



**Report on the 2007 Survey of
The State of FM Broadcasting
in
Grand Cayman**

February 29, 2008

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**Report on the 2007 Survey of
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Executive Summary

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Preface

Since Hurricane Ivan, Broadcast Signal Lab has been retained by the Cayman Islands' Information Technology & Communications Authority ("ICTA") on two occasions to perform surveys of the evolving state of the FM spectrum in Grand Cayman. During the fall of 2007, the ICTA requested that a further survey be conducted by Broadcast Signal Lab to assess the impact of various recent developments in the FM broadcasting sector, including:

- One station had not returned to the air since Ivan (ICCI 101.1).
- Another recently had its licence revoked (Ocean 95.5).
- A recent request for a licence was awarded, but subsequently relinquished voluntarily by the licensee (The Cuda 95.7).
- One licence application outstanding on the West Bay side is being actively reviewed (West Point Radio 94.3).
- One licence was acquired by a group broadcaster, enlarging its portfolio to four stations on the island (CAYROCK 96.5).
- One signal (Weather 107.9) was not operating.
- With the loss of two broadcast operators over the past two years, presently five operators broadcast a total of 12 stations (13, including weather); and
- No stations are operating from temporary transmission facilities.

Introduction

During the week of 25 November 2007 Broadcast Signal Lab, LLP performed a survey of the FM broadcasting environment in Grand Cayman. This survey follows similar surveys commissioned by the ICTA in 2005 and 2006. The primary objective of each survey was to provide the ICTA and all FM broadcasting stakeholders with coverage and interference analysis that would inform the ICTA policy making and enforcement processes while giving FM broadcasters independent analysis of the condition of the FM broadcast band on the island.

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The objectives of the 2007 survey were:

- 1) To assess the results of the recent move of the dms Broadcasting Ltd. (“DMS”) transmitters (Hot 104.1, Kiss 106.1 and X-107.1) from the government tower in George Town to the government tower in Northward, in response to the interference concerns identified in the 2006 survey;
- 2) To determine the remaining interference conditions, if any, resulting from the continued operation of Heaven 97.7, Gospel 88.7, and newly renamed CAYROCK 96.5 (previously named Style 96.5) in George Town;
- 3) To address any pertinent spectrum issues raised by FM broadcasting stakeholders; and
- 4) To review the spectral purity and overall coverage of each station operating on the Island.

To remind the reader, there are two forms of interference that are examined. One is the interference induced into a receiver by the presence of one or more locally transmitted, strong signals. This is dependent on circumstance and the particular susceptibility of the receiver to such interference. This type of interference is commonly referred to as “receiver-induced interference” or “blanketing.” The other form of interference is that which is generated by a radio station’s transmitter and emitted over the air outside its assigned channel. It is also known as “radiated interference.” Receiver-induced interference is much more common than radiated interference.

Reception quality was evaluated objectively and subjectively. Objective measurements with a spectrum analyzer were conducted at numerous sites across the island. Subjective listening was done with the rental car dashboard radio and an inexpensive clock radio. The inexpensive clock radio demonstrated how the vast majority of non-mobile receivers that populate the marketplace behave. The clock radio is much more susceptible to interference than the car radio.

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Findings

The following are highlights of the findings of the survey, which are detailed in Section 6, the Conclusion of the report:

- The move-out of DMS transmitters to the centre of the island has been successful;
- There remains some blanketing interference in George Town;
- Vibe 98.9 is experiencing interference in George Town from the George Town stations;
- Several stations do not provide all-island coverage;
- George Town receives good stereo signals from Newlands/Northward;
- The signal of Vibe 98.9 is still dirty;
- The signal of Radio Cayman 1 (89.9) is weaker to the east and excessively strong on the ground in the vicinity of the tower;
- The Northward stations are interfering with the Aeronautical Band;
- The George Town stations emit spurs; and
- The Heaven 97.7 antenna is physically obstructed.

Conclusion

Detailed recommendations are presented in Section 6.1 of this report. In summary, the following specific actions are recommended:

- Vibe 98.9 should repair its exciter promptly.
- All stations operating within a mile of any other station should have bandpass filtering that is sufficiently selective to minimize spurious emissions.
- An emissions mask should be adopted to provide broadcasters with regulatory certainty as to what constitutes permissible spurious emissions.
- Each station should compute its Effective Radiated Power (“ERP”) and provide the calculation to ICTA along with antenna height above ground.
- Stations on combined antenna systems should ensure their combining system design results in sufficient suppression of spurious emissions resulting from the interaction of the transmitters on the shared antenna.

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- If the license requirement of providing universal service to the entire island remains a policy priority, then all stations should be encouraged or required to increase power to provide at least a rural monophonic signal (48 dB μ) to the entire island or nearly the entire island (such as 90% of the land mass or population).
- The interaction of the 97.7 antenna and the other antenna mounted close to it should be further examined.
- The issue regarding whether to move the three remaining stations in George Town is a policy matter that this report informs but cannot decide.
- An evaluation of the antenna pattern of Radio Cayman 1 on 89.9 is recommended.
- Field surveys subsequent to the 2007 survey are recommended on an as-needed basis, with a suggested annual review cycle to determine whether a consultative visit is required.

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February 2008



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Report on the 2007 Survey of The State of FM Broadcasting on Grand Cayman Island

1 Report Introduction

1.1 2007 Survey

From 25 through 30 November 2007, Broadcast Signal Lab performed a follow-on survey of the state of FM broadcasting on Grand Cayman Island. Surveys were previously conducted in 2006 and 2005. The objectives of the 2007 survey were

- 1) To assess the results of the recent move of the dms Broadcasting Ltd. (“DMS”) transmitters (Hot 104.1, Kiss 106.1 and X-107.1) from the government tower in George Town to the government tower in Northward, in response to the interference concerns identified in the 2006 survey;
- 2) To determine the remaining interference conditions, if any, resulting from the continued operation of Heaven 97.7, Gospel 88.7, and newly renamed CAYROCK 96.5 (previously named Style 96.5) in George Town;
- 3) To address any pertinent spectrum issues raised by FM broadcasting stakeholders;
- 4) To review the spectral purity and overall coverage of each station operating on the Island.

1.2 Methodology

To conduct the survey, field measurements were performed at certain locations on the island, including many locations previously visited in earlier surveys (see Appendix 2). In addition,

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visits were made to all operating transmitter facilities to view equipment configurations and meet with technical personnel. A joint meeting was also held with stakeholders, under the auspices of the Cayman Islands' Information Technology & Communications Authority (“ICTA”), to discuss FM licensee issues and provide preliminary observations about the FM broadcasting environment.

A compact rental car was equipped with a quarter-wavelength magnetic mount whip antenna. This was connected to an Anritsu MS2721-B spectrum analyzer. Also available was a Potomac FIM-71 field intensity meter that was utilized to corroborate the Anritsu measurements. The Potomac was operated in some instances with its calibrated telescoping antenna and in others with the rooftop antenna, to develop comparison data.

The rental car was delivered with a JVC in-dash radio. This was employed as monitoring device for received audio quality and station programming confirmation. It was monitored in motion and standing still.

An inexpensive (less than \$20) clock radio was operated within the test vehicle when the vehicle was not in motion. The clock radio wire antenna wire extended vertically inside the windshield. The clock radio was tested with the engine running and not running to ensure that ignition and other electrical noise was not affecting reception.¹

The JVC proved to have excellent selectivity, sensitivity and dynamic range, while the clock radio, which is representative of 80% of the receivers in the marketplace, is quite the opposite. The clock radio was insensitive, easily challenged on selectivity, and had difficulty handling strong local signals. Reception quality was judged subjectively and noted.

¹ For the technically inclined, the clock radio we employed is a traditional inexpensive one-chip receiver design containing basic pre-detection filtering (IF filtering). It is not the “walkman” style design, which has no pre-detection filtering. With the filtering in place, the clock radio may be more selective than models built with the more recent unfiltered design. On the other hand, the automatic level control on the clock radio’s antenna input amplifier is relatively unsophisticated. In contrast, name brand in-dash radios employ numerous techniques to conceal the impairments that mobile reception can create. Such methods include sophisticated controls of input signal levels to manage strong nearby signals and rapid changes in incoming signal levels, and audio quality management that incorporates stereo blend, high frequency blend, dynamic IF bandwidth adjustment and other tricks to hide received impairments from the listener. Because it is likely to have such features, the in-dash JVC can be expected to be more robust in the presence of reception impairments than the inexpensive clock radio, as was the case.

1.3 Report Structure

The Reception Quality Report Table (Table 1) is discussed in Section 2 of this report. Because reception quality and signal strength are interrelated, Section 3 discusses both the signal strength measurements and the reception quality assessment. Appendix 3 contains signal strength bar graphs for selected locations around the island.

Receiver-induced interference is discussed in Section 4 of the report. Listening tests illustrated the variety of mechanisms and resulting sonic characteristics of receiver-induced interference. Signal strength measurements confirm the intensity of local signals and the relative levels of local signals and distant ones.

In Section 5, the Spectrum Purity section, undesirable spurious emissions generated by some transmission facilities are discussed. These are unwanted emissions outside a station's assigned channel that can cause interference to other radio communications. They typically are the result of defective transmission equipment or insufficient filtering and isolation from other transmitters at the same site.

Section 6 is the Conclusions section and includes specific recommendations for further action.

2 Reception Quality Report Table Explanation

To evaluate each licensed FM station's performance across the island, a listening test was conducted. This is a subjective test by an expert listener with three decades of qualitative and diagnostic experience listening to FM broadcasts. The Reception Quality Report Table (Table 1) lists the results of listening tests at the locations tested. At these locations each station was tuned in and the quality of the received signal was logged.

The Reception Quality Report Table is split in two parts to fit on the page. The body of the table contains descriptions of the received signal quality of each station at each site indicated. The left columns of the table indicate the station name and frequency, listed in order of frequency. The stations are color coded by row to represent the general location of the station (George Town, Newlands, Northward). The top rows of the table indicate the general area of the island and the

specific site identification (name and number)² for each set of quality notes. For those locations that are relatively near to one of the three broadcast sites, the columns are highlighted in either yellow or blue (showing as gray if not in color). These sites near transmitters have the potential to overload the receiver or otherwise compromise the performance of the receiver. Reception quality at these locations will be determined by the strength of the desired signal plus any interference induced by the strong local signals. The remaining locations on the table are left in the original white background, indicating each location is sufficiently remote that there is no nearby transmission facility to affect reception. These are sites where the dominant factor affecting reception quality will be the strength of the desired signal.

Term	Meaning	Term	Meaning
OK	Clean reception	Hard to tune in	Must position tuning wheel just so to lock in station among interference
Mild Multipath	A little reception noise not caused by interference	Will not lock	Interference prevents receiver from locking onto station
Crosstalk	Two or more stations audible at once	Barely audible	Noise overpowers audio
Not Receivable	No program audible on channel, even though station was transmitting a signal	Not on Air	Station was not transmitting a signal during the evaluation
Noisy ^{1,2,3}	Noisy audio, 1 moderate, 2 more, 3 most	Shaded sections (yellow or blue) have strong local signals. Unshaded sections are remote from transmitters.	

