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<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACMA</td>
<td>Australian Communications and Media Authority</td>
</tr>
<tr>
<td>AMT</td>
<td>Aeronautical Mobile Telemetry</td>
</tr>
<tr>
<td>ATC</td>
<td>Ancillary Terrestrial Component</td>
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<tr>
<td>ATSC</td>
<td>Advanced Television Systems Committee</td>
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<tr>
<td>AWS</td>
<td>Advanced Wireless Service</td>
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<tr>
<td>BAS</td>
<td>Broadband Auxiliary Service</td>
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<tr>
<td>BRS</td>
<td>Broadband Radio Service</td>
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<tr>
<td>CAGR</td>
<td>Compound Annual Growth Rate</td>
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<tr>
<td>CARS</td>
<td>Cable TV Relay Service</td>
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<tr>
<td>CDMA</td>
<td>Code Division Multiple Access</td>
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<tr>
<td>CEPT</td>
<td>European Conference of Postal and Telecommunications Administrations</td>
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<tr>
<td>DFS</td>
<td>Dynamic Frequency Selection</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated Short-Range Communications</td>
</tr>
<tr>
<td>DTV</td>
<td>Digital Television</td>
</tr>
<tr>
<td>ECC</td>
<td>Electronic Communications Committee</td>
</tr>
<tr>
<td>EDGE</td>
<td>Enhanced Data for GSM Evolution</td>
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<tr>
<td>EESS</td>
<td>Earth Exploration Satellite Service</td>
</tr>
<tr>
<td>ENG</td>
<td>Electronic News Gathering</td>
</tr>
<tr>
<td>EV-DO</td>
<td>Evolution Data Optimized</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>FDD</td>
<td>Frequency Division Duplex</td>
</tr>
<tr>
<td>FS</td>
<td>Fixed Service</td>
</tr>
<tr>
<td>FWA</td>
<td>Fixed Wireless Access</td>
</tr>
<tr>
<td>GPRS</td>
<td>Global Packet Radio Service</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
</tr>
<tr>
<td>HDFS</td>
<td>High-Density Fixed Service</td>
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<tr>
<td>HDFSS</td>
<td>High-Density Fixed Satellite Service</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronic Engineers</td>
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<tr>
<td>IMT</td>
<td>International Mobile Telecommunications</td>
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<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISM</td>
<td>Industrial, Scientific and Medical</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transport Systems</td>
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</table>
ITU International Telecommunication Union
ITU-R Radiocommunication Sector of International Telecommunication Union
LMCS Local Multipoint Communication Systems
LMDS Local Multipoint Distribution System
LPA Low-Power Apparatus
LTE Long-Term Evolution
MBS Mobile Broadband Services
MCS Multipoint Communication Systems
MDS Multipoint Distribution Service
MSAT North American Mobile Satellite System
MSS Mobile Satellite Service
MSV Mobile Satellite Ventures
NPRM Notice of Proposed Rulemaking
NTIA National Telecommunications and Information Administration
NTSC National Television Systems Committee
PCAST President’s Council of Advisors on Science and Technology
PCS Personal Communications Service
PSTN Public Switched Telephone Network
RABC Radio Advisory Board of Canada
RLAN Radio Local Area Network
RRBS Remote Rural Broadband Service
SDARS Satellite Digital Audio Radio Service
SPFC Spectrum Policy Framework for Canada
STL Studio Transmitter Link
TDD Time Division Duplex
TDRS Tracking and Data Relay Satellite
TT&C Tracking Telemetry and Command
TVWS Television White Spaces
UHF Ultra-High Frequency
VHCM Very High Capacity Microwave
WBS Wireless Broadband Service
WCS Wireless Communication Services
WRC World Radio Conference
Commercial Mobile Spectrum Outlook
Message from the Minister of Industry

With uncertainty continuing to weigh on the global economy, Canada has an opportunity to lead in creating a world-class, competitive digital economy that attracts investment, creates jobs and builds a sustainable and prosperous society.

To achieve this vision, we need a modern communications infrastructure that makes efficient use of wireless technology. All wireless services rely on the availability of radio frequency spectrum – a finite resource used by a wide range of sectors across the Canadian economy.

As Minister of Industry, it is my responsibility to ensure that spectrum is managed fairly, and to the maximum benefit of all Canadians.

Mindful of the rapid growth in the use of mobile broadband services, our Government recognizes that sufficient and appropriate spectrum resources must be available to Canada’s wireless providers to ensure that Canadians continue to reap the benefits of technology as we strive to become one of the top digital economies in the world.

With this publication, the Government of Canada is opening a new dialogue with spectrum users, licence holders and other stakeholders. This document makes mention of consultations that will be held before we free up spectrum – we hope you will add your voice on how best to use this precious public resource.

The Honourable Christian Paradis
Minister of Industry and Minister of State (Agriculture)
Executive Summary

The purpose of the Commercial Mobile Spectrum Outlook is to provide stakeholders with an overview of Industry Canada’s overall approach and planned activities to ensure appropriate spectrum resources are available to meet the demand for commercial mobile services over the next five years.

The rapid growth of commercial mobile services presents significant economic and social benefits for Canada. This growth is also increasing the amount of spectrum required to deliver these services in Canada. Various projections estimate that Canada will require at least 473 MHz and as much as 820 MHz of spectrum to be allocated to commercial mobile services by 2017. Based on these projections, Industry Canada has set an objective of allocating a total of 750 MHz of spectrum to commercial mobile services by the end of 2017.

Taking into account the already-announced auctions, Canada currently has plans in place to have a total of 528 MHz of spectrum available for commercial mobile services. This means that an additional 222 MHz of spectrum will have to be allocated to commercial mobile services over the next five years in order to meet this objective.

Taking into account action being taken by countries around the globe to identify additional spectrum for mobile, Industry Canada has identified 300-415 MHz of additional spectrum in the following bands that could potentially be allocated to commercial mobile services by 2017:

- AWS 2  10 MHz
- AWS 3  50 MHz
- AWS 4  40 MHz
- WCS   20 MHz
- 600 MHz  80-120 MHz
- 3500 MHz  100-175 MHz

Industry Canada will have separate and comprehensive consultations with industry stakeholders before making any specific decisions with respect to these bands. It is also recognized that not all of these spectrum bands will be available by 2017, and that the timing of specific decisions will be subject to international developments.

The rapid growth in commercial mobile services is also increasing demand for spectrum to support wireless backhaul services. Overall, Industry Canada believes that the 24 GHz of backhaul spectrum available is sufficient to support the growing wireless sector until 2017, although efforts will need to be made to find sufficient spectrum in mid-range frequency bands (11-23 GHz).

Wi-Fi is playing an increasingly important role in the wireless networks by offloading data traffic from cellular networks onto wired networks. It is estimated that by 2015, Wi-Fi networks will carry half of all Internet traffic. As a result, Industry Canada is taking steps to provide additional spectrum for licence-exempt equipment. Canada recently announced a decision to allow the use of TV white spaces, and is joining other countries in examining the potential of making additional spectrum available in the 5 GHz range for use by licence-exempt equipment.
Beyond 2017, mobile data traffic will undoubtedly continue to grow, likely resulting in additional spectrum requirements. It is conceivable that at least 1000 MHz of mobile broadband spectrum will be required by the start of the next decade. As a result, Industry Canada will continue to monitor developments, both in Canada and abroad, and will update this plan accordingly.
1. Introduction

The radio frequency spectrum is a unique, finite resource that is used in a broad range of applications. It is an integral component of Canada’s telecommunications infrastructure, and provides access to a range of private, commercial, consumer, defence, national security, scientific and public safety applications.

The Minister of Industry is responsible for managing the use of spectrum in Canada, in accordance with the provisions of the Radiocommunication Act. As set out in the 2007 Spectrum Policy Framework for Canada, Canada’s overall objective is to maximize the economic and social benefits that Canadians derive from spectrum use. Industry Canada is responsible for the allocation and assignment of spectrum resources to various services and applications, as well as the licensing of specific frequencies through radio or spectrum licences.

One of the principal challenges in managing spectrum is the fact that it is a limited resource that must support a continually growing and increasingly sophisticated range of applications. As a result, Industry Canada must continually monitor trends in spectrum usage and re-evaluate current spectrum allocations and assignments.

The biggest challenge for spectrum managers around the globe today is the rapid growth in demand for commercial mobile services. Commercial mobile services provide the general public with telephony, and increasingly, data and video applications. Growing consumer demand for greater geographic coverage, faster data rates and more sophisticated applications is driving a rapid increase in the spectrum requirements for commercial mobile services, as well as affecting the spectrum requirements for backhaul and for licence-exempt devices that use Wi-Fi technology for Internet access.

The purpose of the Commercial Mobile Spectrum Outlook is to provide stakeholders with an overview of Industry Canada’s overall approach and planned activities in order to ensure additional spectrum resources are available to help meet demand for commercial mobile services over the next five years. Part 2 provides an overview of Industry Canada’s policy approach, based on the 2007 Spectrum Policy Framework for Canada. Part 3 provides a review of expected future demand for spectrum to support commercial mobile services. Part 4 provides an assessment of potential spectrum bands that could be allocated and assigned to commercial mobile services and associated services over the next five years.

The Outlook is intended to reflect Industry Canada’s current direction and efforts to provide spectrum for commercial mobile services. As such, it may be updated from time to time in order to reflect changing priorities, significant technological changes or international developments. The Outlook will be updated following the auction of spectrum in the 700 MHz and 2500 MHz bands as well as after the 2015 World Radiocommunication Conference is held.

The observations and conclusions expressed in the Outlook are based on the current situation in Canada and abroad, and are therefore subject to change. Stakeholders are welcome to provide feedback and comment on an ongoing basis; however, the Outlook is not intended to be a substitute for separate,

commercial consultations with stakeholders on specific spectrum management issues. For a complete list of recent and ongoing public consultations, please refer to the Industry Canada website.  

2. Industry Canada’s Policy Approach

2.1 Spectrum Policy Framework for Canada

Industry Canada maintains a number of official policy documents that provide guidance on the administration and implementation of the Radiocommunication Act. Chief among these is the 2007 Spectrum Policy Framework for Canada (SPFC), which articulates the overall objective and underlying principles that the Minister of Industry relies upon in exercising his authorities under the Act. The overall objective of the spectrum management program is “to maximize the economic and social benefits that Canadians derive from the use of the radio frequency spectrum resource.” The Framework also sets out the following enabling guidelines for achieving this policy objective and for directing Industry Canada’s spectrum management activities:

a. Market forces should be relied upon to the maximum extent feasible.

b. Notwithstanding (a), spectrum should be made available for a range of services that are in the public interest.

c. Spectrum should be made available to support Canadian sovereignty, security and public safety needs.

d. Regulatory measures, where required, should be minimally intrusive, efficient and effective.

e. Regulation should be open, transparent and reasoned, and developed through public consultation, where appropriate.

f. Spectrum management practices, including licensing methods, should minimize administrative burden and be responsive to changing technology and marketplace demands.

g. Canada’s spectrum resource interests should be actively advanced and defended internationally.

h. Spectrum policy and management should support the efficient functioning of markets by:
   o permitting the flexible use of spectrum to the extent possible;
   o harmonizing spectrum use with international allocations and standards, except where Canadian interests warrant a different determination;
   o making spectrum available for use in a timely fashion;
   o facilitating secondary markets for spectrum authorizations;
   o clearly defining the obligations and privileges conveyed in spectrum authorizations;
   o ensuring that appropriate interference protection measures are in place;
   o reallocating spectrum where appropriate, while taking into account the impact on existing services; and
   o applying enforcement that is timely, effective and commensurate with the risks posed by non-compliance.

3 Recent and ongoing public consultations can be viewed online (http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf08436.html).

4 A complete list of official publications is available online (http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf01841.html).

2.2 International Context

Canada, like most other countries, participates in the global coordination and harmonization of spectrum management through the International Telecommunication Union (ITU). The Radiocommunication Sector of the ITU (ITU-R) serves to facilitate the equitable, efficient and economic use of spectrum among all radiocommunication services. The ITU-R maintains the international Radio Regulations, which define the allocation of spectrum bands to various types of services on the basis of the International Table of Frequency Allocations. Additionally, the ITU-R specifies technical standards to be observed by radio stations, as well as procedures for international coordination, in order to ensure technical compatibility of radio systems between countries. The Radio Regulations are reviewed and amended at the ITU’s World Radiocommunication Conferences (WRCs), which are typically held every three to four years. The last WRC was held in 2012, and the next conference is scheduled for 2015.

Canada strongly supports the global harmonization and coordination of radio frequency allocations and technical standards through the ITU. Global harmonization and coordination contributes to greater certainty for radio equipment manufacturers, who can design and manufacture devices to meet the requirements of global-scale markets, rather than multiple devices to meet the divergent requirements of different jurisdictions. Larger markets lead to larger technology ecosystems, which result in greater economies of scale and more affordable equipment. The Canadian market alone is simply not large enough to attract manufacturers to build equipment for unique Canadian band plans. Consequently, Industry Canada will continue to use the ITU to promote international harmonization, particularly as spectrum managers from around the world work to identify spectrum that could be reallocated to meet the requirements of commercial mobile services at the next WRC in 2015.

