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**Conference Paper**

## Spectrum scarcity and Canada's urban core

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## **Spectrum Scarcity and Canada's Urban Core**

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**Table of Contents**

**Introduction.....2**  
**Methodology: .....4**  
**The Canadian Spectrum Scarcity Debate .....6**  
**What We Found .....8**  
**The Bands .....8**  
**Advanced Wireless Services.....15**  
**Results:.....18**  
**Personal Communication Services (PCS) Rx .....21**  
**Rx Results .....24**  
**Conclusion .....24**  
**Recommendations: .....24**  
**Sources: .....26**

**Introduction**

The explosive growth in the wireless communication industry in the last two decades rests upon one all-encompassing truth: without access to spectrum, you cease to exist. Wireless service cannot be provided without making use of the invisible, finite, publicly owned frequencies that serve as the conduit for mobile devices.

Despite the centrality of spectrum to the entire wireless industry, there are still nagging essential questions regarding how much spectrum is required to provide widespread broadband access, and what exactly companies are doing with the spectrum they already own. Spectrum scarcity has been a common policy orthodoxy for decades; however, questions of spectrum scarcity are currently being contested around the world (international Telecommunication Union - Radiocommunication Sector, 2014; LS Telcom, September, 2014). In many countries, it is

difficult to judge what exactly is happening with currently allocated frequencies, and licensed providers do not wish to share information. There are clear economic reasons wireless companies are hesitant to show their hand in this way: commercial access to spectrum is a site of intense political manoeuvring and licenses are increasingly precious commodities. In Canada there has been a very public battle between the three major incumbent wireless providers and the sitting Conservative government (Dobby, January 2, 2014). Given the limited nature of the radio frequencies, there is increasing pressure on governments to prioritize service access and to rely on market forces to allocate this resource to those who most covet it. But the supply side in the classic supply and demand model is not so clear.

American studies have demonstrated that in major urban centres, less than 20% of the licensed spectrum may in be in use during peak hours (Bacchus, 2011; McHenry, 2003). There is no such independent study in Canada. This research has enormous consequences for the future of spectrum allocation. According to the 2011 PCAST report “The incongruity between concern about a “looming spectrum crisis” and the reality that only a fraction of the Nation’s prime spectrum capacity is actually in use suggests the need for a new policy framework...” (President’s Council of Advisors on Science and Technology, 2012, p. 16)

This paper presents the results of a unique project designed to measure spectrum usage in Canada’s urban core. In doing so, it explores the legitimacy of questions of spectrum scarcity using a test case in Canada’s most populous city. Toronto is Canada’s largest urban centre, and Yonge/Dundas Square is an open area at one of Canada’s busiest intersections that advertises itself as the “heart of the city”. In the summer of 2013, the authors of this paper measured spectrum usage at this busy urban hub, monitoring Canada’s licensed wireless frequencies at regular intervals over the course of three days.

This project sought to fill a void in the available information concerning this public resource. Though a publicly owned resource, easily accessible data on spectrum usage is rare. The most recent spectrum inventory in Canada was conducted in 2010 and the conclusion there was clear: the AWS frequencies auctioned in 2008 were 100% licensed, but with only approximately 33% in operation and that was largely usage by new entrants since there were no deployments by incumbents at that time (Industry Canada, 2010). No such complete information was made public in the ensuing years, so the use of these prime frequencies was something of a mystery. For those willing to dig through the website, it is possible to find whether or not a licensee has launched service, but there is no data available as to the density of traffic; therefore the “scarcity” argument is largely taken as an article of faith. Much of the wireless licensing data on Industry Canada’s Spectrum Direct website remains locked from public view (Industry Canada, Oct, 2014)

This study involved a survey of the primary literature in the field, including the submissions of Canadian wireless providers to the Industry Canada in the period preceding the 700 MHz auction, which took place in January - February 2014. There was an intense power dynamic at

play in this call for comments since this was the sought-after prime spectrum of Canada's digital dividend. Given the uncertainty of most of the publicly accessible data, the research team approached this experiment with the hypothesis that it was very possible the major incumbent wireless providers had not deployed service on newly acquired spectrum or, if deployed, were experiencing low traffic density.

The research team was convinced if a spectrum shortage exists in Canada, it would be most apparent at a major urban centre such as Yonge/Dundas square.

Key questions for this paper include:

- Have Canadian wireless companies deployed services in their assigned frequencies?
- Are their services operating near peak capacity as they often claim in government submissions?
- Is wireless spectrum truly "scarce" in urban Canada?

### **Methodology:**

A list of spectrum licenses in the area was compiled using the Spectrum Direct Geographical Area search on the Industry Canada website. Coordinates for Yonge-Dundas Square were acquired using Google maps and entered into the search area. The latitude in degrees, minutes, seconds was 433922, and the longitude was 792245. The station type for the search was set to Spectrum License stations and since the study was specific to Yonge/Dundas Square the radius of the search was set to 0.2 km, after a search of one km showed over 450 transmitters in the area – a number too difficult to monitor. A search was conducted for three of the licensed wireless bands in Canada.

Two students from Ryerson University's department of electrical and computer engineering collected data using a spectrum analyzer. Yonge-Dundas Square was chosen because it is a place of great population density and we anticipated high usage of wireless services in this location.

Data was collected hourly for each licensed band in twelve-hour shifts on July 2, August 28, and September 5, 2013.

The following bands, licensed for wireless use in Canada, were monitored by this project:

	TX	RX	Year Auctioned/ Licensed
Cellular	869-894 MHz	824-849 MHz	1983
Personal Communication Services	1930-1995 MHz	1850-1915 MHz	1995, 2001 , 2008
Advanced Wireless Services	2110-2155 MHz	1755-1780 MHz	2008 (auction)

Other bands including Broadband Radio Services (BRS) and Mobile Broadband Service (MBS) are not part of this study as they had not been licensed at the time (MBS) or are still waiting to be auctioned in some frequencies (BRS).

**Apparatus:** The measurements were taken using a broadband omni directional antenna SAS-2300 available from ARA Inc. This antenna had two connectors; one for low band (20 – 1000 MHz) and the other for high band (800 - 3000 MHz). This is a fairly rugged antenna ideal for spectrum surveillance applications. The antenna is followed by two low noise amplifiers, for both low and high bands. The lower cut-off of the low band low noise amplifier was selected to be about 580 MHz although the antenna could operate all the way up to 20 MHz. This is because we were not interested in frequencies lower than ~600 MHz. Output of the low noise amps were connected to WCA 380, Tektronix Wireless Communications Analyzer that that works from DC to 8 GHz. The whole links was matched 50 ohm. Span and the video bandwidth of the WCA were appropriately selected to get the best spectrum snapshot. The WCA also has a waterfall view, in which the received signal strength is color coded and plotted in the time-frequency axis. The waterfall mode helped us to not miss even signal bursts that had shorter durations.



Spectrum Analyzer



Yonge/Dundas Square (the spectrum analyzer was positioned above the red sign in the top left of the photo)

## **The Canadian Spectrum Scarcity Debate**

The Canadian wireless industry is dominated by the “Big Three” incumbent companies: Rogers, with 34 % of wireless subscriber market share; Bell at 28%; and Telus at 28% (Canadian Radio-Television and Telecommunications Commission, 2014). Numerous other regional and smaller players divide the remaining 10% of the market. In preparing for this project the team reviewed

submissions to Industry Canada's *Consultation on a Policy and Technical Framework for the 700 MHz Band and Aspects Related to Commercial Mobile Spectrum*, originally made public in November, 2010. This call for comments was key in setting the parameters for the auction of Canadian digital dividend – the valuable 700 MHz frequencies made available after Canada's transition to digital television. A great deal of the uncertainty surrounding spectrum usage in Canada plays out before the national regulator. Submissions varied wildly depending upon the market position of the company.

The Big Three were unanimous that an impending spectrum crunch was a real and present danger to the Canadian wireless broadband network.

