the significant distinctions among them. They have been examined in the context of a Shared Network, as recommended above.

[49] Ibid., p 6-8

[50] Defence Research and Development Canada. March 2017. Scientific Report DRDC-RDDC-2017-R038: Implications of Service Delivery Model Options on Interoperability and Operational Efficiency in a PSBN.

Under the Shared Network model, commercial users will be allowed access to the PSBN spectrum but authorized PSBN users would be the only ones on the PSBN. Where the RAN is shared between commercial users and PSBN users, each with their own core, Multi-Operator Core Network (MOCN) architecture can be applied.

Analysis, opportunities and risks

With the above considerations in mind, the TNCO qualitatively assessed the four possible service delivery models against their ability to fulfill the PSBN Principles, using a rating of low, moderate or high likelihood of success.

The opportunities and challenges identified within each model are summarized in *Table 4: Summary of Service Delivery Models Analysis* and examined below.

Table 4: Summary of Service Delivery Models Analysis

Legend	High likelihood of success (H)	Moderate likelihood of success (M)	Little likelihood of success (L)

Service Delivery Models				
PSBN Principles for Assessment	**Model A** One National MNO / One Network	**Model B** Multiple Regional MNOs / Multiple Regional Networks	**Model C** Multiple Regional MNOs / Single Network *(no National Functions body)*	**Model D** Multiple Regional MNOs/ Single Network *(with National Functions body)*
Interoperability	M*	L	L	H
Network Access Always	H	H	H	H
Coverage	M*	H	H	H
Resiliency/Robustness	M*	M	M	H
Deliver Mission Critical Services	H	M	M	H
Security	H	M	M	H
Sustainability	M*	L	L	H
Affordability	M*	L	L	H
Efficient Use of Spectrum	H	H	H	H

* The provided rating is based on the assumption that one MNO is contracted to provide nationwide coverage. In the case that the PSBN MNO leverages the RAN of other MNOs where required, moderate (orange) ratings would change to high likelihood of success (green).

Interoperability: Fundamental to interoperability is that users can access the PSBN and, as such, the availability of the network is critical to user adoption. Model A is assessed as having a moderate likelihood of success as no single MNO currently has adequate nationwide coverage therefore a single PSBN MNO would need to extend their own coverage sufficiently to meet PSBN needs. Alternatively a single PSBN MNO could augment PSBN coverage by entering into

agreements with other MNOs that have RAN coverage in areas the PSBN MNO does not. With this second approach, there is still a risk that nationwide coverage is not achieved if agreements cannot be reached. Either of those options risks regional public safety organizations remaining with local commercial networks for a host of business reasons, hindering national interoperability as PSBN users would not be able to easily exchange data with responders who remain on commercial networks.

If one or more MNOs cannot collectively provide nationwide coverage, Model D has the highest likelihood of achieving interoperability. The central management of interoperability standards and the ability to align with the MNO in the region that would best meet public safety needs make it more likely that the majority of public safety users are on the same network.

Models B and C present the least likelihood of achieving interoperability. Multiple regional MNO application and service platforms would create network-hosted application and service interoperability challenges if standards are implemented differently, and if networks do not agree to interconnect their core networks. Multiple regional MNOs would also be less able to support federal users across Canada without additional complexity and risks to end-to-end quality and service performance.[51] Models B and C also introduce additional requirements for roaming agreements domestically and internationally (as an example, up to 210 agreements that must be made and managed, in contrast with up to 36 for Models A and D).

Network Access Always: All models are assessed as having a high likelihood of success as the service delivery model does not affect the ability to access the network.

Coverage: Models B, C and D are assessed as having a high likelihood of achieving maximum possible coverage as the relationship with the MNOs will be at the regional level, which could allow for greater regional flexibility. It could also be easier in Models B, C and D to leverage existing contractual or organizational relationships to access provincial, regional or municipal infrastructure with the aim of expanding PSBN coverage with the MNO.

Model A has a moderate likelihood of success as a single national network will not have the relationships with provincial, regional or municipal organizations to be able to readily leverage their infrastructure and expand network coverage. Additionally, at this time there is no MNO with adequate nationwide coverage - meaning that some areas of the country will not have access to PSBN service unless MNOs cooperate to provide seamless nationwide coverage or new investments are made to fill coverage gaps in areas where the business case has previously been considered weak.

[51] Ibid.