Given Canada’s proximity to the United States, spectrum coordination within North America is most critical. Canada has entered into a number of treaties and arrangements with the United States to allow certain radiocommunication equipment that has been duly authorized in one country to operate in the other, thereby avoiding cross-border interference. Among other things, these arrangements for the Coordination and Use of Radio Frequencies specify:

- Frequency bands for which new radio systems must be coordinated between the two countries;
- Geographic areas (near the border) where coordination must occur for certain frequencies;
- Notification and consultation procedures that must be followed between regulatory agencies for the two countries concerning new frequency assignments; and
- Common specifications for use of radio systems in various frequency bands, including antenna height limits, maximum radiated power, etc.

For these reasons, it is critical that Industry Canada monitor and influence, to the extent possible, the spectrum management decisions in other major markets, particularly the United States.

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6 A full list of arrangements can be found online. See Industry Canada’s Coordination and Use of Radio Frequencies (http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01238.html).
2.3 Canadian Table of Frequency Allocations

The Canadian Table of Frequency Allocations establishes the frequency allocations available for radio services in Canada for frequencies between 9 kHz and 275 GHz. For the purpose of spectrum allocations, radio services are identified as primary and secondary services. Primary services have priority use of the frequencies allocated to them and have a right to claim protection from harmful interferences originating from other co-primary services through frequency coordination, as well as from secondary services at all times. Secondary services may also be permitted to use a particular band, but are prohibited from causing harmful interference to primary services.

The Canadian Table of Frequency Allocations is generally, though not entirely, consistent with the International Table of Frequency Allocations maintained by the ITU. Canada is committed to harmonizing spectrum use with international allocations and standards, except where Canadian interests warrant a different determination. In some cases, the Canadian Table reflects only a subset of services allocated in the International Table, reflecting the most desirable services in Canada.

In June 2011, Industry Canada published Radio Spectrum Inventory: A 2010 Snapshot – Canada, which provides an overview of current spectrum allocations and assignments, within the range of 52 MHz to 38 GHz, among 12 different groups of services and applications: commercial mobile, fixed systems (backhaul and fixed wireless access), land mobile, amateur service, public safety, broadcasting, satellite services, space science services, aeronautical services and applications, marine mobile services, radiodetermination and licence-exempt devices. The report provides historical trends in assigned spectrum, an analysis of current spectrum usage and a comparison with spectrum use in the United States. Furthermore, the report provides a basis for ongoing evaluation of current spectrum allocations as the department aims to balance the spectrum needs of existing services with those of new or growing services.

2.4 Demand-side and Supply-side Management

Spectrum is a limited resource, and the “usable” spectrum range (given current technologies) is completely allocated to existing services. As a result, and within the policy context set-out above, Canada must rely on a combination of demand-side and supply-side measures in order to meet the spectrum needs of new or growing services.

Network Investments and Technological Developments to Improve Efficiency

On the demand-side, licensees must use existing spectrum allocations more efficiently in order to provide improved service without requiring additional spectrum resources. Greater spectrum use efficiency can be achieved by optimizing infrastructure deployment (for example, increasing network density in order to increase frequency reuse) or by adopting innovative technologies (such as 4G wireless mobile broadband technologies).

Industry Canada has an important role to play in facilitating spectrum use efficiency, notably through the identification of contiguous and larger bandwidth allocations, through the market-based pricing of spectrum resources, through supporting innovative research and development into new techniques to

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improve spectrum efficiency and by supporting competition in the wireless sector. However, primary responsibility to improve spectrum use efficiency rests with licensees themselves, especially in their ability to make appropriate and continual investments in network infrastructure and to utilize new technologies that improve the efficiency of spectrum use.

Canadian commercial mobile service providers have improved spectrum use efficiency by investing over $13 billion in their wireless networks between 2003 and 2010 (Figure 1). This amount does not include the $4.25 billion spent to acquire new commercial mobile spectrum in the 2008 AWS auction, nor investments that were made to expand wireline infrastructure. Instead, these investments have gone toward expanding network coverage and density (for example, by adding additional cell sites) as well as toward upgrading technology and network applications (for example, the deployment of 4G technologies). As well, major gains in spectral efficiency have been achieved as providers move from older technologies, such as Global System for Mobile Communications (GSM), to newer ones, such as High Speed Packet Access (HSPA) and Long Term Evolution (LTE) (Table 1).

In order to meet future demands for spectrum, key determinants include continued capital investment as well as the development of additional technological and business innovations designed to significantly increase spectrum use efficiency. It is therefore critical that Canada’s wireless providers be encouraged to actively pursue innovations such as dynamic spectrum sharing and cognitive radio, small cell networks, smart antennas and others that have the potential to improve spectrum use efficiency.

Supply-side Management

While the private sector must lead the way in making better, more efficient use of spectrum, Industry Canada recognizes that efficiency improvements alone cannot meet the growing demand for commercial mobile services, and that in order to meet the objective of the SPFC, it has an obligation to manage the supply of spectrum by reallocating limited spectrum resources between radio services. Such reallocation decisions need to consider not only the requirements of commercial mobile services, but also those of associated services, such as fixed systems that provide backhaul capacity or licence-exempt devices, which allow for the offloading of traffic from commercial mobile networks.

When determining the need for spectrum reallocations, Industry Canada will be guided by the SPFC and will endeavour to make decisions in a timely and transparent manner after consultation with stakeholders. In addition to considering stakeholders’ views, Industry Canada’s approach to determine whether and how to reallocate spectrum is based on two main considerations. The first consideration is the expected additional demand for spectrum presented by the new or growing service, taking into account the potential to increase spectrum use efficiency through the application of best available technologies. The second consideration is an assessment of candidate bands, based on a combination of the following three factors: (1) the current use of the band in Canada; (2) projected technological developments and the expected availability of equipment able to use the reallocated bands in order to deliver the new or growing service (often referred to as a “technology ecosystem”); and (3) international trends and whether the new use of the band is compatible with Canada’s international obligations (also known as international frequency coordination).

The next part of the Outlook (Part 3, “Demand for Spectrum to Support Commercial Mobile Services”) provides a summary of Industry Canada’s current analysis of the future expected demand for spectrum in the mobile communications category, given existing trends in network investments and technological
improvements to improve efficiency. Part 3 also includes a summary of the impacts that growing commercial mobile services are expected to have on the spectrum requirements for backhaul services and for licence-exempt devices, which are used to offload mobile traffic onto wired networks.

Based on this analysis of the expected future demand for spectrum from these services and applications, Part 4 of the Outlook (“Additional Spectrum to Support Commercial Mobile Services”) details Industry Canada’s current assessment of candidate bands that could be reallocated to meet future requirements.

Figure 1: Capital Expenditures by Canadian Wireless Telecommunications Service Providers

Note: This does not include investments to acquire spectrum licences in 2008.
Source: Based on CRTC Communications Monitoring Report, various years.
Table 1: Estimated Spectral Efficiency of Various Wireless Technologies

<table>
<thead>
<tr>
<th>Mobile Generation Technology</th>
<th>Efficiency (Bits/S/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G-GSM - GPRS</td>
<td>0.085</td>
</tr>
<tr>
<td>2.5G CDMA</td>
<td>0.29</td>
</tr>
<tr>
<td>3G EV-DO</td>
<td>0.68</td>
</tr>
<tr>
<td>3.5G HSPA</td>
<td>0.68</td>
</tr>
<tr>
<td>4G LTE</td>
<td>1.3</td>
</tr>
</tbody>
</table>


3. Demand for Spectrum to Support Commercial Mobile Services

3.1 Commercial Mobile Services

The Growth of Commercial Mobile Services

Commercial mobile services provide wide-area ubiquitous radiocommunication services to the general public. These services consist of mobile access to the public switched telephone network (PSTN) and mobile access to the Internet. These services have evolved significantly over the last 30 years, from the simple first generation mobile voice telephony in the 1980s to complex 4G technology supporting voice and data transmissions in the high-mobility environment of today. Over this period, consumers have increasingly demanded extended coverage, faster data transmission rates, and more advanced, data-intensive mobile applications (such as video-on-demand). In response, service providers deployed ubiquitous, high-capacity radio networks based on state-of-the-art technologies.

Since 2000, the number of subscriptions for commercial mobile services in Canada has more than tripled, increasing by an average of 1.5 million per year over the last decade (Figure 2). In fact, the total number of wireless subscriptions in 2008 surpassed wireline subscriptions, which have remained stable over the same period.

The increase in mobile subscriptions has been accompanied by the adoption of more sophisticated mobile devices, such as smart phones and tablets, which provide access to the Internet. Canadians are among the most ardent adopters of these types of devices. ComScore estimated that in 2011, forty-five percent of mobile subscribers in Canada owned a smart phone. This places Canada third among reported markets in smart phone adoption, and ahead of the United States, where smart phone owners represent forty-two percent of total U.S. mobile subscribers.

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9 This data is taken from ComScore’s publication entitled 2012 Mobile Future in Focus (http://www.comscore.com/Press_Events/Presentations_Whitepapers/2012/2012_Mobile_Future_in_Focus).
The adoption of these devices significantly increases data traffic on mobile networks, as users access a diverse array of data-intensive content and applications (Figure 3). Ericsson estimates that mobile Internet traffic worldwide surpassed mobile voice traffic in 2009.\textsuperscript{10} This trend is reflected in the revenues of Canadian providers of commercial mobile services, which have remained relatively stable for voice services since 2008, but have grown significantly for data services (Figure 4).

These two trends — increasing mobile subscriptions and increasing demand for data-intensive content and applications — are expected to continue into the foreseeable future. The CRTC estimates that the number of mobile Internet subscriptions in Canada will increase from 3.8 million in 2011 to around 14 million in 2015 — a compounded annual growth rate of over twenty-nine percent.\textsuperscript{11} In fact, the Cisco Visual Networking Index estimates that by the end of 2013, the number of mobile-connected devices will exceed the world’s population, and that by 2017, video content will represent sixty-six percent of total mobile traffic.\textsuperscript{12}

As a result, traffic over Canada’s commercial mobile networks is expected to increase fifteen-fold between 2011 and 2017, from eight petabytes per month in 2011 to 122 petabytes per month in 2017 (Figure 5).\textsuperscript{13} To provide perspective, it is estimated that all of the information in every university research library in the United States would amount to just 2 petabytes of information.

**Forecasts of Future Spectrum Demand for Commercial Mobile Services**

In 2012, Industry Canada released a study, prepared by RedMobile Consulting, which provides a forecast of the future demand for spectrum to support commercial mobile services in the 2011-2015 time frame.\textsuperscript{14} The views expressed in this study are those of the authors and do not necessarily reflect those of the Department or those of the Government of Canada. The RedMobile study concluded that commercial mobile services in Canada will require 375 to 500 MHz of spectrum by 2015. Extrapolating this forecast using a simple linear regression suggests that 475-650 MHz of spectrum will be required to support commercial mobile services by 2017 (Figure 6). Given that there will be 528 MHz of spectrum available for commercial mobile services (once the upcoming 700 MHz and 2500 MHz auctions are completed), meeting the demand at the upper range of the estimate will require an approximate twenty-five percent increase in available spectrum.


\textsuperscript{11} See the Canadian Radio-television and Telecommunications Commission’s August 2011 report entitled *Navigating Convergence II: Charting Canadian Communications Change and Regulatory Implications 2011* (http://www.crtc.gc.ca/eng/publications/reports/rp1108.htm).


\textsuperscript{13} These figures are taken from Cisco’s *VNI Mobile Forecast Highlights, 2012-2017* (http://www.cisco.com/web/solutions/sp/vni/vni_mobile_forecast_highlight/index.html#–Country) and can be found by filtering by country and selecting Canada.

The RedMobile study looked at three possible scenarios, which differed in their assumptions regarding three key factors: projected traffic growth, investment and network densification, and spectrum use efficiency.

The business-as-usual (BAU) scenario assumes no major changes in current patterns of traffic growth, network densification or efficiency. Traffic is forecast to double every year, site counts of each operator are expected to continue growing at between five to ten percent per year, and spectrum use efficiency is forecast to increase to 1.078 Bits/Sec/Hertz. Total spectrum requirements in the BAU scenario were forecast to be 375 MHz and 473 MHz in 2015 and 2017, respectively.

A wire-free-world (WFW) scenario was also examined, where traffic growth was assumed to be twice as fast as the BAU scenario, and investment and efficiency improvements were modelled in response. Total spectrum requirements in this scenario were forecast to be 460 MHz and 594 MHz in 2015 and 2017, respectively.

Finally, a low-investment (LI) scenario was examined. Traffic growth was forecast to be the same as the BAU scenario, but this scenario showed lower investment in networks and devices. Total spectrum requirements in this scenario were forecast to be 500 MHz and 649 MHz in 2015 and 2017, respectively.

Since the RedMobile report was prepared, actual Canadian mobile data traffic in 2011 has become available. Based on this data, as well as the exponential traffic growth estimates provided by Cisco, Industry Canada has prepared an alternate forecast of future spectrum demand (see Annex A for a full description of Industry Canada’s alternate forecast). This forecast assumes similar increases in network investments observed over the past few years and concludes that between 650 and 820 MHz of spectrum will be required by 2017 (Figure 6). The range of these estimates is a function of the degree to which technologies, such as Wi-Fi, are deployed to offload data traffic from mobile wireless networks.