“It is widely acknowledged that the industry faces a pending spectrum crunch in the very near future” (Bell Mobility Inc., 28 Feb, 2011)

“Capacity limits are a true threat in the face of continued growth in wireless data.” (Rogers Communications Inc., April 6, 2011)

“There is no merit to the claims that TELUS has no spectrum scarcity and that TELUS is using spectrum inefficiently. Explosive growth in mobile data demand is challenging TELUS' networks and spectrum holdings”. (Telus Inc., Nov. 30, 2010)

However, smaller carriers across Canada presented a starkly different position before the regulator and several brought arguments that ran contrary to the prevailing orthodoxy of spectrum scarcity put forth by the Big Three.

“It would seem that any spectrum scarcity that may exist is being manufactured, at least in part, by the Big Three. EastLink submits that there is no reason to believe that the Big Three have any legitimate need for additional spectrum in most areas of Canada” (Bragg Communications Inc., Feb 28, 2011).

“The incumbent operators have no obligation to acquire spectrum, nor do they clearly have any desperate need, as evidenced by the lack of deployment in the AWS band.” (Mobilicity Inc., April 6, 2011)

It was in this environment of uncertainty that the research team at Ryerson University decided to use the area around Ryerson as a laboratory to find our own measurements for spectrum usage in urban Toronto. Data of this nature is not publicly available in Canada.



## **What We Found**

Images shots from the spectrum analyzer were taken on the three licensed bands every half hour over three separate days in 2013. Though there are dozens of images available and on file for this project, the images chosen for presentation here were all taken at 17:00 because the authors thought this would demonstrate peak demand since many people in the area are leaving work and the nearby university at that point of the day.

The following images are the screen shots taken from the spectrum analyzer at 17:00 on the three days of the project: July 26, August 28 and September 5, 2013.

