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MOBILE DTV (ATSC M/H) FIELD TESTING AND MEASUREMENTS

TORONTO, ON

Submitted by

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LIST OF ABBREVIATIONS

ATSC – Advanced Television Systems Committee (Also known as DTV over-the-air)
ATSC A/53 – ATSC Digital Television Standard
ATSC A/153 – ATSC Mobile Digital Television Standard
ATSC M/H – Advanced Television Systems Committee - Mobile/Handheld
CBC – Canadian Broadcasting Corporation
DTV – Digital Television
FCC - Federal Communications Commission
FEC – Forward Error Correction
FST – Field Strength Thresholds
Mbps – Megabits Per Second
MPEG – Moving Picture Experts Group
OMVC – Open Mobile Video Coalition
PSIP – Program and System Information Protocol
SCCC – Serial Concatenated Convolutional Coder
RS-CRC – Reed-Solomon and Cyclic Redundancy Check
SQA – Subjective Quality Assessment
SVSQA – Subjective Video and Sound Quality Assessment
VSB – Vestigial sideband (modulation)

EXECUTIVE SUMMARY

Mobile DTV is a technology that allows small portable devices such as cell phones, iPods/iPads and automobile-based displays to receive digital television signals over-the-air. In North America, the adopted standard for mobile DTV is ATSC M/H (where M/H stands for mobile/handheld) and it's compatible with the existing ATSC standard and infrastructure. One or more mobile DTV services can be added to an existing DTV channel by allocating a certain amount of the bandwidth of the main program to this new mobile service.

Let us be clear: this new technology uses radio waves reserved for digital television broadcasters and not for cell phones. Unlike typical streaming services, mobile DTV will allow viewers to watch live, local and national programming without using a single bit of your cell phone data plan.

Signal robustness is key for mobile DTV. In order to achieve the required robustness for mobile reception, two forward error correction (FEC) methods have been implemented in the ATSC M/H standard: the Reed-Solomon Cyclic Redundancy Check (RS-CRC) at the packet layer and the Serial Concatenated Convolutional Coder (SCCC) at the physical layer. Various FEC configurations are obtained by changing the parameters of these FEC methods and each have an impact on robustness and bandwidth of the mobile DTV signal. A very robust signal will result in a greater coverage, but will also require more bandwidth. Since the bandwidth is shared between the ATSC M/H and the main ATSC services, more bandwidth for the ATSC M/H means less bandwidth for its main ATSC counterpart.

The Spectrum Engineering group was mandated with performing field testing and measurements in order to assess the potential of this technology in terms of coverage. Mobile DTV transmitting equipment was installed on the CBLFT-DT DTV transmitter at the CN Tower in Toronto and on CMBT-DT DTV transmitter in Montreal for the duration of the trials. Although field testing was done in both cities, more in-depth measurements and analysis were made in Toronto and it's the focus of this report.

Specifically, objectives of the field testing and measurements were:

- Assess the impact of the FEC configurations on the coverage
- Identify the best parameters for realistic prediction algorithms used with our software prediction tools for mobile DTV coverage analysis
- Recommend optimal FEC configurations that meet CBC/Radio-Canada's requirements for future installations
- Gain expertise with this new technology

In total, four different FEC configurations have been tested during the measurement campaign. By analyzing the different configurations, it became clear that the RS-CRC encoder was a great way to improve the reliability of the M/H signals with low bandwidth requirements. Many coverage gaps were eliminated after increasing the RS-CRC from 24 bytes to 48 bytes. The SCCC also had a big impact with improving the coverage, but the bandwidth requirement is higher. It has been concluded that RS-CRC should always be set to 48 bytes as a first step, and then the SCCC should be increased for further improvement of the coverage.

After analyzing data collected from the trials, two FEC schemes have been chosen to meet requirements for future installations: configuration 4 (QQQQ RS48) when only one mobile DTV service per digital channel is used and configuration 2 (HHHH RS48) when two mobile DTV services are desired on a single digital channel.

Configuration 4 is by far the most robust and reliable of the tested configurations. In Toronto, the signal was reliable from Burlington to Oshawa and up to Aurora in the North in a moving-vehicle and pedestrian outdoor evaluation. This configuration also provides adequate penetration for indoor reception. While configuration 2's coverage is very good in a moving-vehicle and pedestrian outdoor reception, it did not perform as well for indoor reception for locations far from the CN Tower transmitter. However, configuration 2 requires half the bandwidth of configuration 4, making it ideal for two M/H services per digital channel. Also, with either of these configuration choices, there shouldn't be any noticeable degradation on the main ATSC DTV signal.

The measurement campaign also provided an opportunity to identify the best parameters for a propagation model and its associated field strength thresholds (FST). This will be useful when planning the coverage of future mobile DTV services. The selected propagation model is CRC-Predict v3.21 and FST for Vehicle use cases were validated during the survey. FST for pedestrian use cases were inconclusive, because data are limited since they cannot be collected in an automated manner with our equipment.

For the viewer, mobile DTV may be seen as a suitable and affordable substitute media platform as more and more people are streaming television content on their cell phones using costly data plans.

For the broadcaster, mobile DTV technology is a great way broadcast additional content to large urban populations with the use of a single DTV transmitter without significantly compromising the quality of the main DTV service. At the time of this report, there were over 130 mobile DTV services offered in the US. In large cities such as New-York, Los-Angeles, Dallas and Atlanta, there are at least five different stations broadcasting mobile DTV content.

1 INTRODUCTION

Mobile DTV is a technology that allows portable devices such as cell phones, iPods/iPads and automobile-based displays to receive digital television over-the-air. On the user side, the advantage compared with a typical cellular streaming service is that it's free. There will be no additional cost for exceeding your bandwidth usage since the content signal isn't coming from the service provider's cellular network, but from your local over-the-air broadcaster's DTV channel. For the broadcaster, providing mobile DTV content may represent an added value to an existing DTV service. As per the Open Mobile Video Coalition: "*mobile DTV represents a significant new revenue stream for the broadcasting industry as well as a new way to reach more customers*[1]".

In North America, the accepted standard for mobile DTV is the ATSC A/153. This standard was developed to be compatible with the current DTV standard for fixed reception, the ATSC A/53.

The objective of the report is to examine the impact on the coverage while using different error correction schemes allowed by the standard. More precisely, objectives of this report are:

- Assess the impact of the different forward error correction (FEC) configurations on the coverage
- Identify the best parameters for realistic prediction algorithms used with our software prediction tools for mobile DTV coverage analysis
- Recommend optimal FEC configurations that meet CBC/Radio-Canada's requirements for future installations
- Gain expertise with this new technology

2 A FEW CONCEPTS

To be able to understand the reasoning behind some of the choices and recommendations found in this report, essential concepts are explained in the following sections.

2.1 WHAT IS MOBILE DTV?

Mobile DTV is a technology that allows portable devices to receive digital television in a reliable and efficient manner by using a portion of the bandwidth of an existing digital television channel. The broadcaster may decide to offer the same content or localized services such as news, weather or traffic information. Receivers for this particular technology include compatible mobile phones, portable media players, laptops, tablet PCs (Ipads) or automobile-based displays. Figure 1 shows an example of an Ipod touch and an Ipad using a Tivizen Dongle[2] to receive a mobile DTV signal. Also shown is the Samsung Galaxy S Lightray™ 4G[3] smartphone with fully integrated mobile DTV capabilities.

[1] OMVC: http://www.openmobilevideo.com/broadcasters, 2012
[2] Tivizen, http://www.tivizen.com/usb-dongle.html, 2012
[3] MetroPCS, http://www.metropcs.com/, 2012

FIGURE 1 - EXAMPLES OF AN IPAD, AN IPOD AND A SAMSUNG GALAXY S LIGHTRAY™ 4G RECEIVING A MOBILE DTV SIGNAL

While the ATSC standard is well designed for fixed reception, it is not appropriate for mobile applications; training sequences for the equalizer are not repeated fast enough, the forward error correction scheme is too weak and the signalling needs to be improved. A new standard for mobile digital television, the ATSC A/153 (also called ATSC M/H, mobile DTV and ATSC mobile), has been adopted in October 2009 by the Federal Communications Commission (FCC).

The ATSC M/H standard contains important features such as:

- Compatible with existing ATSC infrastructure (i.e. existing HD receivers will ignore the new mobile DTV data)
- Better forward error correction (FEC), allowing mobile devices to receive the signal and improve carrier to noise(C/N) thresholds
- Lower video resolution adapted to mobile/handheld devices (416x240)
- Video compression : H.264 (MPEG-4 AVC), Audio Compression : HE AAC v2
- Same spectral characteristics of current DTV channels

Because of the compatibility between ATSC and ATSC M/H standards, it is fairly simple and low cost to implement mobile DTV in an existing ATSC infrastructure. The standards are flexible and they allow to add multiple mobile DTV programs by varying bandwidth of each programs. This concept will be further explained later in the report.

2.2 ADDITIONAL HARDWARE REQUIRED TO BROADCAST MOBILE DTV

There are three additional hardware components required to broadcast mobile DTV from an existing DTV installation. An MPEG-4 encoder that encodes and compresses the signal into the correct standard (video H.264 + audio HE AAC v2), an ATSC-M/H multiplexer that will incorporate the ATSC M/H signal into the main ATSC stream and finally, an ATSC M/H enabled exciter for post-processing and modulation before final amplification.

Figure 2 shows a basic ATSC M/H block diagram. Yellow blocks represent the existing ATSC hardware, and green blocks are the ATSC M/H hardware. The corresponding devices are shown for Montreal's setup (from manufacturer Harris) and Toronto's setup (from manufacturer Rohde and Schwartz).

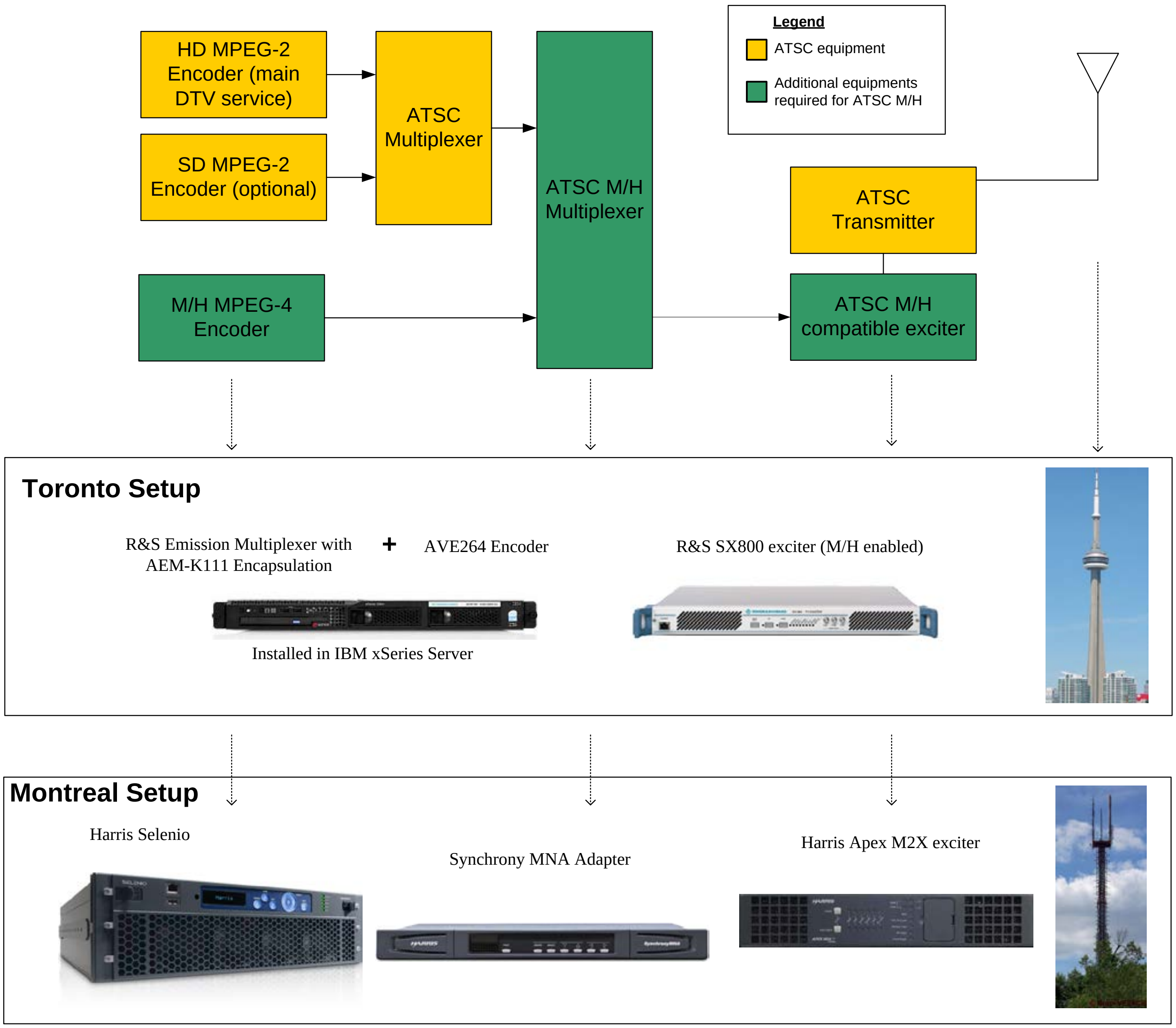


FIGURE 2 – ATSC M/H BLOCK DIAGRAM: MONTREAL AND TORONTO

Other equipment, which are non-related to the ATSC standard, can be used to add features such as weather data, financial data, news feed, advertising content, traffic information or any other type of metadata. Figure 3 shows a screenshot of the mobile DTV signal in Montreal with some of these additional metadata features. The screen layout is customizable and can be modified to meet the broadcaster's requirements

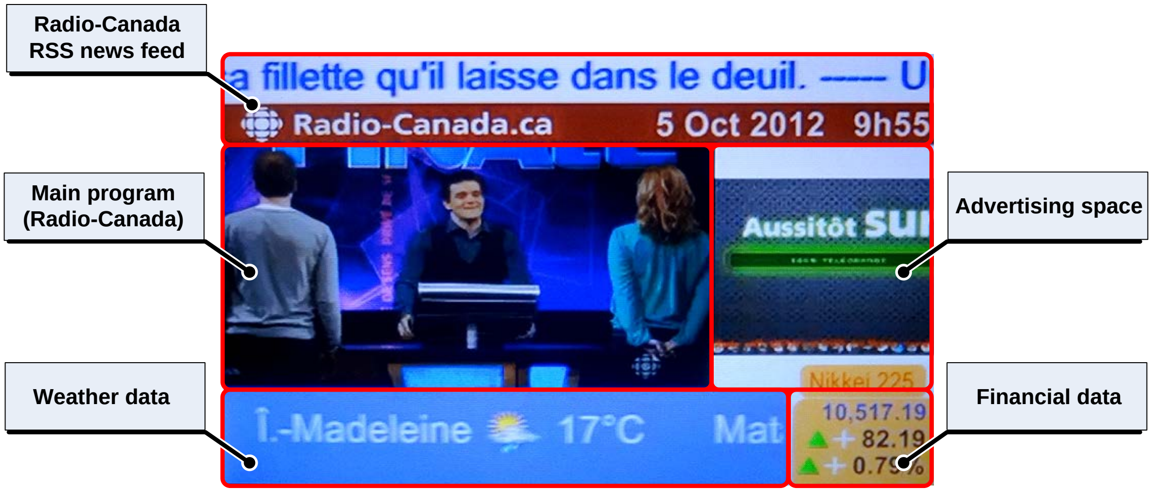


FIGURE 3 - Mobile DTV screenshot showing metadata features (Montreal mobile DTV service shown)

2.3 Methods used to maximize signal robustness for mobile DTV reception

There are three main features in the ATSC M/H standard to achieve the required robustness for mobile reception:

1) New forward error correction methods
2) Additional virtual training sequence
3) Robust mobile signalling

This report will focus on the new forward error correction methods, because it's the only feature that we are able to modify that has an influence on coverage whereas the additional virtual training sequences and robust mobile signaling features do not allow any parameters change.