**Comparison to Other Forecasts of Future Demand**

In October 2010, the United States Federal Communications Commission (FCC) released a study which provided a technical analysis to validate the need for additional spectrum to support commercial mobile services. The FCC analysis concluded that the demand for spectrum will reach 822 MHz by 2014. This amounts to a fifty percent increase from currently available levels in the United States (547 MHz).

Similarly, in May 2011, the Australian Communications and Media Authority (ACMA) released *Towards 2020 — Future spectrum requirements for mobile broadband*. The ACMA report forecasts

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that the demand for mobile spectrum in Australia will reach 760 MHz by 2014, 932 MHz by 2015 and 1,081 MHz by 2020.

Considering these estimates from other countries, the estimates for Canadian mobile spectrum requirements appear somewhat conservative, particularly those cited in the RedMobile study.

**Conclusion**

Estimates of future spectrum required to support commercial mobile services are extremely sensitive to changes in underlying assumptions of future traffic growth, network investments and efficiency improvements. Complicating future projections is the fact that these variables are not independent; they interact with each other in response to market forces. For example, a scarcity of spectrum to support commercial mobile services could encourage greater network investments to increase efficiency, which could put upward pressure on consumer prices. Increased prices, in turn, could change consumer behaviour, leading to slower traffic growth and a corresponding decrease in spectrum demand. Conversely, more spectrum could also lead to healthier levels of competition and/or reduced network deployment costs, thereby reducing consumer prices and having the reverse effect — greater traffic growth and an increased demand for spectrum.

While a precise estimate on future spectrum demands may be difficult to identify, the overall direction is clear: given current trends, additional spectrum will need to be allocated to commercial mobile services to support future requirements. As a result, Industry Canada has set an objective of allocating a total of 750 MHz of spectrum to commercial mobile services by 2017. This objective recognizes that the wireless sector must remain innovative and find ways to increase spectrum use efficiency, while at the same time acknowledging that Canada must increase the overall supply of spectrum for these services.
Figure 2: Number of Wireless and Wireline Subscriptions in Canada

Sources: Based on data from CWTA website and on CRTC Communications Monitoring Report, various years.
Figure 3: High-end Devices Significantly Increase Data Traffic (Basic Mobile Phone = 1)

Source: Cisco, *VNI Global Mobile Traffic Forecast*. 
Figure 4: Wireless Voice and Data Revenues in Canada

Note: Total wireless industry revenues ($19 billion in 2011) also include revenues from sales of terminals, paging and other sources.

Source: Based on CRTC Communications Monitoring Report, various years.
Figure 5: Forecast Mobile Data Traffic Growth in Canada

Note: One Petabyte is equal to 1,024 terabytes.

Source: Cisco, *VNI Global Mobile Traffic Forecast*. 
### 3.2 Backhaul

**Demand for Backhaul Services**

The growing demand for commercial mobile services has significant consequences for backhaul services — the transmission of aggregate communication signals between cell sites and the core networks. There are multiple technical solutions for providing backhaul, including wireline (e.g., fibre optics and copper) as well as wireless radio and satellite, all of which require the allocation of appropriate spectrum resources.

Each type of backhaul solution has different advantages with regard to technical performance, cost and speed of deployment. In Canada, service providers favour a mix of fibre and wireless backhaul, reflecting the country’s varied geography, distances between population centres and the number of rural and remote communities. Major telecommunications and cable providers have built extensive fibre networks in populated areas and along major highway corridors. In these circumstances, fibre is the best option as it supplies virtually unlimited capacity and can, in certain instances, be more economical than multiple wireless radio relay systems when the costs of towers, radio equipment and antennas are factored in.
However, over the past few years, there has been a considerable increase in requests for backhaul licences. Wireless backhaul allows for fast deployment, which is an important factor in rapidly growing and expanding wireless networks. It is also more cost-effective in providing service to low-density suburban, rural and remote communities. The increase in wireless backhaul is a result of new entrants into Canada’s wireless market who are seeking to quickly build their own networks, as well as the efforts of incumbents to upgrade and expand their own networks.

Different spectrum frequencies are used to deliver different types of backhaul services:

**Low frequencies** (below 11 GHz) are used for long-haul links (20 km or more) due to their ability to propagate very far. There are roughly 3 GHz of backhaul spectrum available in low frequencies. These frequencies have traditionally been used to support Canada-wide multi-link networks, most of which are currently in place or are being decommissioned in favour of fibre. However, while limited demand is expected in a portion of this range, these frequencies will continue to be employed along certain corridors to reach areas where other backhaul options may be cost-prohibitive.

**Mid-range frequency bands** (11-23 GHz) are used for medium-haul links (between 8 and 20 km) and have larger channel widths. Of all backhaul spectrum, this frequency range is the most heavily used in Canada. There are roughly 3 GHz of backhaul spectrum available to support more than 20,000 frequency assignments. In particular, from 1998 to 2010, the 11 GHz and 18 GHz bands have experienced a six-hundred percent and eight-hundred percent increase in frequency assignments, respectively. Some areas of Canada are experiencing congestion. In recent years, 570 MHz of this spectrum was the subject of reallocation and re-designation in order to support the implementation of other services, including DTH satellite broadcasting and national defence aeronautical radios. Based on the above, backhaul demand in mid-range frequencies appears to be growing. The evidence of congestion further suggests that additional spectrum may be needed to address the demand.

**High frequency bands** (above 23 GHz) are generally used for short-haul links (less than 8 km) and have very large capacities. This spectrum is ideally suited to address the backhaul needs of small cell sites used in dense urban areas. Recognizing the need for additional backhaul capacity in this frequency range to support the latest technologies used in commercial mobile deployments, Industry Canada has made available roughly 15 GHz\(^{19}\) of backhaul spectrum in the 25 GHz, 27 GHz, 70 GHz, 80 GHz and 90 GHz bands in order to support the deployment of broadband applications. This large increase in short-haul spectrum availability is expected to address the demand for short-haul, high-capacity links both in and around urban areas.

**Forecasts of Future Spectrum Demand for Backhaul**

The study prepared by RedMobile concluded that demand for backhaul spectrum in frequencies below 38 GHz will grow from 878 MHz in 2010 to between 2603 MHz and 3394 MHz by 2015, depending on the modelling scenario (business-as-usual, wire-free-world or low-investment). Extrapolating this forecast using a linear regression suggests that a total of 3438-4435 MHz of backhaul spectrum will be required by 2017 (Figure 7). This projection assumes the continued offloading of traffic from wireless to fibre, and that the proportion of network traffic carried over fibre will increase over the period of 2010-15. Over the same period, the volume of traffic carried over wireless backhaul links is assumed to increase with the rapid growth in fixed and mobile broadband traffic.

**International Forecasts of Future Backhaul Demand**

In 2011, a consortium of Aegis Systems Ltd., Ovum Consulting and dB Spectrum Services Ltd. provided the UK regulator, Ofcom, with a report that outlined the drivers of wireless backhaul demand. The study indicated that although there is sufficient spectrum to meet anticipated needs in the frequency bands above 20 GHz, additional spectrum might be required in the lower and medium frequency bands (3 GHz to 20 GHz frequency range).

Similarly, the Australian Communications and Media Authority (ACMA) has identified continued pressure within lower frequency bands (1.5-8 GHz), while sufficient spectrum exists to accommodate demand in the higher frequency bands.

In 2011, the United States’ FCC made additional spectrum available for backhaul use in bands below 13 GHz, and provided additional flexibility to facilitate the use of backhaul in rural areas with the release of its *Wireless Backhaul Report and Order* (R&O).

**Conclusion**

With a total of roughly 24 GHz of spectrum available in Canada for backhaul in all frequency ranges, there should be sufficient spectrum overall to accommodate expected demand to 2017. However, in mid-range frequency bands (11-23 GHz), finding sufficient spectrum for increasingly large data rates and throughput to cover longer distances remains a challenge. This is consistent with the backhaul challenges identified in other countries.

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23 The FCC allowed Fixed Services to share the 6875-7125 MHz and 12700-13150 MHz bands currently used by the Broadcast Auxiliary Service (BAS) and the Cable Television Relay Service (CARS), in areas where there are no licensed TV pickup operations. See the August 2011 *Amendment of Part 101 of the Commission’s Rules to Facilitate the Use of Microwave for Wireless Backhaul and Other Uses and to Provide Additional Flexibility to Broadcast Auxiliary Service and Operational Fixed Microwave Licensees*, WT Docket No. 10-153, FCC 11-120 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-120A1.pdf).
More spectrally efficient equipment and the ability to offload traffic onto fibre networks can address some of the growing backhaul requirements of the wireless industry. Industry Canada believes that technological advances provide opportunities to increase flexibility and to promote increased spectrum efficiency across all backhaul frequency bands.

Industry Canada plans to address these issues — including any future reallocation or repurposing of spectrum bands for backhaul — through stakeholder consultations. These consultations were launched on December 21, 2012, to consider the requirements in each of the three frequency ranges and to address updated policies and technical requirements for increased efficiency and flexibility, as well as the utilization of all backhaul spectrum.

**Figure 7: Estimates of Future Demand for Spectrum to Support Backhaul**

![Figure 7: Estimates of Future Demand for Spectrum to Support Backhaul](image)

*Source: RedMobile Consulting.*

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3.3 Spectrum Used by Licence-Exempt Devices

Commercial mobile service providers are increasingly relying on heterogeneous network architectures, which are a mix of large and small cells, in order to meet the explosive growth in traffic. These small cells, which use licensed spectrum, allow service providers to increase their network capacity by reusing spectrum, offloading traffic from their macro networks, expanding their service footprint both indoors and outdoors, and delivering better quality of service to their customers. However, due to the high cost, scarcity and capacity constraints of licensed mobile spectrum, service providers are increasingly turning to licence-exempt spectrum to meet the bandwidth requirements for mobile data. For example, in the United States, AT&T supports approximately 45,000 hotspots, which provide Wi-Fi access for the company’s wireless customers. In Canada, Shaw Communications announced in September 2011 that it has elected to abandon a traditional cellular strategy in favour of Wi-Fi hotspot deployments.

A recent study found that the number of Wi-Fi hotspots is expected to increase by three-hundred-fifty percent over four years (2011-2015) as more and more operators around the world deploy hotspots to offload traffic from their mobile networks. In fact, while laptops have traditionally been the primary means of connecting to Wi-Fi hotspots, smart phones enabled with Wi-Fi are set to overtake laptops as the most popular way to connect to hotspots.

To foster even greater use of Wi-Fi hotspots by mobile users, the industry is developing standards to allow seamless roaming between mobile networks and Wi-Fi hotspots. Similarly, the Wi-Fi industry is working to increase adoption rates of Wi-Fi among consumers and enterprises by allowing for seamless roaming between Wi-Fi access points. The “Next Generation Hotspot” initiative of the Wi-Fi Alliance and the Wireless Broadband Alliance will allow users to move from access point to access point without having to re-authenticate.

By 2015, Wi-Fi-enabled devices are expected to carry forty-six percent of all Internet traffic, up from thirty-six percent today. The growing use of Wi-Fi is increasing pressure on spectrum used by licence-exempt devices. To date, the 2.4 GHz and 5.8 GHz ISM bands have supported the fast adoption

25 Femtocells and picocells, which are low-power base stations, use licensed spectrum to provide for enhanced coverage and capacity in areas of high data usage and weak signal levels — for example, in homes, shopping centres, train stations and airports.

26 See the section marked AT&T Wi-Fi Basic (http://www.att.com/gen/general?pid=5949).


28 Ibid.

29 Ibid.

30 The representative body of the mobile industry is the GSM Association; the representative body of the Wi-Fi industry is the Wireless Broadband Alliance. The Wi-Fi Alliance is an industry body that is responsible for certification.

of Wi-Fi capability in millions of consumer devices in Canada. However, the 2.4 GHz band is becoming increasingly crowded due to the presence of Wi-Fi-enabled devices (such as cameras, game consoles, laptops, tablets, and smart phones) as well as numerous other radiocommunication devices (such as baby monitors, garage door openers, Bluetooth headsets and cordless phones), all of which use the same spectrum bands.

To date, the 5.8 GHz band has not been as heavily used by Wi-Fi-enabled devices due to less favourable propagation conditions at this frequency range. More recently, additional frequencies were identified on a global basis for wireless radio local area networks (RLANs), such as Wi-Fi access points in the 5 GHz band. To date, these frequencies have been lightly used, but certification data in Canada and the United States shows an upward trend in the certification of RLAN equipment for this band over the past few years.

Newer versions of the Wi-Fi standard (IEEE 802.11) allow Wi-Fi access points to operate in the 2.4 GHz and 5 GHz bands. The new Wi-Fi standard will support channel bandwidths of 20 MHz, 40 MHz, 80 MHz and 160 MHz, allowing for the much higher capacity and throughputs required by data-intensive applications. As well, the total amount of spectrum available in the 5 GHz range is 530 MHz (compared to 83.5 MHz in the 2.4 GHz band). With operators seeking to offload more and more traffic onto Wi-Fi access points, the 5 GHz band is set to become more heavily used.

The RedMobile study concluded that there is sufficient spectrum available for Wi-Fi for the next five years, given the very local operation of Wi-Fi devices (namely, a very small coverage area) coupled with the ability of a large number of transmitting devices to coexist in the same spectrum.