Table 1-A - Key to Table 1

Most location columns are marked *Clock*, referring to the received signal quality on a clock radio. For some locations, an additional column appears labeled by the title *Dash*. The in-dash JVC aftermarket receiver in the rental car was employed at these locations to acquire an alternative reception quality sample. Appendix 1 contains a more detailed discussion of the signal quality characteristics

² In the case of the unnumbered Hirst Road location, it is unnumbered because it is not spectrum analyzer measurement location #3, Hirst Road at the North Sound, or #20 at the Avcom tower site. Instead, it is a location on Hirst Road approximately ¼ mile north of Shamrock Road. Likewise, the unnumbered East End location is near the John McLean Road location #6. These locations are unnumbered because measurements were not performed and only listening tests were conducted. See Appendix 2 for a table of sites.

Table 1 - Reception Quality Report Table

Green- Northward	Locale		Boatswain Bay		Vixville		East End	Gun Bay	East End	Northward	
Orange- George T.	Site		#1 Dunlop		#18 Turtle Farm		#6 McLean	#7 Turnpipe	East End PO	#16 Northward Tower	
Violet- Newlands	Freq.	Radio	Dash	Clock	Dash	Clock	Clock	Clock	Clock	Dash	Clock
GOSPEL88	88.7		OK	Not receivable	OK	Noisy3	Not receivable	Not receivable	Not receivable	Not on air	Not receivable
Radio Cayman 1	89.9		OK	Barely audible	OK	Noisy2	Noisy2	Noisy1	Noisy2	OK	Noisy1
SPIN	94.9		OK	Barely audible	OK	Noisy2	Noisy1	Noisy1	Noisy1	OK	Noisy1
CAY-ROCK	96.5		OK	Will not lock	OK	Not receivable	Noisy2	Noisy2	Noisy2	OK	Noisy2
HEAVEN	97.7		OK	Will not lock	OK	Not receivable	Noisy2	Noisy2	Noisy2	OK	Noisy2
VIBE	98.9		OK	Noisy3	OK	Noisy2	Noisy1	Noisy1	Noisy1	OK	Noisy1
Z99	99.9		OK	Will not lock	OK	Noisy2	OK	OK	OK	OK	OK
ROOSTER	101.9		OK	Barely audible	OK	Noisy1	OK	OK	OK	OK	OK
HOT104	104.1		OK	Noisy2	OK	Noisy1	OK	OK	OK	OK	OK
BREEZE	105.3		OK	Noisy1	OK	Noisy1	OK	OK	OK	OK	OK
KISS106	106.1		OK	Noisy1	OK	Noisy1	OK	OK	OK	OK	OK
X-107.7	107.1		OK	Noisy2	OK	Noisy1	OK	OK	OK	OK	OK

Green- Northward	Locale		George Town	George Town	George Town	Newlands		Newlands	
Orange- George T.	Site		#11 GKF Ind Park	#15 Kirk Home Centre	#12 Washington & Grackle	Hirst Road		#20 Avcom	
Violet- Newlands	Freq.	Radio	Dash	Clock	Clock	Dash	Clock	Dash	Clock
GOSPEL88	88.7		OK	OK	OK	OK	Not receivable	OK	Not receivable
Radio Cayman 1	89.9		OK, Mild Multipath	Crosstalk	OK	OK	Noisy1, hard to tune in	OK	Noisy1, hard to tune in
SPIN	94.9		OK	Crosstalk, mild multipath	Not Receivable	OK	OK	OK	OK
CAY-ROCK	96.5		OK	OK	OK	OK	Not receivable	OK	Not receivable
HEAVEN	97.7		OK	OK	OK	OK	Not receivable	OK	Not receivable
VIBE	98.9		OK, Mild Multipath	Noisy1, crosstalk	Not receivable	OK	OK	OK	OK
Z99	99.9		OK	OK	Noisy1, Hard to tune in	OK	OK	OK	OK
ROOSTER	101.9		OK	OK	Hard to tune in	OK	OK	OK	OK
HOT104	104.1		OK	OK	Hard to tune in	OK	OK	OK	OK
BREEZE	105.3		OK	OK	OK	OK	OK	OK	OK
KISS106	106.1		OK	OK	OK	OK	OK	OK	OK
X-107.7	107.1		OK	OK	OK	OK	OK	OK	OK

3 Reception Discussion

Two reception conditions are tested in the reception quality test: a) the signal quality around the island when reception is not impaired by unwanted signals, and b) the signal quality in locations where reception may be impaired by unwanted strong signals.

3.1 *Island-wide Coverage Assessment*

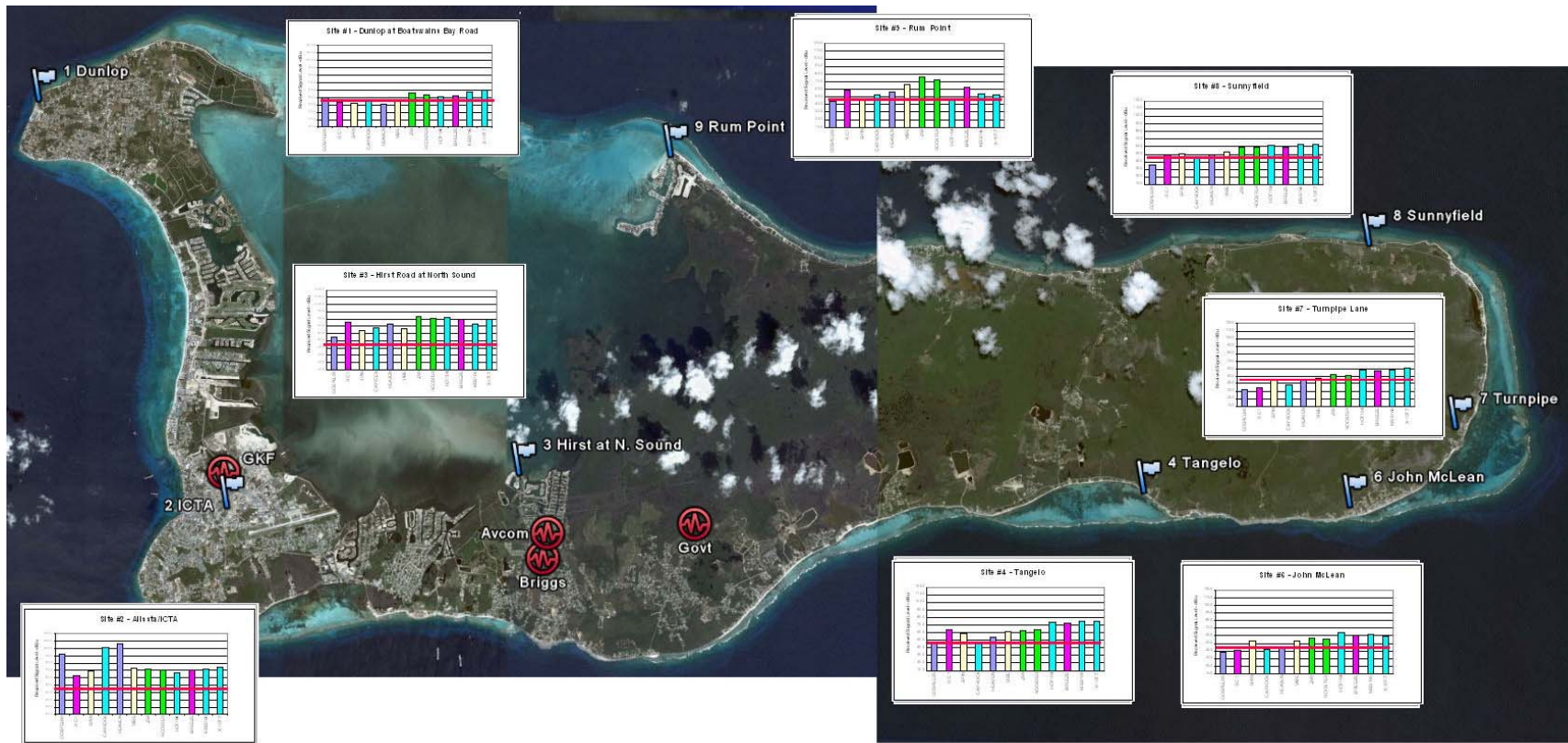
Considering the quality of each station's signal across the island, we can consider reception quality at opposite ends of the island and, to the extent that interference is not involved, we can also consider reception quality in more central locations on the island. Areas near East End and West Bay are most distant from all stations on the island. This means there is no strong signal nearby to overwhelm the receivers. Any reception impairments are the result of how well the desired signal gets out to the fringe areas. Broadcast antenna height, station power, antenna orientation and tower location affect the ability of each station to reach certain areas.

To further illuminate the island-wide coverage assessment, the map (Figure 1) displays measured signal strength bar-graphs at various locations on the island. For closer inspection, a full set of measurement graphs is presented in Appendix 3. These are based on spectrum analyzer power measurements adjusted for the receiving antenna and cable losses and for the antenna factor on the measurements. By comparing the subjective notes in the Reception Quality Report Table with the objective signal strength measurements, one can develop a sense for the usefulness of the signal levels at the various places on the island.

An example graph is shown in Figure 2. The key issue to consider on the bar graphs is whether a given station's signal level is above the red line (ITU Rural Mono signal strength) or the blue line (ITU Urban Stereo signal strength). The stations are sequenced on the bar graphs from low frequency to high (88 to 108 MHz), left to right. The colors of the bars are coordinated to show common station ownership.

Figure 1

Aerial Photo of Grand Cayman Showing Selected FM Measurement Locations and Corresponding Signal Strength Graphs



Measurement sites marked with flags. Tower sites marked with circles. Red line on graphs is 48 dBµ mono reception threshold.

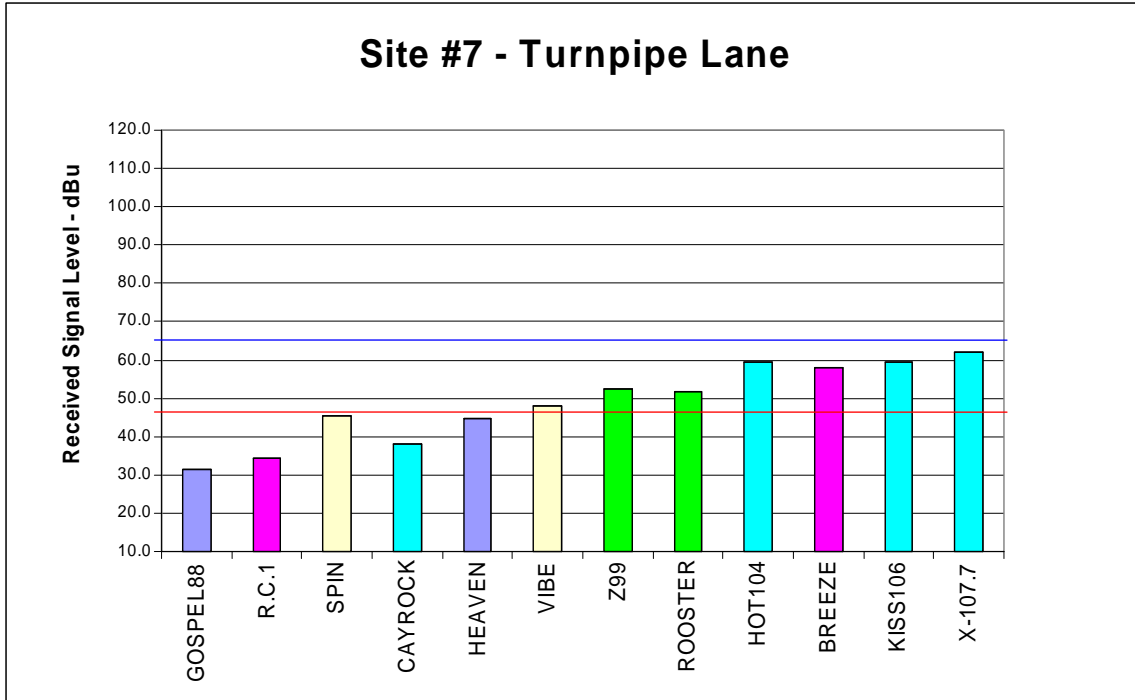


Figure 2

Example Graph Showing Signal Strengths of All Active FM Stations Received at Turnpipe Lane Location Compared to ITU Rural Monophonic Reception Threshold (red line) and ITU Urban Stereo threshold (blue line)

There were twelve FM stations on air during the 2007 survey. Since the 2006 survey, the three original DMS stations (104.1, 106.1, and 107.1) have relocated to the Northward tower site. DMS has also acquired 96.5, renaming it CAYROCK. It remains in George Town. The station at 95.5 is no longer licensed. The ICCI station at 101.1 has not returned to the air since hurricane Ivan. Weather station 107.9 was not operating during the week of the survey.