Resiliency/Robustness: Model D is assessed as having the greatest resiliency/robustness. It requires strong national level coordination to ensure a resilient national backbone while also having regional redundancy to limit the impact of shocks to the network.

Models B and C are assessed as having the least likelihood of achieving national resiliency although their local or regional resiliency could be acceptable. With the lack of national coordination in Models B and C, there is a higher risk of the national backbone not having sufficient resilience when compared to Models A and D. As a single network, Model A is assessed as being less resilient. Shocks to the network could more easily affect the national network and would require investments in redundant capabilities in contrast to Models B, C and D that have some regional redundancy.

Deliver Mission Critical Services: Models A and D have a high likelihood of success as the presence of a co-ordinating entity at the national level facilitates evolution of technology to ensure consistent delivery of MC Services. Where multiple networks exist, such as in Models B and C, a greater level of complexity is introduced regarding the coordination of technology and network standards.

Security: Models A and D have the highest likelihood of meeting security standards, as network and security standards can be more easily implemented on a single network.

Models B and C will be more challenged to support federal users or any other users that would operate across different regions. This would particularly apply to mobile Virtual Private Network (VPN) solutions which the multiple networks in models B and C would have great difficulty supporting.

Sustainability: In general, the complexity and cost of both establishing and sustaining interoperability over the life of the PSBN is a function of the number of actors in the service delivery fabric and the number of vendors that comprise the PSBN.[52] Model D is assessed as having a high likelihood of success at achieving sustainability due to the flexibility in how it can be implemented. For example, regions could work together to share resources and some network functions could be centralized, where possible, to reduce costs. Roaming cost and complexity could also be reduced by having the regions act as a single network. It is recognized that the market for the PSBN is not uniform nationwide, and as such, independent regional entities may experience varying abilities to be sustainable.

Model A is assessed as having a moderate likelihood of success. There will be a requirement for capital investment to expand coverage where current MNO coverage is deficient. However, if multiple MNOs can cooperate to achieve better nationwide coverage, then Model A is more sustainable than Model D.

[52] Defence Research and Development Canada. April 2017. Scientific Letter DRDC-RDDC-2017-L121: Implementation models for a public safety broadband network.

Models B and C are assessed as the least sustainable way to deliver mobile broadband services. Significant capital and operating expenses would be incurred due to the multiple instances of identical network resources needed to create and sustain multiple different public safety networks. As previously referenced additional complexity and cost will also be incurred by the need to initiate and sustain exponentially more roaming agreements. Model C also has the added complexity of trying to implement a non-standard roaming agreement which will add extra initial, and potentially on-going, costs. However, some complexity and cost could be reduced if multiple regions work together to act as a single network.

Affordability: Models A and D have a high likelihood of affordability as their more centralized structure will reduce costs that cannot similarly be reduced in Models B and C. As a result, Models B and C are assessed as the least affordable, having high amounts of duplication and complexity that public safety users will ultimately have to pay for.

Efficient Use of Spectrum: Based on the assumption that the PSBN will employ a Shared spectrum utilization approach, Models A to D all have a high likelihood success in achieving efficient use of spectrum.

Service delivery model approaches

While it is feasible to deliver a PSBN under each of the evaluated service delivery models, comparative analysis demonstrates various risks and opportunities associated with each, including satisfying the PSBN Principles. Taking these risks and opportunities into consideration, the TNCO assesses that a future PSBN would be best delivered using either a Model A or Model D approach.

The main weakness of Model A is the lack of an established MNO that has adequate nationwide coverage for PSBN users across the entire country. Addressing coverage gaps will require investment, which will ultimately impact sustainability and affordability. The option of the PSBN MNO acquiring coverage in underserved areas through contracts for access to other MNOs RAN infrastructure is reliant on the willingness of the RAN MNOs to enter into contracts with the PSBN MNO. There is no certainty of this. Model D becomes the best model in the absence of the ability of a collective of MNOs to form a Model A.

Model D is preferred as it allows for the best regional coverage footprint while still operating as a single nation-wide network. This ensures nationwide interoperability and the fulfillment of other PSBN Principles while at the same time being sustainable and affordable.

Comparative analysis demonstrates that Models B and C will not be able to achieve the PSBN Principles. The structure of multiple networks with little or no national coordination and facilitation structures poses a risk to national interoperability

and the ability to support federal users. Additionally, the more complex structure presents extra costs for those stakeholders involved.