Along with Wi-Fi devices, licence-exempt television white space (TVWS) devices operating in the unused portions of the broadcasting bands may provide additional options for offloading commercial mobile services. Based on geographic location and channel availability, TVWS devices will be able to operate by finding available spectrum using real-time databases. Also, TVWS devices will be able to take advantage of the propagation characteristics intrinsic to this spectrum between 54-698 MHz, enabling improved range and excellent penetration to complement the cellular network. Industry Canada released its first decision on TVWS devices on October 30, 2012, encouraging the manufacturers and service providers to deploy such technology.

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32 The 5 GHz range refers to 5150-5350 MHz and 5470-5725 MHz. In Canada, the frequency range 5600-5650 MHz is not available for RLAN use.

33 Older versions of the Wi-Fi standard only support 20 MHz channels.


4. Additional Spectrum to Support Commercial Mobile Services

Despite expected improvements in spectrum use efficiency resulting from new technologies and network investments, the growing demand for commercial mobile services and the explosive growth in mobile data traffic will necessitate the reallocation of additional spectrum resources to commercial mobile services. As well, the spectrum requirements for backhaul services and licence-exempt equipment will have to be carefully monitored.

Part 4 of the Outlook provides Industry Canada’s current assessment of candidate bands that could be reallocated to meet future requirements in these areas. This assessment is based on a combination of the following three considerations: (1) the current use of the band in Canada; (2) projected technological developments and the expected availability of equipment that is able to use the reallocated band (creating a “technology ecosystem”); and (3) international trends and whether the new use of the band is compatible with Canada’s international obligations.

It is important to note that the observations and conclusions expressed are based on the current situation in Canada and abroad, and are therefore subject to change. Any specific decisions with respect to the reallocation of spectrum would be subject to full public consultations.

4.1 Existing Spectrum for Commercial Mobile Services

Industry Canada’s 2010 Radio Spectrum Inventory identified 460 MHz of spectrum that was available for commercial mobile services as of June 2010. This total will increase to 528 MHz after the upcoming auctions of spectrum in the 700 MHz and 2500 MHz bands.

Licences for the first 50 MHz of spectrum for commercial mobile services were awarded between 1983 and 1989 to provide analog cellular services. In 1995, a further 80 MHz was licensed for Personal Communication Services (PCS), which enabled the start of a transition to digital cellular technology. In January 2001, Industry Canada held an auction for another 40 MHz of PCS spectrum that was not licensed during the 1995 licensing decision. Finally, in 2008, Industry Canada auctioned 90 MHz of Advanced Wireless Services (AWS) spectrum and the remaining 10 MHz of PCS spectrum.

In 2006, Industry Canada designated the 2500 MHz band (Broadband Radio Service, BRS) for mobile, fixed or broadcasting services deployment. This band was previously allocated to the fixed and/or broadcasting services, and was licensed to Multipoint Communication Systems (MCS) and to Multipoint Distribution Service (MDS) operators. Most of the legacy MCS and MDS licences have already been transitioned to the BRS licences, and the remaining 60 to 120 MHz of spectrum (amount varying by area of the country) will be auctioned in 2014. Once this auction is complete, all 190 MHz of BRS spectrum will be available for mobile broadband use.

See Industry Canada’s document entitled Radio Spectrum Inventory: A 2010 Snapshot – Canada (http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10023.html). Note that the total amount of spectrum identified in the Inventory for commercial mobile includes the entire 190 MHz of spectrum in the 2500 MHz band; however, some will be returned to Industry Canada for auction in 2014.

The 700 MHz band (Mobile Broadband Services, MBS) became available due to the efficiencies gained when television transitioned from analog into digital. A total of 68 MHz of this spectrum, commonly referred to as the “digital dividend,” will be auctioned in 2013.

The status of the remaining 40 MHz of spectrum in the 698-806 MHz band is as follows:

- 26 MHz has been designated for public safety use (broadband and narrowband applications);
- 2 MHz in guard bands;
- 2 MHz in reserve; and
- 10 MHz (D Block) is currently subject to consultation.38

Table 2: Summary of Plans for the Upcoming Auction of Spectrum in the 700 MHz and 2500 MHz Bands

<table>
<thead>
<tr>
<th>Band</th>
<th>Amount in MHz</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>700 MHz (MBS)</td>
<td>68 MHz</td>
<td>• Decisions on technical, policy and licensing issues released in March 2012.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Consultations on auction design and rules launched in April 2012.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decisions on auction design and conditions of licence to be released in March 2013.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Auction in 2013.</td>
</tr>
<tr>
<td>2500 MHz (BRS)</td>
<td>60-120 MHz</td>
<td>• Decision on band plan and incumbent migration made in February 2011.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decisions on technical, policy and licensing issues released in March 2012.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Consultations on auction design and rules were launched in October 2012.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decision on licensing process to be published in 2013 (in advance of the 700 MHz auction).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Auction within a year of the 700 MHz auction.</td>
</tr>
</tbody>
</table>

4.2 Potential Bands Under Consideration for Commercial Mobile Services

Mobile wireless communications require the radio waves to penetrate, reflect and diffract (or simply said, go through and around obstacles), since the transmitter and the receiver are usually not in direct view of each other. At lower frequencies, the radio waves penetrate obstacles (such as building walls) and propagate further distances. From this point of view, lower frequency bands are generally preferable for mobile communications. However, consumer terminal devices for mobile commercial services have small-form factors that create challenges to fit in the larger antennas found in the lower frequency bands. Moreover, while lower frequencies are very good at providing long-range coverage and deep-building penetration, spectrum is relatively more abundant in the higher frequency bands, enabling the provision of higher capacity systems. Based on these and other considerations, it is generally accepted that the

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38 See Industry Canada’s 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) (http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10459.html).

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frequency range practical for mobile broadband communications is approximately between 400 MHz and 6 GHz.

Considerable time is needed to bring a given spectrum band in service for mobile commercial operations. First, the international regulatory provisions — such as spectrum allocations to the mobile service and identification of bands for International Mobile Telecommunications (IMT) systems — must follow the World Radio Conference (WRC) regulatory cycle, with new provisions available at intervals of every three to five years. Secondly, policy and technical rules must be set domestically.

In parallel, once the regulatory certainty exists, equipment starts to become available — typically developed for first-tier operators, who can provide large orders that take advantage of economies of scale through mass-manufacturing. After a stable equipment ecosystem emerges for a given frequency band, deployments can start. For a smaller market such as Canada, there is a trade-off between the economic and social benefits of “early adoption” versus the possible risks posed by premature deployment of a band into a configuration which later may not be widely adopted by other countries, leading to a “fringe” equipment ecosystem.

Global (or at least regional) harmonization and interoperability are essential in order to ensure equipment availability at a low cost, to enable roaming and to avoid cross-border interference. Consequently, the timing of when additional spectrum is made available for mobile commercial services in Canada cannot be independent of international developments.

4.2.1 Wireless Communications Services (WCS)

Bands

2305-2320 MHz and 2345-2360 MHz

Current Use in Canada

These bands were auctioned in Canada for commercial broadband services in 2004 and 2005. WCS spectrum was auctioned as a single paired 15+15 MHz block. At the time, the band was used for legacy point-to-point microwave systems. Keeping in line with the WCS spectrum policy, these systems would have to clear the band if they were found to be incompatible with new WCS systems. As the deployment of WCS systems remains very limited, some of these legacy point-to-point systems continue to operate in the band.

Technical Considerations

WCS spectrum is adjacent to spectrum that has been licensed for Satellite Digital Audio Radio Service (SDARS; 2320-2345 MHz). There is a significant potential for mutual interference between the WCS and SDARS systems under certain scenarios. Up until now, restrictive technical rules have been in place in the United States and in Canada to avoid mutual interference. As a result, a viable equipment ecosystem has yet to emerge for mobile systems, and there has been no significant deployment of commercial mobile services in the WCS bands.
International Considerations

In June 2012, AT&T and Sirius XM submitted to the FCC a joint proposal that reflects a compromise between WCS and SDARS interests in the United States. The proposal is meant to enable the deployment of LTE systems in the WCS bands while protecting the SDARS operations. In October 2012, the FCC accepted the proposal, which will allow 20 MHz to be used for mobile broadband services and two 5 MHz blocks (adjacent to the SDARS band) to be used for Fixed Wireless Access (FWA) applications.

The entire 2300-2400 band has been identified for mobile broadband services in the ITU Radio Regulations. In the Asia-Pacific countries, where the allocation is mostly contiguous and of wider bandwidth compared to the North American plan, a significant ecosystem for mobile broadband is expected to emerge over the entire 2300-2400 MHz range. This ecosystem is unlikely to influence the North American equipment availability due to differences with the WCS band plan and technical rules.

Conclusion

A viable equipment ecosystem has yet to emerge in the WCS band, which has thus far prevented licence holders in Canada from using the spectrum for commercial mobile services. However, given the recent decision in the United States to resolve potential interference issues between WCS and SDARS applications, it is expected that equipment will become available in this band over the next two to three years in order to support commercial mobile services.

In a letter sent to WCS licensees (published in March 2012), the Department extended deployment deadlines to the end of each licence’s 10-year term (2014), given the lack of available equipment. In October 2012, Industry Canada published a consultation considering the renewal of licences in this band.

Given the decision in the United States, Industry Canada plans to revise the technical standards in consultation with the Radio Advisory Board of Canada (RABC) in 2013, so as to allow for the deployment of new mobile broadband equipment in this band.

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39 Copies of the ITU’s International Radio Regulations can be obtained from the ITU website (http://www.itu.int/pub/R-REG-RR).


4.2.2 Advanced Wireless Services 3 (AWS 3)

**Bands**

1755-1780 MHz and 2155-2180 MHz\(^{42}\)

In the United States, originally it was only the band 2155-2175 MHz which was referred to as AWS-3. Subsequently, as part of the tendency to aggregate frequencies in larger blocks of spectrum, the 2175-2180 MHz block (previously part of the AWS-2) was also added to this band. The wireless industry in both Canada and the United States has made proposals — supported by Industry Canada — to pair the 2155-2180 MHz and 1755-1780 MHz frequency bands. These bands are referred to in this document as AWS-3.

The advantage of pairing these two frequency bands is that they could form part of the AWS ecosystem, as an extension to the original AWS band (AWS-1).

**Current Use in Canada**

In 2007, Industry Canada indicated that the designation of the band 1755-1780 MHz for AWS (Advanced Wireless Services) may be the subject of a future public consultation. At that time, the Department indicated that it was not ready to designate or license the bands 1755-1780 MHz and 2155-2180 MHz until potential service applications, band pairing and technology clearly emerged. Currently, the bands 1755-1780 MHz and 2155-2180 MHz are being used for low-capacity fixed point-to-point microwave links, which are mostly legacy systems. These bands have seen little demand for new fixed systems due to the expectation that these frequencies will be repurposed for mobile services.

**Technical Considerations**

The wireless industry in North America has repeatedly requested that this band be identified for mobile broadband commercial systems since it is an extension to the original AWS bands. Implementing this band in commercial equipment would require minimal changes from the existing hardware configuration and would contribute to a more harmonized global wireless ecosystem.

**International Considerations**

The bands 1710-2025 MHz/2110-2200 MHz (encompassing PCS, AWS-1, AWS-2, AWS-3 and MSS/AWS-4 bands) are identified for IMT systems by the ITU. However, two main band plan arrangements (leading to separate equipment ecosystems) are in use for PCS and AWS — one is used in North America, and the other is used in Europe, Japan and other countries.

The band 1755-1780 MHz is currently held by the United States Government and is used for a variety of applications. In March 2012, the National Telecommunications and Information Administration (NTIA) released a study that indicated the majority of their users from the 1755-1780 MHz band could be relocated in five years, but some systems would need to remain in the band for at least another five years. Recent proposals in the United States suggest that a regulatory framework, where mobile

\(^{42}\) See Figure 8 for a band chart.
commercial systems would share the band with existing government users, is being considered. Pilot projects to evaluate the feasibility of sharing solutions have been initiated. One aspect that may slow down progress on repurposing this band in the United States is that the NTIA is considering the entire 1755-1850 MHz range (rather than just the 1780-1850 MHz range) in their assessment of future mobile broadband requirements.

In February 2012, the United States Congress passed Bill H.R. 3630, which stipulated that the FCC will auction the band 2155-2180 MHz by 2015, but remained silent on the possibility of pairing with the band 1755-1780 MHz.

**Conclusion**

The wireless industry in both Canada and the United States has indicated that a paired identification of the two bands 1755-1780 MHz and 2155-2180 MHz would be very valuable in the delivery of mobile broadband services to consumers. Given that these bands are part of the North American wireless ecosystem, a prudent approach is to wait for the usage of this spectrum to be clarified in the United States. At this point, these two frequency bands have not yet been linked into a paired structure due to the United States Government’s use of the 1755-1780 MHz range.

A solution based on a sharing framework between the government and the commercial industry in the United States would lead to equipment availability in this band, which would be beneficial for Canada. The amount of spectrum made available by the repurposing of the AWS-3 bands would then be 50 MHz.