3.1.1 To the East

At the eastern end of the island, the East End and Gun Bay locations on the Reception Quality Report Table (Table 1) reveal that two Newlands signals (Rooster 101.9 and Z 99.9) and four Northward signals (Hot 104.1, Breeze 105.3, Kiss 106.1 and X 107.1) are received in an acceptable condition there. There are three exceptions. Radio Cayman 1 (89.9) and the two lower-powered stations at Newlands (Spin 94.9 at 1 kW and Vibe 98.9 at 1.8 kW) are audible but received with various degrees of noise on the clock radio. Two of the three George Town stations

(Heaven 97.7 and CAYROCK 96.5) do not come in satisfactorily, while the lowest power station on the island at present, Gospel 88.7, is not even perceptible.

The signal level map (Figure 1) corroborates this conclusion. For illustration, the Turnpipe Lane (Gun Bay) graph from the map is reproduced in Figure 2. The ITU specification for rural monophonic reception at acceptable quality is $48 \text{ dB}\mu^3$, which is marked as a red line on the graph (see also our 2006 report). The graph shows that the successfully received stations are at an equivalent level of $48 \text{ dB}\mu$ or greater. All stations with difficult-to-receive signals at this location are at or well below the $48 \text{ dB}\mu$ cutoff.

Looking at the transmitter power levels of the stations in Table 2, it is evident that the stations most successful at reaching the eastern end of the island are the stations that are both the most powerful and the closest.

Comparing Spin and Radio Cayman 1

One possible exception to the favorable easterly performance from Northward is the Radio Cayman 1 (89.9) signal. With a transmitter power level only 1.5 dB less than its sister station on 105.3, the 89.9 signal seems a weaker in the east than one would expect it to be, compared to the other stations. This may have to do with how the 89.9 antenna is positioned on the tower, or due to some other signal loss. For comparison, refer back to the map (Figure 1) or peruse Appendix 3, looking at the general signal levels of 89.9 versus 94.9 (Spin) transmitting from Newlands. Spin employs a transmitter power of 1 kW, compared to the 2.5 kW of Radio Cayman 1 (a 4 dB differential). Antenna heights are similar. Spin is only about 2 miles closer to George Town. Based on these conditions, if anything should be observed, 89.9 would be expected to be a few dB stronger than Spin in the eastern portion of the island, particularly at site numbers 6, 7, and 8.

³ $\text{dB}\mu$, pronounced dee-bee-you, is the measure of field strength in decibels above one microvolt per meter.

		Transmitter Power Output (kW)	Filtering, combining cabling‡	Antenna height (centre, ft)	Antenna type
GOSPEL88	88.7	0.210	none	75 est.	4 bay vertical dipole
RADIO CAYMAN 1	89.9	2.5	4 stage BPF, -10 dB @550 kHz offset, -30 dB @ 900	220 est.	4 bay circular (SW leg)
SPIN	94.9	1	½ in. jumpers to 2 stage BPF to ½ to 7/8 up tower	200 est.	4 bay vertical dipole (South face)
CAYROCK	96.5	1	½-in. cable exits building	190	4 front by 2 back vertical yagi array
HEAVEN	97.7	2	2 stage BPF	235 est.	4 bay vertical dipole
VIBE	98.9	1.8	½ in. jumpers to 2 stage BPF to 7/8 up tower	200 est.	4 bay vertical dipole (North face)
Z99	99.9	4.9	Shively combiner, 2.25 in. line to antenna		
ROOSTER	101.9	2.9*			
HOT104	104.1	4.5	DMS 3 point star combiner connects to wideband hybrid to join with Breeze.	220 est.	4 bay circular (North leg)
BREEZE	105.3	3.5			
KISS106	106.1	4.5			
X-107.7	107.1	4.5			

Table 2
Characteristics of FM Stations

*Upon the inspection visit to the 101.9 transmitter, it was found to have a failed power module. Normal power is nominally 5 kW, but it was running at 2.9 kW. The station was not certain how long it had been in this condition. Repairs could not be made right away. We assume the station was at reduced power for the entire survey week.

‡ This column contains information about the presence of a band pass filter (“BPF”) to protect the transmitter from unwanted energy coming in from other stations, the use of a combiner to join the signals of more than one transmitter on a single antenna, and the size of the transmission line (coaxial cable) carrying the energy from transmitter to antenna.

The results are different than the expectation. At the three easterly locations measured – #6- McLean Road, #7- Turnpipe Lane, and #8- Sunnyfield Road – Spin 94.9 was consistently and clearly stronger than 89.9. The Reception Quality Report Table (Table 1) suggests the same

thing. Closer to Northward, at Tangelo, Radio Cayman 1 had the advantage. At Rum Point, 89.9 had an apparent advantage over 94.9.

On the western portion of the island, the two stations had similar signal strength. In George Town and in West Bay, 89.9 and 94.9 competed fairly evenly for dominance at each site. The 4 dB power advantage of Radio Cayman 1 was not evident.

Despite the differences in the field measurements, and minor differences in reception quality at the fringes, according to the Reception Quality Report Table (Table 1), reception quality of 94.9 and 89.9 around the island was pretty well matched (ignoring interference-induced problems for one or the other when near a strong undesired signal source). The signal levels of both stations are low at the fringe areas; low enough to be less than desirable on inexpensive radios. A recently approved proposal to increase the power of 89.9 to 5 kW should offer improvement in island-wide coverage. Interference issues relating to this proposal are discussed elsewhere in this report.

3.1.2 At the Core – George Town

Returning to discussion of the general state of all stations' coverage on the island, let us turn to the signal strengths in and around George Town. The signals from Newlands and Northward must travel about 5.3 and 7.5 miles to reach the centre of George Town. This is a workable distance. These signals arriving in the George Town area generally satisfy or nearly satisfy the ITU Urban Stereo threshold of 66 dB μ .⁴ Sites #2, and 10, (Alissta and Owen Roberts Drive, reveal strong signals from Northward and Newlands, consistently above the 66 dB μ urban stereo threshold. At the GKF Industrial Park, these signals fell below the 66 dB μ threshold.

The impact of frequency selective fading may be evident in the graph of site #11, the GKF site. There is a curve formed by the signal level bars of the seven stations from the middle to the top of the band – Vibe (98.9), Z99 (99.9), Rooster (101.9), Hot104 (104.1), Breeze (105.3), Kiss (106.1), and X-107 (107.1). We will call these stations the Central Seven in order to simplify discussion of them as a group. In a fading-free radio environment the measurements of the

⁴ In the USA, the 70 dB μ signal contour is regarded as a “city-grade” signal. The ITU science on the subject is better documented and more recent, so we are comfortable relying on the ITU figure in Grand Cayman.

Central Seven at each George Town site would be nearly identical, with minor variations due to transmitter site distance and transmitted power. Due to the normal local effects on propagation to each site, the measured signal levels of these stations vary with respect to one another. The somewhat lesser measured levels of the Central Seven stations that were found at the GKF Industrial Park (Site #11) are expected, considering that just around the corner at Alissta/ICTA (Site #2) and Owen Roberts Drive (Site #10) the signals were at and above 66 dB μ . The industrial park measurement location was more enclosed among surrounding structures than the other two sites. It is important to understand that when the goal is a 66 dB μ signal strength, that is the intended free-space signal strength (high antenna) that is necessary to provide quality service among and inside the buildings. Inherently, measurements near the ground will be more variant due to obstructions and reflections.

Based on the signal strength measurements of the Central Seven in George Town, it is reasonable to conclude that the signal levels are strong enough in the George Town area for high quality reception, including inside buildings. These seven stations' signals appear to meet a reasonable standard for urban building penetration. (Also consider that the ITU definition of an urban area is likely to be much more oppressive to FM signals than is the "urban" development in George Town.)

Based on the Reception Quality Report Table (Table 1), the Central Seven appear to provide ample signal strength in the George Town area, even for the inexpensive clock radio, so long as no interfering signals dominate the receiver.

In George Town, Spin 94.9 was consistently above the 66 dB μ threshold, but Radio Cayman 1 teetered above and below it. It was close enough to the threshold that the slightly lower levels could have been the result of frequency selective fading on 89.9, if not simply the result of a lower transmitted power and greater distance. The proposed power increase to 5kW for 89.9 will provide a 3 dB improvement – a beneficial change, but it still may not perform as well in George Town as the others at the Northward site. The 89.9 transmission plant (antenna and transmission line) should be evaluated as part of the upgrade program. By optimizing the transmission system, there might be more improvement available than strictly that obtained by a 3 dB power increase.

The Reception Quality Report Table (Table 1) also suggests that the primary obstacle to reliable reception of the Northward and Newlands stations in George Town is the presence of strong

undesired signals transmitting from George Town (88.7, 96.5 and 97.7 – we will call these the George Town Three). Certainly, the greater the disparity that exists between the undesired signal level and the desired signal level, the greater the probability that interference will be experienced. Therefore, the weaker 89.9 and 94.9 signals, and the signals closest in frequency to the George Town Three are the most likely to experience interference phenomena in George Town. This is discussed further in the interference section.

Reception of the George Town Three within George Town is, as expected, robust. Signal strengths are far stronger than necessary for good Urban Stereo reception. Signal quality is logged as being fine in each listening sample conducted in George Town.