Assessment of mixed implementation approaches

A mixed implementation of the PSBN presents the following additional risks:

Implementation of PSBN Principles and standards: It is anticipated that standards will be developed from the PSBN Principles. In the case that there are multiple independent PSBNs without overall coordination or direction, it is likely that standards (either identical or different) would be implemented in various ways across the country. This increases the risk of not satisfying principles such as interoperability or security, and presents significant challenges for users (especially federal users) that will be unable or unwilling to adopt the PSBN as a result.

Common User Experience: It is assumed that PSBN users and organizations will have varying capacities to implement the PSBN in their respective jurisdictions. Some municipalities and/or regional organizations will be willing and able to invest the capital and operational funds to implement a Dedicated or Shared PSBN, using Band 14, at the local or regional level. Those jurisdictions who cannot commit the financial resources will find themselves at a disadvantage, thus exacerbating inequities across potential users and beneficiaries of a nationwide PSBN.

Interoperability: Some public safety users will remain with commercial providers either because there is no PSBN service available, a preference for or obligation to their current service providers or it may be too expensive for them. Competing MNOs may offer PSBN-like services, including priority and pre-emption, for an additional fee in competition to PSBNs in some areas. Voice interoperability would remain at its current state where some areas have voice LMR interoperability. Data interoperability would vary by jurisdiction and/or by discipline (e.g. police, fire, paramedic, critical infrastructure, etc.) depending on whether PSBN services were being offered and which organizations are on PSBN services versus commercial services.

Sustainability and Affordability: The overall sustainability and affordability of the PSBN would be compromised in the case that different islands of the PSBN are implemented across the country. In areas where Band 14 spectrum is highly valued commercially, the PSBN will be more sustainable and could require little or no additional public funding. However, in areas where Band 14 spectrum is not as valuable, sustained public funding could be required. Additionally, a lack of coordination may result in duplication of network infrastructure and the human capital required to operate and govern the network.

Use of Spectrum: In any Dedicated Network it is estimated that PSBN users will only use up to 10% of the 20MHz of spectrum in day-to-day operations.[53] In a fragmented approach to implementation, spectrum may therefore be used inefficiently in some areas of the country compared to others who support both public safety and commercial use.

Licensing structure

Context

As previously mentioned in this report, ISED made the following decisions with regard to licensing of the 700 MHz public safety broadband spectrum:[54]

D-1	Spectrum in the band 758-763 MHz and 788-793 MHz (D Block) is designated for public safety broadband use.
D-2	The spectrum in these bands will not be auctioned.
D-3	Spectrum licenses will be issued either directly to a single Public Safety Network Entity (PSNE) or multiple PSNEs, to be determined at a future date.
D-4	Commercial use of unused capacity will be allowed provided that public safety users will have priority and pre-emptive rights over any form of commercial usage.
D-5	ISED will not mandate specific technology, though any technology employed on the 700 MHz public safety broadband spectrum must ensure national and cross border interoperability and ensure priority and pre -emption capability for public safety services and must be consistent with the interoperability solution "sharing standards based systems."

It is anticipated that ISED will undertake additional consultations on a Band 14 licensing framework prior to awarding a license for Band 14 spectrum.

Assumptions

In addition to the decisions above, the following assumptions apply to analysis of the licensing structure of a future PSBN:

- There will be national standards based on the PSBN Principles in order to ensure a uniform and equitable user experience nationwide;

[53] Defence Research and Development Canada. May 2017. Bandwidth Requirements for Day-to-Day Operations on Canada's 700 MHz Public Safety Broadband. P. 7. http://cradpdf.drdc-rddc.gc.ca/PDFS/unc273/p805324_A1b.pdf

[54] Innovation, Science and Economic Development Canada. June 2017. Decisions on Policy, Technical and Licensing Framework for Use of the Public Safety Broadband Spectrum in the Bands 758-763 MHz and 788-793 MHz (D Block) and 763-768 MHz and 793-798 MHz (PSBB Block).

- The network will use a Shared Spectrum Utilization approach; and
- A combination of licensing and contractual agreements would be used to ensure PSBN Principles are respected.

With these assumptions in mind, the TNCO is considering the following licensing approaches:

License at a national level with no sub-license(s): The national-level licensee is solely accountable for the delivery of the PSBN and may subcontract as necessary. This licensing structure corresponds to service delivery Model A: One Public Safety Network/One National Commercial MNO.

