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TV TechCheck

The Weekly NAB Newsletter for Television Broadcast Engineers

Creation of Real World Test Signals for ATSC Mobile DTV Receiver Performance Examined at NAB Show

Yiyan Wu, Principal Research Scientist, CRC, accepts Best Paper Award from BEC Conference Committee Chairman Steve Fluker, Cox Radio

Each year, presenters at the NAB Broadcast Engineering Conference are urged to submit written papers on the subject of their presentations. The yearly *NAB Broadcast Engineering Conference Proceedings*, published as both a book and a CD-ROM, and sold at the NAB Store in the Las Vegas Convention Center during the NAB Show – and at www.NABStore.com after the Show – is a compendium of these technical papers, and an important archive of the leading edge of broadcast engineering issues. The NAB Best Paper Award, established in 2010, honors the author(s) of a paper of exceptional merit published in the *Proceedings*, and is announced at the annual Technology Luncheon. At this year's Show, the award was given for the paper "Creation of a Library of RF Recorded Signals for ATSC Mobile DTV in a Single Frequency Network Environment" authored by Charles Nadeau, Benoit Ledoux, Yiyan Wu, Gilles Gagnon, Robert Gagnon and Sébastien Laflèche, of the Communications Research Centre, Canada. The paper is excerpted below.

INTRODUCTION

With the growing interest in Single Frequency Networks (SFN) as a possible solution to increase reception coverage for mobile receivers and handheld devices, it is desirable to have a reliable and repeatable way of testing ATSC-M/H receivers' performance in mobile SFN environments. One such way is to test the ATSC-M/H receivers by using a library of well characterised RF captured field ensembles. The Communications Research Centre Canada (CRC) took the initiative of working on such a library, which contains RF captures of SFN mobile channels from areas with various types of population density, vehicle speed and carrier-to-noise ratio. This article describes how the RF captured field ensembles were recorded, selected and evaluated. Furthermore, this is followed by an analysis demonstrating how using real field captures to test current generation ATSC-M/H receivers yield interesting results that were not apparent during standard laboratory characterisation of these receivers.

ATSC-M/H SFN TRANSMISSION SYSTEM

The transmission system used in the creation of the RF captured field ensembles is a Single Frequency Network located in Ottawa, Ontario, and operated by CRC for television broadcast research. Four low-power transmitters cover the Ottawa region and transmit the ATSC-M/H signal on UHF channel 46. Figure 1 illustrates the topology and power output of the four transmitters, with lighter areas indicating reception power over -80 dBm, as predicted by CRC-COVLAB [1].

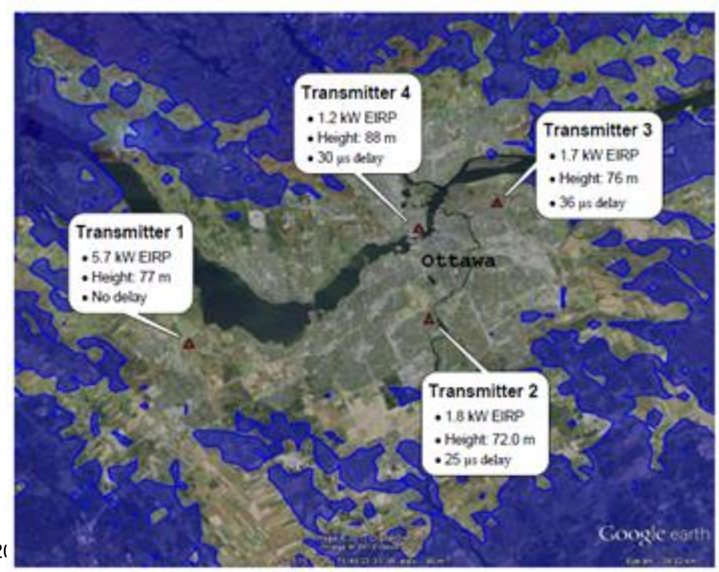

FIGURE 1: CRC SFN TRANSMITTERS AND COVERAGE MAP

The synchronization delay at each transmitter was set to minimize multipath spread in the downtown Ottawa area. Each transmitter also broadcasts a watermark TxID injected at 30 dB below the main signal, as per standard A/110 [2].
The ATSC-M/H signal carries three services, each with its own ensemble and its own Serial Concatenated Convolution Code

(SCCC) rate, as described in standard A/153 [3]. All ensembles use the Reed-Solomon parity of 48 bytes. The three services are identified as follows throughout this paper:

· **½ Rate**: All SCCC regions are ½ rate coded
· **¼ Rate**: All SCCC regions are ¼ rate coded
· **Mixed Rate:** SCCC Region A is ½ rate coded. Regions B, C and D are ¼ rate.

RF RECORDING FIELD CAMPAIGN

I. Selection of Areas of Interest
In order to build a library of diverse and representative RF captured field ensembles, different areas of interest were identified within the coverage of the Ottawa SFN. Areas of interests include regions of densely populated areas with high rise buildings (urban areas) and residential and low-density areas (suburban areas). Testing areas were also chosen to have a variety of traffic conditions and speed limits, from high traffic downtown streets to high speed freeways.