ATSC M/H uses two different forward error correcting methods. There is an inner code FEC method (at the physical layer) and outer code FEC method (at the packet layer). Table 2-1 shows a comparison between ATSC and ATSC M/H FEC methods.

methods	A/53 (ATSC) (main DTV signal)	A/153 (ATSC M/H) (mobile DTV signal)
Inner code (physical layer)	2/3 Trellis Encoder in 8-VSB	Turbo Encoder, also called Serial Concatenated Convolutional Code (SCCC)
Outer code (packet layer)	Reed-Solomon (RS)	Reed-Solomon and Cyclic Redundancy Check (RS-CRC)

TABLE 2-1 - FEC METHODS COMPARISON BETWEEN ATSC AND ATSC M/H

The Reed-Solomon algorithm has been improved in the ATSC M/H standard. Combined with CRC, it can correct twice as many bytes as the RS only. The ATSC A/153 standard accepts 24, 36 or 48 bytes of error correction per column of 187 payload bytes. In the ATSC A/53 version, only 10 bytes of error correction per column of 187 bytes are possible. Therefore, ATSC M/H achieves at least twice the amount of error correction at the packet layer compared with the ATSC A/53 standard.

As shown on figure 4, the Turbo Encoder is the combination of the ATSC 2/3 Treillis encoder with a new convolutional encoder which can be configured at a rate of ½ (Half or H) or ¼ (Quarter or Q). These two encoders are separated by a long sequence interleaver to minimize the probability of a burst of errors.

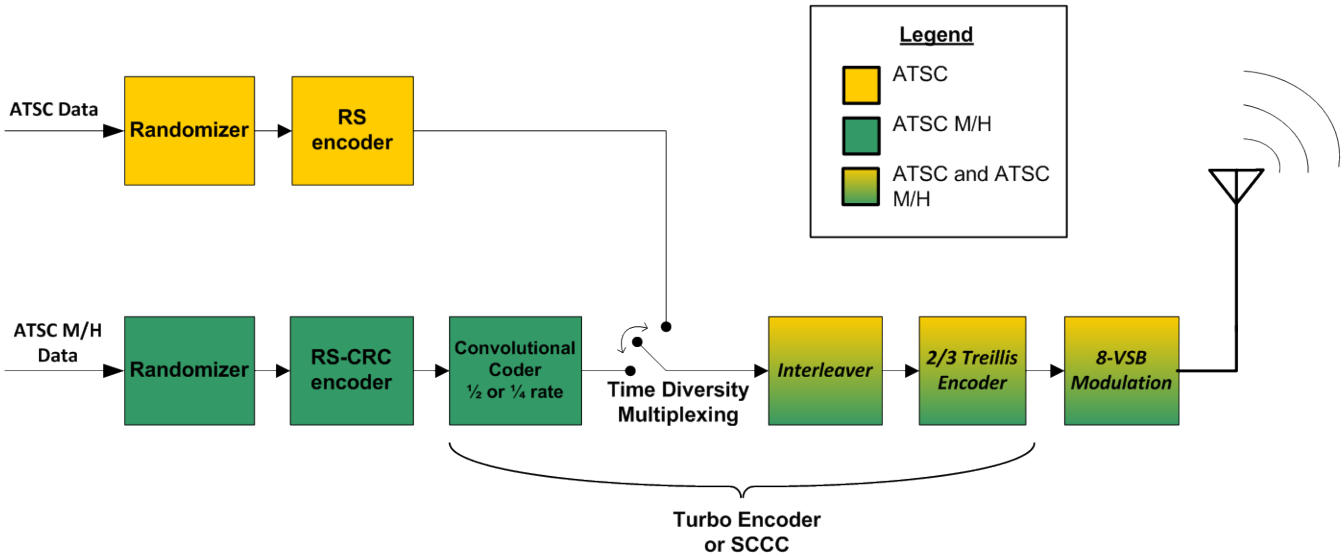


FIGURE 4 – SIMPLIFIED ATSC M/H PHYSICAL LAYER BLOCK DIAGRAM

There are 4 ATSC M/H group regions designated as A, B, C and D. A group region is "a defined series of contiguous transmitted vestigial sideband (VSB) data segments containing ATSC M/H data or a combination of ATSC and ATSC M/H data"[4]. Region A is more protected than B, B more than C and C more than D (A>B>C>D). Each of these regions can be encoded at a rate of ½ (Half or H) or ¼ (Quarter or Q). At a 1/4 rate, for every input bit at the encoder, there will be 4 bits at the output. It means that the signal will be more robust than at a 1/2 rate, but it will use more bandwidth. By changing the parameters of the RS-CRC and the Turbo Encoder, it is possible to obtain different configurations with more or less robustness, by using more or less bandwidth.

Please note that the following notation will be used in the report when talking about FEC schemes: HHQQ RS48 means regions A and B are encoded at ½ (H), regions C and D at ¼ (Q) rate with the SCCC and the Reed-Solomon error correction is set to 48 bytes.

2.4 ALLOCATION OF BANDWIDTH TO ATSC M/H

It is possible to allocate different amounts of bandwidth to the ATSC M/H portion of the channel. Of course, allocating more bandwidth to the ATSC M/H means less bandwidth for the main ATSC service. In a 6 MHz DTV channel, there is 19.39 Mbps available and how the bandwidth is allocated depends on the application.

Table 2-2 shows payload (video and audio bit rates) examples of an ATSC M/H program for various quality levels. It is also possible to put more than one program on a single DTV channel. For example it's possible to have two high quality and one medium quality programs: 656+656+300 = 1612 kbps total payload.

[4] ATSC-Mobile DTV Standard, Part 2 – RF/Transmission System Characteristics

	Video bit rate (kpbs) H.264 (MPEG-4 AVC)	Audio bit rate (kbps) HE AAC v2	Other (kbps) (ex: service guide)	ATSC M/H Payload bit rate (kbps)
High quality	500	56	100	656
Medium quality	400	32	100	532
Low quality	300	18	100	418

TABLE 2-2 - ATSC M/H PAYLOAD BIT RATE FOR DIFFERENT VIDEO/AUDIO QUALITY[5]

Note[6]: For the trials in Toronto, the setup was at high quality. The video bit rate was approximately 512 kbps and the audio bit rate was 48 kbps. In Montreal, the setup was at medium quality: 440 kbps for the video bit rate and 32 kbps for the audio bit rate.

Let's look at how ATSC and ATSC M/H data share the available bandwidth of the DTV channel.

- The ATSC M/H frame is 968 ms long, which corresponds to a total bit rate of approximately 19.39 Mbps.
- There are 5 sub-frames within the ATSC-M/H frame. An ATSC M/H sub-frame capacity is approximately 3.754 Mb and this sub-frame will be repeated 5 times per 968 ms. The structure will be the identical for the 5 sub-frames.
- Each of these sub-frames is divided into 16 slots which contain either ATSC or ATSC M/H data. This means there are 80 slots in the ATSC M/H frame, but since the structure is identical for the 5 sub-frames, when we refer to slot 1, it is implied that we refer to every first slot of the five sub-frames.
- Also, since we are only using one ATSC M/H parade, it should be noted that a maximum of 8 slots can be used. An ATSC M/H parade is a collection of ATSC M/H groups that have the same FEC parameters.

Then we have the ATSC M/H sub-frame, which is represented on Figure 5. Each of the 16 slots uses 917 Kbps of the total data rate and can be occupied either by ATSC M/H or ATSC data. Considering that the payload (video and audio only) for one program ranges approximately from 300 to 700 kbps, one slot should be sufficient to transport the signal. However, for the signal to be robust, a lot of the bandwidth needs to be used for FEC code. The broadcaster must allocate enough slots for the payload and the FEC code. It should be noted that even if half a slot is used (as an example), the bitrate occupied by ATSC M/H will always be multiple of 0.917 Mbps.

[5] For audio bit rate, See GOERIG, Claudia, HAGEMEIER, Denis (Rohde & Schwarz). *Upgrade to ATSC Mobile DTV - Application Note,* 2009, http://www2.rohde-schwarz.com/file_12736/7EB02_0E.pdf

[6] For video bit rate assumptions, See ADRICK, Jay (Harris Corporation). *Implementing ATSC Mobile DTV*, 2011 (Techcon11

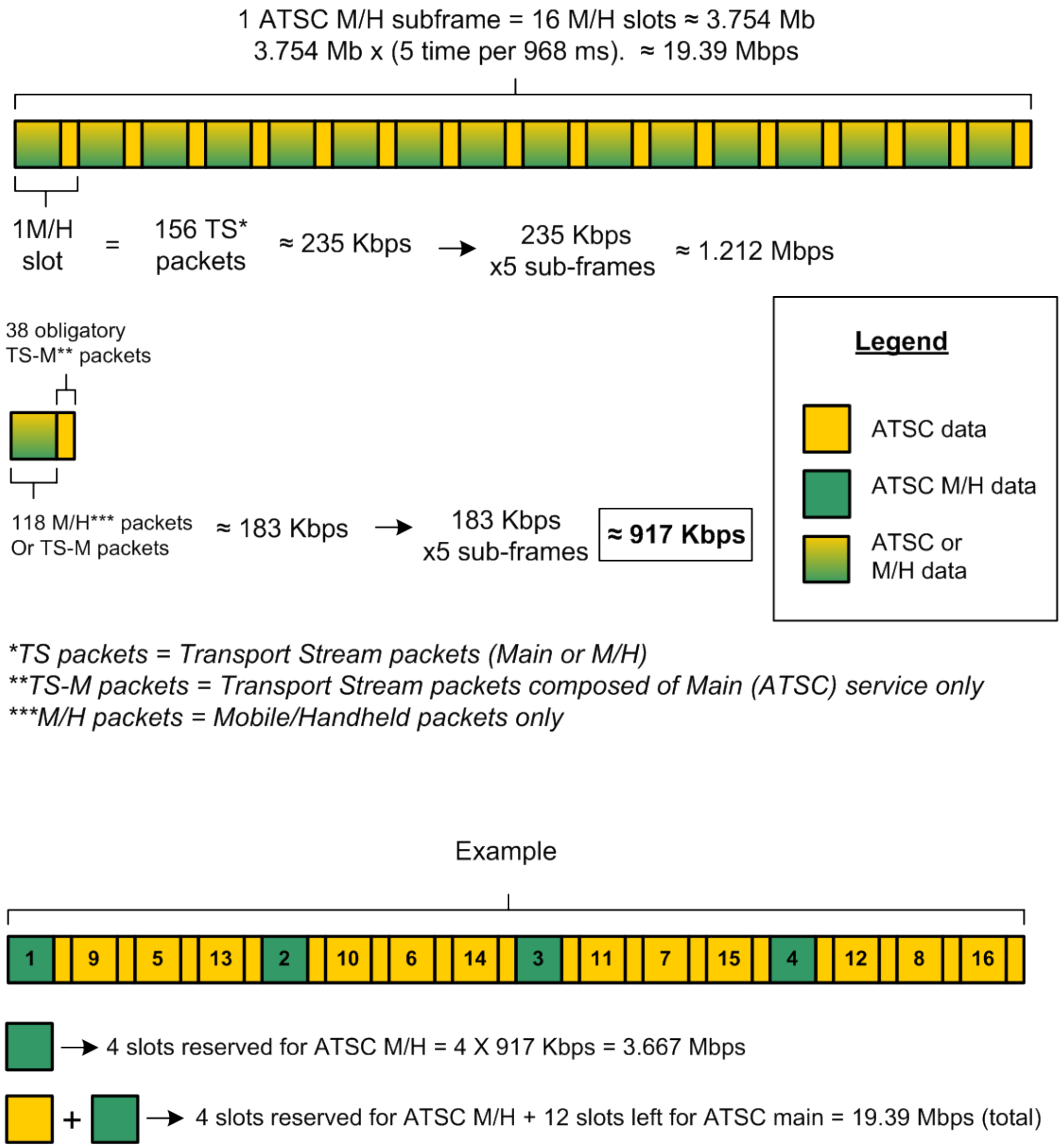


FIGURE 5 - ATSC M/H SUBFRAME AND SLOTS SCHEMATIC

2.5 TESTED CONFIGURATIONS

Figure 6 shows the bandwidth allocation of the tested configurations. It shows the portion of the channel allocated for the ATSC M/H payload, the ATSC M/H FEC and the main ATSC. The bit rate for the main ATSC should not be lower than 13.5 Mbps. At less than 13.5 Mbps, the degradation may be noticeable. We could use up to 6 slots for ATSC M/H without compromising the quality of the main channel. Figure 6 also highlights how little the RS-CRC uses bandwidth in comparison with the SCCC. It should also be noted that only one ATSC M/H program was on air during the trials, but with a second encoder, we could put two programs on a single digital channel. When designing DTV and mobile DTV configurations, a certain amount of overhead bitrate needs to be considered in the total bandwidth. This overhead is mostly function of the peak to average ratios of the video and audio encoder equipment in use.

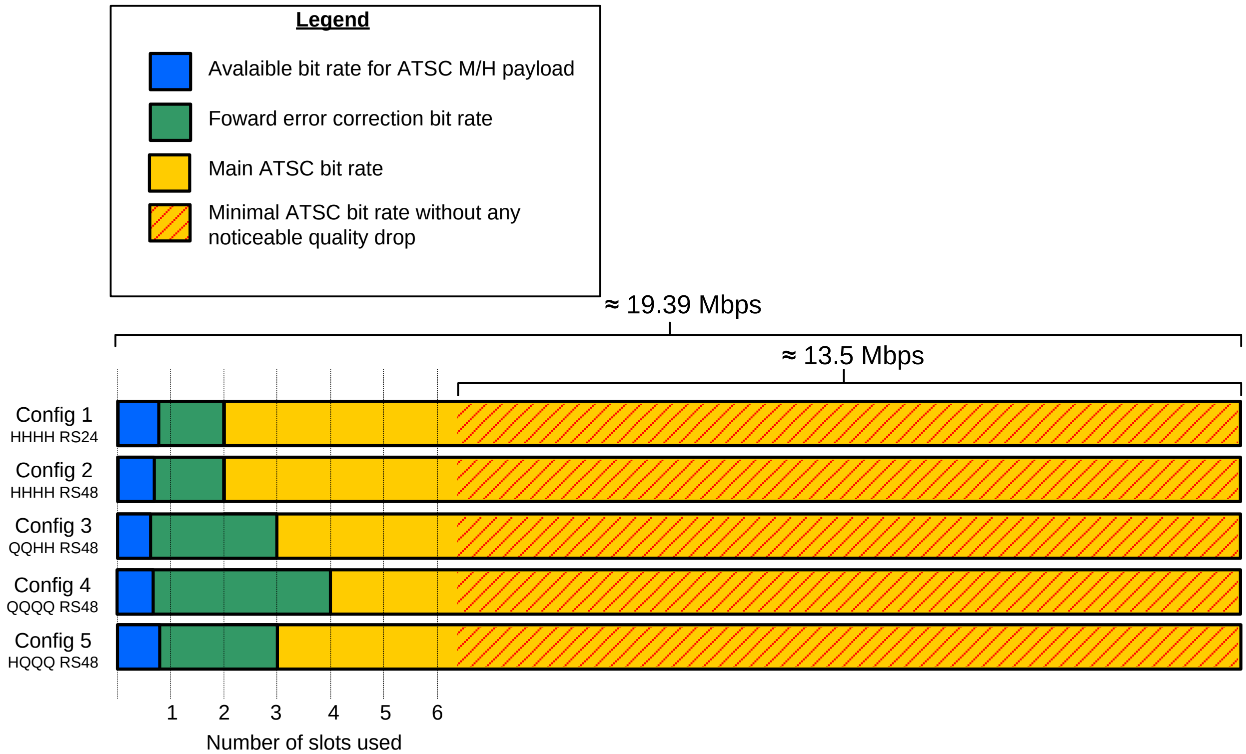


FIGURE 6 - BANDWIDTH ALLOCATION FOR THE DIFFERENT TESTED CONFIGURATIONS

Figure 7 shows how the bandwidth allocation would look like with two programs. In the example, the first program uses config. 1 FEC scheme and the second config. 4 FEC scheme.