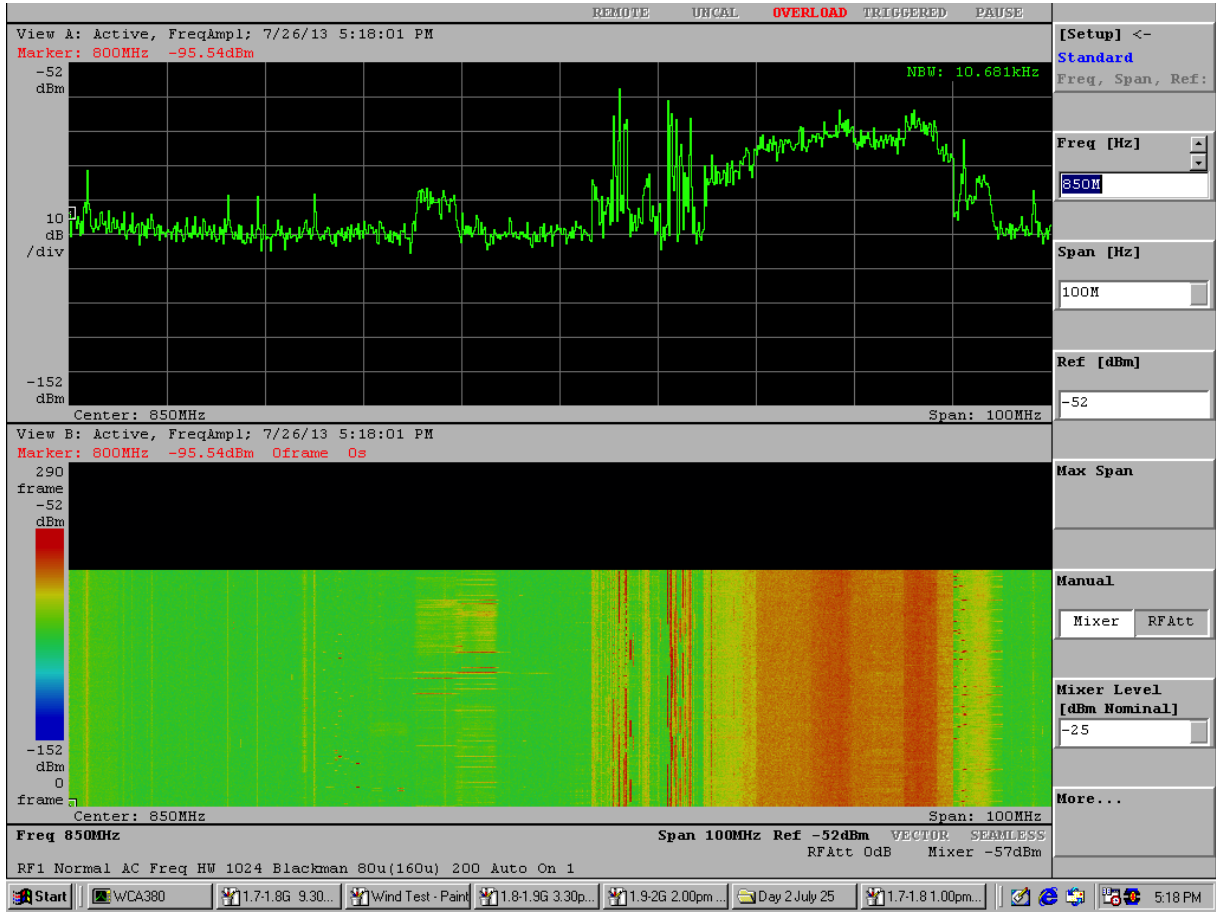
## **The Bands**

**Cellular:** 824-849 MHz/869-894 MHz (850 MHz is the centre line)

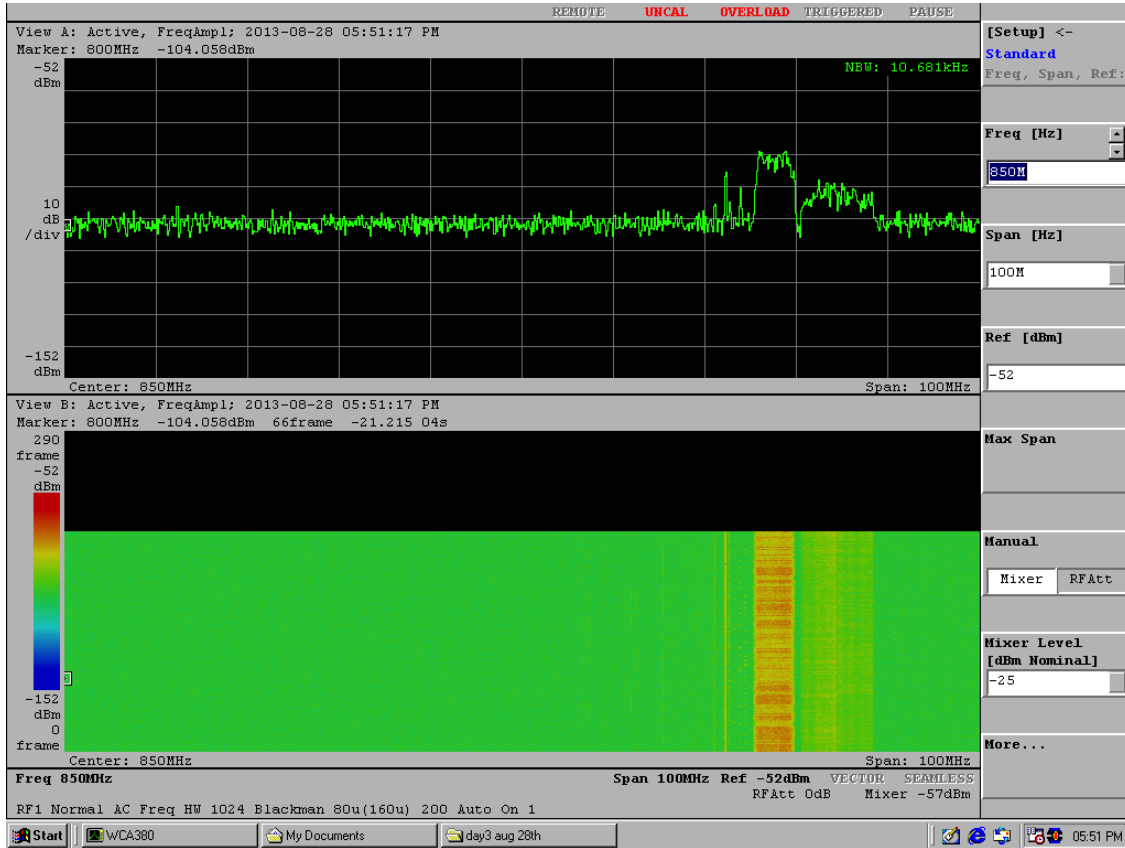
Rogers: 869 – 877

Bell: 882 - 886

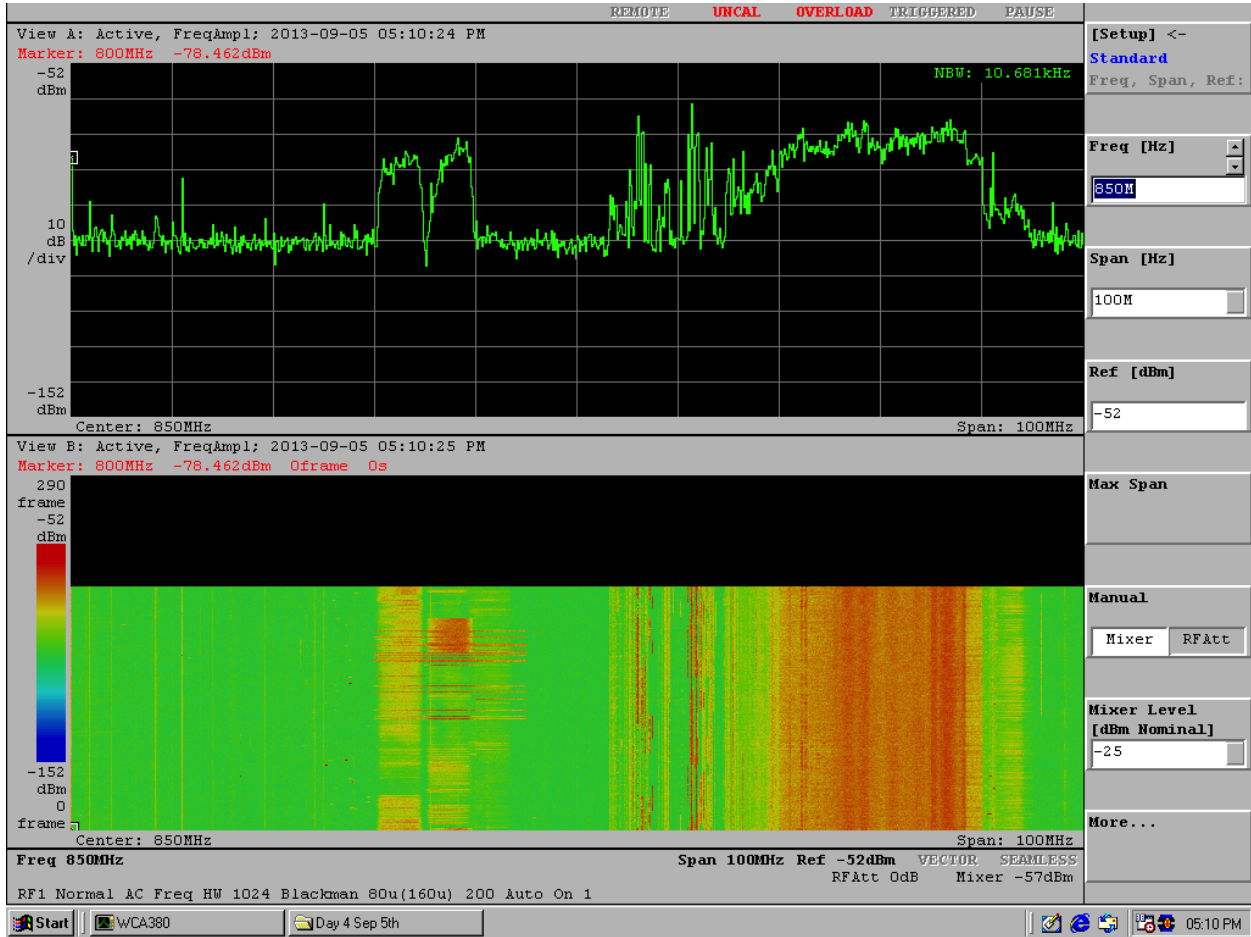
July 26, 2013 17:00



August 28, 2013 17:30 pm



Sept 5, 2013 17:30 pm



# Personal Communication Services (PCS) Centre line 1.95 GHz

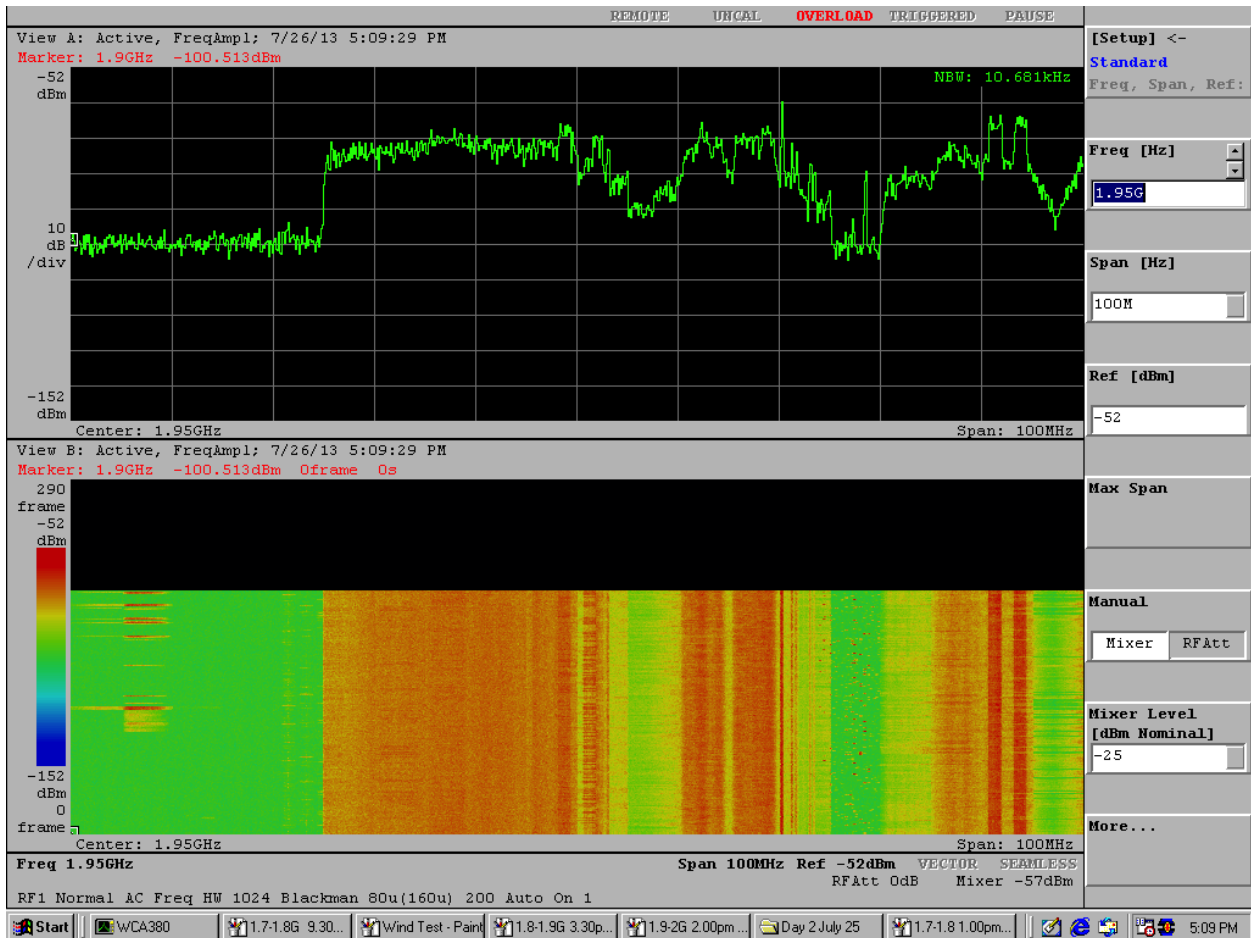
July 2, 2013 17:00

Rogers: 1930 – 1941; 1970 - 1971 (also used by Fido, Rogers discount service)