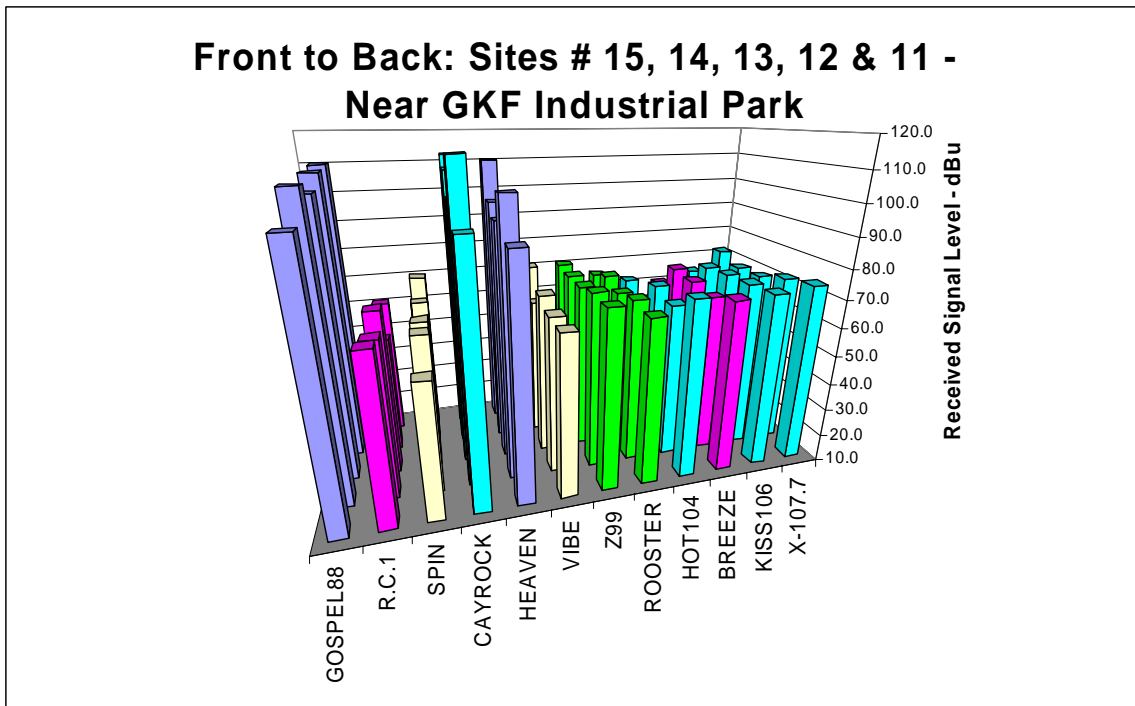


Figure 3
FM Signal Strengths at Five Georgetown Area Measurement Sites

To illustrate how signal levels vary within a small area, Figure 3 stacks measurements of each station in 3-D form, showing, front to back, Bodden Road at Eastern Avenue, Washington Road at Grackle, Woodpecker Close at Cypros Road, end of Greenwood Drive, and in the GKF Industrial Park. As the figure shows, it is not uncommon to experience a 10 dB spread in signal levels within a small area. The signal levels of the George Town Three vary more because they are transmitted locally, and two effects are at play. First, the antenna patterns can create hot spots within a short radius of the tower sites. Second, as one moves away from a local antenna, the

change in signal strength is more pronounced than the gradual diminishment of a distant signal over the same distance. The more distant sources show a more moderate variation in signal strength from site to site in this area.

3.1.3 To the North

Measurements were taken at three locations north of George Town. Site #1 is at Dunlop Drive and Boatswains Bay Road. Site #18 is at a driveway near the turtle farm. Site #19 is the parking lot of the Marriott Courtyard hotel, with the measurement location such that the building may partially obstruct signals coming from Northward/Newlands and interact to a lesser degree with signals emitted from George Town. The Reception Quality Report Table (Table 1) indicates that the inexpensive clock radio did not perform well for any station in the West Bay area. In contrast, the car radio managed to satisfactorily receive every station's signal. The three stations with the worst performance on the clock radio were the George Town Three. Table 3 shows the approximate distances between selected locations and the three transmitter sites – Northward, Newlands, and George Town. Ironically, the George Town transmitter sites are about 2/3 the distance to the West Bay sites as the Northward and Newlands sites, yet the signals from George Town do not fare as well in West Bay. This is likely due to two primary causes. First, the power levels of the George Town stations are lower than the most powerful of the Northward and Newlands stations. Second, the best results in West Bay came from the four stations on the Northward common antenna (104.1, 105.3, 106.1, 107.1) and all of the Central Seven seem to do well enough in West Bay. Meanwhile, the two remaining Newlands/Northward signals, 94.9 and 89.9, just lack the power to equal the performance of the Central Seven, transmitting from the same area. Spin 94.9 was consistently below the 48 dB μ threshold at all three sites, while 89.9 was above it at two of the three sites.

Not only are the power levels of the George Town Three a potential cause of their poorer West Bay performance, but also the antenna configurations (and in one case, height) are probable contributors to the poorer performance of the George Town Three in West Bay. It is interesting to note that among the three, it was the lowest power station, 88.7, that fared the best to the north of George Town.

Site	Northward	Newlands	George Town
1 Dunlop	12	11	7
18 Turtle Farm	12	10	7
19 Marriott	9	7	4
7 Gun Bay	12	14	19
2 George Town	8	5	

Table3
Table of Approximate Distances (Miles)
Between Transmitter Sites and Selected Measurement Sites

The Heaven 97.7 antenna is mounted relatively high on the Westar tower in George Town, but its vertical dipoles appear to be within a couple of feet horizontally of a UHF panel antenna. This is most certainly disturbing the pattern of the Heaven 97.7 emissions. It is difficult enough to account for the interaction of a tower's structure with an FM antenna; the insertion of another antenna in the near-field of the FM antenna can only make things worse.

The CAYROCK 96.5 antenna in George Town is a split affair, with an array of directional antennas pointed in two directions off the tower. This arrangement might reduce the impact of the tower structure on the pattern, but it can instead cause unpredicted coverage patterns between the antennas pointed in each of two directions. Typically, careful placement and spacing of such opposing antennas must be conducted to optimize the pattern. Also, the antenna array appears to deliver half the effective power in the north and westerly direction that it does to the east, due to the use of two antennas pointed westerly, and four easterly. It is not known to what extent the original antenna pattern was designed for the tower on which it is mounted.

Finally, those stations that employ circularly polarized antennas have an advantage in multipath conditions. As signals bounce and diffract off objects, their polarization can be rotated. To smooth the choppiness caused by an environment where rotated reflections create sharp peaks and dips in signal strength, circular polarization is employed. Circular polarization is also intended to maximize not only in-vehicle reception (with typically vertical receiving antennas) but also fixed reception using horizontal antennas.⁵ The disadvantage of circular polarization is

⁵ In the golden days of FM reception, particularly on the continents, high gain antennas utilizing horizontal polarization were often attached to rooftops to obtain the best reception. Now, the most common horizontally polarized antenna is the "T"-shaped wire dipole that comes with home hi-fi gear and only rarely is carefully posted horizontally by the most meticulous receiver owners. Often such antennas are left

that a circularly polarized antenna of a given size (such as a four-bay antenna) has less effective radiated power than a vertically polarized antenna of the same size with the same input power from the transmitter. This disadvantage does not seem to affect the performance of the shared antenna at Northward, where 104.1, 105.3, 106.1, and 107.1 are emitted from a circularly polarized antenna, with transmitter output powers of 3.5-4.5 kW. In contrast, the George Town Three operate vertically polarized antennas with transmitter output powers of 0.2 to 1.8 kW.

Overall, West Bay is not a good place to use the most inexpensive receivers. The Central Seven appear to meet the ITU 48 dB μ mono reception threshold there (although Vibe 98.9 is borderline). Radio Cayman 1 89.9 also does pretty well in keeping above 48 dB μ . Spin 94.9 do not fare as well in West Bay, falling more consistently below the 48 dB μ ITU threshold. Of the George Town Three, only Gospel 88.9 hovers up to 48 dB μ . The inexpensive clock radio is unable to obtain a useful signal from stations at or below the 48 dB μ target level for rural monophonic reception.

3.1.4 Centre of the Island - Northward and Newlands

Reception quality in Northward and Newlands is as expected. When close to a tower at these sites, the George Town signals are difficult to receive on inexpensive radios. The JVC car radio was resistant to overload and received all signals at both locations (note, however that the weakest station, Gospel 88.7, was not on the air when the listening test was conducted at Northward).

In contrast, at the two Newlands locations, the clock radio was unable to receive the George Town Three. In Newlands, all Northward stations but Radio Cayman 89.9 were picked up satisfactorily on the clock radio.

In Northward, directly at the base of the tower, only the local stations on the government tower were picked up by the clock radio, while the JVC car radio was able to receive all island FM stations on the air at the time. Since the Northward result on the clock radio differs from the Newlands result, because all non-local stations were blocked in the Northward clock radio test, further discussion is in order.

to dangle behind the receiver in an unplanned orientation. Thus, the benefits of circular polarization primarily tend to address choppy mobile reception.

One difference is that two locations were tested for reception quality in Newlands – one on the street at the Avcom tower driveway and one about a mile south, or ½ mile from the nearest tower – while only one location was monitored at Northward, at the tower base. In Newlands, the use of the listening location not near a tower base may have contributed to the appearance of less clock radio overload in the Newlands unnumbered site listening evaluation.

A comparison of measured signal levels also enlightens the comparison between Newlands and Northward reception. At Newlands site #20 by the Avcom tower site, four stations hovered around the 110 dB μ level, while at Northward site #16 one station exceeded 120 dB μ , one exceeded 110 dB μ , and the other three were at 100 dB μ . In terms of raw receiver overload power, the four Newlands signals at about 110 dB μ sum to a total power that is about 6 dB higher than a single 110 dB μ signal. In contrast, the 123 dB μ signal at site 16 in Northward, on its own, is about four times more powerful than the sum of the four Newlands signals at site 20. This 123 dB μ signal is extremely challenging for a receiver to reject.

Meanwhile, the strengths of the stations arriving from the opposite sites were comparable (Newlands stations in Northward and Northward stations in Newlands), measuring very sturdy levels in the 80's to 90's dB μ . The clock radio apparently was more affected by the overload environment at Northward than at Newlands. A reduction in the downward radiation of the 89.9 antenna could help to reduce the overload experienced by inexpensive radios in Northward that are trying to tune in Newlands signals. The measurements (not accompanied by a clock radio listening test) at Shamrock Road in Northward (Site #17) reveal the 89.9 signal still being substantially stronger near the Northward tower than the other four stations at the site. With 100 dB μ , at Shamrock, the impact of the 89.9 signal on an inexpensive radio would be substantially less than at 123 dB μ at the tower base.

Overall, the reception in Newlands and Northward is subject to the same interference mechanisms observed in George Town. Each area has a radius that defines the blanketing area where some reception of some stations on some radios will be compromised by strong local signals. Our 2006 report estimated blanketing areas for these facilities.

4 Interference Assessment

In addition to assessing the ability of signals to reach various locations, listening to the in-dash radio and the clock radio around the island also provides information for assessing interference issues. One of the objectives of the 2007 survey is to provide information on which the ICTA may establish policy regarding facility siting. Specifically, what is the impact of the remaining radio stations in George Town on reception of the other stations?

4.1.1 Reduction of Interference in George Town

With the removal of the three stations in George Town operated by DMS, the interference picture in George Town has significantly improved. Meanwhile, three stations continue to operate in George Town and appear to have been causing similar reception problems. We have dubbed these the George Town Three (Gospel 88.7, Heaven 97.7 and CAYROCK 96.5). Recall from the 2005 and 2006 reports that stations do not have to actually put energy on another station's channel to induce interference in a receiver. Interference results when receivers cannot isolate desired signals from the receiver-generated noise that strong local signals can induce.

In this section we employ the terms *undesired* and *desired* to represent stations with which a particular listener is working. The desired station is the one he/she wants to listen to. The undesired station is any other station on the spectrum.