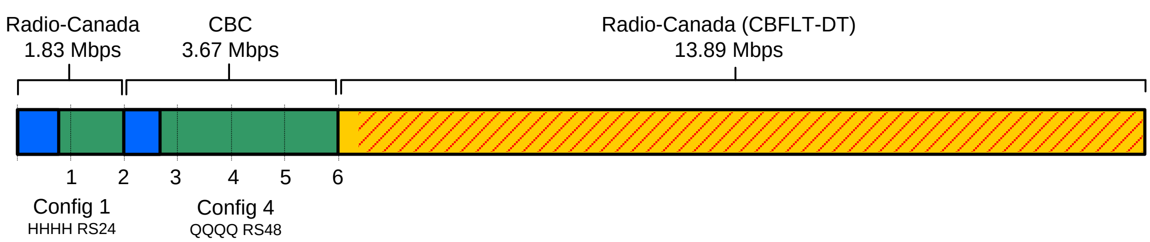


FIGURE 7 - EXAMPLE OF THE BANDWITH USAGE WITH TWO ATSC M/H PROGRAMS ON A SINGLE CHANNEL

Figure 8 shows a chart of the ATSC M/H total bit rate in function of its associated payload. With this chart, it's possible to determine how many slots will be required for a desired payload rate with a certain FEC configuration. Five configurations have been illustrated on the chart. Equations 5.1, 6.5 and 6.6 from part 2 of the ATSC M/H Standard[7] have been used to draw the chart. The parade repetition cycle was set to 1 and the mode to "single frame".

[7] ATSC-Mobile DTV Standard, Part 2 – RF/Transmission System Characteristics

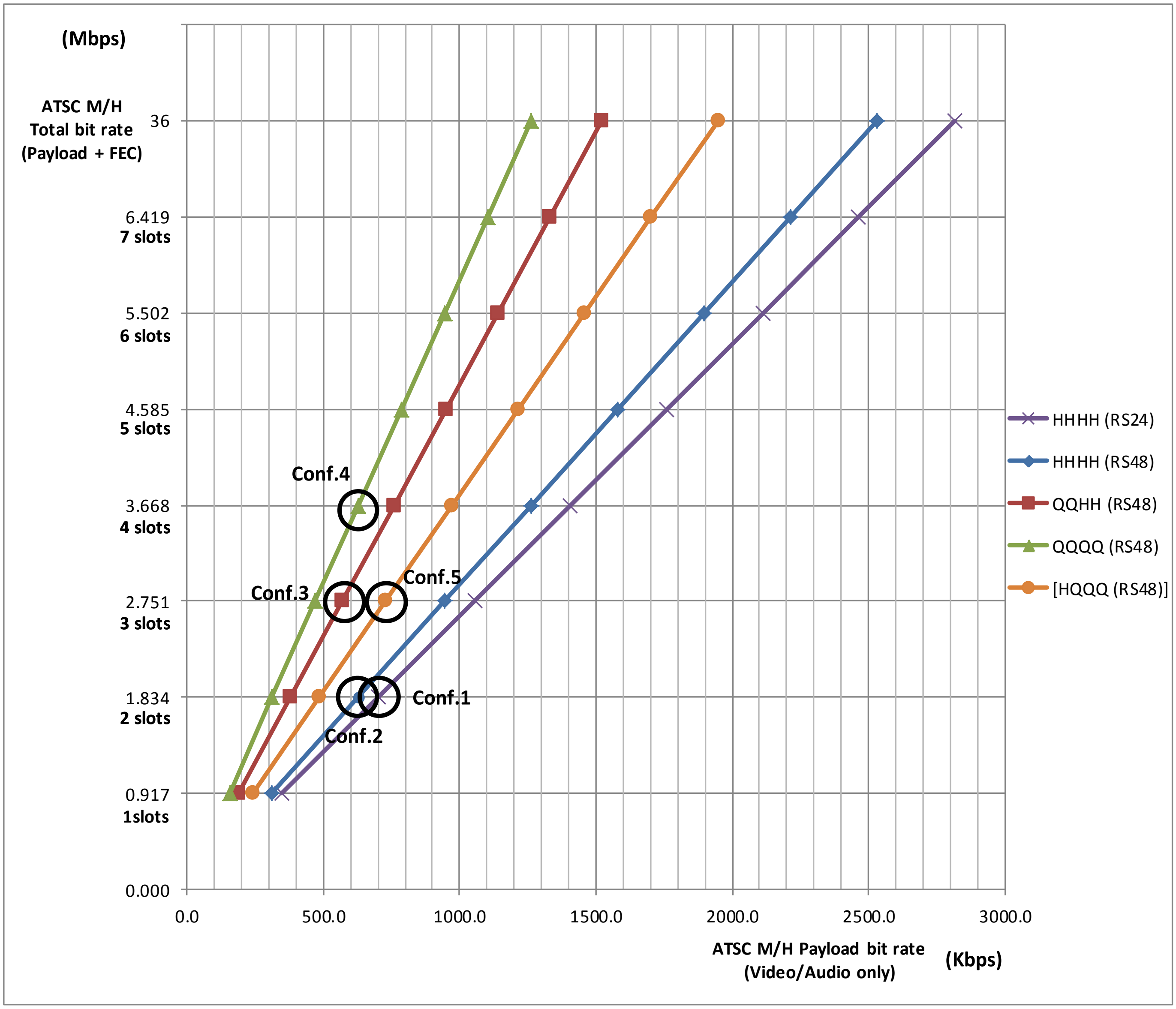


FIGURE 8 - ATSC M/H TOTAL BIT RATE (PAYLOAD + FEC) VS. M/H PAYLOAD BIT RATE (VIDEO / AUDIO ONLY)

Here is an example of how to use the chart:

- Question: A DTV station requires a minimum bandwidth of 16 Mbps with its main ATSC service. We wish to implement a high quality ATSC M/H service with a payload of 700 kbps on this DTV channel. Knowing that there is only 3.39 Mpbs left (19.39 Mbps – 16 Mbps), which FEC configuration should we use?
- Answer: Since there is only 3.39 Mbps left, we can only use 3 slots or 2.751 Mbps for the ATSC M/H service (since 4 slots = 3.668 Mbps > 3.39 Mbps). Looking at the chart, we know that we need at least 700 kbps of payload and that we cannot go higher than 3 slots. The first "point" that we encounter that is both on the 3 slots horizontal line and at the right of the 700 kbps vertical line should be the optimal choice. In this case, configuration 5 is the best choice, since it gives us the best robustness and just enough payload bit rate (~720 kpbs).

Table 2-3 shows the main parameters of the tested configurations during the measurement campaign.

	Number of M/H slots	Total M/H Rate (Mb/s)	Available Payload Rate (Mb/s)	FEC					Efficiency (M/H Payload / M/H Total)	Robustness Ranking
				SCCC / Region				RS-CRC (bytes)		
				A	B	C	D			
Config. 1	2 / 16	1.834 / 19.39	0.702	H	H	H	H	24	38.4%	4th
Config. 2	2 / 16	1.834 / 19.39	0.623	H	H	H	H	48	34.5%	3rd
Config. 3	3 / 16	2.751 / 19.39	0.569	Q	Q	H	H	48	20.8%	5th
Config. 4	4 / 16	3.667 / 19.39	0.623	Q	Q	Q	Q	48	17.2%	1st
Config. 5	3 / 16	2.751 / 19.39	0.728	H	Q	Q	Q	48	26.5%	2nd

TABLE 2-3 – PARAMETERS OF THE TESTED CONFIGURATIONS

The robustness ranking shown above was determined following our analysis of the field measurements and configuration 4 was determined to be the most robust. Please refer to section 5 (Subjective Video and Sound Quality Assessment (SVSQA)) for the process behind this ranking.

2.6 STATISTICS FOR MOBILE DTV IN AMERICA

We found a few sources of information on stations that are offering mobile DTV in America. In Canada, the technology is still being evaluated, but we know that at least one private station, CKCO-DT (London, ON), is performing tests.

The following information was found on Rabbitears website[8]. A similar list is available on the Open Mobile Video Coalition website[9]. At the time of this report, there were over 100 stations broadcasting mobile DTV content. Because sometimes there are more than one mobile DTV service per station, there are over 130 different services offered. These American mobile DTV services are distributed in 62 markets. In addition to the 100 stations already on air, another 83 announced that they will offer mobile DTV in the near future.

Actual		**Planned**	
Stations	**Services**	**Stations**	**Services**
100	131	183	N/A

TABLE 2-4 - ACTUAL AND PLANNED MOBILE DTV STATIONS IN THE US

An interesting statistic to look at is the dedicated bit rate for ATSC M/H per station. Figure 9 shows a compilation of the stations currently on air in the US. 71% of stations allocate 1.834Mbps to ATSC M/H (2 slots). With 2 slots, it would be very difficult to use a FEC scheme more robust than HHHH RS48 without compromising the video and sound quality of the ATSC M/H service (refer to Figure 8).

[8] ERICSON, Trip. http://www.rabbitears.info/market.php?request=atscmph, 2012
[9] OMVC, http://www.mdtvsignalmap.com/, 2012

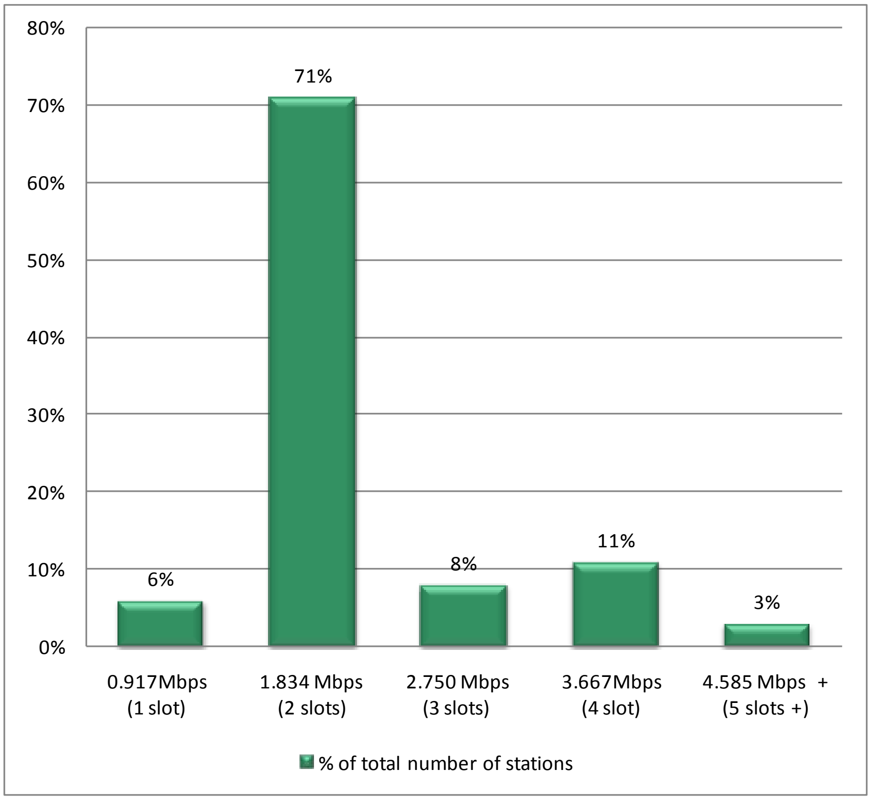


FIGURE 9 - PORTION OF THE BIT RATE DEDICATED TO ATSC M/H ON DTV CHANNELS IN USA

3 STATION PARAMETERS FOR FIELD TESTING

In Toronto, during the trials, CBC mobile DTV content was inserted on the French DTV channel, CBLFT-DT, on channel 25. Station parameters for CBLFT-DT are shown in Table 3-1. For the duration of these tests, the main ATSC channel was limited to 14 Mbps to allow sufficient bandwidth for the mobile DTV service under test.

Channel:	25 R		Frequency:	536 MHz
Service:	CBLFT-DT		TX power:	5.8 kW
Lat/Long:	43° 38' 33 "	North	EHAAT:	491 m
	79° 23' 14 "	West	Radiation center:	597.8 m
Maximum ERP:	106200 kW		Antenna:	Omni.
Average ERP:	106200 kW		Polarization:	Horizontal

TABLE 3-1 - CBLFT-DT TORONTO PARAMETERS

It is worth mentioning that CBLFT-DT antenna is horizontally polarized. The consensus amongst studies is that circular and elliptical polarization provides much better results in term of coverage. For example, a study by SPX Corporation[10] came to the conclusion that there is a 4 to 5 dB signal-to-noise ratio (SNR) improvement when using a circularly polarized instead of a horizontally polarized transmitting antenna.

4 MEASUREMENT SETUP

4.1 FIELD STRENGTH MEASUREMENTS

Field strength measurements were carried out using a Rohde and Schwartz ETL TV analyzer with the RF preselector (R&S option B203). The ETL was connected to a UHF monopole antenna with a gain of approximately 0 dBd at the center frequency (539 MHz). Cable losses were estimated at 1.4dB. Using Rohde and Swartz BCDRIVE software, the channel power was measured along the determined path. The setup is shown on Figure 10.

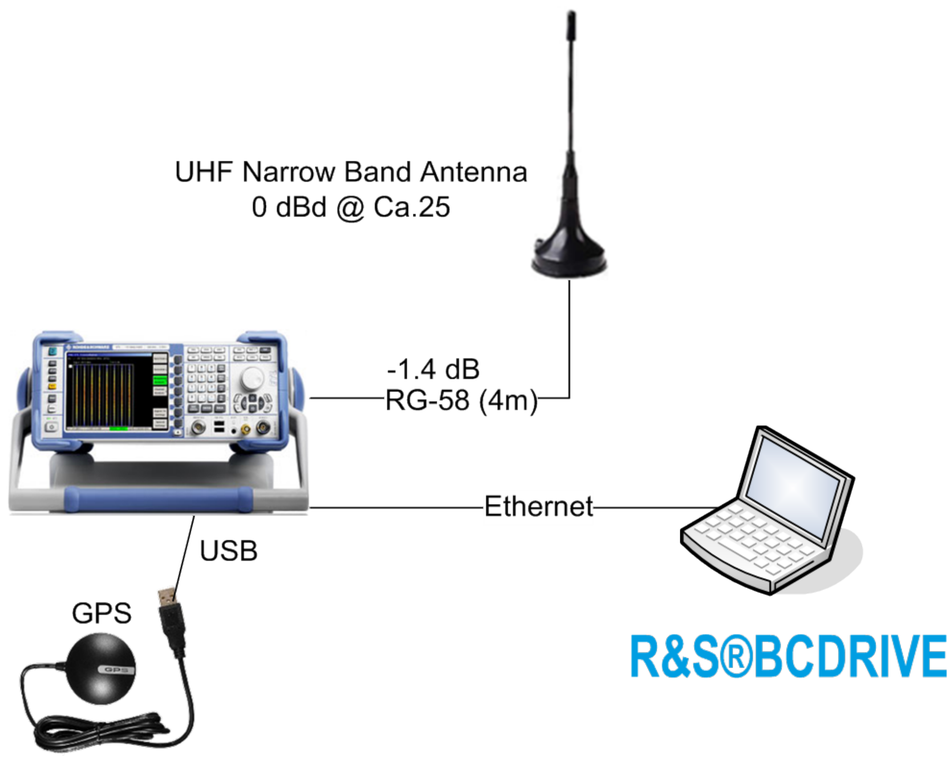


FIGURE 10 - MOBILE FIELD STRENGH MEASUREMENTS AT 2M SETUP

[10]See COZAD, Kerry W. (SPX Corporation). *Mobile DTV Antenna System, 2008*
http://www.tvfmtranslators.com/past_papers/2010%20NTA%20Papers/Mobile%20DTV%20Antenna%20Systems%20-%20Kerry%20Cozad%20-%20Dielectric%20Jun2010.pdf

4.2 SUBJECTIVE VIDEO AND SOUND QUALITY ASSESSMENT

Three receivers were used for the subjective video and quality assessment. Figure 11 shows these receivers and antennas.

FIGURE 11 – (A) 3.5" RCA RECEIVER WITH BUILT-IN ANTENNA (B) 3.5" RCA RECEIVER WITH EXTERNAL ANTENNA (C) 7"RCA RECEIVER WITH BUILT-IN ANTENNA

Setup A is a RCA receiver model DMT 336R and it uses its built-in telescopic antenna. Setup B uses the same receiver but with an external monopole antenna mounted on the roof of the measurement truck. Setup C is a RCA receiver model DMT 270R and it uses its built-in telescopic antenna.

5 SUBJECTIVE VIDEO AND SOUND QUALITY ASSESSMENT (SVSQA)

5.1 SVSQA COLOR CODE

A subjective video and sound quality assessment has been conducted by the occupants of the measurement vehicle along the determined path. Table 5-1 shows the color code for the SVSQA maps.