It is anticipated that the AWS-3 bands will be available for licensing as early as 2015. In 2013, Industry Canada plans to start a dialogue about the band plan with the wireless industry and with other countries that are planning to implement mobile services in the AWS band. As mentioned earlier, Industry Canada has contacted the United States Government (both the FCC and the NTIA) to indicate a strong preference for the band pair 1755-1780 MHz and 2155-2180 MHz.
4.2.3 Advanced Wireless Services 2 (AWS-2) and Other Bands Near 2 GHz

Bands

1695-1710 MHz, 1915-1920 MHz /1995-2000 MHz and 2020-2025 MHz (see Figure 8)

Originally the AWS-2 designation in the United States referred to the bands 1915-1920 MHz/1995-2000 MHz and 2020-2025 MHz/2175-2180 MHz. As discussed in Section 4.2.2, the 2175-2180 MHz block was subsequently appended to the AWS-3 band.

Current Use in Canada

The band 1695-1710 MHz is allocated to meteorological aids and meteorological-satellite (space-to-earth) services. Radiocommunication systems, such as meteorological earth stations and weather balloons, are deployed in this band. As well, the band 1700-1710 MHz is used for low-capacity point-to-point microwave systems, such as one-way audio Studio Transmitter Links (STL) systems.

In 2007, the 1915-1920 MHz and 1995-2000 MHz bands were designated for licensed PCS and are being held in reserve until technical issues, related to possible interference with existing PCS use (resulting from the narrow duplex separation) and to the mobile-satellite service above 2000 MHz, are investigated and addressed.

Similarly, Industry Canada is not ready to designate or license the band 2020-2025 MHz for AWS until potential service applications, band pairing and technology are clearly defined.
Currently, there are few point-to-point microwave systems operating in the 1915-1920, 1995-2000 MHz and 2020-2025 MHz bands.

**Technical Considerations**

When the 1915-1920/1995-2000 MHz bands (also referred to as PCS Block H) were first considered for auction, the following technical concerns were raised by the wireless industry, both in Canada and in the United States:

- If Block H is appended to the PCS band (currently 1850-1915/1930-1995 MHz), the remaining duplex gap will be reduced to only 10 MHz (1920-1930 MHz). Some viewed this spacing as insufficient for ensuring proper duplex filter operations, introducing a risk of self-interference (due to intermodulation products) to the PCS terminal devices. Although new state-of-the-art filter technology may be capable of properly operating within the confines of the 10 MHz spacing today, existing already-deployed PCS terminals could still be exposed to interference.

- Another concern was the potential interference to the uplink of MSS satellite service operating in the adjacent band above 2 GHz. A recent decision by the FCC on the use of the MSS band above 2 GHz (AWS-4) requires that existing MSS licensees accept interference to their terrestrial operations from future licensees in the H block.43

The 2020-2025 MHz band (also referred to as Block J) was initially intended to be paired with 2175-2180 MHz (now part of AWS-3). Currently, a band to pair with Block J has not been clearly identified.

**International Considerations**

In February 2012, the United States passed the *Middle Class Tax Relief and Jobs Creation Act of 2012*44 (commonly known as the “Jobs Act of 2012”), which requires the FCC to auction the bands 1915-1920 MHz, 1995-2000 MHz and 2020-2025 MHz by 2015, along with 15 MHz from the 1675-1710 MHz band.

The NTIA has indicated that the 1695-1710 MHz (15 MHz) portion of the meteorological band could be reallocated to mobile services, with exclusion zones of 72-121 km around meteorological-satellite receiving stations.

**Conclusion**

Since the AWS-2 bands are very small, they are best used as extensions of other, larger bands where possible. As a result, the band most likely to be effectively deployed is the 1915-1920/1995-2000 MHz band as an extension of the PCS band, subject to resolving the band pairing gap issue.

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The 1915-1920/1995-2000 MHz and 2020-2025 MHz bands are lightly used in Canada and could be available for repurposing to mobile broadband systems in a relatively short time frame, provided that the specific technical, spectrum pairing and North American ecosystem issues that affect these bands can be resolved.

Repurposing the 1695-1710 MHz sub-band would need to take into account compatibility with existing meteorological systems operating in the band. Also, there is not an obvious band with which to pair this spectrum in a manner that would be consistent with other bands used for commercial services. As a result, the amount of spectrum possibly repurposed from the AWS-2 bands is most likely 10 MHz, but could be as high as 30 MHz.

As the AWS-2 bands are relatively small and numerous, it is difficult to estimate when they would be available to the Canadian market. However, it is reasonable to expect that they could be available, in whole or in part, by 2017. As an equipment ecosystem starts to emerge, Industry Canada will conduct a public consultation on the appropriate policies, standards and licensing rules.

4.2.4 Mobile-Satellite Service in the 2 GHz Band (AWS-4)

Bands

2000-2020 MHz and 2180-2200 MHz

Current Use in Canada

The bands 2000-2020 MHz and 2180-2200 MHz are allocated to mobile-satellite service (MSS). In 2004, the Department decided to accommodate the development of an Ancillary Terrestrial Component (ATC) mobile service in these bands as an integral part of mobile-satellite service offerings.

The TerreStar-1 satellite (currently operated by Gamma Acquisition Canada ULC, a Canadian licensed satellite operator) has been operating at the 111.1°W orbital position since 2009. This satellite uses the 2000-2010 MHz and 2190-2200 MHz bands, and is capable of delivering mobile-satellite services throughout North America. However, very limited services are currently being offered to the public. TerreStar Solutions, a Canadian reseller of capacity from the TerreStar-1 satellite, has an authorization from Industry Canada to reuse the 2000-2010 MHz and 2190-2200 MHz bands in Canada for ATC.

The DBSD satellite, a UK satellite, has been in orbit at 93°W since 2008 and uses the other 20 MHz in the 2010-2020 MHz and 2180-2190 MHz bands. This satellite is also capable of delivering mobile-satellite services throughout North America.

In the past, MSS licensees have argued that the MSS services in this band, while technically feasible, cannot achieve sufficient scale (even when considering the entire North American market) to be economically self-sufficient. They argue that the addition of terrestrial mobile services, which can be delivered in the same frequencies, are necessary in order to ensure financial sustainability of the mobile-satellite operations.
**Technical Considerations**

The United States recently defined a duplexing direction for terrestrial mobile broadband systems that would be consistent with the MSS service (2000-2020 MHz for uplink and 2180-2200 MHz for downlink). While this duplexing direction would minimize issues of coordination and coexistence between the terrestrial and satellite systems, it would create a conflict with future PCS systems operating below 2000 MHz, as referred to in Section 4.2.3 *Advanced Wireless Services 2 (AWS-2)*.

**International Considerations**

In 2010, the FCC’s National Broadband Plan proposed repurposing the 2000-2020 MHz and 2180-2200 MHz bands (AWS-4) for mobile broadband services. In 2011, the FCC added co-primary mobile and fixed allocations (in addition to the MSS allocation) in these bands.

In December 2012, the FCC released its decision on the rules for the bands 2000-2020 MHz and 2180-2200 MHz. The decision allows for the deployment of a terrestrial-only mobile broadband service (AWS-4) in these bands. The decision also grants authority to the current 2 GHz MSS licensee, DISH Network, to operate the terrestrial AWS-4 licence in order to eliminate a need for coordination between the two services. The FCC also decided that AWS-4 terrestrial operations need to protect the MSS operations in this band.

The two MSS satellites that are authorized to serve North America have completed the international satellite coordination process through the ITU. In the 2000-2020 MHz band, the ITU regulations protect MSS satellites, with power limits on terrestrial services, and coordination is required between MSS terminals and terrestrial stations. In the 2180-2200 MHz band, existing MSS satellites are not required to protect new terrestrial services. MSS systems in these bands provide the flexibility to deploy multiple spot beams and to manage power and capacity as customer demand dictates. If a decision is made to use these frequencies for terrestrial broadband, the satellites have the potential to reduce the amount of spectrum being used in the spot beams or to turn off the power delivered to the beams. These considerations, among others, may determine Canada’s obligations to protect incumbent MSS operations, and implicitly, may determine who would be eligible in Canada to deploy terrestrial systems using these frequencies (namely, the existing MSS operators or other entities). It is also noted that one of the two satellites is licensed by Canada and has an authorization to provide MSS services within this country. The other satellite operator has a pending application.

**Conclusion**

Given that this spectrum will become available for mobile broadband services in the United States, these bands could also be considered, subject to public consultations, for mobile broadband services in Canada. Up to 40 MHz of spectrum could potentially be made available in the AWS-4 band. Awarding authorizations for terrestrial applications to the existing MSS operator(s) could ensure proper coordination of the applications, resulting in maximum use of the available spectrum. Alternatively, awarding authorizations for terrestrial applications to new terrestrial mobile broadband operators would

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require coordination challenges to be addressed. In these circumstances, it is likely that sharing the frequencies between the AWS-4 and the MSS operations would result in less than 40 MHz of spectrum being available for terrestrial mobile broadband.

It is anticipated that this spectrum could become available in 2014, or perhaps sooner, and that an equipment ecosystem would follow, depending on the level of industry interest.

### 4.2.5 600 MHz Band

**Band**

Below 698 MHz (specific 600 MHz range is yet to be defined)

**Current Use in Canada**

The 600 MHz band (512-698 MHz) is being used by over-the-air TV broadcasting services (in 6 MHz channels), except for 608-614 MHz (Channel 37), which is used by the radio astronomy services and by medical telemetry devices. Most of the broadcasting operations are based on the digital ATSC standard (DTV), although some TV stations in suburban and rural areas are still operating with analog transmission based on the NTSC standard. In 2006, Industry Canada released rules enabling the remote rural broadband service (RRBS) to operate within the 512-698 MHz band, except on Channel 37, on a no-interference, no-protection basis with respect to all TV broadcast services. Based on the Department’s spectrum management database, 68 RRBS stations are currently licensed at this time. Licensed low power apparatus (LPA), such as wireless microphones, are also operating in the band.

In August 2011, Industry Canada initiated a public consultation process on introducing TV white space services in the television bands.\(^{47}\) Industry Canada released its decision on TVWS devices on October 30, 2012, encouraging the manufacturers and service providers to deploy such technology.\(^{48}\) This decision will be followed by additional work in 2013 on specific technical and operational requirements. In the United States, the band 512-698 MHz also accommodates TV broadcasting in 6 MHz channels, licensed and unlicensed wireless microphones, and broadcast auxiliary services (BAS). In addition, the FCC has allowed unused TV channels to be used by TV white space (TVWS) devices.

In February 2012, the United States Congress directed the FCC to conduct an incentive auction of broadcast television spectrum\(^ {49}\) in order to reallocate portions of the UHF TV bands to mobile and fixed services. On October 2, 2012, the FCC launched a public consultation on the proposed rules for such an

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Commercial Mobile Spectrum Outlook

It is expected that between 80 and 120 MHz spectrum could be made available for mobile broadband services through this process.

**Technical Considerations**

After decisions have been made about the amount of spectrum repurposed for mobile services in the United States, Industry Canada will be in a position to determine if the broadcasting use in Canada can be supported using a reduced amount of spectrum.

If a portion of the television band is allocated to mobile broadband services, it is expected that white space devices could adjust to operating on a reduced frequency range for broadcasting systems, since the operation of these devices is adaptable to existing conditions based on geospatial databases. However, potential impacts to the users of wireless microphones, wireless medical telemetry devices and other low-power devices may need to be mitigated by either reserving some spectrum for these applications or preventing their operation in mobile bands.

**International Considerations**

TV broadcasting operations functioning in the proximity of the shared Canada-USA border are governed by the 2008 *Interim Agreement between Canada and the U.S. Concerning Digital Television (DTV)*, which includes an agreed DTV allotment plan. The Agreement will need to be updated to reflect the significant changes in the band that are forthcoming in the United States (assuming a successful process), and potentially in Canada as well.

The 600 MHz band is currently a subject of deliberations in advance of the World Radiocommunication Conference 2015 (WRC-15). The conference will look to address the need for additional internationally harmonized spectrum for mobile broadband services. In North America and in some countries in the Asia-Pacific region, the 700 MHz band was reallocated for use by mobile services following the conversion to digital television, which required less spectrum to satisfy the broadcasting spectrum demand. Additional spectrum under 1 GHz could be made available in the 600 MHz band. In Europe, the digital transition is occurring in the 800 MHz band, and a possible next step may be to consider the 700 MHz band. The 600 MHz may also be considered in the context of a future WRC.

**Conclusion**

The 600 MHz band is in the process of being reallocated to commercial mobile services in the United States. This reallocation is being done through a complex incentive auction process, which includes financial compensation to the current broadcasters as determined by a market-based valuation of the spectrum. The auction is targeted for 2014. If the process is successful, the resulting outcome will restructure the UHF TV band, enabling deployments of mobile broadband systems in the 600 MHz range. Due to complexities involved, this process is expected to take a number of years, possibly resulting in 80 to 120 MHz of additional spectrum for mobile broadband services.

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It is expected that the Canadian usage of the UHF TV band will eventually be harmonized with usage in the United States. Industry Canada will evaluate the timing and the process that could be used in Canada for the repurposing of the 600 MHz band, based on the outcome of the incentive auction process in the United States. Any decision to review these bands will be made following consultations with the public.