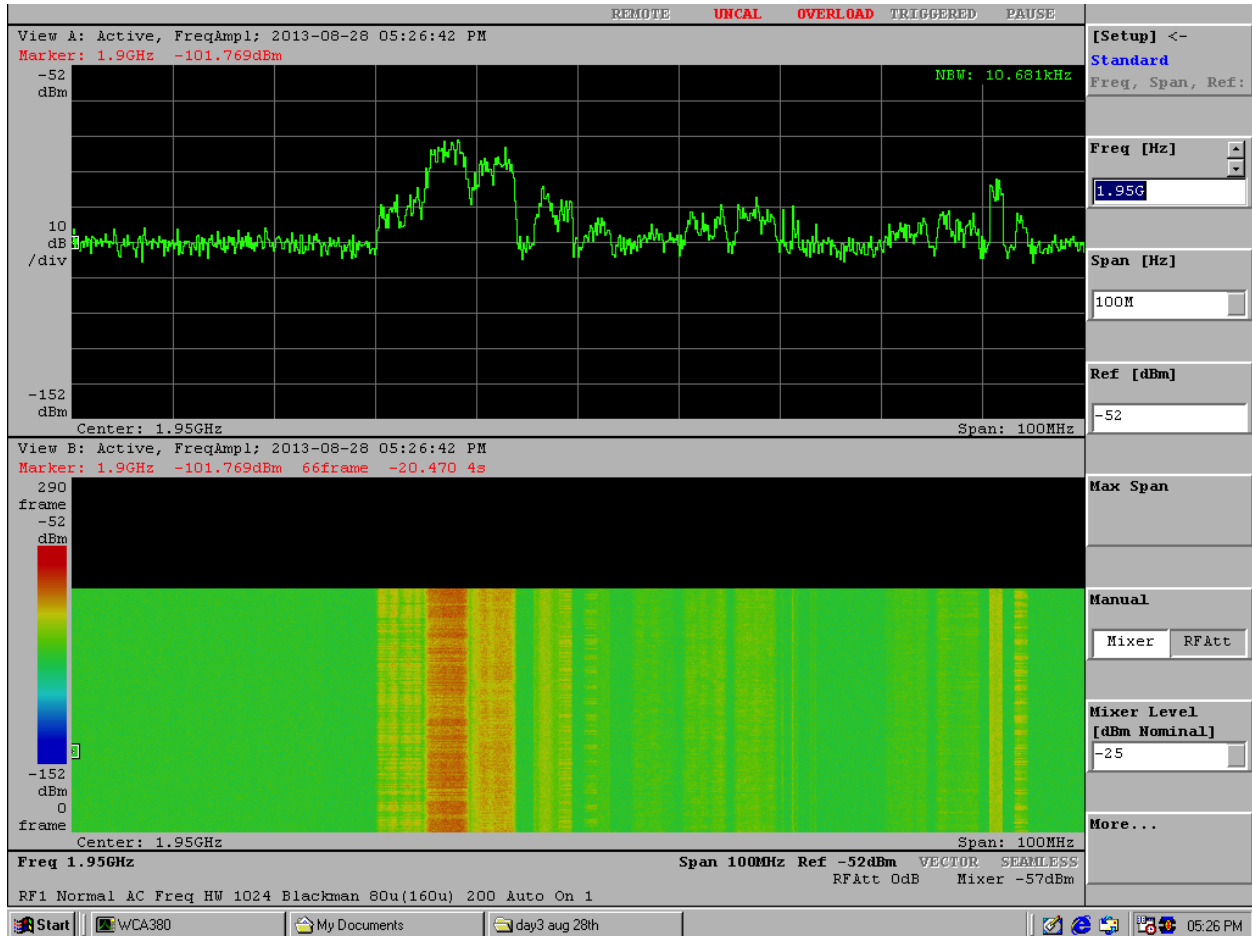
Bell: 1945-1948; 1960; 1962; 1965-1967; 1985-1987