	Corresponding color	Description of Video and Sound Quality
	Green	Perfect
	Blue	Blocking / Flickering
	Red	No reception

TABLE 5-1 - SVSQA COLOR CODE

5.2 USE CASES

Viewers will use their receiver in different scenarios. For example, they could be watching their favourite mobile DTV channel while walking home, while riding the bus or during lunch time at work. For each of these scenarios, the field strength required to reach the receiver will be different. Higher field strength will be required for a receiver that is inside a building than one that is outside. This is why we treated these situations as different use cases.

For this report, we refer to the use cases described in the paper *Planning Factor (Link Budget) ATSC Mobile DTV Whitepaper*[11] (see Table 5-1).

Use Cases	Characteristics
Vehicle Roof Antenna	2m, 100km/hr
Vehicle Inside (built-in antenna)	2m, 100km/hr
Pedestrian Outdoor	2m, 3km/hr
Pedestrian Indoor	2m, 3km/hr
Pedestrian Deep Indoor	2m, 3km/hr

TABLE 5-2 - MOBILE DTV RECEIVER USE CASES

5.3 Vehicle Built-in and Roof-Mount Antenna Results

5.3.1 Observations between receiver setups

The subjective video and sound quality assessment (SVSQA) results were obtained using two RCA DMT336R receivers. One of the receivers had an external roof-mount dipole antenna while the other one was simply using its built-in telescopic antenna.

It was expected that setup B with the external antenna would produce better results. Most of the time, this was true because the dipole antenna has a higher gain and a higher elevation (rooftop on the truck) than the built-in telescopic antenna. However, there are some exceptions where the internal antenna gave better results. In the south-west region of Toronto, see maps DT-575 and DT-576 in APPENDIX A (config. 1 - going west on Queen Elisabeth way), receiver A could receive the signal where the receiver with the external antenna could not. This can be explained by destructive or additive multipath signals. Because the carrier wavelength is small (carrier frequency = 539 MHz, λ = 56 cm), the environment around the receiver can make a big difference on the reception. For example, the antenna outside could receive two destructive signals that would prevent reception. Inside the truck, those two signals would bounce multiple times before reaching the receiver antenna, causing the resultant signal to be decodable.

5.3.2 Observation between configurations

The order of performance that was expected, from best to worst coverage, was: config. 4 (QQQQ RS48) > config. 3 (QQHH RS48) > config. 2 (HHHH RS48) > config. 1 (HHHH RS24). However, during the survey, it became clear that configuration 3 was underperforming.

Also, configuration 5 has not been tested in the field during Toronto's campaign. Unfortunately, the potential of this configuration has been discovered only after we completed Toronto's field measurements. This explains why there are no maps for Configuration 5. However, another survey was performed in Montreal and configuration 5 was confirmed as the second most robust configuration.

The final order of performance in terms of robustness is: config. 4 > config. 5 > config. 2 > config. 1 > config. 3 (See Table 2-3).

[11] SIMON, Mike (Rohde & Schwarz). *Planning Factor (Link Budget) ATSC Mobile DTV Whitepaper,* 2010 http://www2.rohde-schwarz.com/file_14460/mh2_wp-v1.pdf

Overall best vs. Overall worst – Config. 4 (QQQQ RS48) vs Config. 3 (QQHH RS48).

There are significant improvements in coverage between the most robust configuration (config. 4) and least robust configuration (config. 3). Comparing maps DT-0579 and DT-0581, it is very easy to notice how much the coverage changes in every azimuth. Most of the blocking from config. 3 is now gone, and the coverage limit has been pushed further. With config. 3, the signal was only reliable in Toronto and with config. 4 the signal is reliable from Burlington to Oshawa and up to Aurora in the North.

RS-CRC effect – Config. 1 (HHHH RS24) vs. Config. 2 (HHHH RS48)

The main difference between config. 1 and 2 is the increase of RS-CRC from 24 to 48 bytes. Comparing maps DT-576 with map DT-578 (APPENDIX A) reveals that the coverage is better with config. 2. The improvement is not as big as between config. 3 and 4, but still very noticeable in every azimuth where blue sections are now replaced with green ones. It means that for many locations, deep fades[12] degrades the signal below the threshold level of the receiver, causing burst of errors. 24 bytes of RS-CRC were not enough to correct all these errors, but 48 bytes were. The improvement is also noticeable downtown, where there is almost no blocking at all with config. 2. It should also be noted that this improvement comes at no additional bandwidth. Config. 1 and. 2 both require at least two slots (1.834 Mbps) to work properly. Remember that chunks of bandwidth allocated to ATSC M/H are multiples of 917 Kbps and if you are using it all, it is considered lost bandwidth. Because of these reasons, there is no scenario where config. 1 should be used instead of config. 2. The RS-CRC should always be set to 48 bytes.

Convolutional encoder rate effect – Config. 2 (HHHH RS48) vs Config. 4 (QQQQ RS48)

Between configurations 2 and 4, the rate of the convolutional encoder has changed from HHHH to QQQQ. Because this new setup requires approximately twice the bandwidth, 4 M/H groups instead of 2 were allocated for ATSC M/H data. Once again, the improvement is quite significant. However, the improvement gap is not as big as between configurations 1 and 2. This doesn't necessarily mean that the RS-CRC has a bigger effect than changing the convolutional encoder rate. It can also mean those coverage gaps were already mostly filled by the RS-CRC improvement (from 24 to 48 bytes) and that there were not many gaps left when we increased the convolutional encoder rate. If we had tried to increase the SCCC rate before the RS-CRC, maybe we would have made the same observation. On the other hand, considering the bandwidth requirement of the RS-CRC vs the SCCC, putting the RS-CRC to maximum should always be a priority.

Mixed rate – Config. 2 vs Config. 3

Before the measurement campaign, it was expected that the config. 3 (QQHH RS48) would do well, because it was a compromise between the efficiency of config. 2 (HHHH RS48) and the robustness of config. 4 (QQQQ RS48). The results were a lot worse than expected; config. 3 was even worse than config. 1.

There is an hypothesis that could be explained as follows:

SCCC Region	RS-CRC bytes
ABCD ↓↓↓↓ QQHH	No.bytes ↓↓ RS48

- First, with QQHH RS48, regions A and B [QQ] are given more protection than regions C and D [HH]. It's a mistake, because regions A and B are already more protected than C and D. "*This is closely related with the coverage of pilot sequence. The impact of pilot sequence is better in order of A, B and C, D. A region is quite well protected (Equalizer performs well) by pilot sequence, then*

[12] SIMON, Mike (Rohde & Schwarz). *Understanding ATSC Mobile DTV Physical Layer,* 2010 http://www2.rohde-schwarz.com/file_14103/mh1_wp-v1f.pdf (Section on Rayleigh Fading)

B, C and D regions are less protected by pilot sequence." [13] The recommended case for a mixed rate should be HQQQ RS48 (config. 5).

- Second, QQHH uses separate block mode and HHHH uses paired block mode. "*With QQHH, SCCC block is built as separate ones, but combined [paired] mode is used with HHHH. In a combined mode, part of A and B and a part of C and D are used to construct SCCC blocks. So with HHHH, region A and B is well protected by pilot sequence and combined to C and D. So C and D may have a possibility to be well protected rather than the case with separate SCCC of QQHH."* [14]

In summary, configuration 3 would not be recommended in any case. It takes more bandwidth than configurations 1 and 2 and it's less robust. Configuration 5 (HQQQ RS48) was the compromise we were trying to reach by doing mixed rate.

5.4 PEDESTRIAN OUTDOOR RESULTS

The subjective quality evaluation for this section was carried out using the 7" RCA receiver (Figure 11 - setup C). The map of interest is DT-0591 (APPENDIX B). Each location has been tested with every FEC configurations and the color code of Table 5-1 applies. Results are shown on a bar graph from less robust (top) to most robust (bottom); config. 1 (HHHH RS24), config. 2 (HHHH RS48), config. 3 (QQHH RS48) then config. 4 (QQQQ RS48).

Results are mostly as expected, configuration 4 being the best and configuration 1 the worst in terms of coverage. Configurations 2 and 3 results are in between and fairly similar. Locations #8 and #23 results were lower than expected. This is because those locations have no line of sight with the CN tower antenna even if it doesn't appear on the maps (elevations database have a certain precision, in this case CDED is 250m). Location #17 results are also lower than expected, where configuration 1 (the less robust) being the only one to get a perfect reception. This could be explained by a slight change of location between configurations evaluation or a favorable transmission climate (each configuration has been measured on a different day).

Table 5-3 shows the results of the measurements in terms of percentage of locations. This is simply to demonstrate which configurations performed best overall. As expected, configuration 4 is the most robust with 83% of location with a perfectly decodable signal. Notice that configuration 3, which was the worse configuration with the vehicle tests, performs better during pedestrian outdoor testing. The speed of the mobile receivers could be a factor when this configuration is used.

	Perfect	Blocking	No reception
Config 1: HHHH RS24	39%	42%	19%
Config 2: HHHH RS48	50%	28%	22%
Config 3: QQHH RS48	43%	25%	32%
Config 4: QQQQ RS48	83%	8%	8%

TABLE 5-3 - SUBJECTIVE QUALITY VS FEC CONFIGURATIONS FOR PEDESTRIAN OUTDOOR RESULTS (IN PERCENTAGE OF LOCATIONS)

A downtown walk and evaluation was also performed using the same 7" RCA mobile DTV receiver. The pedestrian path is shown on map DT-0586 (APPENDIX B). During these downtown tests, only configuration 1 suffered some rare blocking. These glitches were difficult to reproduce, so the main hypothesis is that they were due to the heavy traffic at that time. Moving vehicles can momentary produce destructive multipath at the receiver. All other configurations performed well during these tests.

[13] Joo-Hong Jeong (http://dstreamtech.com), HDTV systems, Customer Support (Tech, department),
[14] Joo-Hong Jeong (http://dstreamtech.com), HDTV systems, Customer Support (Tech, department)

5.5 PEDESTRIAN INDOOR RESULTS

The 7" receiver was also used for the pedestrian indoor evaluation. Map DT-0592 in APPENDIX B shows that the evaluation results are a lot sparser this time. One of the reasons is because each building has their own attenuation when it comes to radio-frequency penetration. The numbers of windows, building materials and thickness of the walls are all factors that can play a role.

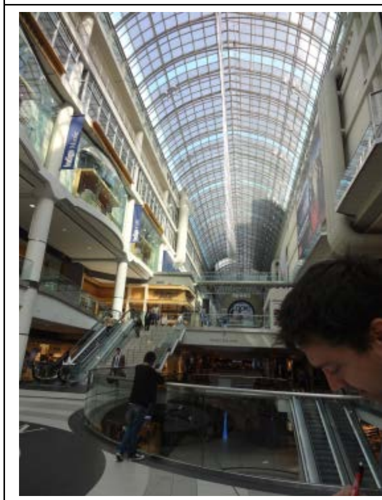
Looking at the map, it's difficult to see a geographical tendency and deduce a certain field strength threshold from this. Even if it's not easily determined from these maps, it was obvious that being in proximity to the transmit antenna greatly increases the probability of picking up the mobile DTV signal indoor. However, what we can conclude with these results is that configuration 4 is again the best one. Table 5-4 shows that configuration 4 received a perfect score 3 time out of 4 compared with less than 1 out of 4 for other configurations.

	Perfect	**Blocking**	**No reception**
Config 1: HHHH RS24	7%	46%	46%
Config 2: HHHH RS48	22%	44%	34%
Config 3: QQHH RS48	25%	29%	46%
Config 4: QQQQ RS48	74%	13%	13%

TABLE 5-4 - SUBJECTIVE QUALITY VS FEC CONFIGURATIONS FOR PEDESTRIAN INDOOR RESULTS (IN PERCENTAGE OF LOCATIONS)

5.6 PEDESTRIAN DEEP INDOOR RESULTS

The pedestrian deep indoor evaluation was performed in the downtown core where the signal is very strong, but where the line of sight is often obstructed by buildings. The evaluated building locations are found on map DT-0586 (APPENDIX B). Results for each visited building are available below in Table 5-5.

 Source : http://www.marriott.com	**MARRIOTT**		
	Config1:	Indoor :	Perfect reception
		Deep Indoor (basement) :	No reception after 5m
	Config2:	Indoor :	Perfect reception
		Deep Indoor (basement) :	No reception after 10m
	Config3:	Indoor :	Perfect reception
		Deep Indoor (basement) :	No reception after 10m
	Config4:	Indoor :	Perfect reception
		Deep Indoor (basement) :	No reception after 20m
	**EATON CENTER**		
	Config1:	Indoor :	Perfect reception under skylight
		Deep Indoor (Lower floor) :	Blocking after 5m
	Config2:	Indoor :	Perfect reception under skylight
		Deep Indoor (Lower floor) :	Some Blocking
	Config3:	Indoor :	Perfect reception under skylight
		Deep Indoor (Lower floor) :	Some Blocking
	Config4:	Indoor :	Perfect reception under skylight
		Deep Indoor (Lower floor) :	Some rare blocking, otherwise perfect reception
	**THE BAY**		
	Config1:	Indoor :	No reception after 10m
		Deep Indoor :	No reception
	Config2:	Indoor :	Blocking
		Deep Indoor :	Blocking after 5m, No reception after 50m
	Config3:	Indoor :	Blocking
		Deep Indoor :	Blocking after 5m, No reception after 50m
	Config4:	Indoor :	Perfect Reception
		Deep Indoor :	Blocking after 5m, No reception after 50m

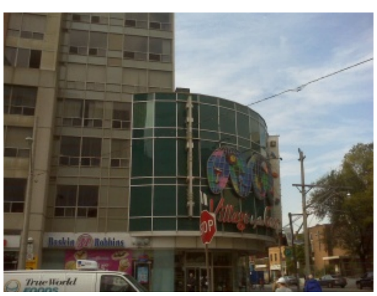
 Source : Wikimedia Commons, Upstateknitter	**BAY ADELAIDE CENTRE (333 BAY STREET)**		
	Config1:	Indoor :	Perfect reception
		Deep Indoor (basement) :	No reception after 15m
	Config2:	Indoor :	Perfect reception
		Deep Indoor (basement) :	Blocking
	Config3:	Indoor :	Perfect reception
		Deep Indoor (basement) :	Blocking
	Config4:	Indoor :	Perfect reception
		Deep Indoor (basement) :	Blocking
 Source : Wikimedia Commons, SimonP	**OXFORD TOWER (150 YORK STREET)**		
	Config1:	Indoor:	Some Blocking
		Deep Indoor (basement) :	Blocking after 5m, No reception after 15m
	Config2:	Indoor:	Some Blocking
		Deep Indoor (basement) :	Blocking, No reception after 50m
	Config3:	Indoor:	Some Blocking
		Deep Indoor (basement) :	Blocking, No reception after 50m
	Config4:	Indoor:	Some Blocking
		Deep Indoor (basement) :	Blocking, No reception after 60m
 Source : http://www.wikito.org/	**275 DUNDAS**		
	Config1:	Indoor :	Blocking after 20m
	Config2:	Indoor :	Some blocking, but overall good reception
	Config3:	Indoor :	Some blocking, but overall good reception
	Config4:	Indoor :	Some rare blocking, otherwise perfect reception

TABLE 5-5 - PEDESTRIAN DEEP INDOOR EVALUATION RESULTS

In summary, a building with a lot of windows performs very well with every configuration. Reception on higher floors, even in the center, is expected to be adequate. On the first floor of very tall buildings, having a more robust configuration helps to get a reliable signal. When venturing down in basements, the attenuation is too high even with the best configuration. After a few meters, the receiver is unable to decode the signal. For buildings with only a few floors, it is sometimes possible to decode the signal in the basement.

6 FIELD STRENGTH MEASUREMENTS RESULTS

6.1 MOBILE MEASUREMENTS AT 2M RESULTS

Mobile field strength measurements at 2m are important in order to quantify the expected coverage while on the move (i.e. in a bus). They will also help us determine the field strength threshold in the following section.

The map of interest of this section is DT-0614 at APPENDIX C. The different color shades represent field strength values obtained from a realistic prediction algorithm. Calculations were made with CRC-COVLAB, a coverage planning software. The colored path represents actual field strength measurements at 2m.