Primary license at a national level with sub-license(s) at a regional level: The national-level licensee may enter into contractual agreement(s) with sub-licensee(s), all of whom will be required to serve the public safety community. The contractual agreement(s) would be used in conjunction with CoL in order to ensure PSBN Principles and standards are satisfied. Such a licensing structure corresponds to service delivery Model D: Multiple Regional MNOs/Single Network.

Multiple primary licenses at a regional level: The regional-level licensees are accountable for the delivery of the PSBN in the region while adhering to national PSBN standards. This licensing structure is applicable in the case of service delivery Models B, C and D: where there are Multiple Regional MNOs.

ISED is the ultimate authority with regards to the licensing regime and a distinct process will be undertaken to develop a licensing framework for Band 14. As such, the TNCO is examining the implications of potential licensing approaches on fulfilling the PSBN Principles, which will be further addressed in the Policy Paper.

Commercial use of excess capacity

In its 2017 decision paper, ISED stated that "commercial use of unused capacity will be allowed provided that public safety users will have priority and pre-emption rights over any form of commercial usage."[55] Through ongoing stakeholder consultations with service providers and manufacturers the TNCO continues to develop recommendations with respect to the sharing of unused capacity of the Band 14 spectrum with commercial users.

As outlined in the DRDC CSS 2019 Network Architecture Description, commercial traffic on Band 14 would likely be carried on the commercial core network only. This means that commercial traffic and public safety traffic would be kept separate when both are using Band 14 spectrum. This alleviates security and privacy concerns from the public safety community with respect to the protection and security of data and information being carried on the network.

[55] Ibid.

In the United States, the First Responder Network Authority entered into a covered lease arrangement with their commercial network partner which permits the commercialization of the dedicated spectrum with priority and pre-emption rights. This arrangement has not adversely affected the experience of FirstNet users. According to some estimates, outside of emergencies, public safety agencies' day-to-day use will make available a large portion of the spectrum for commercial uses.[56]

Certain rural and remote areas continue to have limited broadband access because of the challenging business case for private-sector deployment in those areas. Shared use of Band 14 spectrum in rural and remote communities could enable greater PSBN coverage while also supporting improved last-mile access to broadband for users in rural and remote communities.

Commercial utilities and other infrastructure operators have also identified synergies with a PSBN and have expressed interest in leveraging Band 14 spectrum to support their mission critical communication requirements. These potential partners in a PSBN could bring valuable communications infrastructure thereby speeding deployment and increasing the coverage footprint of the PSBN.

Consequently the TNCO continues to evaluate the possibility that commercial uses of Band 14 spectrum could be leveraged as an in-kind contribution to subsidize investments in a PSBN, in particular with respect to establishing and enhancing coverage, bolstering network resiliency, or reducing potential financial barriers which could impede widespread public safety user adoption.

The TNCO also continues to consider opportunities arising from developments of new uses for spectrum and ways of managing Band 14 which ensure that PSBN Principles are best met. As the analysis for the Policy Paper continues, the TNCO will assess the impact of its proposals on the potential commercial value of the Band 14 spectrum which could support or limit potential business cases.

Next steps

This progress report can serve as a checkpoint to ensure that the proposals put forward by the TNCO are consistent with the needs of users across the country, while also being viable for all stakeholders. The goal is to ensure that responders are able to use the PSBN to improve their communication capabilities as soon as possible. Stakeholders are encouraged to examine the recommendations included herein and share their views and comments with the TNCO.

[56] Forbes. 2017. How Much Does AT&T Stand to Gain from FirstNet? https://www.forbes.com/sites/greatspeculations/2017/12/12/how-much-does-att-stand-to-gain-from-firstnet/#78dae0772997.

The TNCO will continue to pursue its engagement with federal, provincial and territorial partners, stakeholders, experts and users to solidify its principles, implementation and operational delivery options. The Policy Paper will be delivered in early 2020 to FPT Ministers responsible for emergency management. The TNCO will also continue to explore the following additional considerations:

- Research and further define objectives for PSBN Principles.
- Describe the potential PSBN market in Canada.
- Identify federal user needs.
- Analyze potential PSBN funding models to assess viability for all stakeholders and determine which offer(s) the greatest likelihood of achieving PSBN Principles.
- Considering the diverse interests of PSBN stakeholders, define governance requirements including proposing roles and relationships in the deployment, operation, and evolution of the network.