There are several factors that go into inducing interference in a receiver.

- 1) The strength of the desired signal;
- 2) The number of channels separating the desired and undesired signal;
- 3) The strength of the undesired signal;
- 4) The ratio of the strength of the desired signal to the undesired signal;
- 5) The mathematical relationship between one or more undesired signal frequencies and the desired signal frequency;
- 6) The capability of individual receivers to reject each of the contributing factors described above.

In 2005 and 2006, we provided reports to ICTA and discussed these issues at length. In summary, we suggested that the size of Grand Cayman is nearly ideal to support single-

transmitter coverage of the island. Each station can fulfill its licence requirement of serving the entire island by locating near the geographic centre of the island. Considering the geographic constraints on station placement, it would produce the least interference, in the aggregate experience of all residents, if the stations were to transmit from a common location in a less densely populated area.

This suggestion may have been seen by some as a utopian view of how broadcasting could work on Grand Cayman, as it involved creating a central tower site on the island, placing all stations there, and obtaining as much tower height as possible. However, achieving this ideal, or at least coming close to doing so, would have accomplished three things.

- First, with greater antenna height, coverage can be improved without increasing transmitter power and corresponding interference area.
- Second, with greater antenna heights, and more neighborhood-friendly broadcast antenna designs, the interference within the neighborhood of such a tower can be minimized.
- Third, by going to a single-site (or effectively single-site) placement for all radio stations, the *near-far* problem is resolved. The near-far problem is the primary cause of interference complaints among radio stations. At any location where the desired signal is substantially lower in power than undesired signals, such as near an undesired transmitter site, the strong undesired signals can induce receivers to create interference internally.

4.1.2 Same Problem, Different Players

A situation now exists that is analogous to one addressed in a previous visit. Previously, the presence of the DMS signals affected George Town reception in general, and significantly affected the studios of, and listeners to, Radio Cayman 105.3 (now Breeze). Similarly, the presence of the George Town Three stations at the GKF Industrial Park affect reception in general, and significantly affect the studios of and listeners to Paramount's Vibe 98.9.

The present condition affecting reception of 98.9 is significant but not as pronounced as the prior concern with affected reception of 105.3. When the DMS stations went on the tower above the Radio Cayman studios, the Radio Cayman studios suffered a loss of the ability to reliably receive their stations transmitting from Northward, and particularly 105.3. Listener complaints were also received. The locally emitted signals on 107.1 and 106.1 could overload local receivers to the

extent that the receiver generated a difference signal on the opposite side of 106.1 at 105.1. With this difference signal appearing in the receiver, the desired signal at 105.3 was unlistenable or even unreceivable in locations in George Town. The extent of the interference was dependent on the model of receiver and its location. It was also dependent in part on the received signal strength of the desired signal (such as 105.3). Removing the three stations from the George Town site eliminated the problem.

In addition to this peculiar way of interfering with reception of 105.3 by inducing mix products on 105.1 in the receiver, the presence of the three strong signals also created a *blanketing* effect that desensitized some receivers tuned to a more distant desired signal. Much as the full moon causes stars nearby it to be invisible, a receiver contending with a strong undesired signal may not be able to “see” stations on other frequencies. If the desired station is the star and the undesired station is the moon, the receiver’s ability to “see” the “star” depends on how “bright” the “moon” is, how far apart the “moon” the “star” appear (how far apart in frequency), how bright the “star” is relative to the “moon,” and how narrowly focused the “eyes” of the receiver are.

The former blanketing interference from the three DMS stations affected George Town reception of other stations as well. With this interference now removed, the impact of the George Town Three was shown to affect Paramount’s reception of its stations in the George Town area. Paramount has its studios on Eastern Avenue in George Town, one block from the transmitter sites of the George Town Three. Similar to the conditions experienced by Radio Cayman at their studios, Paramount has difficulty keeping interference out of its operations.

In addition to blanketing interference issues, a specific interference mechanism to Vibe 98.9 was observed. When the stronger signals of 97.7 and 96.5 mix in an overloaded receiver, they produce a difference product precisely on 98.9 in the receiver. If the received signal of 98.9 is not strong enough to overcome that receiver-induced mix product, the receiver captures the combined signals of Heaven 97.7 and CAYROCK 96.5 instead of Vibe 98.9. ⁶

⁶ Indications are that the interference experienced is due to, or at least predominantly due to, receiver behavior. However it is also possible that 96.5 and 97.7 mix to produce radiated interference on certain channels, including 98.9, but without turning 98.9 off, it will not be visible or audible. Such potentially transmitted interference is generated in the transmitter by the same mechanism that occurs in the receiver. Instead of the receiver’s mixer producing the unwanted product, a transmitter takes in too much energy from another station at the same site where it mixes in the output stage of the transmitter. Because a mix product of 96.5 and 97.7 falls directly on 98.9, it is not possible to verify its presence without turning off the radio station on 98.9. To conduct a controlled experiment of such a possibility, an observer may take a

To demonstrate the problem in a mobile setting, Vibe provided its promotional vehicle equipped with a Sumishi in-dash radio. In performing a test drive from the studios of Vibe, around the GKF Industrial Park, and southerly to North Sound Road and Thomas Russell Avenue as far as Smith Road, the interference product was experienced repeatedly. As the receiver encountered the natural variations in 98.9 signal level, the 96.5/97.7 product would appear when the 98.9 signal fell low enough. The measured signal levels reported herein indicate that despite the natural variations in signal level, the Vibe 98.9 signal would otherwise be receivable in George Town were it not for the interference. Since this effect extended intermittently for almost 1.5 miles from the tower site, it is not likely to be strictly the result of receiver blanketing. In the 2006 survey we determined that the most likely area of 96.5 blanketing interference was within about ½ mile of the GKF Industrial Park. With 97.7 running at about twice the power as 96.5 (although the antenna systems are not entirely comparable), the most significant blanketing interference area of 97.7 might extend to ¾ mile radius.

To verify the demonstration in the Vibe vehicle, we re-drove the route with the rental car while listening to the JVC in-dash receiver. The effect was also experienced on the JVC, although to a lesser degree. This difference in performance is likely due to the internal design of the two radios, with the JVC probably having a cleaner mixing and amplification stage than the Sumishi. We did not do the same experiment with the clock radio because it is not appropriate to test a clock radio in a mobile environment. Clock radios are meant to stand still on a tabletop and are not designed to handle the effects of mobile reception. Nevertheless, under comparable signal level conditions a clock radio could be at least as susceptible to this interference phenomenon as the car radios.

The Reception Quality Report Table (Table 1) shows the listening quality of the clock radio at several locations within ¼ mile of the GKF Industrial Park towers. Figure 3 shows signal strength measurements at these locations and others. The clock radio was most susceptible to interference on desired frequencies that were closer to the frequencies of the George Town Three. Radio Cayman 89.8, Spin 94.9, and Vibe 98.9 were most affected. At the most injurious of the

very good quality automotive radio to a location that is well outside the blanketing area of 97.7/96.5 (say, about 2-3 miles) and listen while the 98.9 transmitter is turned off. If there is a radiated interference mix product on 98.9 it should be audible as a mixture of the two stations appearing on 98.9. The more distance away from George Town that such interference can be heard, the stronger it is. This issue is discussed further in the Spectrum Purity section below.

locations tested, Z 99.9, Rooster 101.9, and Hot 104.1 were also affected. The in-dash radio was unaffected at the base of the two towers at GFK industrial park. It received all signals satisfactorily.

As we stated in the 2006 report:

The two towers at the GKF Industrial Park... [have a blanketing area whose] ...small-building count may still exceed 250-300. In urban areas, small-building counts understate the potential impact on reception because they overlook the impact on radio reception in the large quantity of commercial, industrial, and government buildings in George Town that are occupied daily.

Figure 4 is taken from Map 7 from the 2006 report, modified to show only the then-estimated blanketing area of the stations at the GKF Industrial Park. Of course, with Gospel 88.9 running at about 200 watts, its blanketing area will be less than the others. However, its antenna is substantially closer to the ground than the others, possibly amplifying its blanketing effect closer to the industrial park site.

In summary, the three stations transmitting from towers at the GKF Industrial Park do create interference phenomena in receivers tuned to the other stations. It is expected that the impact is somewhat less pervasive than what occurred with the three DMS stations that were on the tower above the Radio Cayman studios in George Town, primarily because their power output levels are lower than the DMS transmissions originally were. Before moving out to Northward, DMS reduced power in George Town to levels more comparable to the levels transmitted from 97.7 and 96.5, which reduced the intensity of the interference, but did not eliminate it. However, if the George Town Three stations are expected to provide more nearly island-wide coverage from George Town, then additional power, antenna height, and/or antenna gain (larger antennas) would be necessary at their current locations. Additional transmitted power would increase the interference potential and radius in the George Town area.

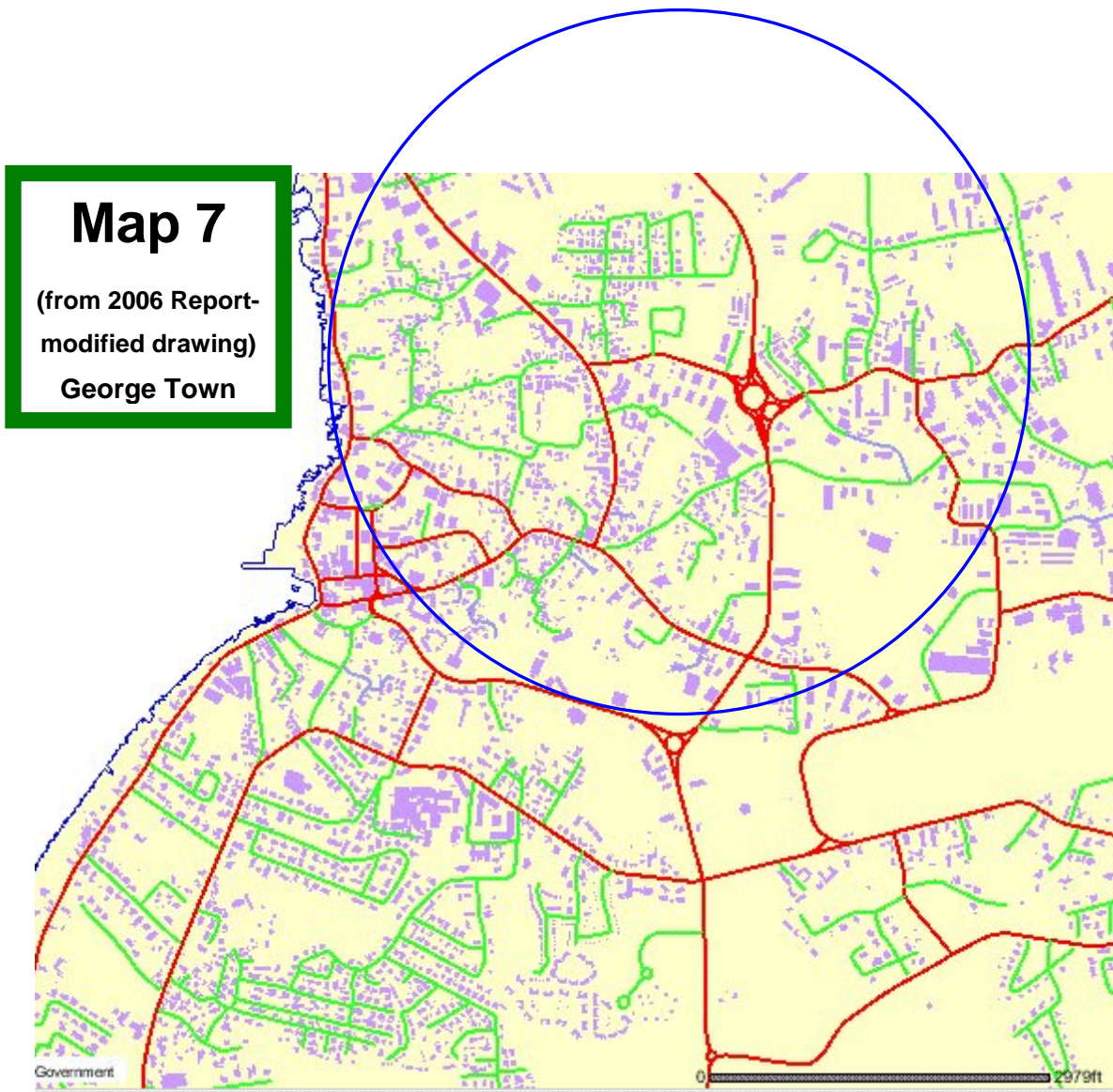


Figure 4
Approximate Probable Interference Area of Stronger Stations
Transmitting from GKF Industrial Park