Many different realistic propagation models were tested in order to find the best match with the measurements: Longley-Rice v1.2.2, TIREM v3.19, Predict v2.08 and Predict v3.21. All simulations were made at 2m to reflect the height of the actual receiver. At the end, Predict v3.21 was chosen with the following parameters:

Propagation model	CRC-Predict v3.21
Height of the receiver	2 m
Location and time availability	50%, 90%
Elevation database	Canadian Digital Elevation Database (CDED)
Landcover database	CRC landcover driver

TABLE 6-1 - PARAMETERS FOR THE CHOSEN PROPAGATION MODEL

In addition to these parameters, landcover definitions for certain terrain types had to be adjusted in order to reflect the measurements. An additional attenuation of 3 dB was adjusted to “Suburban” terrain and an additional attenuation of 5 dB to “Bare ground” terrain. These attenuations were applied after realizing that most areas that were defined as “Suburban” were in fact larger urban cities and that villages and small forests where defined as “Bare ground”.

As can be observed on map DT-0614, with these additional attenuations, measurements generally correspond to the simulation. Near the transmission site, field strength measurements are slightly lower than expected, but as we move away from the site, the measurements fit better with the simulation.

It should be noted that the landcover characteristics and precision have a significant influence on the results in the UHF band with a receiver at 2 metres.

7 FIELD STRENGHT THRESHOLD ANALYSIS

Previous mobile DTV studies have proposed field strength thresholds (FST) for different usage of mobile devices. Here is such a table from the whitepaper titled *A New Prediction Model for Mobile DTV Service*[15] prepared for the OMVC (Table 7-1).

Use Case	**FST** (dBuV/m)
Automotive Mode	55
Pedestrian Mode - Outside	72
Pedestrian Mode - Inside	82

TABLE 7-1 - FIELD STRENGHT THRESHOLDS FROM OMVC WHITEPAPER

The methods used to determine the field strength thresholds are "semi-empirical". They analyzed field data and chose a propagation model accordingly. TIREM v3.19 propagation model was chosen and "best fit" parameters were determined from the field data. However, there were no mentions in the paper on the effect of the FEC configurations on the different thresholds.

Another study by Rohde & Schwarz titled *Planning Factor (Link Budget) ATSC Mobile DTV*[16] also proposes field strength thresholds (See Table 7-2).

Use Case	**FST Config 4 QQQQ RS48** (dBuV/m)	**FST Config 2 HHHH RS48** (dBuV/m)
Pedestrian Deep Indoor	84	88
Pedestrian Indoor	77	81
Vehicle Inside	70	75
Pedestrian Outdoor	63	67
Vehicle Roof Antenna	62	67

TABLE 7-2 - FIELD STRENGHT THRESHOLDS FROM R&S WHITEPAPER

The methods developed by Rohde & Schwarz is a first approximation of ATSC mobile DTV service contours (it uses F(50,90) curves) and is more theoretically based. A realistic propagation algorithm that uses terrain and landcover databases should be used with the planning factors described in the paper. The advantage of this paper compared with the OMVC paper is that it takes FEC configurations into account.

Thresholds from both these papers could be used in planning the coverage of future mobile DTV station at CBC, but first we have to assess if they match our observations in the field. The methodology used is simple: compare the different subjective evaluations from our campaign with simulations using Predict v3.21

[15] *See* COOPER, Charles, TAWIL, Victor (OMVC). *A New Prediction Model for M/H Mobile DTV Service,* June 2011 http://www.openmobilevideo.com/_assets/docs/OMVC_Paper_Mobile_Propagation.pdf

[16] SIMON, Mike (Rohde & Schwarz). *Planning Factor (Link Budget) ATSC Mobile DTV Whitepaper,* 2010 http://www2.rohde-schwarz.com/file_14460/mh2_wp-v1.pdf

(determined from section 6.1). By varying the thresholds of the simulation, we can determine visually the field strength threshold of each use cases.

Figure 12 shows the FST obtained with the QQQQ RS48 configuration for the "Vehicle Roof Antenna" use case. The FST for this case was determined to be 56 dBuV/m. This is very close to the result of 55 dBuV/m of the OMVC paper which also used a semi-empirical method, but it is 6dB lower than the R&S whitepaper, where a theoretical method was used. Figures for the other use cases are available in APPENDIX D.

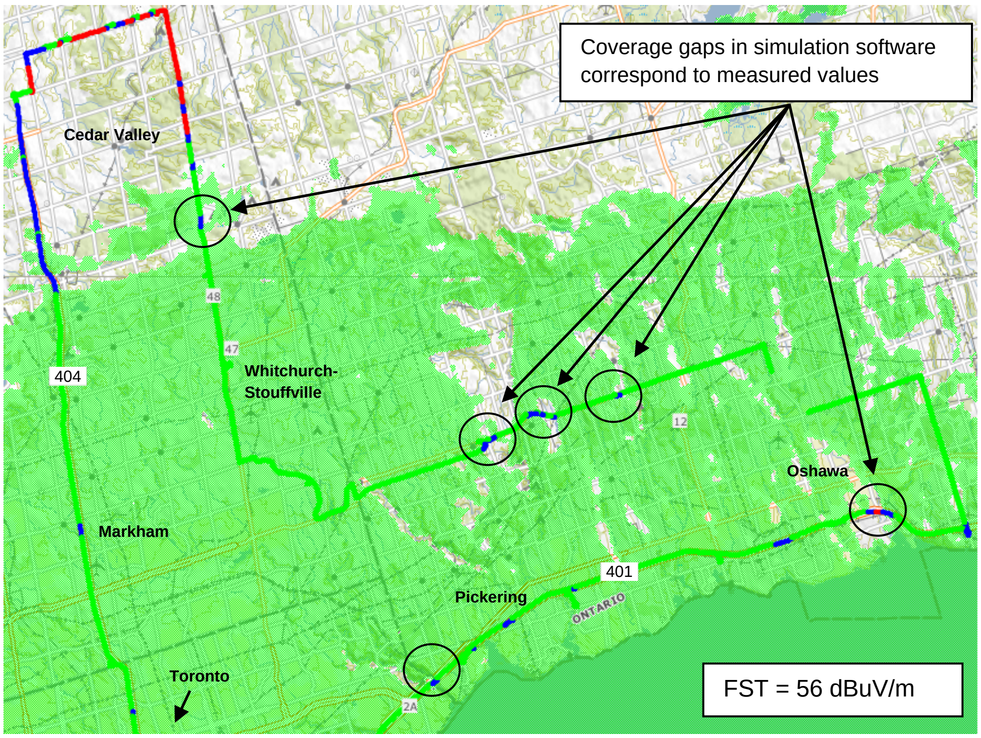


FIGURE 12 - VEHICULE ROOF ANTENNA CASE (QQQQ RS48): PREDICT V3.21 WITH A FST OF 56 DBUV/M AND CONFIG. 4 SVSQA

Table 7-3 summarizes the FST that were found for the vehicle use cases. These thresholds should be used for future mobile DTV coverage planning at the CBC.

Use Case	FST Config 4 QQQQ RS48 (dBuV/m)		FST Config 2 HHHH RS48 (dBuV/m)	
	CBC	R&S	CBC	R&S
Vehicle Inside	**62** (-10)	72	**72** (-3)	75
Vehicle Roof Antenna	**56** (-6)	62	**68** (+1)	67

TABLE 7-3 - FIELD STRENGHT THRESHOLDS FROM CBC'S TRIALS (EMPIRIC METHOD)

A comparison between our results and those of the Rohde & Schwarz paper was made. For configuration QQQQ RS48, the FST required to decode the ATSC M/H signal is clearly lower than what was stated in the Rohde & Schwarz paper. For configuration HHHH RS48, the results are similar to those of the Rohde & Schwarz paper.

For the Pedestrian Outdoor and Indoor use cases, while it's true that evaluation results match to some extent with the proposed FST, there is not enough data to come to a conclusion (measured data is not collected in automated manner). For the Pedestrian Deep Indoor case, it is the opinion of the evaluators that there is no FST that can guarantee reception. It depends too much on the specific attenuation of the particular building. The higher the field strength at that location, the higher the chance you will be able to decode the signal deep inside. But even if you are in proximity to the transmission site, if you are below a few feet of concrete, there is no guarantee that the signal will not be completely attenuated. Because of these reasons, it is recommended not to take the Pedestrian Deep Indoor case into account in future mobile DTV coverage planning.

8 CONCLUSION AND RECOMMENDATIONS

Mobile DTV field testing and measurements in Toronto was the first coverage tests and analysis performed by CBC/Radio-Canada with this new technology. A number of different forward error correction configurations were tested with the goal of finding one that is best suited for CBC's requirements.

- If it is desired to implement one Mobile DTV program on a DTV channel, it is recommended to use configuration 4 (QQQQ RS48). It is the by far the most robust and reliable configuration. It comes at a certain bandwidth cost, but since there is no sub-channel on any of CBC's digital channel, there is sufficient bandwidth for the main ATSC service (with PSIP) and a mobile DTV service.
- If it is desired to implement two Mobile DTV programs on a single DTV channel, it is recommended to use configuration 2 for both. It would take the same total bandwidth amount as the first option, but the coverage would be reduced. Depending on the target market, it is also possible to use a combination of configuration 2 and 4 (as shown on Figure 7).
- Configurations 1 and 3 have been discarded because of their bad performance and bandwidth usage.

Coverage tests have also given us the opportunity find a suitable method of planning the coverage of future mobile DTV installations. A proper prediction algorithm has been identified and some proposed thresholds have been evaluated.

- Predict v3.21 gave the best results and Table 7-3 field strength thresholds were validated as a starting point for future Mobile DTV studies. These thresholds could be revalidated or readjusted during future coverage tests. The use case "Pedestrian Deep Indoor" was not retained for future mobile DTV planning, because deep indoor attenuation varies too much from building to building and there are no thresholds that can guarantee deep indoor reception.
- Land cover attenuations for certain terrain types have been adjusted. Special attention to the land cover database should be made when planning the coverage of future ATSC M/H stations. In the UHF band, with a receiving antenna at this height, the land cover has a big influence on field strength simulations.

For future Mobile DTV analysis, it is also recommended to:

- Fine-tune the field strength thresholds with the newly collected data
- Study the impact of the polarization of the transmit antenna on the coverage

As a last note, should the CBC be interested in implementing mobile DTV technology, other advance features such as Single Frequency Networks can also be evaluated to improve coverage.

9 AKNOWLEDGEMENT

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Sébastien Gasse – Senior Maintenance Technician – CBC Transmission
Neil Irvine – Senior Maintenance Technician – CBC Transmission
Marc Germain – Project Manager - CBC Transmission
François Bachand – Senior Project Manager – CBC Transmission

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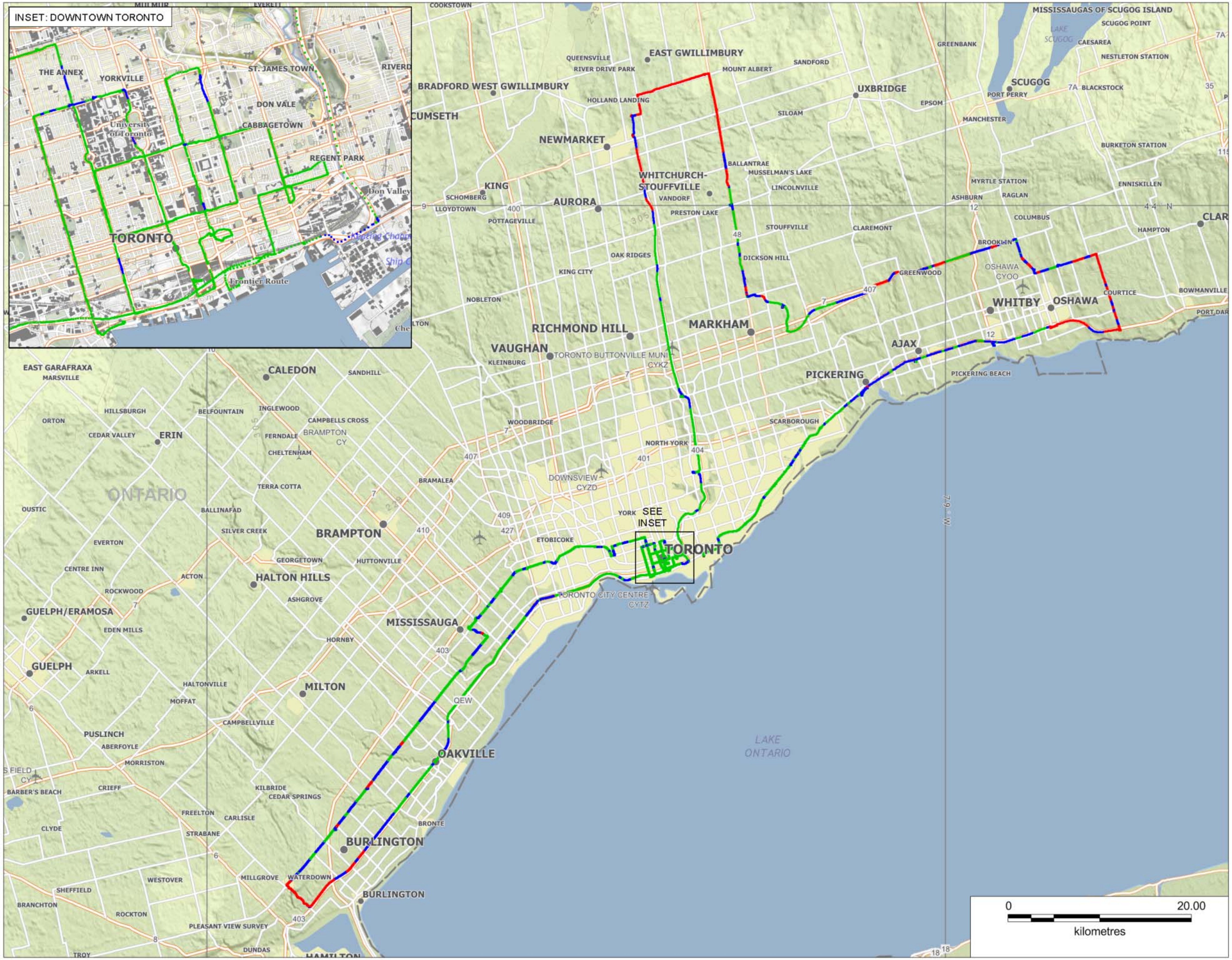
APPENDIX A - SUBJECTIVE AND SOUND QUALITY EVALUATION AT 2M (VEHICULE)



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With Built-In Antenna - Configuration #1