Importance of coordinated action

The PSBN offers a technological solution to reduce data communication silos by establishing a single secure and available network in Canada for all first responders. Should a national PSBN not be implemented in a coordinated fashion, the TNCO anticipates there being negative implications for first responders and Canadian citizens. First and foremost, a fragmented or uncoordinated approach would magnify the risk of inequity within and across stakeholder groups. Such inequity is inconsistent with the fundamental principles of a PSBN, and as a result may compromise the integrity and success of a nationwide PSBN.

Governmental priorities on rural broadband

Recent budget announcements from the Government of Canada and a number of provinces and territories have included proposals for considerable investment in high-speed internet and wireless service expansion. The Federal Budget 2019, for example, has proposed $1.7 billion over 13 years to ‘top up’ the *Connect to Innovate* program; to establish a *Universal Broadband Fund*; and to secure advanced Low Earth Orbit satellite capacity to serve the most rural and remote regions of the country. The *Accelerated Investment Incentive* will also encourage greater private sector investment in rural and remote high-speed internet, with more than $1 billion worth of telecommunications sector activity signaled to date. This incentive is expected to encourage competition in the telecommunications sector for current and emerging technologies. Investments in rural broadband will support the improvement of wireless broadband communications, helping in the deployment of a PSBN.

At the provincial level, Saskatchewan has proposed a capital investment of $321 million to upgrade SaskTel's networks, and Quebec has proposed $400 million over seven years to improve high-speed internet and cellular access in remote regions. Similarly, in its 2019 Speech from the throne, Alberta promised investments in a rural broadband strategy.

These announcements are positive signals that nationwide broadband connectivity is a priority at multiple levels across the country, which should help to enhance the positioning of a PSBN in Canada. In addition, there may be potential linkages with other sectors which may need to be considered in the assessment of a nationwide PSBN. The TNCO will continue to monitor developments in existing and proposed initiatives to leverage opportunities presented by complementary investments.

Definitions

Term	Definition
Band 14	A paired block of 10+10 MHz in the bands 758-763 MHz and 788-793 MHz (Block D) and 763-768 MHz and 793-798 MHz (Block PSBB) spectrum ranges.
Commercial users	MNO users with no public safety role.
Conditions of License (CoL)	Conditions ISED imposes on a spectrum licensee in exchange for the use of spectrum.
Coverage	Network coverage can be established by targeting a percentage of the population that resides in the geographic coverage area, or by stating the goal for a land area or road length covered by a network. Mobile network coverage can be extended on a temporary basis by using deployables in a localized incident area and/or by roaming across multiple networks.
Critical infrastructure	Critical infrastructure refers to processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and the effective functioning of government. Critical infrastructure can be stand-alone or interconnected and interdependent within and across provinces, territories and national borders. Disruptions of critical infrastructure could result in catastrophic loss of life and adverse economic effects.[57]
Deployable systems	Portable systems that are temporary in nature and provide wireless service with LTE equipment. Several deployable systems can be linked to serve a larger area. Deployable systems may or may not have backhaul. Systems can be small enough to be easily carried by one person up to vehicle towed or mounted systems and even airborne system.
Hardening	A collection of tools, techniques and best practices used to reduce vulnerability to one or more threats.
Interoperability	The ability of emergency personnel to communicate between jurisdictions, disciplines, and levels of government, using a variety of systems, as needed and as authorized. It includes achieving full national operability using common user credentials regardless of the network deployment method used as well as

[57] Public Safety Canada. 2009. National Strategy for Critical Infrastructure.

	interoperability of PSBN with existing Land Mobile Radio (LMR) services in the near to medium-term. Data interoperability can also be achieved at the application level.
Land Mobile Radio (LMR)	A wireless communications system commonly used by emergency first responders to support voice and low-speed data communications.
Long-Term Evolution (LTE)	A standard for high-speed wireless communication for mobile devices and data terminals.
Mission Critical Services (MC Services)	Mission Critical Services (MC Services) refers to the standards defined by 3GPP, including Mission Critical Push to Talk (MCPTT), Mission Critical Video (MC Video) and Mission Critical Data (MC Data). Details of these standards and their evolution are outlined in the 3GPP Rel-13, Rel-14, and Rel-15.
Mission critical services	Any activity, device, service or system whose failure or disruption will cause a failure or severe degradation in operations can be described as mission critical. In the context of the public safety community and the PSBN, this would constitute any aspect of the essential communications services upon which a given user depends for their day-to-day operations, during emergencies and planned events.
Mobile Network Operator (MNO)	A wireless service provider, wireless carrier, cellular company, or mobile network carrier, is a provider of wireless communications services that owns or controls all the elements necessary to sell and deliver services to an end user, wireless network infrastructure, back haul infrastructure, billing, customer care, provisioning computer systems and marketing and repair organizations.
National entity (NE)	A legal entity that will apply the PSBN Principles and be responsible for operational network and/or governance functions based on the resulting service delivery model.
Network access	Ability to have immediate access to a PSBN for mission critical services
Network capacity	The maximum amount of data that may be transferred between network locations over a link or network path[58].
Pre-emption	Used together with priority to control use of resources by removing active sessions of lower priority users and allow allocation of resources to higher priority users, when network resources are scarce or fully occupied.