### 4.2.6 3500 MHz Band

**Band**

The frequency range 3400-3800 MHz can be divided into four sub-bands: 3400-3475 MHz, 3475-3650 MHz, 3650-3700 MHz and 3700-3800 MHz.

**Current use in Canada**

The 3400-3475 MHz band is allocated to the radiolocation service for radar use in Canada and in the United States.

The 3475-3650 MHz band is allocated to various radiocommunication services, including the fixed service and the radiolocation service. However, the primary use of this band is for fixed wireless access (FWA) applications. Between 2003 and 2009, this band was auctioned in three paired blocks (25 MHz + 25 MHz) and one stand-alone/unpaired block (25 MHz) on a Tier 4 service area basis. A total of 677 licences were awarded to 33 licensees. Few systems have been deployed in this band, and licensees who have deployed are primarily using fixed WiMAX equipment. A licence-review consultation was launched in October 2012 concerning the renewal of licences that are set to begin expiring in 2014.\(^52\)

The 3650-3700 MHz band is used for mobile and fixed Wireless Broadband Service (WBS), based on a light licensing regime (i.e., stations’ locations and radio parameters are accessible through a public database, and licensees are required to deploy equipment that makes use of contention-based protocols). As of September 1, 2012, there were 116 WBS licences across the country with 641 associated stations.\(^53\)

The 3700-3800 MHz band is allocated to both the fixed service and the fixed-satellite service (FSS). The fixed use is for point-to-point links that provide wireless terrestrial backhaul and other two-way data applications. The 3700-3800 MHz band is heavily used by the FSS for the delivery of broadband services as well as feeder links for television broadcasts. It forms part of the larger pairing of 3700-4200 MHz (used for downlink) and 5925-6425 MHz (used for uplink), commonly referred to as the C-Band. The licences held by the top five users of the C-Band account for 65.9 percent of all frequency assignments (approximately 2,350) in this band. Additionally, there are three Canadian and 53 foreign satellites licensed to operate in the C-Band. Industry Canada currently requires that operators provide public benefit satellite capacity in the C-Band as part of their conditions of licence. A large number of remote northern communities depend on this satellite capacity in order to meet their communications needs.

\(^{52}\) See Industry Canada’s 2012 Consultation on Renewal Process for 2300 MHz and 3500 MHz Licences

\(^{53}\) This data can be found using Industry Canada’s Spectrum Direct webpage
**Technical considerations**

The use of radars in the 3400-3475 MHz band impacts the spectrum availability in this frequency range. Such use is generally deemed to be incompatible with mobile broadband deployments.

In the 3650-3700 MHz band, licensees are required to deploy equipment that uses contention-based protocols in order to reduce the potential for interference and to facilitate the shared use of the band. Such technology is likely incompatible with proposed technologies, such as LTE, for mobile broadband.

FSS receiver earth stations operate above 3700 MHz for weather monitoring, national defence and security, TV distribution to TV broadcast stations and cable systems and services in the North. They are susceptible to interference from transmitters operating below 3700 MHz. Therefore, a minimum separation distance is required between any WBS base station or FWA station and the FSS receiver earth stations. Furthermore, in order to protect terrestrial services (including the fixed and mobile services), FSS satellite transmitters operating in the 3700-4200 MHz band are subject to some power flux density limits, specified in Article 21 of the *International Radio Regulations*. Sharing between mobile base stations or subscriber terminals and FSS earth stations would be very difficult.

**International considerations**

Currently, the mobile service allocations among the three ITU Regions in the 3500 MHz band are not harmonized and are subject to different technical requirements. However, many countries around the world are re-examining their plans for the use of this band, in whole or in part, to facilitate the introduction of commercial mobile services.

In the United States, the 3400-3550 MHz band is used by radars in the radiolocation service and there are no plans to repurpose these frequencies. Fixed and mobile services operate in the 3650-3700 MHz band for the deployment of terrestrial wireless broadband systems, using contention-based protocols. The 3700-3800 MHz band is also used for FSS. As part of the National Broadband Plan, the 3550-3650 MHz band is being reviewed to allow for the introduction of wireless broadband systems, possibly on a shared basis with United States Government systems.

The FCC launched a public consultation in 2012, looking to make up to 150 MHz of spectrum available in the 3550-3650 MHz and 3650-3750 MHz bands for mobile and fixed wireless broadband services. The FCC suggest that this band is ideally suited for small cell technology using a contention-based access mechanism (i.e. a protocol that allows multiple users to share the same spectrum by using a set of rules when two or more transmitters attempt to simultaneously access the same channel) and innovative spectrum sharing. The proposed approach builds on experience with spectrum sharing in the television

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54 Copies of the ITU’s *International Radio Regulations* can be obtained from the [ITU website](http://www.itu.int/pub/R-REG-RR).

55 For more information, see the [National Broadband Plan](http://www.broadband.gov).

white spaces, and broadly reflects the recommendations made by the President’s Council of Advisors on Science and Technology (PCAST).  

In Europe, the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT) adopted harmonized frequency arrangements for the 3400-3800 MHz band. The ECC decision on frequency arrangements took into account two possible duplex modes: Frequency Division Duplex (FDD) and Time Division Duplex (TDD). This decision is also intended to facilitate the deployment of high data rate mobile/fixed communications networks requiring large channel bandwidths.

Both Australia and Japan are also moving to review current uses of this band.

**Conclusion**

Many countries are reviewing their current use of frequencies around the 3500 MHz band to allow for the introduction of commercial mobile services. As network operators look to this band in the medium-term, an equipment ecosystem, including LTE equipment, is expected to become available.

Considering the international developments and the likelihood that mobile equipment for the 3500 MHz band will become available, Industry Canada may hold formal consultations to modify current allocations in order to better harmonize these allocations with those in other countries, as appropriate. A review and possible revision of the spectrum utilization policy and the technical rules currently in place for this band, or portion thereof, may be considered in the 2014-2015 time frame.

Once an international equipment ecosystem becomes evident, it is expected that from 100 to 175 MHz of spectrum could be repurposed for mobile broadband deployments without affecting the C-Band spectrum, used to provide FSS services or the critical radar applications near 3400 MHz.

**4.2.7 WRC-15 bands**

The next ITU World Radiocommunication Conference in 2015 (WRC-15) will consider allocating additional spectrum to mobile broadband services.

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58 For more information, see the December 2011 ECC Decision (11)06: Harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz (http://www.erodocdb.dk/docs/doc98/official/pdf/ECCDec1106.pdf).
Among other bands under discussion, spectrum near 1.4 GHz (commonly referred to as the L-Band) is of high interest to a number of countries, equipment manufacturers and service providers. For example, CEPT has established a working group to review the future use of the 1452-1492 MHz band.\textsuperscript{59} Australia is also looking at the potential for mobile broadband in the 1427.9-1510.9 MHz band.\textsuperscript{60} While it is too early to consider this band in Canada, due to a recent decision by the Minister to allocate part of the band for aeronautical mobile telemetry (AMT) for aircraft testing, at some point in the future it may be prudent to review its use.

The 2700-2900 MHz band may also be of interest, as it is located in the vicinity of bands already identified for mobile broadband services. These services offer similar propagation characteristics and may facilitate the use of common radio components, such as antennas. However, spectrum sharing between mobile broadband services and incumbent operations in this band may be challenging.

Other bands between 300 MHz and 6 GHz, including some of the bands discussed in the previous sections, may also be considered by WRC-15 for additional regional and global mobile allocations.

\textit{Conclusion}

Canada is actively involved, both domestically and internationally, in identifying the additional mobile spectrum that will be the subject of discussion at WRC-15. A number of bands will be reviewed, based both on their merit toward global mobile spectrum harmonization as well as on their impact on existing users. It is anticipated that the conference will find sufficient new spectrum to support mobile services. This spectrum, or a subset of it, may be put into service in Canada several years following the WRC-15 decisions.

4.3 Potential Bands Considered for Additional Fixed Backhaul Service

4.3.1 28 GHz - Recent Designation

\textit{Band}

25.25-28.35 GHz

\textit{Current Use in Canada}

In 1996, licences were issued through a comparative process for two 500 MHz frequency blocks in the 28 GHz band for Local Multipoint Communication Systems (LMCS): Block A (27.85-28.35 GHz) and Block B (27.35-27.85 GHz). The remaining four 500 MHz blocks (Blocks C, D, E and F) from 25.35 to 27.35 GHz were held in reserve. Only experimental deployments took place, and all licences were eventually returned to Industry Canada by January 2002.

\textsuperscript{59} See CEPT’s October 2011 newsletter article entitled “ECC launches major review of an attractive band of spectrum” (http://apps.ero.dk/ecenews/oct-2011/attractive-spectrum.html).

\textsuperscript{60} See ACMA’s 2012 document entitled Planning for mobile broadband within the 1.5 GHz mobile band (http://acma.gov.au/WEB/STANDARD.PC/pc=PC_410368).
In June 2011, following a public consultation, the lower and upper portions of the band 25.25-28.35 GHz (25.25-26.5 GHz and 27.5-28.35 GHz) were opened to fixed systems for the deployment of broadband applications. The middle portion of the band (26.5-27.5 GHz) is being held in reserve and will be subject to a future review, given that it is used for Tracking and Data Relay Satellite (TDRS) as well as other systems in the United States.

In addition to the fixed service, in Canada the 25.5-27 GHz portion of the band is allocated for earth exploration-satellite (space-to-earth), inter-satellite, mobile and space research (space-to-earth) on a primary basis, and to standard frequency and time signal-satellite (earth-to-space) on a secondary basis. The 27-28.5 GHz range is allocated to fixed, fixed-satellite (earth-to-space) and mobile on a primary basis, as well as to inter-satellite service in 27-27.5 GHz.

Currently, a total of 19 fixed links and an additional 12 earth station assignments operate within both portions of the band.

**Technical Considerations**

The new Canadian band plan for the 25.25-26.5 GHz and 27.5-28.35 GHz bands allows for the use of some existing equipment produced for the European market. While consideration of the geostationary-satellite orbit by fixed systems operating in the band 25.25-27.5 GHz is essential, the technical requirements of Article 21 of the ITU Radio Regulations 61 also apply to terrestrial fixed systems sharing with space services.

**International Considerations**

The range 25.25-27.5 GHz is currently designated for government use in the United States, while the 27.5-28.35 GHz band is designated for Local Multipoint Distributions Systems (LMDS).

In Europe, the two paired 24.549-25.445 GHz and 25.557-26.453 GHz bands have been designated to fixed services. Europe has also designated the 26.5-27.5 GHz range for government use. In addition, the Fixed Satellite Service (FSS) designations have been made for the 27.5-27.8285 GHz and 28.4445-28.9485 GHz bands.

**Conclusion**

Taking into account that equipment is becoming available on the market and that demand for fixed backhaul systems is expected to increase, 2100 MHz of spectrum (25.25-26.5 GHz and 27.5-28.35 GHz) was opened to fixed systems for the deployment of broadband applications in June 2011.

Given the immediate need for spectrum, licences are being granted on a first-come, first-serve, non-standard basis for deployment at a specific site in parts of the 25.25-26.5 GHz and 27.5-28.35 GHz bands, pending the establishment of technical requirements and a formal licensing process.

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61 Copies of the ITU’s *International Radio Regulations* can be obtained from the [ITU website](http://www.itu.int/pub/R-REG-RR).
4.3.2 70/80/90 GHz — Recent Designation

Bands

71-76 GHz, 81-86 GHz, 92-94 GHz and 94.1-95 GHz

Current Use in Canada

In June 2012, the 70/80/90 GHz bands were designated for fixed service in order to support the deployment of mobile broadband services. There are currently seven backhaul links and seven radar links within these bands. In addition, the 92-95 MHz band remains designated for use by indoor licence-exempt devices.

Once the technical requirements have been finalized, spectrum licences will be issued on a Tier 4 service area basis through a first-come, first-serve process. Licensees are required to share the spectrum with other licensees in a given area.

In addition to the fixed service, the 71-74 GHz band is allocated on a primary basis to fixed-satellite (space-to-earth), mobile and mobile-satellite (space-to-earth) services. The 74-76 GHz range is also allocated to broadcasting, broadcasting-satellite, fixed, fixed-satellite (space-to-earth) and mobile services on a primary basis, and to space research (space-to-earth) services on a secondary basis. The 81-84 GHz band is allocated on a primary basis to fixed, fixed-satellite (earth-to-space), mobile, mobile-satellite (earth-to-space) and radio astronomy services, and to space research (space-to-earth) services on a secondary basis. The 84-86 GHz range is allocated to fixed, fixed-satellite (earth-to-space), mobile and radio astronomy services on a primary basis.

Technical Considerations

The large amount of bandwidth available in these frequencies can provide gigabit capacity in an environment where equipment is deployed in close proximity. At the same time, potential interference can be minimized due to the unique propagation conditions that exist in these millimetre-wave frequency bands as well as the use of highly directional pencil-sized beams. With the potential for high-density fixed service deployments and use by other primary services (including radio astronomy and future FSS), technical and regulatory guidelines are required for sharing purposes.