Telus: 1950

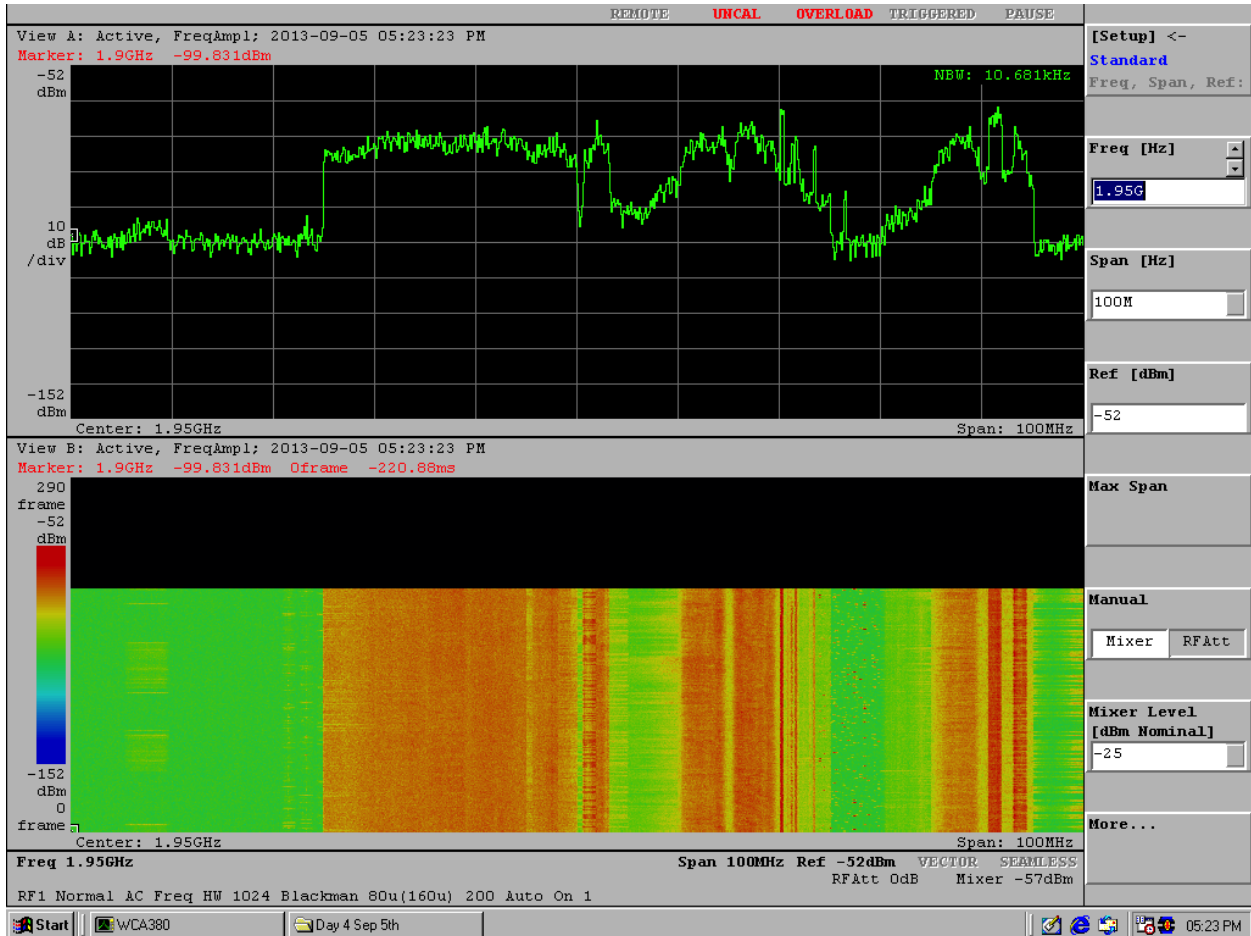
Public Mobile: 1990



August 28, 2013 17:00



Sept 5, 2013 17:00



**Advanced Wireless Services**  
(Centre line 2.15 GHz)

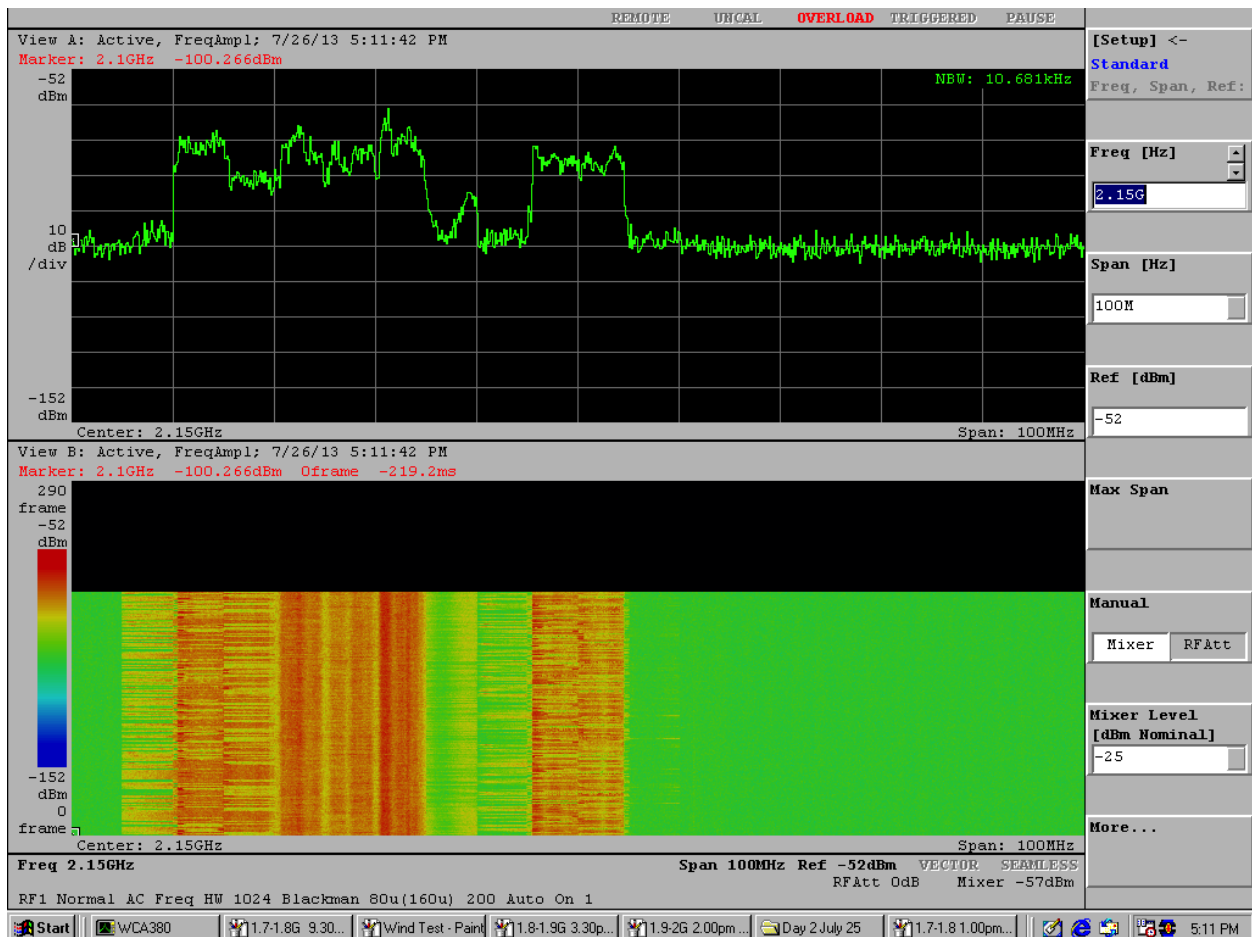
Rogers: 2115

Wind: 2120

Mobilicity: 2130

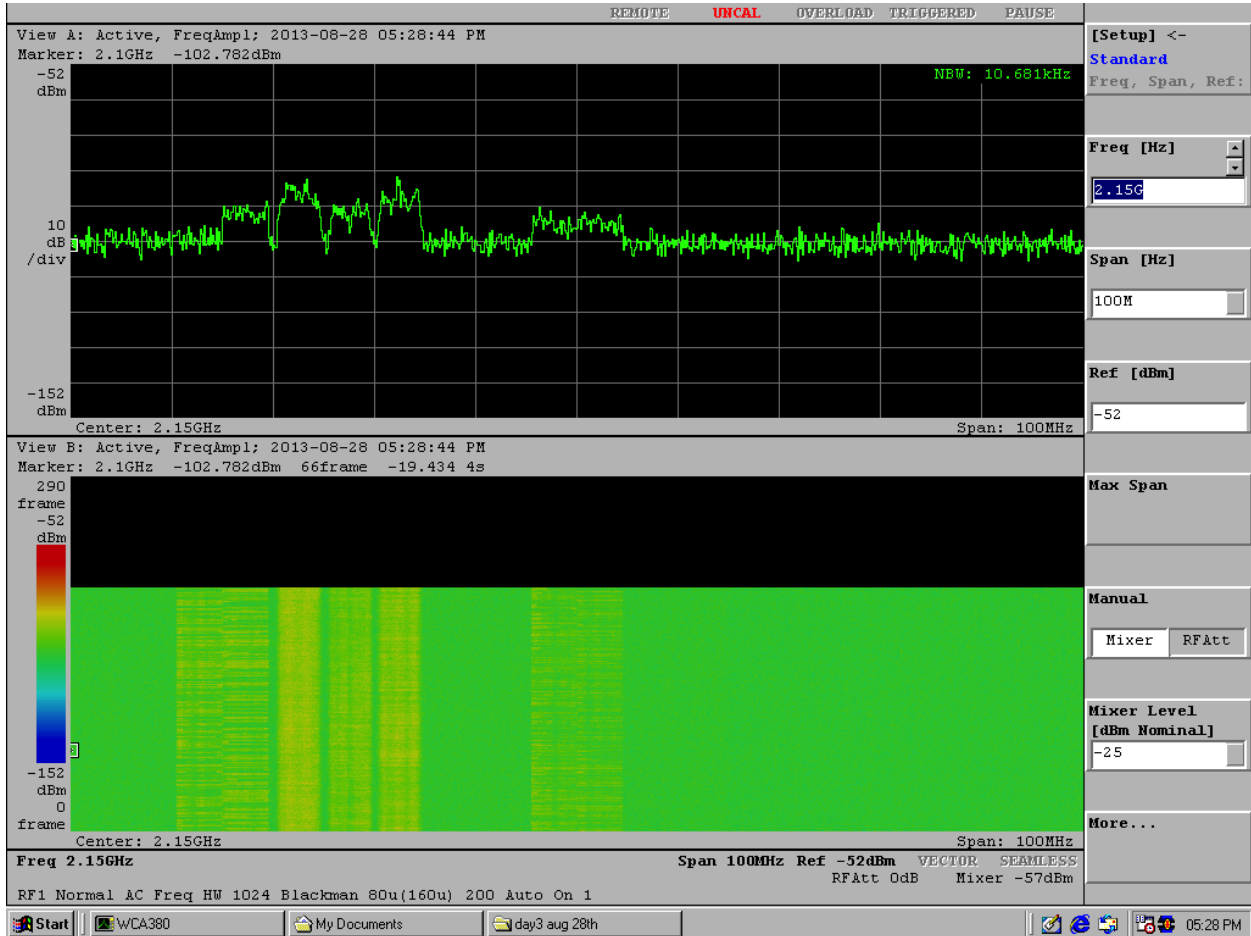
Bell: 2145; 2150

July 26, 2013, 17:00

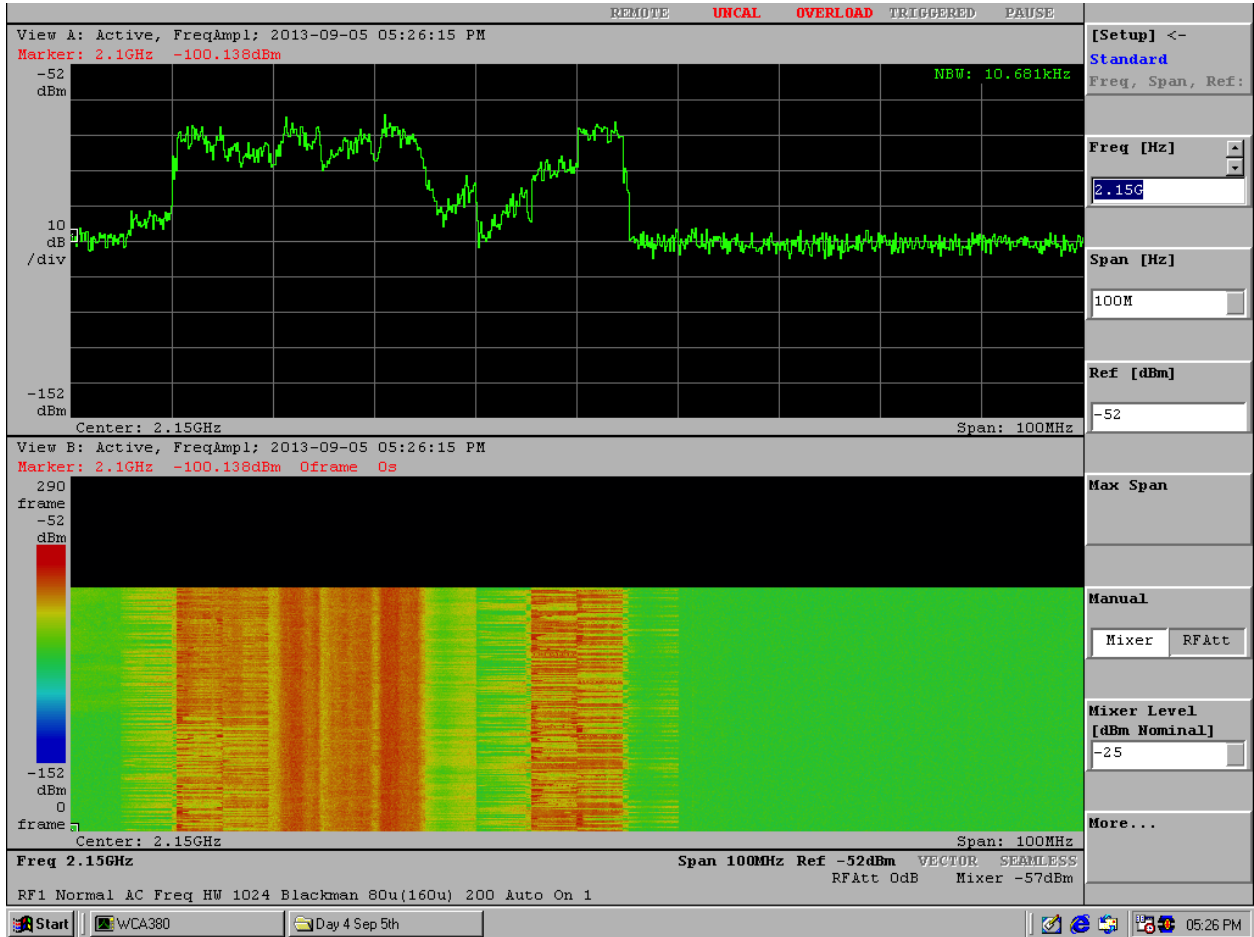




August 28, 2013, 17:00



Sept 5, 2013, 17:00



**Results:**

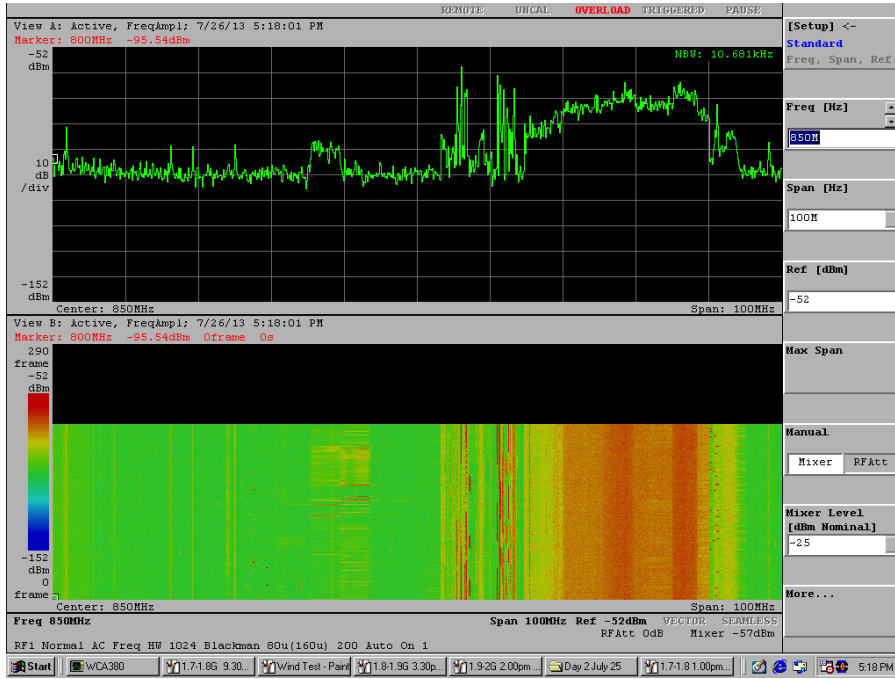
The data clearly demonstrated that wireless telecom operators had indeed launched services in Canada's urban centre, including the debated AWS frequencies, which had been reported idle in the 2010 Canadian Spectrum Inventory. The density of traffic varied but the data indicated that the hypothesis that the spectrum was being "warehoused" or underused was proven untrue. There was clearly strong traffic in all three bands.

However the data revealed something unexpected. The usage measured in the preceding images was largely examining the Tx frequencies – the spectrum used to transfer data from the tower to the hand held device. This is what you would use if you were surfing the Internet on your smart phone in Yonge/Dundas Square.