[58] https://www.techopedia.com/definition/18179/capacity-network

Priority	The means by which users, applications, traffic streams or individual packets take precedence over others in setting up a service session or forwarding packets during periods of congestion in the network.
PSBN users	People, entities/agencies and their devices with a role in or responsibility for the health, safety and security of the public and its infrastructure that access the network.
Public Land Mobile Network Identification Number (PLMN ID)	3GPP – Globally unique network identification code.
Quality of Service (QoS)	Traffic prioritization and resource control mechanisms used to achieve desired levels of performance for a data flow.
Radio Access Network (RAN)	A technology that connects individual devices to other parts of the network through radio connections.
Regional entity (RE)	A legal entity that will be the primary interface for regional/local government public safety agencies with PSBN and perform governance and operational network functions not done by the NE.
Resilience	The ability of the network to provide and maintain an acceptable level of service in the face of various faults and challenges to normal operations. A resilient PSBN infrastructure would be hardened to withstand threats such as power outages, flooding, seismic activity, and terrorism/vandalism and- should failure occur- rapidly restoring communication availability.
Roaming	The ability for a PSBN user to automatically receive service, including home data services, when travelling outside the geographic area of the home network, by means of a visited network.
Service delivery	The approach to delivering mobile broadband services to PSBN users.
Security	The ability to protect and secure physical network infrastructure and to prevent malicious activities such as cyberattacks at the system and application level.
Spectrum	Radio frequencies over which wireless data travels. The spectrum used in communication is regulated by national organizations, which specify which frequency ranges can be used by whom and for what purpose.
Temporary National	Office established by the Government of Canada to play a leadership role in the

Coordination Office (TNCO)	advancement of a national and interoperable PSBN for Canada.
Tri-Services	All organizations in Canada providing police, fire and paramedic services, as represented by the CACP, CAFC, and PCC.
Users	PSBN users can be public safety End User Agencies (EUA), governments or departments of government, or individuals.

Acronyms

Acronym	Definition
3GPP	Third Generation Partnership Project
4G	Fourth-generation
5G	Fifth-generation
CANUS	Canada/United States
CISC	Communications Interoperability Strategy for Canada
CN	Core Network
CNA	Canadian Numbering Administrator
CoL	Conditions of License
CRTC	Canadian Radio-television Telecommunications Commission
DHS	Department of Homeland Security
DRDC CSS	Defence Research and Development Canada Centre for Security Science
EM	Emergency management
EUA	End User Agencies
FPT	Federal/Provincial/Territorial
GoC	Government of Canada
ICT	Information and communications technology
IoPST	Internet of Public Safety Things
ISED	Innovation, Science and Economic Development Canada
ITU	International Telecommunications Union

IWG	Interoperability Working Group
LMR	Land Mobile Radio
LTE	Long-Term Evolution
MCC	Mobile Country Code
MCS	Mission Critical Services
MHz	Megahertz
MNC	Mobile Network Code
MNO	Mobile Network Operator
MOCN	Multi-Operator Core Network
MSIN	Mobile Subscription Identification Numbers
MVNO	Mobile Virtual Network Operator
NE	National entity
NG 9-1-1	Next Generation 9-1-1
NPAS	National Public Alerting System
PLMN ID	Public Land Mobile Network Identification Number
PSBB	Public safety broadband
PSBN	Public Safety Broadband Network
PSNE	Public Safety Network Entity
QoS	Quality of Service
QPP	Quality of Service, Priority & Pre-emption
RAN	Radio Access Network

RE	Regional entity
RFI	Request for Information
SIM	Subscriber identity module
TNCO	Temporary National Coordination Office
UE	User Equipment
VPN	Virtual private network
WPS	Wireless Priority Service