There are a variety of adjacent band services allocated in portions of the 76-81 GHz and 86-92 GHz bands, including radio astronomy, radiolocation, space research (space-to-earth), space research (passive), amateur, amateur-satellite and EESS, earth exploration-satellite services (passive). Given the significance of the information gathered by these adjacent services, particularly by EESS (passive) to predict severe weather and to analyze climate change and its impacts, there is a requirement for adequate protection with respect to unwanted emissions in the 86-92 GHz band.

Technical specifications and standards are currently being developed for these bands.

International Considerations

In the United States, the FCC is employing a light licensing approach to authorize the use of the 71-76 GHz, 81-86 GHz, 92-94 GHz and 94.1-95 GHz bands on a non-exclusive, nationwide basis. This involves the issuance of a licence as well as advance registration of links. Licences are issued for a
period of 10 years and include rights to non-exclusive access to the entire 12.9 GHz of spectrum on a first-come, first-serve basis, with site-by-site registration and coordination by database managers. Although there is no limit to the number of non-exclusive nationwide licences that may be granted for these bands, there is a 12-month build-out requirement that, if not met, voids the database registration for the particular links involved.

In the United Kingdom, Ofcom has also adopted a light licensing approach to the 71-76 GHz and 81-86 GHz bands for broadband fixed wireless systems. Licences are available on an unlimited, non-exclusive, nationwide basis, with an indefinite licence term and a five-year notice period of revocation. Prior to operating in the band, an operator must apply for a licence. Once this prerequisite is met, the licensee is required to register the links with the Ofcom registration database.

**Conclusion**

The introduction of 12.9 GHz of spectrum in the bands 71-76 GHz, 81-86 GHz, 92-94 GHz and 94.1-95 GHz for fixed point-to-point links will provide an opportunity for the deployment of high-capacity links in support of broadband applications.

**4.3.3 13 GHz Band**

**Band**

12.7-13.25 GHz

**Current Use in Canada**

This band is shared between Fixed Satellite Service (earth-to-space) and Fixed Service on a co-primary basis.

In accordance with the ITU Radio Regulations Appendix 30B allotment plan, Canada is currently allocated three geostationary orbital positions (107.3°W, 111.1°W and 114.9°W) in the allotment Ku band (12.75-13.25 GHz), and has access to 106.5°W for the implementation of one additional system (MSAT-1 operated by SkyTerra). The 106.5°W orbital position is only available until the end of MSAT-1’s life cycle, at which point the allotment at 107.3°W will be used for the future launch of MSV-2, replacing MSAT-1. Canada’s allotment at 111.1° W is assigned to Terrastar and is currently in use by the Terrestar-1 satellite. The remaining allotment at 114.9°W is available for assignment to Canadian satellite operators. Two of the three Canadian positions will continue to be assigned for feeder links and tracking telemetry and command (TT&C) in support of Canadian mobile satellites. The feeder link and TT&C operations for each mobile-satellite system typically involve a small number of gateway earth stations. There are currently two such gateway earth stations located in Canada, but there may be more as the service develops.

The 12.7-13.2 GHz portion of the band is used by various FS applications, including Very High Capacity Microwave (VHCM) point-to-multipoint for distribution of cable programming to head-ends as well as TV studio-to-transmitter links. Currently, there are roughly 60 licences comprising more than

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62 Copies of the ITU’s *International Radio Regulations* can be obtained from the [ITU website](http://www.itu.int/pub/R-REG-RR).
2000 licensed frequency assignments. TV pick-up operations, including Electronic News Gathering (ENG), are licensed on a geographical basis over a defined area within the 13.2-13.25 GHz portion of the band, as well as on a case-by-case basis within 13.15-13.2 GHz. There are more than 50 ENG frequency assignments within the 13.15-13.25 GHz range.

**Technical Considerations**

As the band is shared among a variety of services and applications, frequency coordination is required to limit the potential of interference to existing licensees. Since TV operations, specifically Electronic News Gathering, are used to cover breaking news and special events, they traditionally need to be deployed quickly. To accommodate this requirement, special domestic inter-user coordination on an event-by-event basis is used. Given the unpredictable and itinerant nature of TV pickup operations, sharing with future backhaul systems may not be practical in geographic areas where TV operations are licensed. However, for areas without TV pickup licensees, sharing is feasible.

**International Considerations**

The FCC has made available additional spectrum (within the 12.7-13.15 GHz band) for backhaul use by permitting FS operators to share this band with Fixed and Mobile Broadcast Auxiliary Service (BAS) and Cable TV Relay Service (CARS). Backhaul links can now be deployed within the 12.7-13.15 GHz band in geographic areas outside of where BAS and CARS, including TV pickup stations, are licensed.

**Conclusion**

Given the interest and spectrum demand of mid-range frequencies for backhaul, like the 13 GHz band, Industry Canada’s backhaul consultation, released on December 21, 2012, proposed to introduce backhaul services in the band 12.7-13.2 GHz on a coordinated basis with FSS uplinks and other currently licensed FS systems. In the portion of the band shared with TV pickup operations (13.15-13.2 GHz), sharing on an urban/rural basis was proposed (i.e., preference would be given to existing systems in metropolitan areas).

The results of the consultation will allow the Department to make a decision regarding the provision of additional backhaul spectrum in this band.

**4.3.4 31.8-33.4 GHz Band**

**Current Use in Canada**

The band has primary allocations for fixed and radio navigation services, while specific portions are also allocated to space (space-to-earth and deep space) and inter-satellite services. The band is available for high-density applications in the fixed service (as per Resolution 75, WRC-2000).
Technical Considerations

This band is one of very few bands allocated internationally, as well as across all three ITU Regions (apart from the United States), where the fixed service does not share on a co-primary basis with the fixed-satellite service. It is therefore well suited for high-density fixed service (HDFS) applications, including both point-to-point and point-to-multipoint configurations.

International Considerations

The band is not allocated for fixed service use in the United States. The 31.8-32.0 GHz portion is allocated to the radio navigation and space research (space-to-earth and deep space) services, and the 32.0-33.3 GHz portion to the radio navigation and space research (space-to-earth and deep space) services, all on a primary basis. The 32.3-33.0 GHz band is also allocated to the inter-satellite and radio navigation services, while the 33.0-33.4 GHz band is allocated to the radio navigation service, all on a primary basis.

In Europe, this band is allocated for the fixed and radio navigation services shared with the space research services (space-to-earth and deep space) in 31.8 - 32.3 GHz, and with inter-satellite in 32.3-33.4 GHz. It is also used for HDFS applications. In particular, the United Kingdom’s Ofcom divided the band into six nationwide blocks (2 x 126 MHz) and awarded them by auction in 2008.

Conclusion

Industry Canada is seeking comments on making the band available for backhaul or for other fixed service applications through the Department’s backhaul consultations, released on December 21, 2012. The results of the consultation will allow the Department to make a decision regarding the use of this spectrum in 18 to 24 months’ time.

4.3.5 40.5-43.5 GHz Band

Current Use in Canada

The 40.5-41.0 GHz portion of the band is allocated to broadcasting, broadcasting-satellite, FS and FSS on a primary basis, and to mobile and mobile-satellite (space-to-earth) services on a secondary basis. The 41.0-42.5 GHz portion of the band is allocated to broadcasting, broadcasting-satellite, FS and FSS on a primary basis, and to mobile on a secondary basis. The 42.5-43.5 GHz portion is allocated to FS, FSS (earth-to-space), mobile (except aeronautical mobile) and radio astronomy services on a primary basis. Within the entire band, there is currently only a single assignment to a receive-only station for radio astronomy purposes.

Technical Considerations

Although the 40.5-43.5 GHz band is available for high-density applications in the fixed service (pursuant to ITU Radio Regulation footnote 5.547), potential constraints to high-density applications in the fixed service will need to be taken into account, due to the potential deployment of high-density
applications in the fixed-satellite service in the 39.5-40.0 GHz and 40.5-42.0 GHz bands (No. 5.516B). Co-frequency sharing may not be feasible between HDFS and HDFSS systems, but sharing situations (where only one of the services operates) may be possible.

Future use on a shared basis may be feasible, although special consideration will need to be given to radio astronomy station locations when siting FS transmitting stations due to the potential for interference.

International Considerations

In the United States, the FS and FSS operate on a co-primary basis within the 40.5-42.5 GHz band, but segmentation and power flux density limits encourage the use of 40.0-42.0 GHz by FSS and 42.0-42.5 GHz by FS. In November 2010, the FCC released a proposal to increase sharing between terrestrial and satellite services within the 37.5-42.5 GHz portion of the band.

The entire 40.5-43.5 GHz band is available for HDFS applications through WRC-2000 Resolution 75, but the 40.5-42.0 GHz portion is also identified for HDFSS applications (space-to-earth) in Region 2.

In Europe, the 40.5-43.5 GHz band is allocated for HDFS and takes priority over uncoordinated FSS terminals within the 40.5-42.5 GHz portion. The 42.5-43.5 GHz portion of the band is used in the UK by the radio astronomy service. In 2008, Ofcom auctioned the 40.5-43.5 GHz band (six national blocks).66

Conclusion

Through Industry Canada’s backhaul consultation, the Department is exploring whether there is sufficient interest in FS deployments within the band. The results of the consultation will allow the Department to make a decision regarding additional backhaul spectrum in this band in 18 to 24 months’ time. The potentially large bandwidths available make this band suitable for high-capacity backhaul links.

4.4 Potential Bands for Licence-Exempt Use

At the moment, one-third of all IP-based traffic is either originated or terminated on a Radio Local Area Network (RLAN). This figure is expected to jump to half of all IP traffic by 2015, according to Cisco’s Visual Index.10 Such traffic is being driven by both consumer and enterprise demands for applications that are bandwidth- and throughput-intensive.

While RLANs in the 2.4 GHz and 5 GHz band can now operate on channels that are 20 MHz- and 40 MHz-wide, RLANs in the 5 GHz range will be able to operate on channels that are 80 MHz- and 160 MHz-wide once the IEEE 802.11ac standard is ratified. Contiguous channels across the 5 GHz range would allow RLANs to operate at these larger bandwidths, thereby supporting high-throughput applications. RLANs are also becoming key components of mobile operators’ network deployment.

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strategies as operators look to offload more traffic from their cellular networks. As a result, the 5 GHz band will likely play an increasingly important role in network deployment.

The following section provides an overview of Industry Canada’s current assessment of potential bands that could be used to support the deployment of commercial mobile systems, based on a licence-exempt regime. Figure 9 shows the 5 GHz frequency range as well as which bands could potentially support future deployment of RLANs or Wi-Fi-enabled devices, subject to compatibility analyses with existing services.

4.4.1 5350-5460 MHz and 5460-5470 MHz Bands

Current Use in Canada

The 5350-5460 MHz band is allocated to aeronautical radio navigation, earth exploration satellite (active), radiolocation and space research (active) services. The 5460-5470 MHz band is allocated to the earth exploration satellite (active), radiolocation, radio navigation and space research (active) services.

Currently, the 5350-5470 MHz band is used by the Canadian Space Agency’s RADARSAT earth exploration satellites. These satellites provide images of the earth from space and allow for mapping, marine surveillance, ice and environmental monitoring and disaster and resource management. The RADARSAT satellites provide data to the Government of Canada, as well as to many agencies in the United States and to private users worldwide.

Technical Considerations

In 2003, the World Radio Conference (WRC-03) allocated the 5150-5350 MHz and 5470-5725 MHz bands to the mobile service and identified these bands for use by wireless access systems, including RLANs. Compatibility studies between RLANs and incumbent primary services, including the earth exploration satellite services (EESS), were undertaken for these bands. These studies demonstrated that specific technical measures are required so that RLANs can coexist with incumbent services in these bands.

The 5350-5470 MHz band was not considered by WRC-03, and is not currently being used by RLANs. Further studies may be required to determine the feasibility of deploying RLANs in this band, taking into account the potential aggregate interference created by RLANs over the large footprint of the satellite.

International Considerations

The international allocation of the 5350-5460 MHz and 5460-5470 MHz bands is consistent with their current use in Canada. While there are no studies under way at the ITU to identify the bands for mobile broadband or RLANs use, they are being studied in the United States and could be part of the U.S. proposals to WRC-15.
As part of the U.S. Jobs Act of 2012, the NTIA was instructed to evaluate known and proposed spectrum sharing technologies, such as Dynamic Frequency Selection (DFS), as well as the risks to federal licensees if RLANs are allowed to operate in this band. The report, released in January 2013, identified a number of potential risks of harmful interference to federal systems from licence-exempt devices in this band. The report concludes that further analysis will be required to determine whether and how the identified risk factors can be mitigated. EESS systems are not deployed in this band in the United States, but several government agencies in the United States use RADARSAT data.

In September 2012, the European Union announced that it will examine the possibility of additional harmonized licence-exempt spectrum for Wi-Fi types of networks in the 5 GHz range. Expanding spectrum available for licence-exempt applications is seen both as a key driver for wireless innovation and as an efficient use of the radio spectrum.

**Conclusion**

In Canada, the 5350-5470 MHz band is extensively used by the RADARSAT satellites. If RLANs were to be deployed in this band in the United States, the EESS in Canada could be impacted due to the aggregate effects of interference over the large footprint of its operation.

### 4.4.2 5850-5925 MHz Band

**Current Use in Canada**

The 5850-5925 MHz band is allocated to fixed, fixed satellite and mobile services on a primary basis. This band also overlaps with the 5725-5875 MHz band, which is designated for ISM applications. RLANs certified to the IEEE 802.11a/n standards can operate in this ISM band.