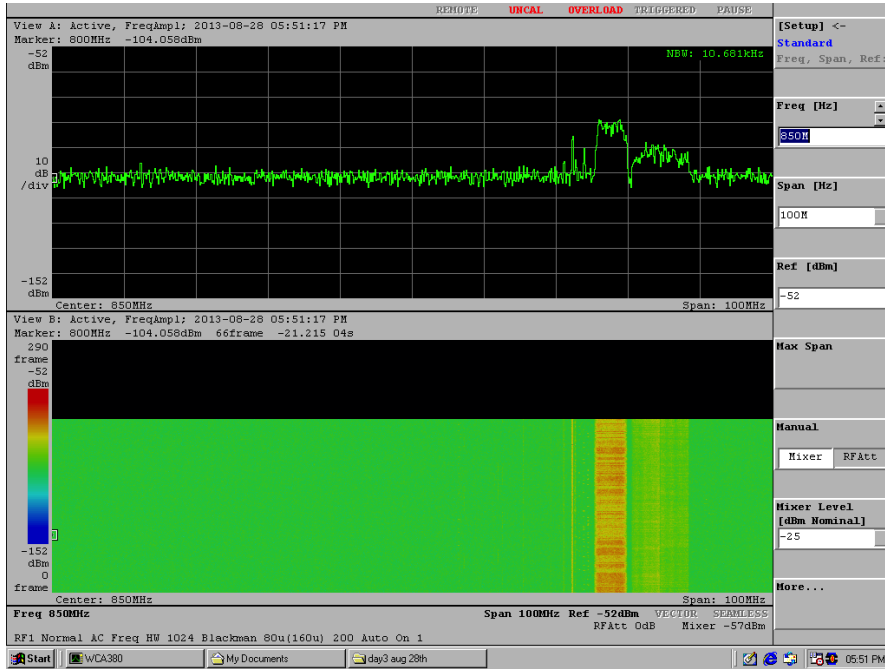
Something much different appeared when examining the RX frequencies – the paired spectrum used for uploading from handsets to the antenna tower. The following images emphasize the Rx frequencies in the same three bands at 17:00 on the three days.

Cellular: Rx: 824-849 MHz (left side of the screen)

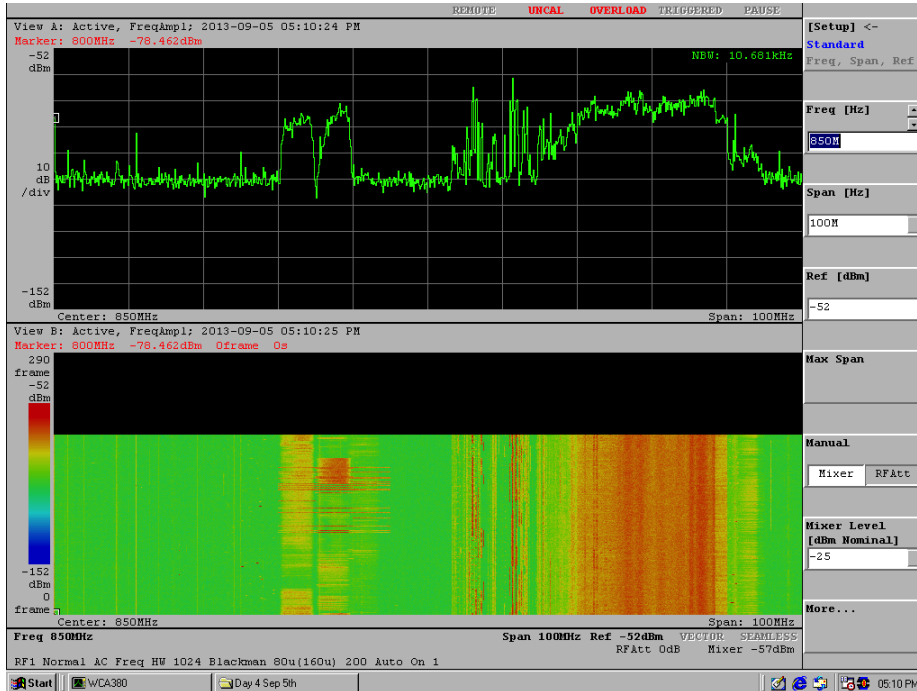
July 26



August 28 (Rx: left of the screen)