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

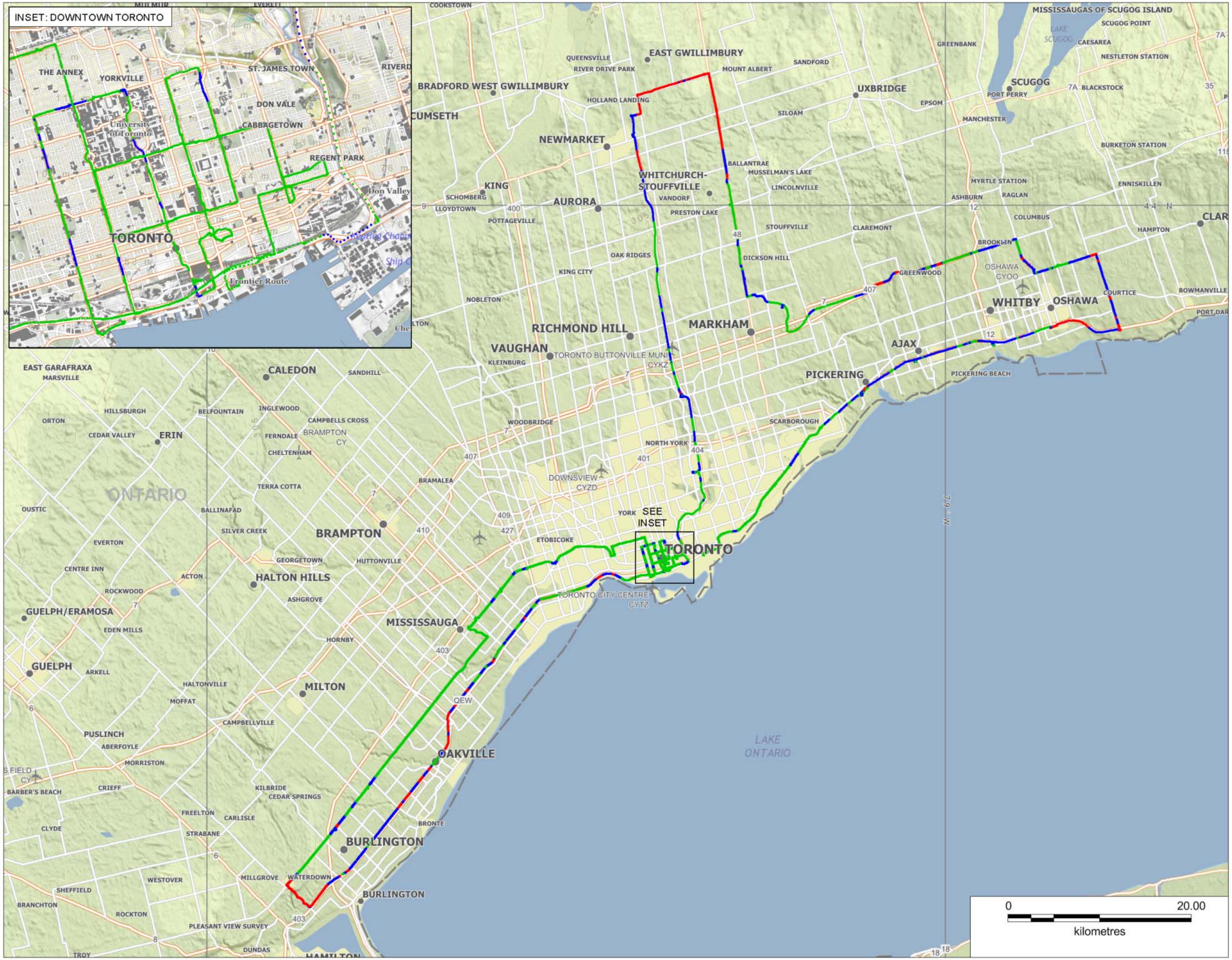
CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH BUILT-IN ANTENNA
CONFIGURATION #1
REED-SOLOMON: 24
SCCC: HHHH

Drawn by/Dessiné par	Date
I. Houle	23 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	
DT-0575	



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With External Antenna - Configuration #1

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

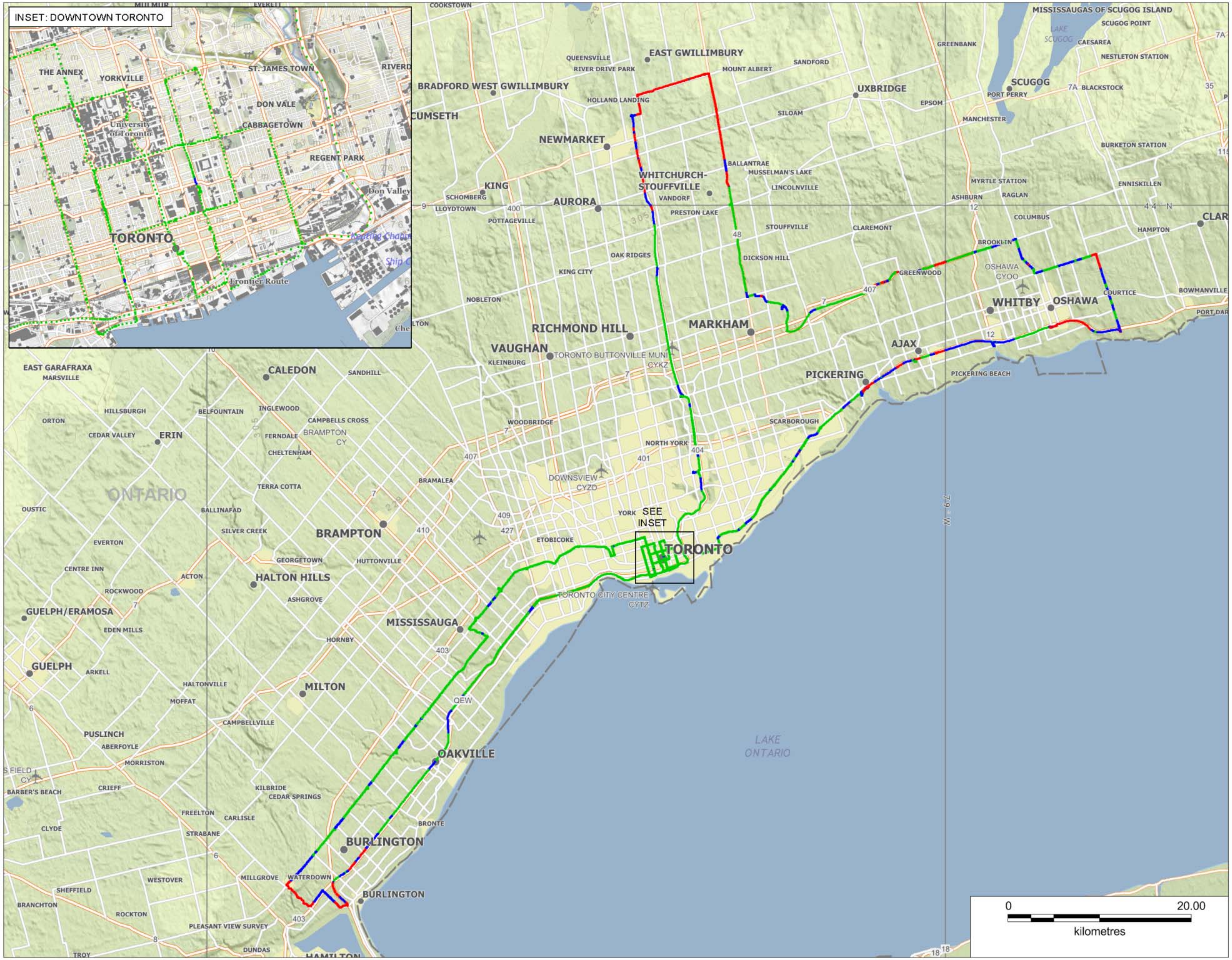
CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH EXTERNAL ANTENNA
CONFIGURATION #1
REED-SOLOMON: 24
SCCC: HHHH

Drawn by/Dessiné par	Date
I. Houle	23 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	DT-0576



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With Built-In Antenna - Configuration #2

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

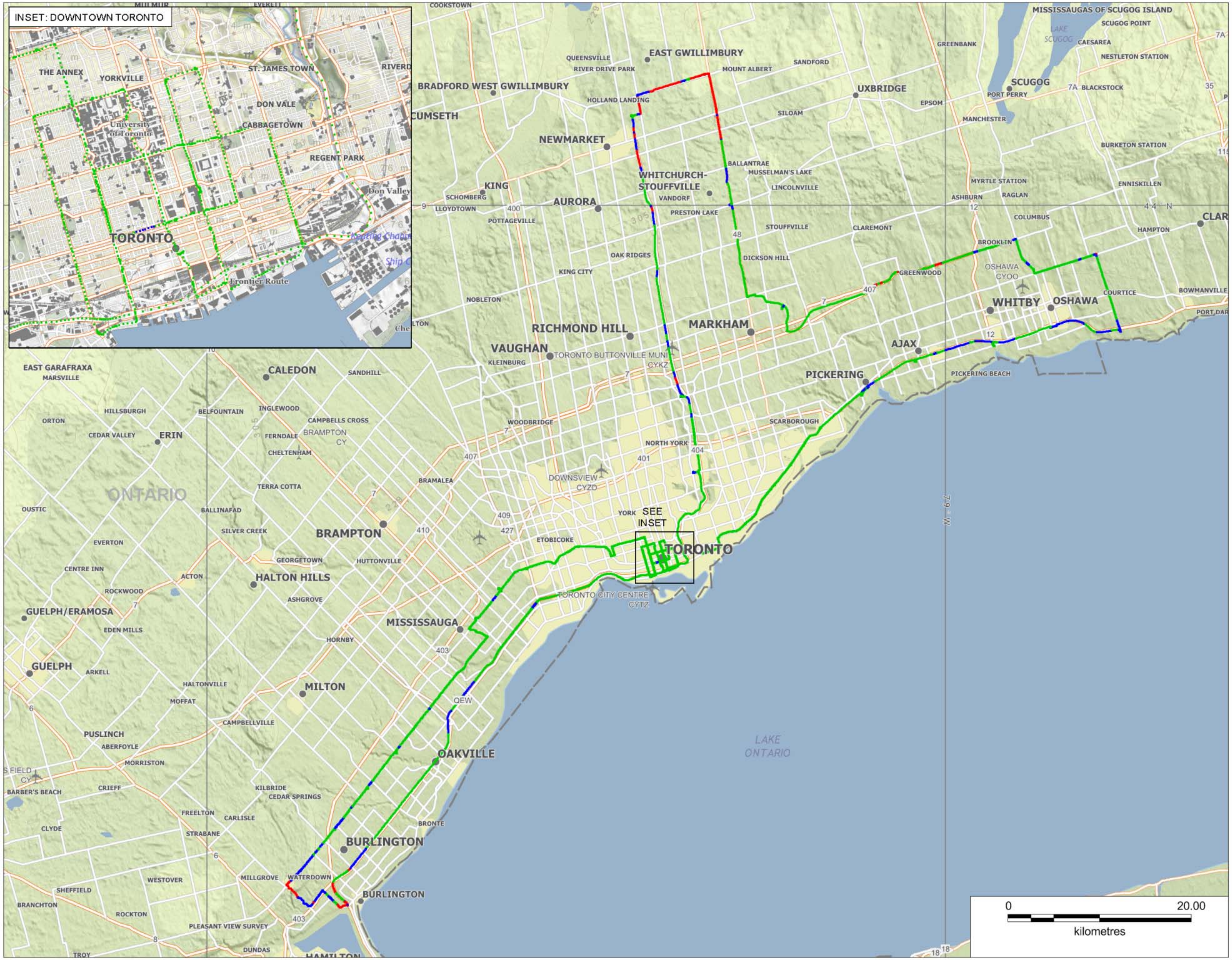
SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH BUILT-IN ANTENNA
CONFIGURATION #2
REED-SOLOMON: 48
SCCC: HHHH

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.

No.

DT-0577



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With External Antenna - Configuration #2

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH EXTERNAL ANTENNA
CONFIGURATION #2
REED-SOLOMON: 48
SCCC: HHHH

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	DT-0578

Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With Built-In Antenna - Configuration #3

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

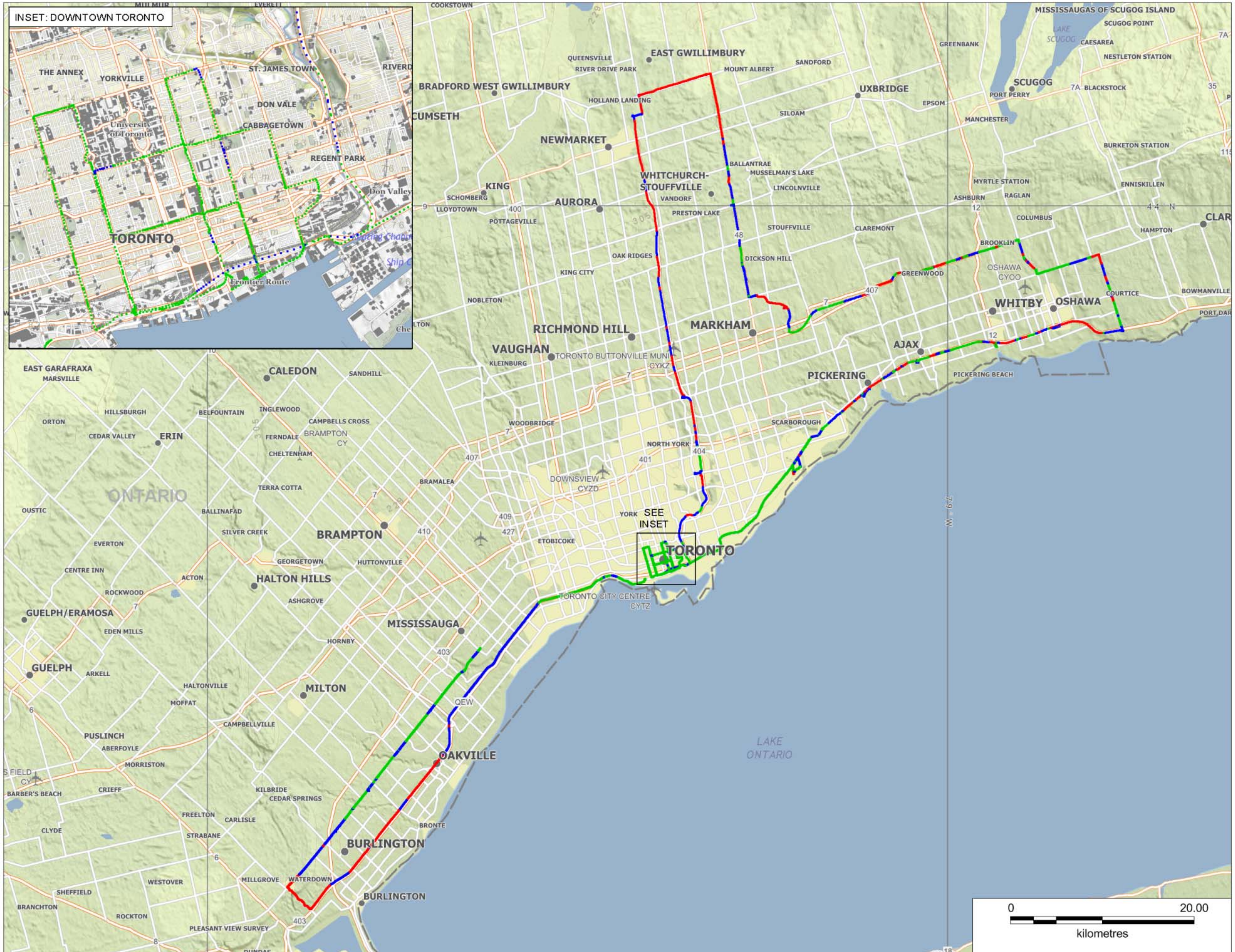
SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH BUILT-IN ANTENNA
CONFIGURATION #3
REED-SOLOMON: 48
SCCC: QQHH

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.

No.