5 Spectrum Purity

Another cause of reception problems is radiated interference. This is the result of a broadcast transmitter emitting unwanted energy on frequencies other than the transmitter's assigned channel. Not all unwanted radiated emissions cause interference. However, when unwanted emissions are observed, they indicate the condition or design of a facility is not consistent with good engineering practice and may produce or develop unwanted emissions that do cause interference. This section discusses instances of radiated interference found during the survey.

5.1 Spin 94.9

In the spring of 2006 we observed emissions radiating from the Spin 94.9 transmitter. In 2006, with the cooperation of the licensee, we determined that the exciter (the first stage of the transmitter) was generating spurious emissions on both sides of the 94.9 channel. On each side of the signal two spurs are evident (on inspection close to the transmitter site there are four spurs). They are the product of defective electronics and are not related to the mixing of the signals of other stations in the transmitter. In the 2007 survey the emissions were also observed, and confirmed on site with the licensee's cooperation. Figure 5 shows a 2007 FM band plot showing 94.9 under marker number 2 and spurs marked with bold arrows to its left and right.

We reviewed a spectrum occupancy report commissioned by the ICTA in late 2006 and found that, at some locations where the contractor collected spectrum sweep data, these spurious emissions were present.⁷ On the upper sideband of 94.9, the emissions on 95.4 were merged with the signal of now-silent 95.5, and were not observed as an independent signal in the spectrum. On the lower sideband of 94.9, at 94.4, the spurious emission was so distinct that the surveyors counted it as a separate radio transmission in the radio spectrum.

We found these spurs visible at most of the locations we visited in 2007. These spurious emissions are quite strong for such emissions, similar to that of a one- to ten-watt low power FM station. While they are presently apparently doing no harm to reception of other stations, it is neither good engineering practice to permit faulty electronics to be on the air nor prudent

⁷ Aero Systems International, November 2006 Spectrum Audit. See charts for 92-96 MHz, pp. 24, 38, 52. Signal marked "1" is the 94.4 spur. Signal marked "2" is 94.9. Signal marked "3" is the 95.5 station with a bulge to the left which is the spur at 95.4.

spectrum stewardship to be emitting such high level spurious emissions. Based on three consecutive surveys over a year and a half, it appears the spurious emissions from 94.9 have been continuous.

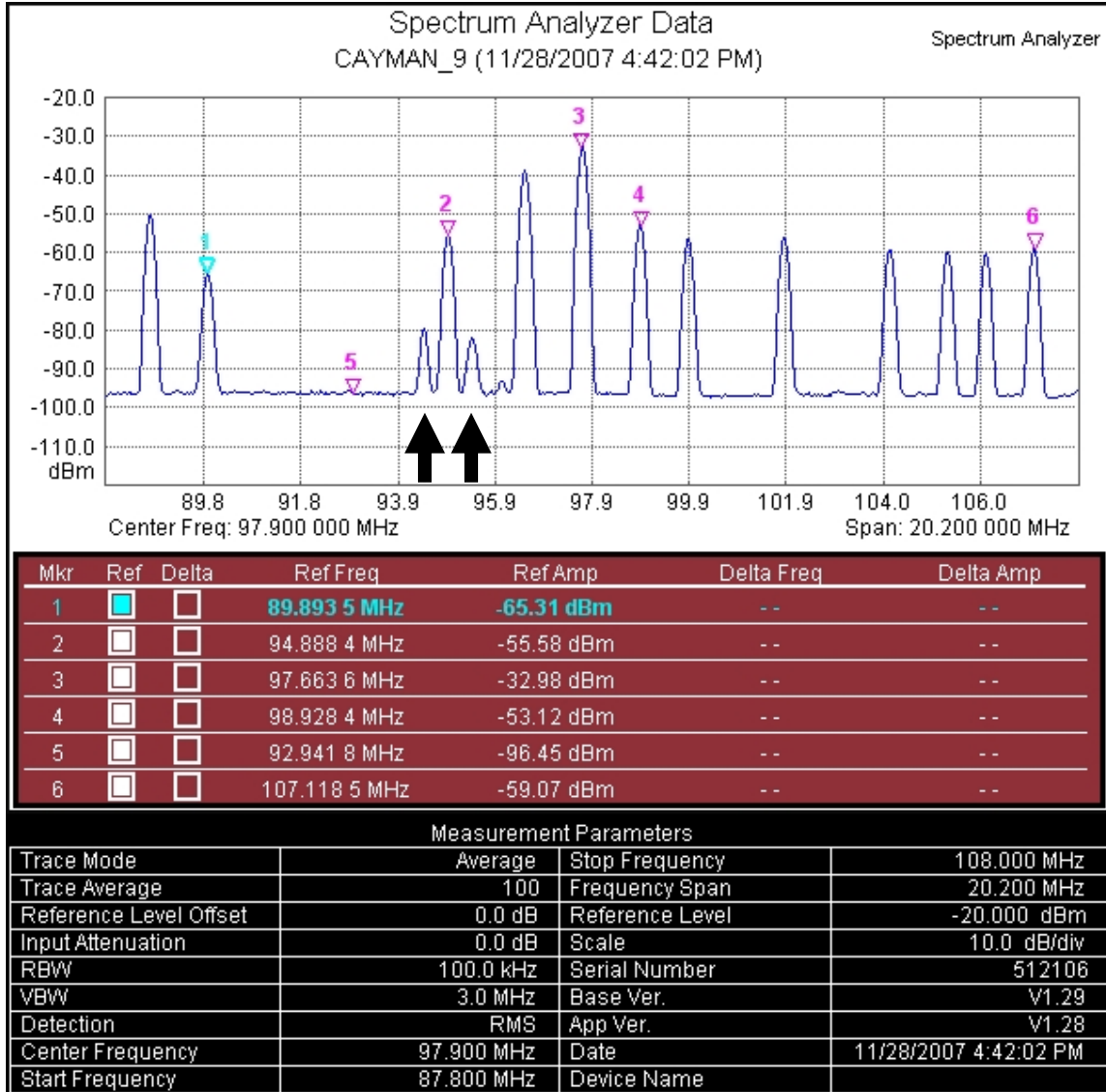


Figure 5
BSL FM Spectrum Plot at Alissta Towers Offices

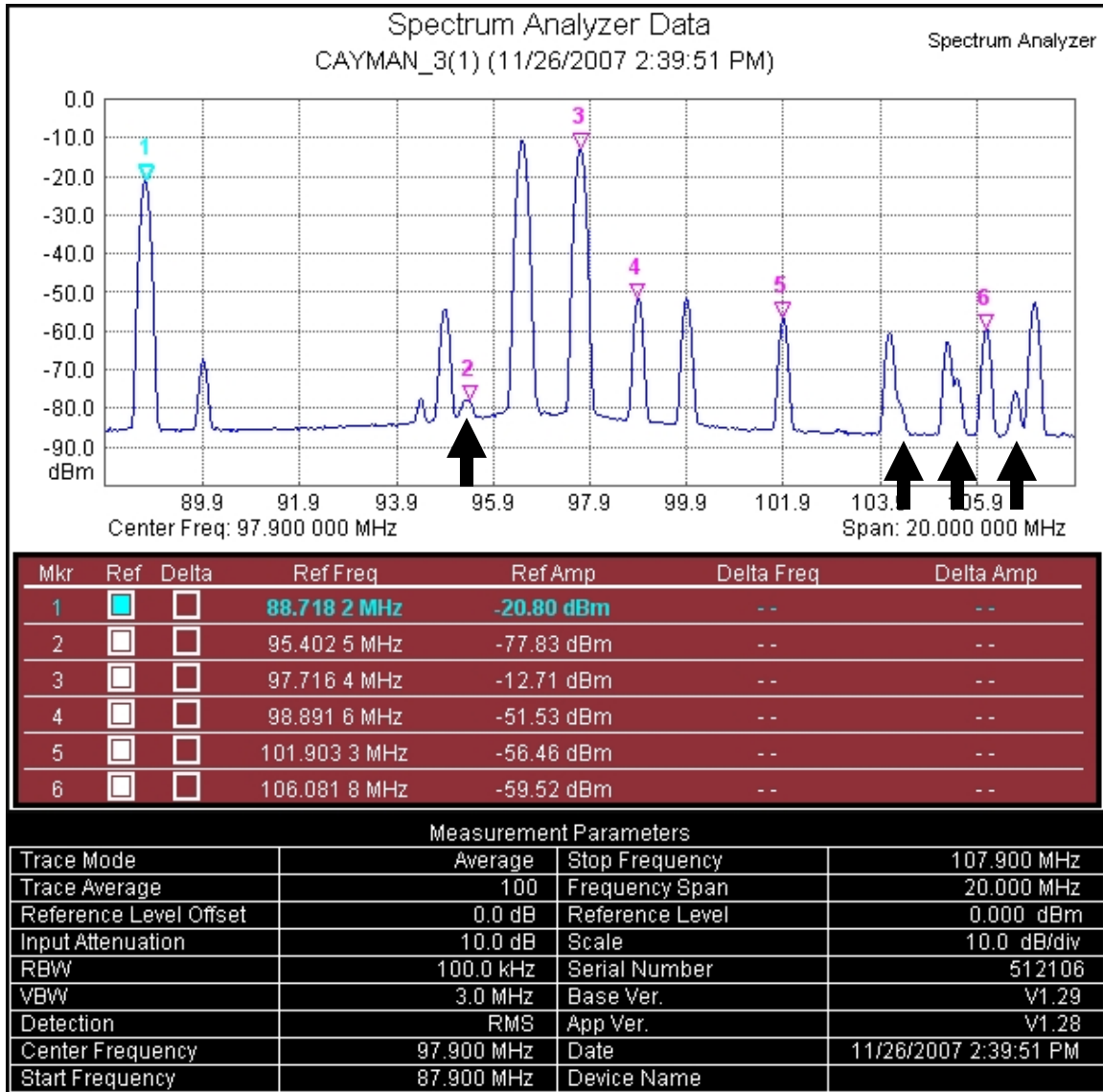


Figure 6
BSL FM Spectrum Plot at GKF Industrial Park

5.2 George Town

The George Town Three in George Town – 88.7, 96.5, and 97.7 – transmit from two closely-positioned towers in the GKF Industrial Park. They operate at 200, 1000, and nearly 2000 watts transmitter power respectively. Figure 6 shows a plot of the FM spectrum taken from within the industrial park location of the towers. Attention was paid, as in all the measurements, to insure that the spectrum analyzer was operating within its linear dynamic range and was not internally

generating its own receiver overload products. The plot has four bold arrows, indicating from left to right spur energy at 95.3, 104.3, 105.5 and 106.7.