A preliminary power survey was first performed to determine the reception power in each area of interest from each individual SFN transmitter. From this information, test routes were created along specific paths, under the following conditions: two or more transmitters had to be operational; if a transmitter had an irrelevant or an overwhelming (single transmitter equivalent) contribution along the test route, it was turned off; and the relative receive power from the active transmitters had to be within 10 dB of each other along the chosen route. This ensured valid and challenging SFN reception conditions for ATSC-M/H receivers.

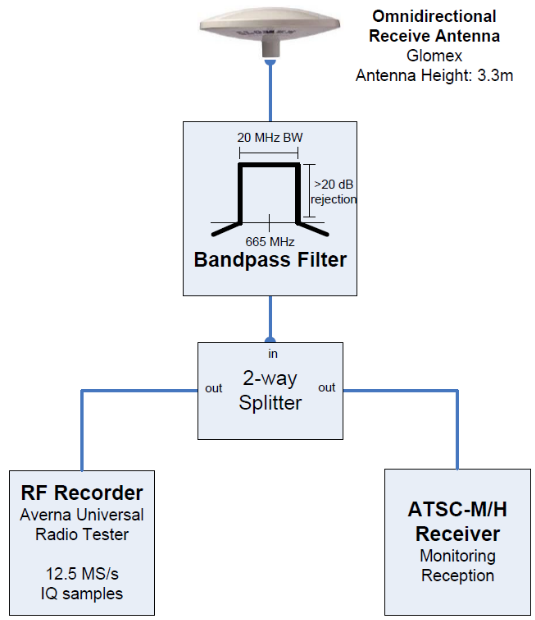

FIGURE 2: RF RECORDING CAMPAIGN TEST SETUP FOR RF SIGNAL RECORDING

II. System Setup and Methodology for RF Signal Recording
The RF recording campaign was done using a well characterized test setup. An omnidirectional antenna was installed on top of a test vehicle at 3.3 meters from the ground. The antenna was connected to a bandpass filter for channel 46 to prevent overloading the RF recorder front end. The filter output was split in two to feed the RF recorder input and an ATSC-M/H receiver to monitor reception. Figure 2 shows the block diagram of the test setup.

Recording the RF signal during the campaign simply involved driving along the chosen routes in each region of interest, respecting speed limits and road signalization. Depending on the area, the routes took between 2 to 25 minutes. Only the transmitters that were identified to produce challenging SFN reception conditions for each test route were turned on during a drive, as explained in the above section. The transmitters' outputs were controlled remotely from the test vehicle. A monitoring test site was also used to verify the transmitters' output power.

III. RF Recorder Hardware Considerations and Setup
Capturing RF signals correctly involves using a test setup that introduces the least amount of distortions to the captured signal while preserving important signal characteristics such as fast power variations and carrier-to-noise ratio (C/N). RF recorder hardware has its limitations in that the tuner has a noise figure and the digitizer has a limited dynamic range. A good recording system usually uses a slow automatic gain control (AGC) to bring the signal within optimal range of the digitizer, as to not overload the system and to maximize C/N. However, this bring its own problems such as the RF recorded power not being the real signal power when there are fast power variations (like in a mobile environment) because the AGC loop response time can impact the detected RF power. Moreover, using an AGC also affects the RF recordings' noise floor for low-power signals since the front end' noise floor becomes dominant and can vary when the AGC chain of amplifiers and attenuators changes states to respond to fast RF power variations that occur during mobile reception.
With this in mind, it was deemed important for this library of RF recordings to preserve signal power variations and to have a known noise floor that would become the noise floor that eventual receivers would see when the RF sequence would be played back. The RF recorder was thus setup with a fixed front end gain so the operating dynamic range at the digitizer is known and fixed. The system was then characterized to know this noise floor and to know the maximum input RF power without overloading the front end or the digitizer. This is a summary of the RF recorder setup:

- Sampling rate: 12.5 MS/s, IQ samples
- 10 MHz of effective bandwidth around the center frequency of 665 MHz (channel 46).
- No automatic gain control
- RF Recording Noise Floor: -94 dBm
- Maximum input power: -45 dBm

SELECTION OF RF CAPTURED FIELD ENSEMBLES

Following the campaign, six hours of raw RF recordings was available to build the library of RF captures. A pre-analysis was done in order to identify interesting portions within the raw data. It was decided that the RF captures should be 2 minutes in duration to be able to thoroughly analyse receivers' behavior over a mobile channel. The analysis was based on a combination of the following three evaluation characteristics considered over the 2 minutes duration:

- Carrier-to-Noise ratio
- Multipath channel profile (impulse response)
- Reception performance of the RF recordings when the signal is played back to a reference receiver.