DT-0579



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With External Antenna - Configuration #3

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

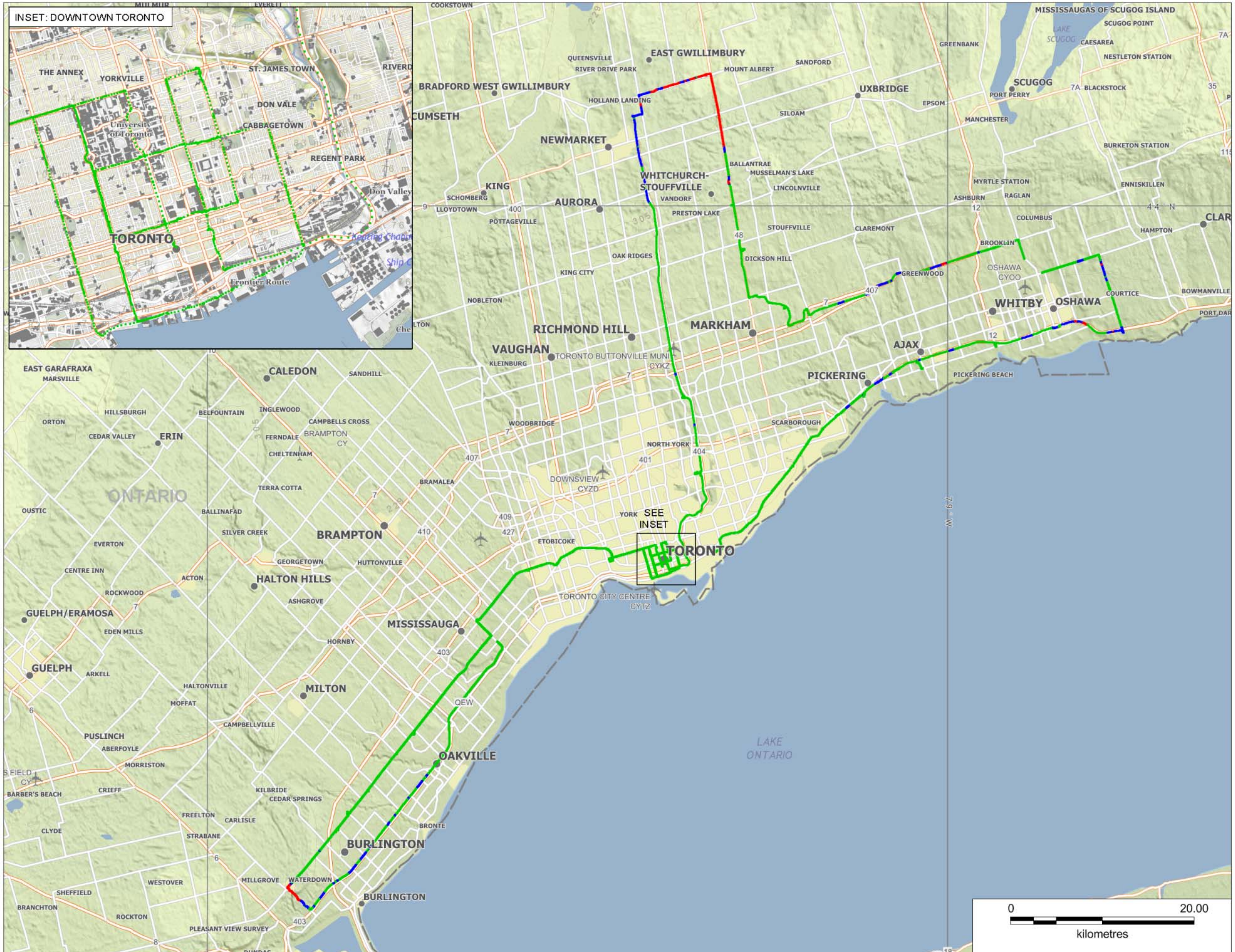
CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH EXTERNAL ANTENNA
CONFIGURATION #3
REED-SOLOMON: 48
SCCC: QQHH

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	
DT-0580	



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With Built-In Antenna - Configuration #4

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

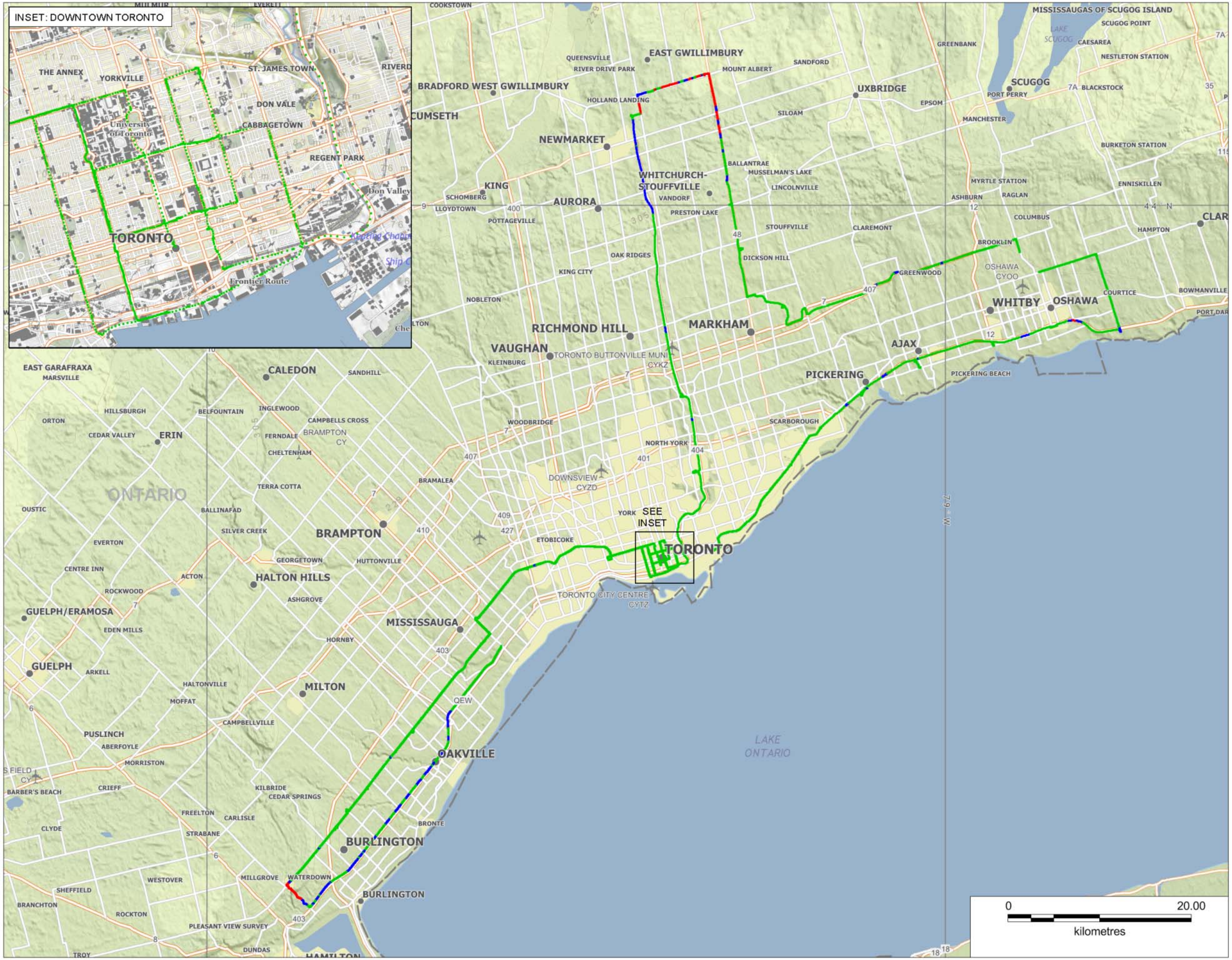
CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH BUILT-IN ANTENNA
CONFIGURATION #4
REED-SOLOMON: 48
SCCC: QQQQ

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	
DT-0581	



Legend

Subjective Quality Evaluation (SQA)

RCA Receiver With External Antenna - Configuration #4

- Excellent (5)
- Blocking/Flickering (3)
- No Reception (1)

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

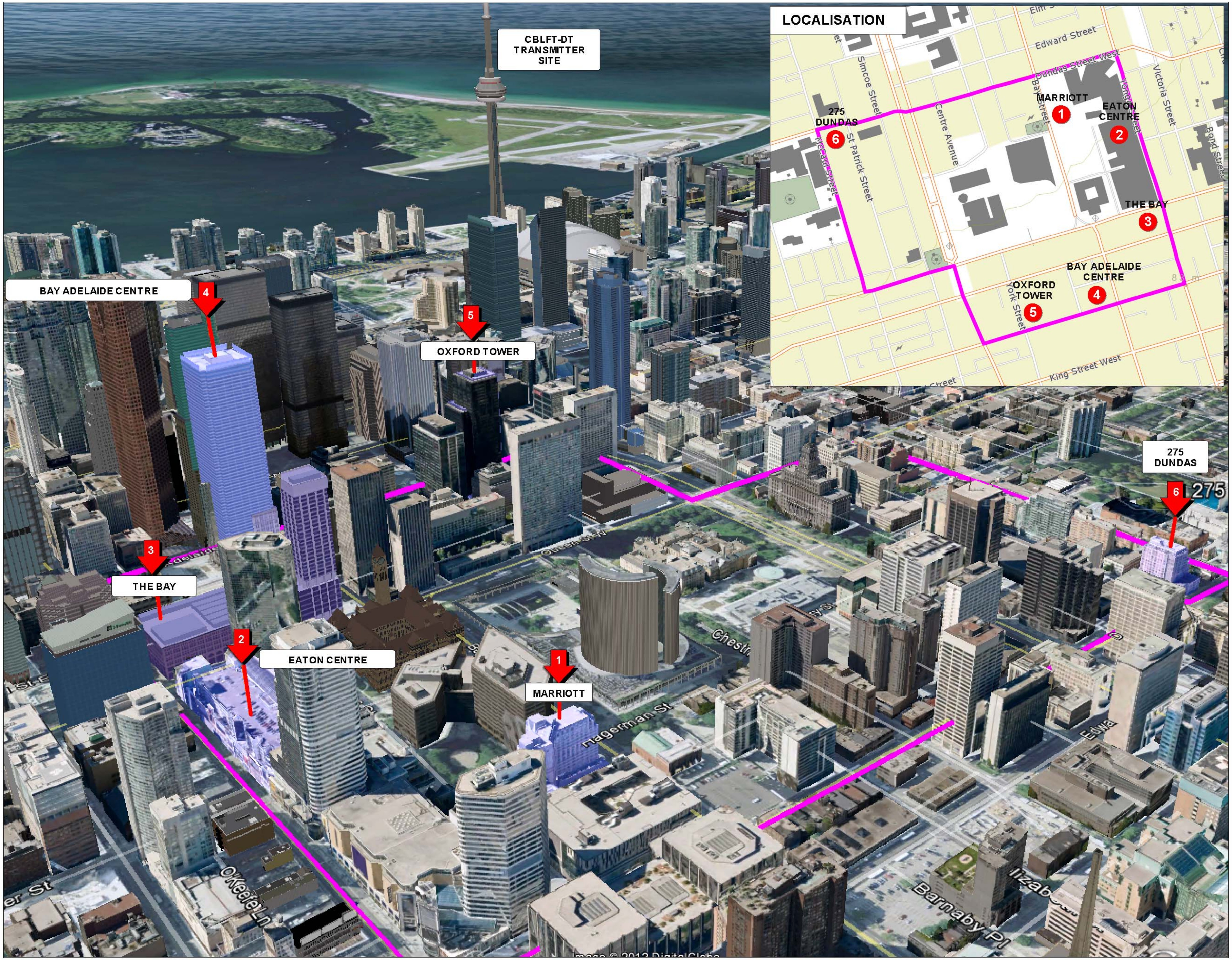
Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

RCA RECEIVER WITH EXTERNAL ANTENNA
CONFIGURATION #4
REED-SOLOMON: 48
SCCC: QQQQ

Drawn by/Dessiné par	Date
I. Houle	24 mai 2012
Checked by/Verifié par	Approved by/Approuvé par
C. Rousseau, Eng.	C. Rousseau, Eng.
No.	DT-0582

APPENDIX B - SUBJECTIVE AND SOUND QUALITY EVALUATION (PEDESTRIAN)



Legend

Pedestrian Path

Evaluated Locations:

1 Marriott
2 Eaton Centre
3 The Bay
4 Bay Adelaide Centre
5 Oxford Tower
6 275 Dundas

Stamp/Sceau

CBC Radio-Canada

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Spectrum Engineering - Ingénierie du spectre

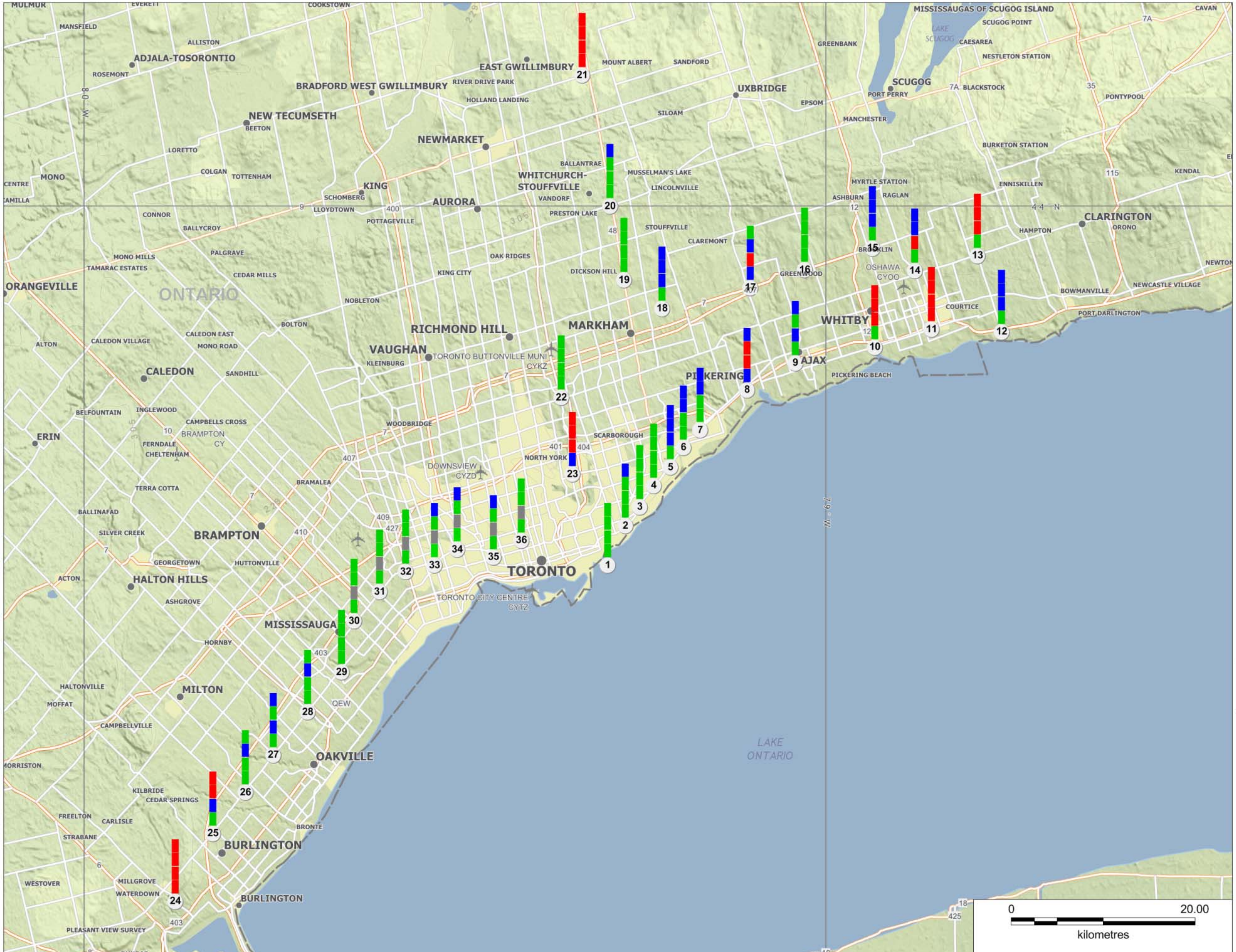
CBLFT-DT - MOBILE DIGITAL
TELEVISION MEASUREMENTS
TORONTO, ONTARIO

PEDESTRIAN PATH

Drawn by/Dessiné par	Date
I. Houle	July 4, 2012
Checked by/Verifié par	Approved by/Approuvé par
P.-A. Nolet, Jr. Eng.	C. Rousseau, Eng.

No.