At 95.3 on Figure 6 a new spurious emission component appears to expand the width of the existing spurious emission on 95.4. The emission on 95.4 is generated at the Spin transmitter in Newlands. Marker #2 points to the frequency of the 95.4 interference product from Newlands, while the “bump” of interference has spread to the left to include 95.3. The product at 95.3 would be the result of a mixing product of CAYROCK 96.5 and Heaven 97.7.

Because the Newlands 95.4 spur partially occludes the view of 95.3, it is difficult to distinguish the spur at 95.3. This is yet another reason why transmitters should be maintained properly; the presence of the still-unresolved spurs from Newlands confounds diagnosis of a spur and potential problem in George Town.

The mechanism for producing a spur at 95.3 is mathematically this:

$$(2 \times 96.5) - 97.7 = 95.3 \quad (1)$$

This would be indicative of a mixing product generated by the CAYROCK 96.5 transmitter. It is about 70 dB below the power of the source signal at 96.5. The target for such emissions in the USA is 80 dB below carrier, for a station with 5 kW ERP, denoted -80 dBc, so the emission if confirmed to exist, is only about ten dB too high. (Compare this with the 94.9-originated spurs which are substantially stronger at their source, at only -25 dBc, some 55 dB too high.)

Another potential product of the 96.5 transmitter is at:

$$(2 \times 96.5) - 88.7 = 104.3 \quad (2)$$

The second arrow from the left on Figure 6 indicates that on the slope of 104.1 there is energy at 104.3. Compared to the source signal at 96.5, this appears to be a little stronger, perhaps at about -65 dBc.

The 97.7 transmitter might produce a product at:

$$(2 \times 97.7) - 88.7 = 106.7 \quad (3)$$

Indeed, the fourth arrow from the left indicates a spur at this frequency. This appears to be about -65 dBc with respect to the 97.7 source. Typically, it is the station whose frequency is multiplied by two (as is 97.7 in Equation 3) that is the source of an emission on the resulting frequency (106.7 in this case). Normally, we would assume that the energy from 87.7 is feeding back into

the output of the 97.7 transmitter, mixing according to Equation 3, and coming out the Heaven 97.7 antenna on 106.7. However, 97.7 has a band pass filter in the transmission line that should be protecting the 97.7 transmitter from a) accepting too much incoming 87.7 energy and b) putting out too much energy on 106.7. It is possible that the filter is not sufficiently selective in rejecting the incoming 87.7 energy and the resulting outgoing 106.7 energy.

The third arrow from the left points to a spur on the slope of 105.3, at 105.5. It appears to be about -60 dBc below either 97.7 or 96.5. The mathematical relationship is such that its source is not readily determined:

$$96.5 + 97.7 - 88.7 = 105.5 \quad (4)$$

Heaven 97.7 is the only station among the three that employs a bandpass filter on its output. This suggests that 96.5 is more likely to be generating this spurious emission than 97.7.

Overall, FM stations at the GKF Industrial Park appear to be generating some unnecessarily high spurious emissions. These George Town Three spurious emissions are not as powerful as the spurs emanating from Spin 94.9 in Newlands and will therefore not reach as far as the Spin spurs do. However some of the George Town Three spurs fall on or near active broadcast channels that are received in George Town from a distance, and there is a potential for such spurs to degrade the received signal quality of the other stations. It is always prudent to filter broadcast transmitters at multi-transmitter sites. It is not clear whether the filtering present on the 97.7 transmitter is insufficient or defective or performing its function properly.

5.3 Northward

In 2006 we observed some intermodulation products resulting from the combination of the three stations active at the Northward site at that time – 89.9, 105.3, 107.9. In 2007 the weather station at 107.9 (a relatively low power operation to begin with) was not on the air. The three DMS stations, 104.1, 106.1, 107.1 were added to the Radio Cayman 105.3 (The Breeze) antenna. The output of the three-port star combiner of the DMS stations is injected into a hybrid balanced combiner into which 105.3 is injected as well. There appears to be no filtering on the system. The combining processes rely on the inherent isolation between ports to minimize the interaction between each transmitter and the other signals.

With Radio Cayman 89.9 operating on a separate antenna at the Northward site, some 15 to 20 MHz below the other four stations’ frequencies, mixing products could appear 15 to 20 MHz above the other four stations’ frequencies, on 118.3, 120.7, 122.3, and 124.3 MHz (two times each frequency minus 89.9). This may happen when the 89.9 signal is received by the output amplifiers of each of the four stations on the other antenna. Other mix products appear as well, such as $104.1 + 105.3 - 89.9 = 119.5$, or $104.1 + 106.7 - 89.9 = 120.3$. See Figure 7 The 120 MHz spectrum is utilized for aeronautical communications. These emissions appear to be 50-70 dB below the carrier levels, when approximately -80 dBc is the FCC target.

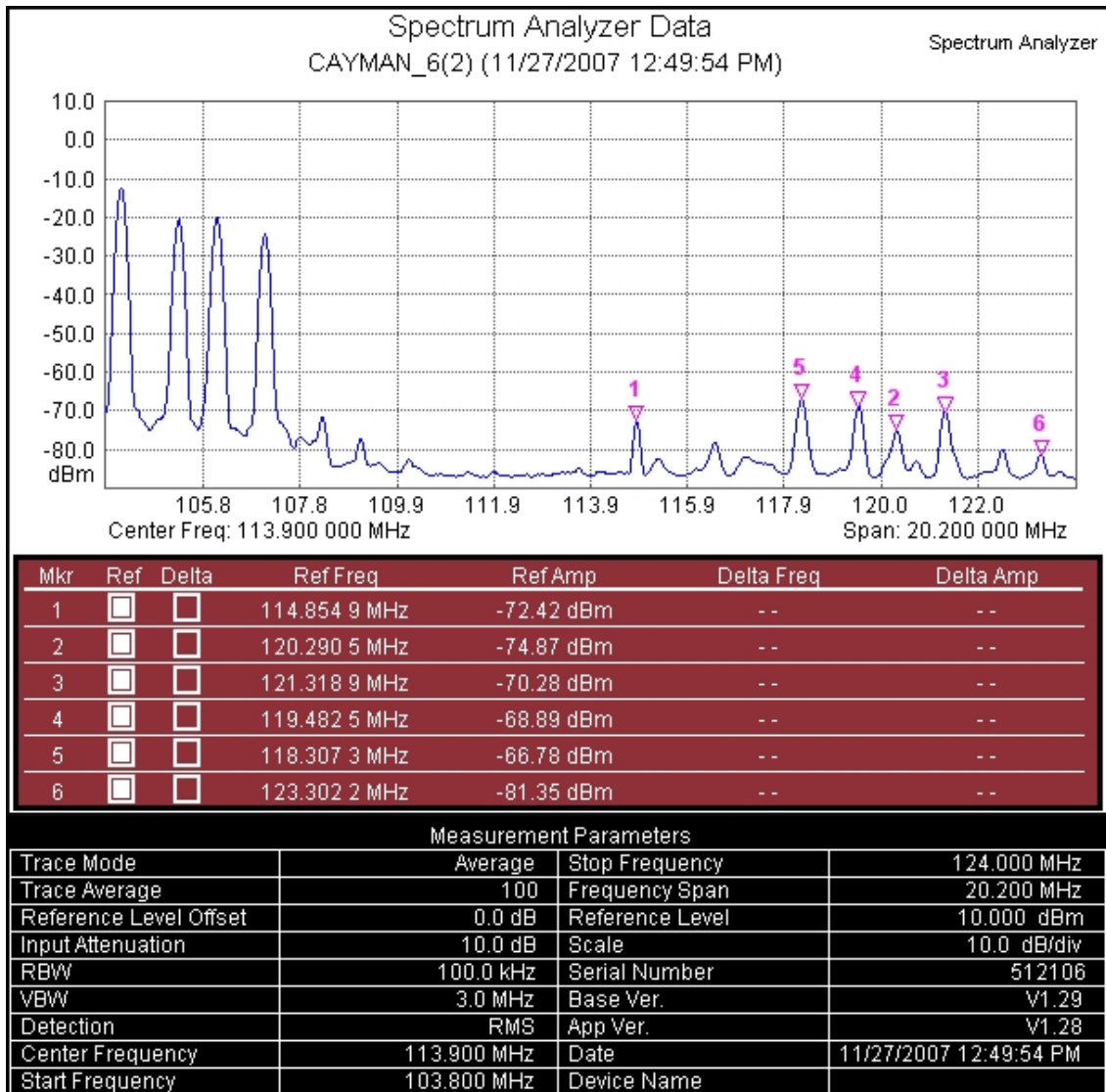


Figure 7

Upper FM band and Aeronautical Spectrum at Northward

The simplest solution for this particular mixing up to the 120 MHz spectrum would be to eliminate 89.9 from the transmission line of the antenna connected to the other four transmitters. This can be done by installing a filter on the output of the four-station combiner. This filtering, however, will not eliminate the other spurious emissions that the interactions of the four combined stations cause, such as at 108.1 and 108.9. These spurs are about -45 to -60 dBc.

Within the FM band, some additional spurs appear at 101.1, 102.3, 103.1 and 107.9. See Figure 8. The spur at 101.1 could be the result of the mixing of $(2 \times 104.1) - 107.1$. The 102.3 spur could be the mix product of $104.1 + 105.3 - 107.1$. Similar sums and differences of the four stations' frequencies can produce the other products observed.