After this pre-analysis, approximately 150 candidate RF captures were identified. From this pool of captures, the final selection was made to have a manageable number of captures that would cover the range of reception difficulty for all three services that were carried over the ATSC M/H signal. Thus, there would be captures that should be difficult for a receiver only for the ½ rate coded service, but easy for the more robust modes, and so on. Table 1 describes the difficulty categories that were used to classify the RF captures when testing them on an ATSC-M/H receiver.

TABLE 1: RECEPTION DIFFICULTY CLASSIFICATION OF RF CAPTURES FOR A GIVEN ATSC-M/H RECEIVER

Difficulty Category	Service SCCC code rate	Requirements to be part of this difficulty category
Very Easy	½ Rate	No errors
	Mixed Rate	No errors
	¼ Rate	No errors
Easy	½ Rate	At least 2 bursts of errors at least 5 seconds long
	Mixed Rate	No errors
	¼ Rate	No errors
Moderate	½ Rate	Lots of errors
	Mixed Rate	At least 2 bursts of errors at least 5 seconds long
	¼ Rate	No errors
Difficult	½ Rate	Lots of errors
	Mixed Rate	Lots of errors
	¼ Rate	At least 2 bursts of errors at least 5 seconds long
Very Difficult	½ Rate	Lots of errors
	Mixed Rate	Lots of errors
	¼ Rate	Lots of errors

*A single small burst less than 5 seconds during the RF playback is considered "No errors"

The final selection for the library of ATSC-M/H RF recordings includes 45 RF captures of 2 minutes length each evenly spread across the difficulty categories described in Table 1, considering reception performance for the best mobile DTV receiver available. The 45 chosen RF captures include many types of reception environments such as urban and suburban building density and different types of road speeds such as the stop-and-go drive of downtown areas, moderate speeds with occasional stops of suburban areas and high speed freeway drive. Table 2 shows how many RF captures fall in each general type of reception environment.

TABLE 2: NUMBER OF SELECTED RF CAPTURES IN EACH TYPE OF MOBILE RECEPTION ENVIRONMENT

Type of Area	Urban	Suburban	Freeway
Type of Driving Speed	<50 km/h Frequent Stops	30-70 km/h Occasional stops	90-110 km/h No stop
Number of Selected RF Captures	17	18	10

The complete paper is included in its entirety in the *2012 NAB Broadcast Engineering Conference Proceedings*, available online from the NAB Store (www.nabstore.com). Other technical papers related to mobile DTV published in the *Proceedings* include the following:

- *DVB-T2-Lite: A Second Wind for Mobile TV?,* Peter Siebert, Executive Director, DVB Project Office;
- *Elliptical Polarization: Influences on the Performance of Digital TV Coverage***,** Valderez Donzelli, MSC Engineer, Universidade Presbiteriana Mackenzie;
- *Mobile DTV Status Report and Transmission Update*, Sterling Davis, Consultant, Open Mobile Video Coalition (OMVC);
- *Mobile DTV as a Digital Radio Distribution Platform*, Joe Igoe, VP & Chief Tech Officer, WGBH.

Future of Broadcast Television Initiative Announces Leadership

Last week's *TV TechCheck* noted the official formation of the Future of Broadcast Television (FOBTV) Initiative at the NAB Show, founded by thirteen broadcast organizations around the world. On Wednesday April 25, the FOBTV Management Committee announced its leadership team. Mark Richer, President, Advanced Television Systems Committee (ATSC), was named Chairman and Phil Laven, Chairman, Digital Video Broadcasting (DVB) Project, was named Vice Chairman. Dr. Wenjun Zhang, Chief Scientist, National Engineering Research Center of DTV (NERC-DTV) of China, was named Chair of the Technical Committee. Three Technical Committee Vice Chairs were also named: Dr. Yiyan Wu, Principal Research Scientist, Communications Research Centre (CRC) Canada, Dr. Toru Kuroda, Director of Planning and Coordination Division, Japan Broadcasting Corporation (NHK) Science and Technology Research Laboratories and Dr. Namho Hur, General Director, Department of Broadcasting System Research, Electronics and Telecommunications Research Institute (ETRI) of Korea. For more information, see www.fobtv.org.

SBE Webinar: TV White Space Devices and Wireless Microphones

Wednesday, May 2, 2012
2 – 3 p.m. EDT

The FCC is now allowing unlicensed wireless devices to operate in vacant, or TV White Space, channels as well as accommodating unlicensed microphone use. This webinar provides an overview of what the FCC has authorized for unlicensed devices and how this will impact the daily operations of a broadcaster, news organization or production company.

Presenting this webinar is Joe Snelson, CPBE, 8-VSB, Vice President for the Society of Broadcast Engineers. Snelson is currently Vice President of Engineering for the Meredith Local Media Group. He is a member of the National Association of Broadcasters TV Technology Committee. He also chairs the SBE National Frequency Coordination Committee, and serves on the SBE National Certification Committee.

This webinar is FREE to SBE members through sponsorship by Shure and $39 for all others. Information on registering for the webinar is available here.