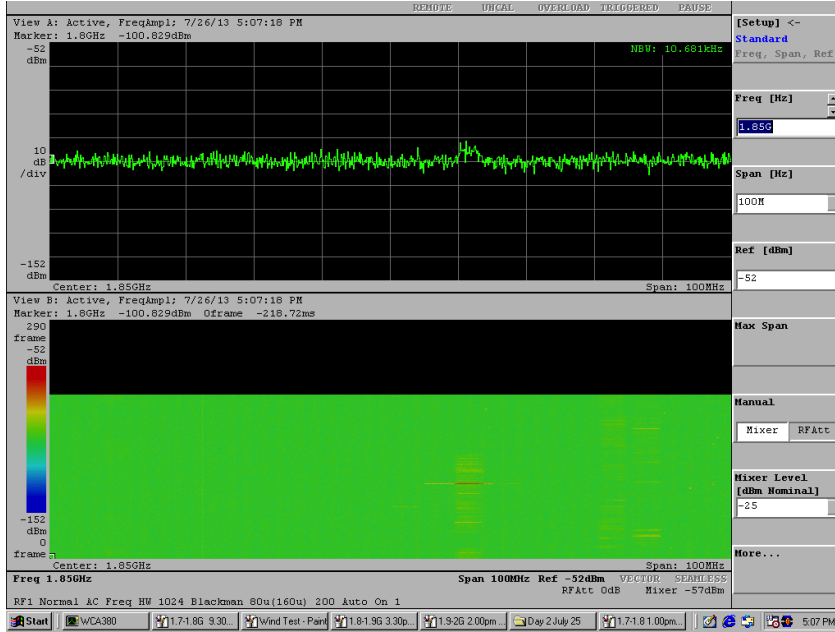


Sept 5

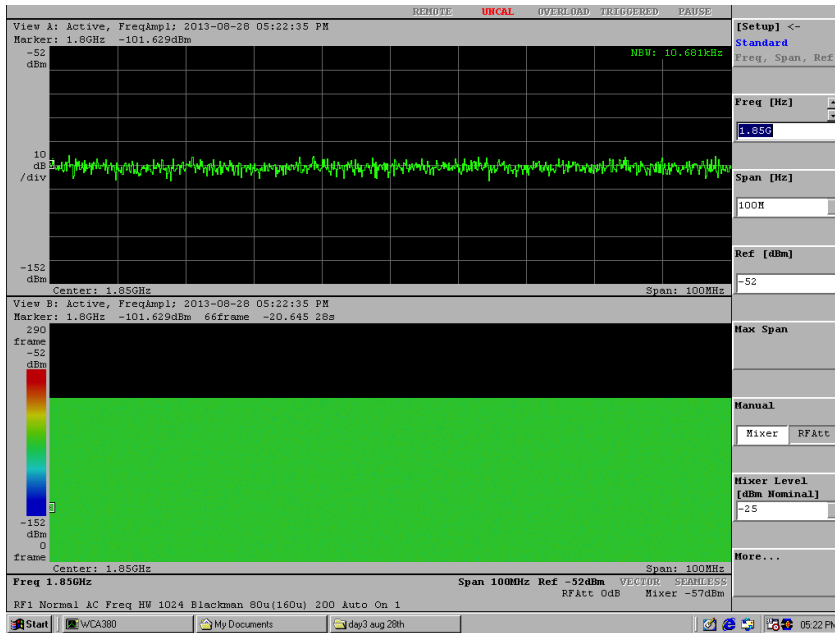


# Personal Communication Services (PCS) Rx

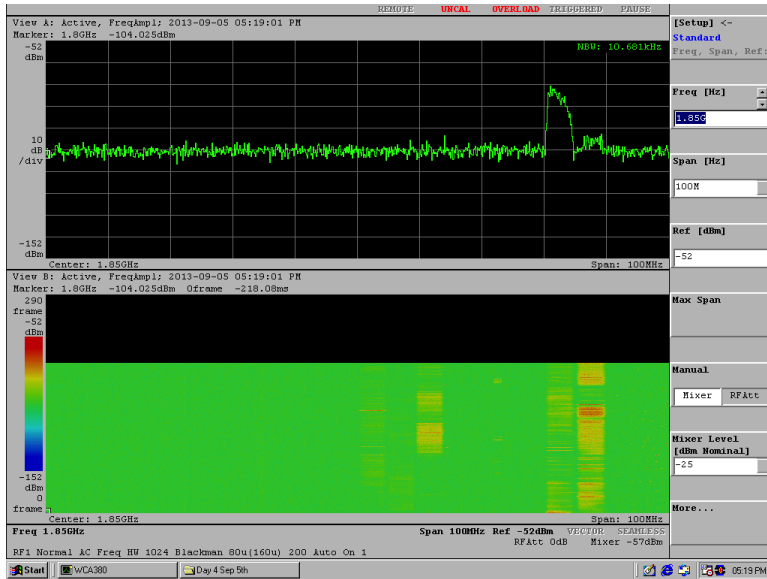
## July 26



## August 28

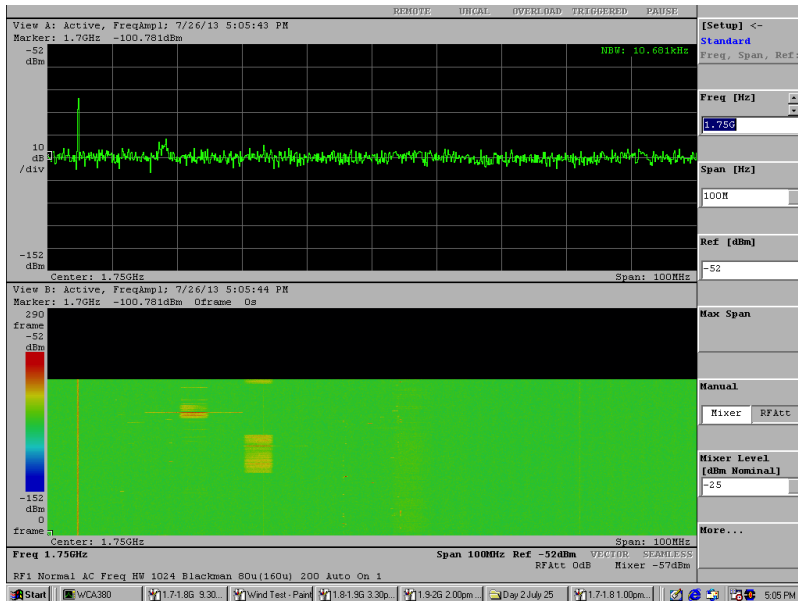


Sept 5

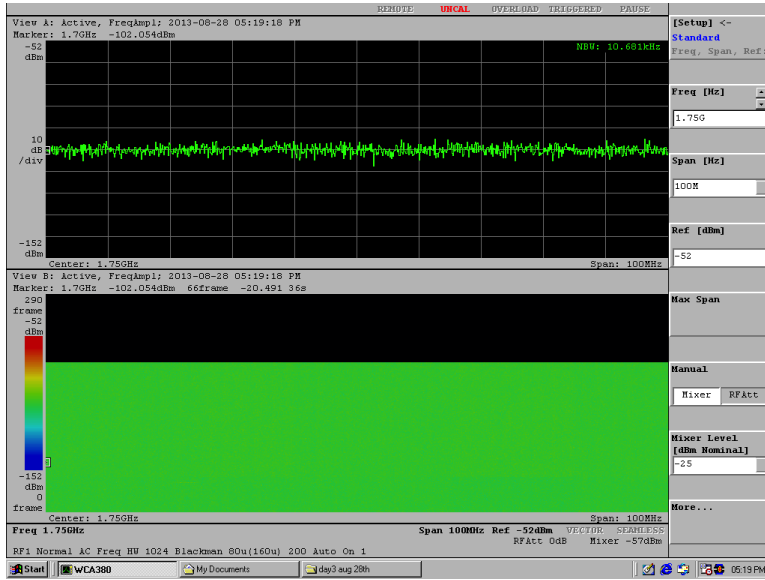


## Advanced Wireless Services Rx (1755-1780)

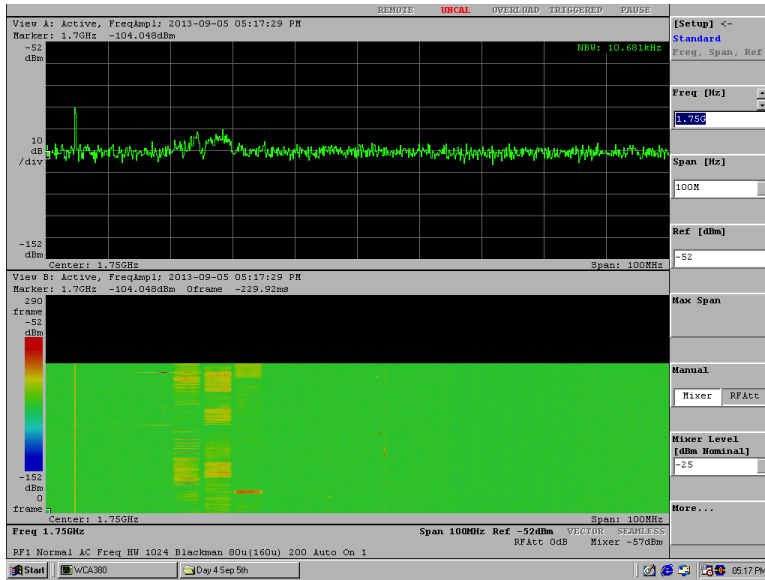
July 26



August 28



Sept 5





## **Rx Results**

What the spectrum analyzer data clearly demonstrated was a clear lack of traffic on the Rx frequencies. In an unexpected development of the project, what the measurements showed were the dramatic inefficiencies of the paired spectrum approach. There is little or no activity on the reception frequencies for the antennas at Yonge/Dundas Square. While people may wish to browse the Internet or check email, very few upload data heavy files such as video or music. This data is still of great consequence for questions of spectrum scarcity since the allocation of spectrum in most jurisdictions still puts equal weight upon reception and transmission. The uplink/downlink legacy of the telephone era is proving a clear hindrance to more efficient spectrum governance in age of wireless broadband.

## **Conclusion**

"Voice communications has little or no growth... But it set the pace on how we use spectrum. It requires paired spectrum and low latency. And notice 3G, which was supposed to be a data service, is constructed as if it was voice – it's paired, symmetric spectrum. And it's a terrible waste of spectrum..."

-Michael Marcus. Canadian Spectrum Summit, Ryerson University, Toronto, May 2013

The data collected demonstrated that major Canadian wireless operators were indeed using their licensed spectrum in 2013, at least in the centre of urban Canada; however, the evidence is also clear that the traditional paired spectrum approach is a woefully inefficient allocation method for the supposedly scarce resource of spectrum. If we are indeed near a spectrum crunch (a contested theory) then a more sustainable approach is to move toward data and away from the traditional call and response of the telephone. Our data demonstrates usage, but only on half of the allocated frequencies. Equal upload and download allocation appears unsustainable.

## **Recommendations:**

1) **Information concerning spectrum usage should be publicly accessible.** Too much information is currently password protected on the Industry Canada site. The public has a right to know how the public resource is being used.

Mark MacCarthy of the Aspen Institute wrote of spectrum in the United States: “The government cannot efficiently manage a resource it does not measure” (MacCarthy, 2010). Similar concerns are true for Canada. Government regulators should be providing regular public updates on the usage of the spectrum resource.

2) **The traditional paired spectrum approach is woefully inefficient.** Governments worldwide need to explore ways on maximizing value from the spectrum

Our data clearly shows that the traditional Frequency Division Duplex, FDD leads to enormous waste of frequencies. Time Division Duplex, TDD, which uses only one frequency channel appears to be the better overall choice, but FDD is far more widely implemented because of prior frequency spectrum assignments and earlier technologies. It appears that FDD will continue to dominate wireless broadband for the foreseeable future but we recommend that governments aggressively pursue a single channel approach. With the explosion of data and voice over Internet, coupled with the flat growth of voice there is increasingly no reason to continue with the dual frequency approach. If spectrum is truly becoming scarcer, an important step is to move away from the twin frequency regime and instead make TDD more widely adopted as spectrum is reallocated and repurposed.

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