DT-0586



Legend

Subjective Quality Evaluation

Pedestrian Outdoor

- SVQA Config. # 1 - HHHH RS24
- SVQA Config. # 2 - HHHH RS48
- SVQA Config. # 3 - QQHH RS48
- SVQA Config. # 4 - QQQQ RS48

0 Point Number & Location

- Perfect
- Blocking/Flickering
- Nothing
- Non Applicable

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

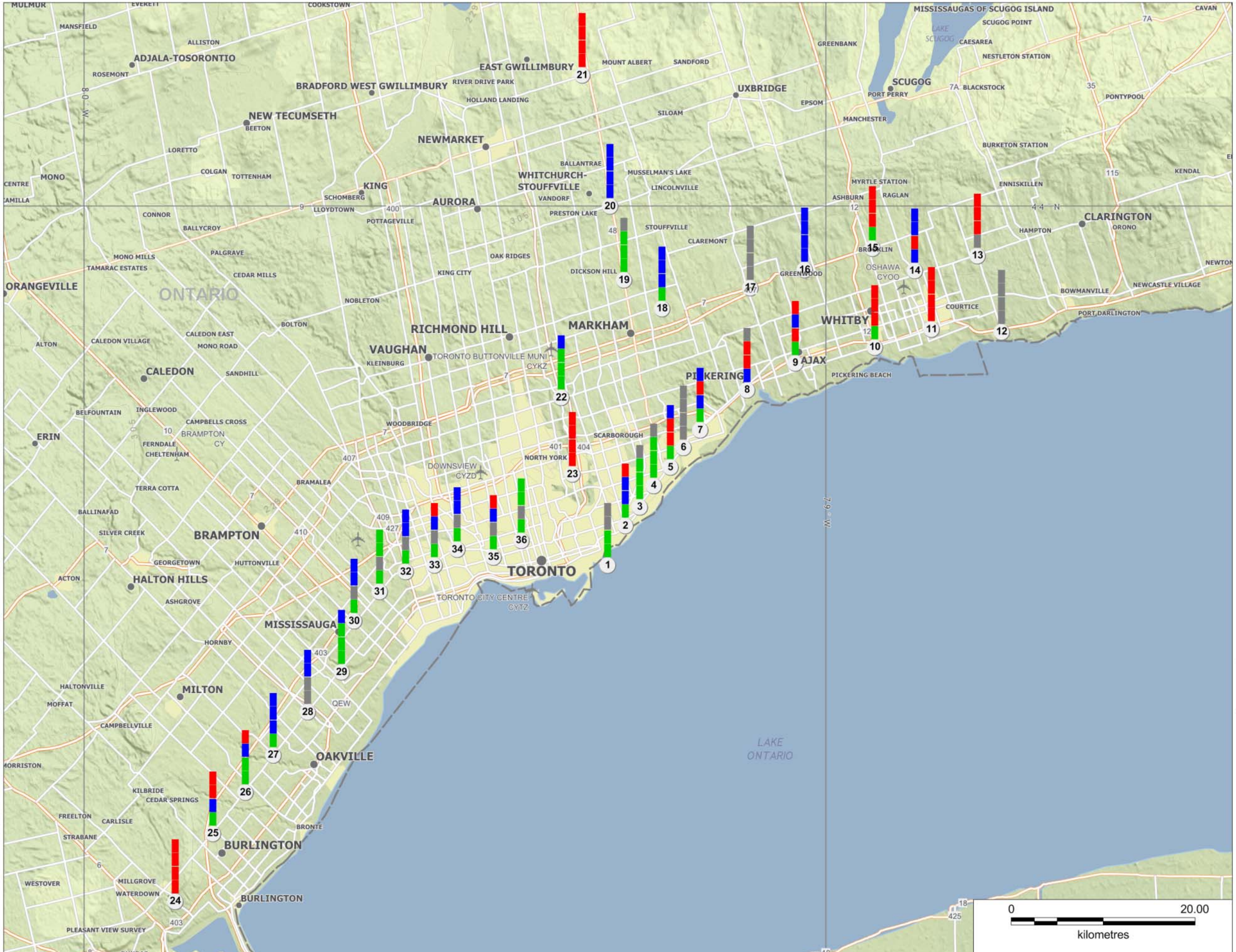
Spectrum Engineering - Ingénierie du spectre

SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

PEDESTRIAN OUTDOOR

CA.: 25R HEASM: 491.0 M
P.A.R.: 106,2 KW
LAT.: 43º 38' 33" N. LONG.: 79º 23' 14" W.

Drawn by/Dessiné par	Date
I. Houle	July 4, 2012
Checked by/Verifié par	Approved by/Approuvé par
P.-A. Nolet, Jr. Eng.	C. Rousseau, Eng.
No.	DT-0591



Legend

Subjective Quality Evaluation

Pedestrian Indoor

→ SVQA Config. # 1 - HHHH RS24
→ SVQA Config. # 2 - HHHH RS48
→ SVQA Config. # 3 - QQHH RS48
→ SVQA Config. # 4 - QQQQ RS48

0 → Point Number & Location

Perfect

Blocking/Flickering

Nothing

Non Applicable

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION

Spectrum Engineering - Ingénierie du spectre

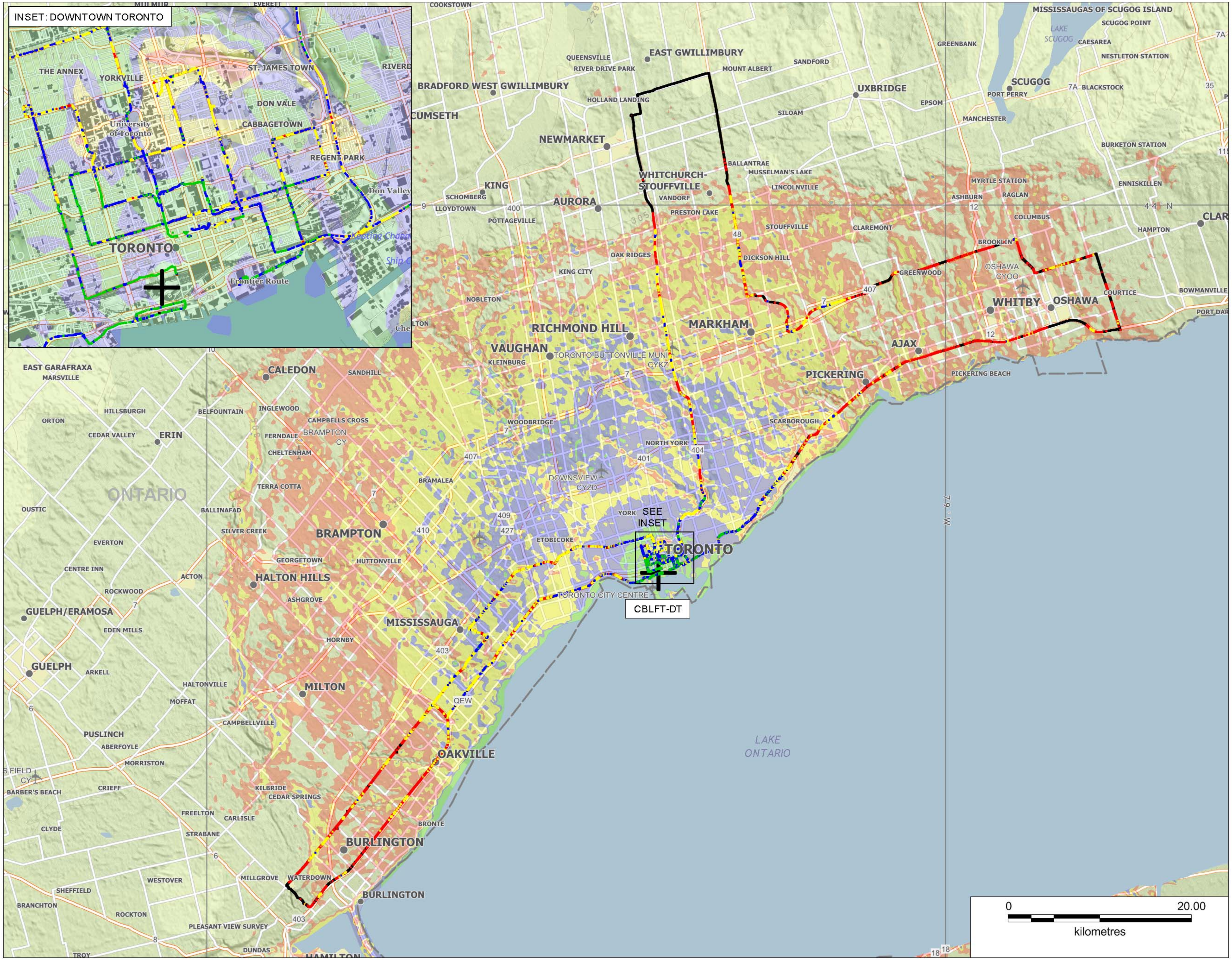
SUBJECTIVE QUALITY EVALUATION
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO

PEDESTRIAN INDOOR

CA.: 25R HEASM: 491.0 M
P.A.R.: 106,2 KW
LAT.: 43º 38' 33" N. LONG.: 79º 23' 14" W.

Drawn by/Dessiné par	Date
I. Houle	July 4, 2012
Checked by/Verifié par	Approved by/Approuvé par
P.-A. Nolet, Jr. Eng.	C. Rousseau, Eng.
No. DT-0592	

APPENDIX C MOBILE FIELD STRENGH MEASUREMENT AT 2M



Legend

Field Strength Measurements at 2 metres

- 84 dBµV/m and + Pedestrian Deep Indoor (B2)
- 77 - 84 dBµV/m Pedestrian Indoor (B1)
- 70 - 77 dBµV/m Vehicle Inside (D)
- 62 -70 dBµV/m Pedestrian Outdoor (A) and Vehicle Roof Antenna (C)
- 0 - 62 dBµV/m

PREDICT V. 3.21 @ 2 metres - P(50,90)*

- 84 - 200 dBµV/m
- 77 - 84 dBµV/m
- 70 - 77 dBµV/m
- 62 - 70 dBµV/m

Elevation and Landcover Databases: CDED and CRC-500
Additional CRC-500 Landcovers Attenuation: Suburban +3dB, Bareground +5dB

Stamp/Sceau

CBC Radio-Canada

CBC/RADIO-CANADA TRANSMISSION
Spectrum Engineering - Ingénierie du spectre

MOBILE FIELD STRENGTH MEASUREMENTS
AT 2 METRES
CBLFT-DT - MOBILE DIGITAL TELEVISION
TORONTO, ONTARIO
CA.: 25R HEASM: 491.0 M
P.A.R.: 106,2 KW
LAT.: 43° 38' 33" N. LONG.: 79° 23' 14" O.

Drawn by/Dessiné par	Date
I. Houle	October 17, 2012
Checked by/Verifié par	Approved by/Approuvé par
P.-A. Nolet, Jr. Eng.	C. Rousseau, Eng.

No.
DT-0614

APPENDIX D – FIELD STRENGTH THRESHOLD ANALYSIS

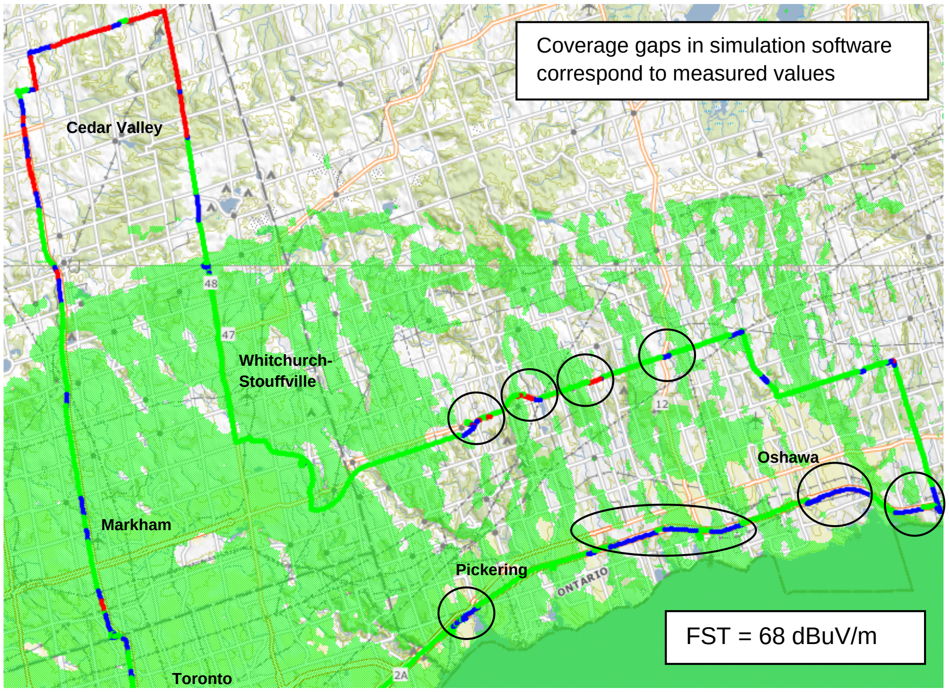


FIGURE 13 - VEHICULE ROOF ANTENNA CASE (HHHH RS48): PREDICT V3.21 WITH A FST OF 68 DBUV/M AND CONFIG. 2 SVSQA

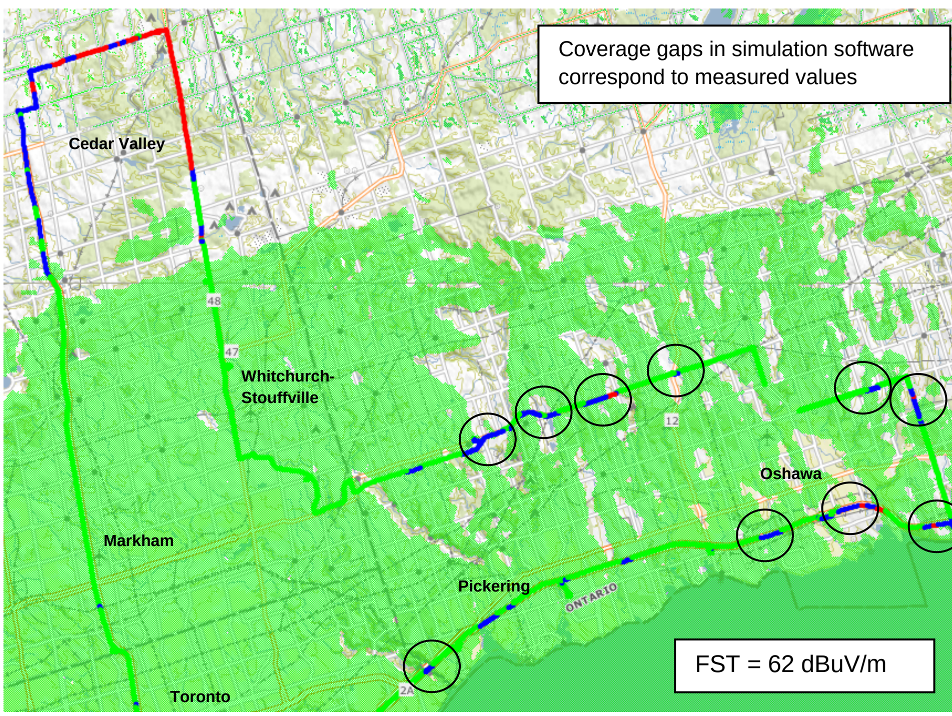


FIGURE 14 - VEHICULE INSIDE CASE (QQQQ RS48): PREDICT V3.21 WITH A FST OF 62 DBUV/M AND CONFIG. 4 SVSQA

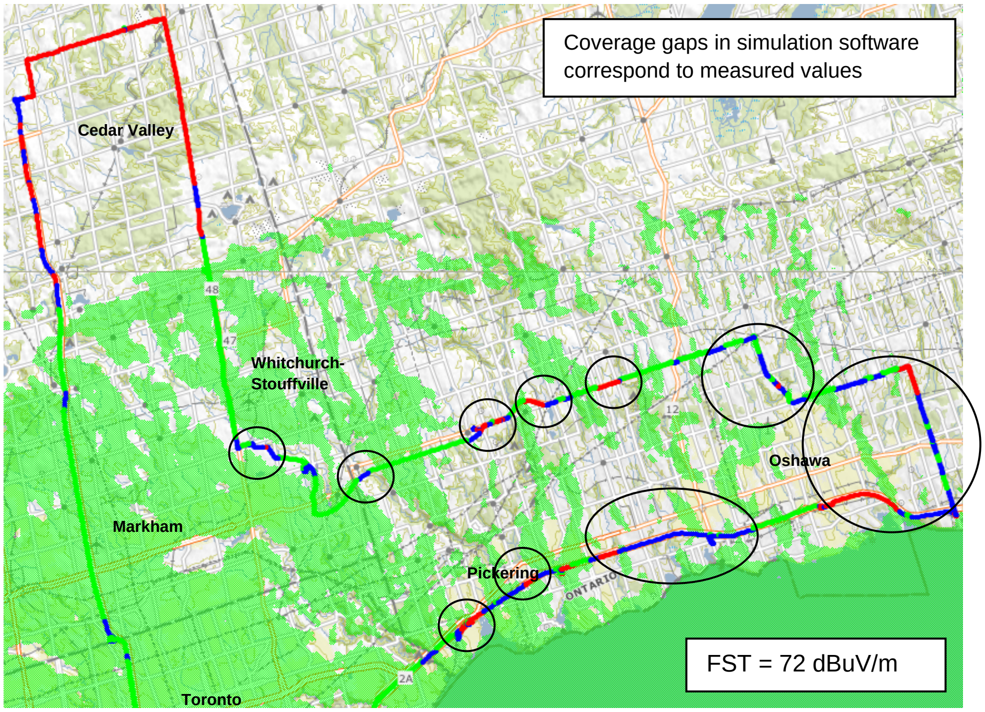


FIGURE 15 - VEHICULE INSIDE CASE (HHHH RS48): PREDICT V3.21 WITH A FST OF 72 DBUV/M AND CONFIG. 2 SVSQA