In Canada and in the United States, the band is designated for ITS-DSRC (Intelligent Transport Systems/Dedicated Short-Range Communications). The ITU-R defines ITS as systems that utilize the combination of computers, communications, positioning and automation technologies to improve the safety, management and efficiency of terrestrial transportation. Many of the ITS applications require radio spectrum, since they involve communications with moving vehicles.

To date, there have been some trials of ITS-DSRC systems in Canada but no deployment in this band. In 2006, a moratorium was placed on the licensing of new fixed systems. Some FSS systems continue to operate in this band.

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68 See the NTIA’s January 2013 report entitled *Evaluation of the 5350-5470 MHz and 5850-5925 MHz Bands Pursuant to Section 6406(b) of the Middle Class Tax Relief and Job Creation Act of 2012* (http://www.ntia.doc.gov/files/ntia/publications/ntia_5_ghz_report_01-25-2013.pdf).

69 See the Computer World September 2012 article entitled “*Proposed EU radio reshuffle could mean more spectrum for 5 GHz Wi-Fi*” (http://www.computerworld.com/s/article/9230879/Proposed_EU_radio_reshuffle_could_mean_more_spectrum_for_5GHz_Wi_Fi).
Technical Considerations

The compatibility between RLANs and ITS is the central technical issue. The NTIA in the United States is studying the possible impact of licence-exempt RLAN use on existing services, including ITS-DSRC systems.

International Considerations

In the United States, the National Highway Traffic Safety Administration is now evaluating whether to mandate an anti-collision technology using DSRC spectrum for all vehicles sold in the United States. A decision is expected in 2013.

In February 2012, the United States Congress instructed the NTIA to evaluate known and proposed spectrum sharing technologies as well as the risks to federal licensees if RLANs are allowed to operate in this band. As discussed above, the NTIA released a report in January 2013, which concluded that further analysis is required to determine whether and how risks of harmful interference can be mitigated.\(^{70}\)

Currently, there are no studies under way at the ITU to identify the 5850-5925 MHz band for broadband mobile systems or RLANs use.

In September 2012, the European Union announced that it will examine the possibility of additional harmonized licence-exempt spectrum for Wi-Fi-type networks in the 5 GHz band. Expanding spectrum available for licence-exempt applications is seen both as a key driver for wireless innovation and as an efficient use of the radio spectrum.\(^{71}\)

Conclusion

Given the importance of harmonized spectrum and regulatory approaches in the North American marketplace, Canada will follow developments in the United States and in Europe before making a decision on the future use of this band.

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\(^{70}\) See the NTIA’s January 2013 report entitled *Evaluation of the 5350-5470 MHz and 5850-5925 MHz Bands Pursuant to Section 6406(b) of the Middle Class Tax Relief and Job Creation Act of 2012* (http://www.ntia.doc.gov/files/ntia/publications/ntia_5_ghz_report_01-25-2013.pdf).

\(^{71}\) See the Computer World September 2012 article entitled “Proposed EU radio reshuffle could mean more spectrum for 5 GHz Wi-Fi” (http://www.computerworld.com/s/article/9230879/Proposed_EU_radio_reshuffle_could_mean_more_spectrum_for_5GHz_Wi_Fi).
5. Conclusion

The rapid growth of commercial mobile services presents significant economic and social benefits for Canada. This growth is also increasing the amount of spectrum required to deliver these services in Canada. Various projections estimate that Canada will require at least 473 MHz — and perhaps as much as 820 MHz of spectrum — to be allocated to commercial mobile services by 2017 in order to keep up with projected growth. The wide variation in these projections is a result of different assumptions regarding efficiency improvements, network investments and data traffic growth. Industry Canada has set an objective of allocating a total of 750 MHz of spectrum to commercial mobile services by the end of 2017. Taking into account the already-announced auctions of spectrum in the 700 MHz and 2500 MHz bands, Canada currently has plans in place to have a total of 528 MHz of spectrum available for commercial mobile services by 2015. This means that at least 222 MHz of spectrum will have to be allocated to commercial mobile services over the next five years in order to meet this objective.

Industry Canada’s analysis of candidate bands to meet this objective is based primarily on a combination of the following considerations: (1) the current use of the band in Canada; (2) the suitability of the band to support new services as well as the potential availability of equipment; and (3) international harmonization. Based on this analysis, Industry Canada has identified 300 to 415 MHz of additional spectrum that could be the source for the additional 222 MHz needed for commercial mobile services by 2017 (see Figure 10 and Table 3). However, any specific decisions to reallocate these bands would be subject to full public consultations.

The rapid growth in commercial mobile services is also increasing demand for spectrum to support wireless backhaul services. Overall, Industry Canada believes that the 21 GHz of backhaul spectrum available is sufficient to support the growing wireless sector until 2017. However, while the overall
amount of spectrum may be adequate, finding sufficient spectrum in mid-range frequency bands (11-23 GHz) capable of handling increasingly large data rates and throughput to cover longer distances remains a challenge. As a result, Industry Canada is consulting stakeholders to obtain their feedback on additional spectrum requirements across frequency ranges, as well as on updated policies and technical requirements developed to increase efficiency, flexibility and the utilization of all backhaul spectrum.

Wi-Fi is playing an increasingly important role in the deployment of wireless networks by offloading data traffic from cellular networks onto wired networks. It is estimated that by 2015, Wi-Fi networks will carry half of all Internet traffic. As a result, spectrum bands reserved for licence-exempt equipment can be expected to become increasingly congested over the next five years. Industry Canada is taking steps to provide additional spectrum for licence-exempt equipment. The Department recently announced its decision to allow the use of TV white spaces, and Canada is joining other countries in examining the potential of making additional spectrum available in the 5 GHz range for use by licence-exempt equipment.

Beyond 2017, mobile data traffic will undoubtedly continue to grow, likely resulting in additional spectrum requirements for commercial mobile services, backhaul and licence-exempt equipment. However, given the rapid pace of technological change — particularly technologies which could have dramatic consequences for spectrum use efficiency, network architecture and consumer behaviour — it is difficult to make credible forecasts. It is conceivable that at least 1000 MHz of mobile broadband spectrum will be required by the start of the next decade. As a result, Industry Canada will continue to monitor developments, both in Canada and abroad, and will update this plan following the auction of spectrum in the 700 MHz and 2500 MHz bands, and the 2015 World Radiocommunication Conference.
Figure 10: Possible Timeline for the Release and Availability of Spectrum to Support Commercial Mobile Services

Notes:

1. This possible timeline is based on available information and is therefore subject to change. Specific decisions with respect to individual bands will be subject to separate and comprehensive consultations with stakeholders.

2. These years of the possible timeline reflect uncertainty over the amount of spectrum that will be available in the 600 MHz and 3500 MHz bands, as well as the timing of decisions in other countries.

3. Depending on the region of the country, between 60 and 120 MHz of spectrum in the 2500 MHz (BRS) band is currently available for commercial mobile services. The remaining spectrum will be auctioned in 2014, bringing the total amount of spectrum available in the BRS Band to 190 MHz in all regions.
## Table 3: Possible Timeline for the Release and Availability of Spectrum to Support Commercial Mobile Services\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014 (MHz)</th>
<th>2015</th>
<th>2016-2017(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently deployed</td>
<td>330-400</td>
<td>330-400</td>
<td>330-400</td>
<td>330-400</td>
<td>330-400</td>
</tr>
<tr>
<td>700 MHz auction</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>2500 MHz auction(^3)</td>
<td></td>
<td>60-120</td>
<td>60-120</td>
<td>60-120</td>
<td>60-120</td>
</tr>
<tr>
<td>WCS</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>AWS 4</td>
<td></td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>AWS 3</td>
<td></td>
<td></td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>AWS 2</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3500 MHz</td>
<td></td>
<td></td>
<td></td>
<td>100-175</td>
<td></td>
</tr>
<tr>
<td>600 MHz</td>
<td></td>
<td></td>
<td></td>
<td>80-120</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>330-400</strong></td>
<td><strong>418-488</strong></td>
<td><strong>588</strong></td>
<td><strong>638</strong></td>
<td><strong>828-943</strong></td>
</tr>
</tbody>
</table>

### Notes:

1. This possible timeline is based on available information and is therefore subject to change. Specific decisions with respect to individual bands will be subject to separate and comprehensive consultations with stakeholders.

2. These years of the possible timeline reflect uncertainty over the amount of spectrum that will be available in the 600 MHz and 3500 MHz bands, as well as the timing of decisions in other countries.

3. Depending on the region of the country, between 60 and 120 MHz of spectrum in the 2500 MHz (BRS) band is currently available for commercial mobile services. The remaining spectrum will be auctioned in 2014, bringing the total amount of spectrum available in the BRS Band to 190 MHz in all regions.
Annex A: Alternative Methodology for Forecasting Future Mobile Commercial Spectrum Use

The intensity of spectrum use is geographically non-uniform — the spectrum demand for less densely populated areas not as high as it is for more metropolitan areas. There are less-populated areas of Canada where the cellular spectrum (licensed almost 30 years ago) is not yet used. Furthermore, there are many rural and lower population density areas where the PCS spectrum (licensed 10 to 17 years ago) is also not completely used today. The peak demand for spectrum is in the large metropolitan areas (such as areas including Greater Toronto, Vancouver, Montréal, etc.). Therefore, the forecasting for spectrum use must be focused in these areas of high demand.

In these metro areas, all of the available cellular and PCS spectrum is being used by mature wireless networks, which achieved full coverage many years or even decades ago. Additional sites are only being deployed in these areas in order to increase the available wireless capacity. Wireless service providers operating in these bands are continuing to deploy new cell sites in order to optimize the balance between the available spectrum, number of sites and traffic demand (i.e., this occurs when there is no idle spectrum in the metro areas, so additional sites are needed).

The spectrum usage for 2011 can be used as a baseline for evaluating future spectrum demand. The PCS and cellular operators in the metro areas had just started to deploy LTE in the AWS band, so virtually all of their traffic was carried over cellular and PCS spectrum — the total amount of spectrum used was 170 MHz. Due to the very large market share of these operators (defined as incumbents) and the typical profile of their users (including most of the high data users), the 170 MHz figure can be used as a baseline for the spectrum usage for the entire wireless industry in 2011. To also account for traffic generated and spectrum used by non-incumbent service providers, 5 MHz was added to the baseline spectrum use — this represents approximately three percent of total use in 2011.

Of the 175 MHz total of all spectrum used in 2011, it was assumed that around thirty percent (52 MHz) was used for voice services, while the balance of 123 MHz was assumed to be used for mobile data. In line with other international forecasts, the amount of spectrum used for voice services is assumed to remain approximately constant, while rapid growth is expected in the traffic demand for mobile data.

The future spectrum use for mobile data services can be estimated based on the spectrum used for mobile data in 2011 (123 MHz, as mentioned above) and by applying correction factors for:

- **Increase in mobile data traffic.** In the 2012 VNI Report for Canada, Cisco forecasts a 1.51 CAGR (Compound Annual Growth Rate) for Canada through 2017.
- **Additional wireless sites deployed.**
  - Based on the departmental database, between 2008 and 2012, the average growth rate for total unique sites in Canada, relative to 2011, is 1.08.
  - Most of the new sites in the metro areas are small cells, microcells, picocells, etc. The heterogeneous networks architectures, with cells of various sizes, include multiple layers (macro coverage layer, pico capacity layer, etc). The small cells cannot operate over the entire available spectrum, as they would interfere with the macro cells overlay. It is assumed that the small cells would only operate over half of the available spectrum, thus the efficiency factor gained from these new sites is half of the growth rate in site deployments.
  - Furthermore, since the traffic demand is highest in metro areas, it was assumed that a majority of the new sites are added in these areas (non-uniform growth). If the growth rate for rural areas is assumed
to be six percent, the metro CAGR will be ten percent, for an overall average of eight percent, as described above.

- The ten percent growth rate for the metropolitan areas is the figure used to evaluate the impact on spectrum demand. Again, this is a conservative assumption.

- **Increase in spectral efficiency** due to advancements in wireless technology. The same figures were used as in the FCC study. A linear extrapolation was used for forecasting beyond 2014 (see Table A1).

### Table A1

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Spectral Efficiency [bps/Hz]</td>
<td>0.88</td>
<td>1.00</td>
<td>1.13</td>
<td>1.25</td>
<td>1.37*</td>
<td>1.49*</td>
<td>1.61*</td>
</tr>
</tbody>
</table>

* Linearly extrapolated.

- **Wi-Fi offloading.** In the 2012 VNI Report, Cisco reports that in 2012, a total of 33 percent of mobile data traffic was offloaded to Wi-Fi networks in Canada. Cisco forecasts this figure to grow to 46% in 2017. As a result, Industry Canada estimated total spectrum demand under two scenarios: the first scenario assumes no change in the ratio of traffic offloaded to Wi-Fi networks (constant at 33 percent), while the second scenario assumes an increase in traffic offloading, as forecasted by Cisco.

The amounts calculated as above are plotted in Section 3, Figure 6.

It should be noted that this estimate is based on forward-looking assumptions, which may not materialize. Like any other forecast, the end results are strongly influenced by the assumptions made.

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