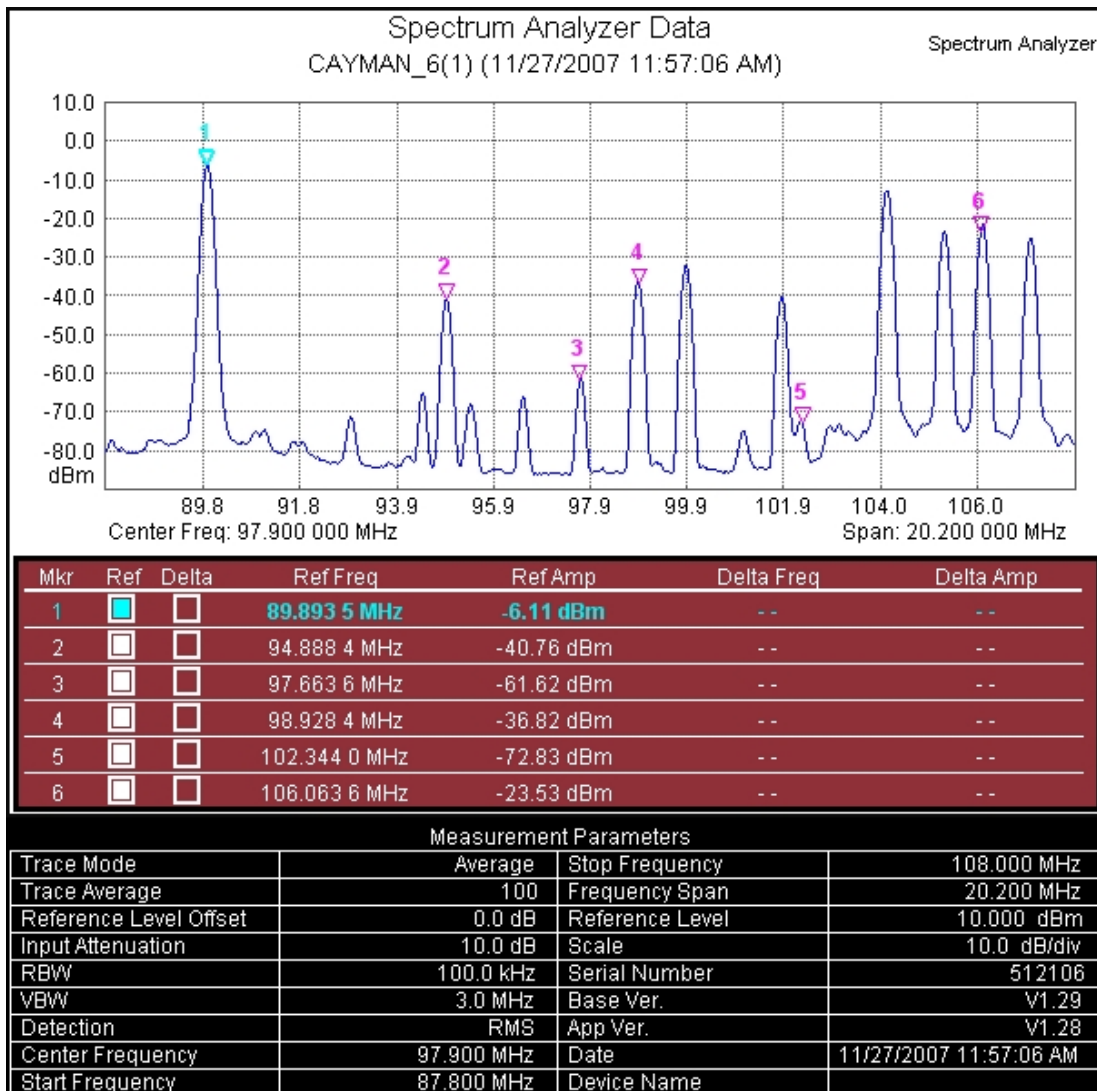


Figure 8

FM Spectrum at Northward Tower Site

The peak at 103.1 has a curious triple peak, where it is joined by 102.9 and 103.3. Similarly, some double-peaked spurs appear around the station on 89.9 – at 90.9/91.1, 91.7/91.9, 88.7/88.9, and 87.9/88.1. Overall, these spurs appear high in level, within a possible range from -45 to -70 dBc, depending on the spur and what transmitter might be its source. The double and triple peaks may be indicative of more complex mathematical relationships of the FM frequencies (employing sums and differences of five frequencies instead of three) or they may be indicative of another interference mechanism. Other non-FM transmitters on the tower could contribute to, or be susceptible to, generating these mixing products.

To address just the ingress of 89.9 into the four-station combining system, a band-reject filter that blocks the 89.9 signal could be installed in the transmission line of the four station combiner. See *Insertion Point A* in Figure 9. This is accomplished by the filter attenuating 89.9 on its way into the output of the combiner (see in Figure 9 the unwanted energy path, dashed line, from Antenna 1 through Antenna 2 to Transmitters 2-5). This filter, if sufficiently selective, could minimize the products generated in the aeronautical band.

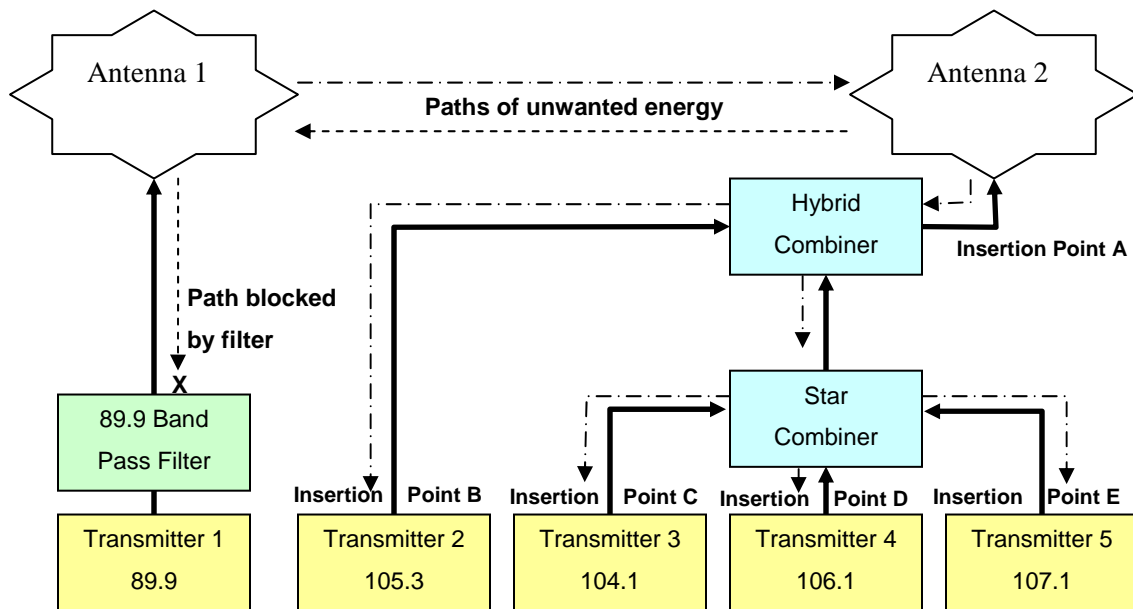


Figure 9

Block Diagram of Northward FM Facilities

Illustrating Paths of Unwanted Energy Toward Transmitters

A more aggressive single-filter approach would involve inserting a band-pass filter for the 104.1 to 107.1 MHz band at Insertion Point A, with skirts steep enough to knock down all emissions beginning 1 MHz outside this range. As with the 89.9 band-reject filter, this filter will also minimize the ingestion of unwanted 89.9 energy by the other four transmitters, thereby reducing the emissions that appear in the aeronautical band. It would also further reduce any outgoing emissions in the aeronautical band that might still be generated within the combined antenna system. This single, wideband filter will also treat the symptoms, not the cause, of any spurs the four stations generate among each other, if the spurs fall outside the frequencies 104.1 to 107.1. Any spurs that the four stations generate near and between 104.1 to 107.1 will be not be blocked by such a filter.

The most comprehensive way to minimize the production of mixing products in each transmitter is to equip each transmitter with a narrow bandpass filter tuned to that transmitter's frequency. Each would be placed at the points in Figure 9 labeled *Insertion Point B, C, D and E*. This protects each of the four combined transmitters from the others on the combining system, and also minimizes the ingress of the 89.9 energy from the other antenna. Any mix products that may still be generated in the aeronautical band would be suppressed as they emanate from each transmitter.

6 Conclusion

6.1 Findings

- *Conditions Improved Since 2006*
The 2007 survey found improved interference conditions in George Town, but interference still remains.
- *Northward Filtering Necessary; Responsibility Shared*
Station filtering can be improved to protect the spectrum from radiated interference. While Radio Cayman's proposed power increase on 89.9 will increase interference levels in the aircraft band already generated by the four transmitters on the common antenna, it was the addition of the DMS stations at the Northward site that significantly increased the number of unwanted emissions in the aeronautical band. To minimize radiated

interference, the parties jointly have responsibilities to protect their individual transmitters from incoming energy from the other transmitters on site.

- *Centralizing FM sites reduces population affected by interference*

The use of a nearly common centralized location on the island for most transmitters (one tower in Northward and two towers in Newlands 2 miles from Northward) is not ideal, but centralizes blanketing interference to two areas less densely developed than George Town. Except when very close to one of the towers, even inexpensive receivers will be able to pick up most Northward and Newlands signals within the Newlands/Northward blanketing areas because all signals are quite strong and the near-far problem is nearly eliminated. Further, with enough power, the island-wide coverage from these locations is robust – with good stereo performance in George Town and satisfactory monophonic reception to nearly the entire island.

- *Some Newlands Stations Low in Power*

To reach the entire island, the lowest power station at Newlands (Spin 94.9) would benefit from a power increase. As well, Vibe 98.9 could benefit from a power increase, as it falls on the edge of the ITU monophonic threshold on the extremes of the island.

- *DMS Move-out*

The receiver-induced interference concerns in George Town identified in the 2006 survey have been eliminated by the relocation of Hot 104.1, Kiss 106.1 and X-107.1 to Northward.

- *Interference Remains in George Town*

Interference from the remaining stations in George Town was documented. While it appears not to be as pervasive as when there was also interference from the former DMS facilities, it is still pronounced and widespread enough to circumscribe hundreds of residences. If the three remaining stations in George Town (which currently broadcast at 200, 1000, and 2000 watts transmitter power, respectively) were to increase power to cover more of the entire island, particularly to the levels of the former DMS facilities (say, between 2000 and 6000 watts), their collective interference potential would be as pernicious as that of the former DMS facilities.

- *Specific Interference to 98.9 in George Town*

Paramount's Vibe 98.9 falls on a frequency that is also the frequency of an interference product of 96.5 and 97.7. This unfortunate coincidence of frequencies closely parallels a similar product of the former DMS facilities that appeared near the Radio Cayman 105.3 frequency in 2005. The Vibe interference phenomenon, depending on the radio and its location, was experienced as much as 1.5 miles from the GKF Industrial Park transmitter site. Also paralleling the Radio Cayman experience with the former DMS facilities, Vibe operates from studios in George Town as does Radio Cayman. In both cases, the proximity of the studios to the sources of potential interference put not only many listeners at risk of interference, but also the studio operations.

- *Coverage- All Island*

The stations in Northward and the higher-powered stations in Newlands had the best overall coverage, not only out to the eastern reaches of the island, but also to the West Bay area. The George Town stations are more severely compromised with respect to island-wide coverage due to their power levels, location, and possibly their antenna configurations. Only the higher power Newlands stations and the Northward stations deliver nearly complete ITU rural monophonic coverage to the island. Clock radio listening across most of the island was possible only with those higher power Newlands stations and the Northward stations.

- *Coverage- George Town*

The higher powered Newlands stations and the Northward stations deliver a nominally 66 dB μ urban stereo signal level to George Town. While not as wall-busting a signal level as a locally-transmitted full power signal, this urban stereo performance should be satisfactory for building penetration in the most densely populated area of the island.

- *98.9 Still Dirty*

As observed in 2006, the 98.9 transmitter continues to generate rather strong spurious signals on adjacent channels. With 95.5 no longer on the air, these spurs no longer directly affect any currently operating stations. However, they indicate a faulty transmitter is in use which could deteriorate and increase its production of spurs at any time. These spurs radiating from Newlands were so strong that they also masked a

potential interference problem we were evaluating in George Town. This should be repaired promptly.

- *89.9 Weaker to the East*

Radio Cayman 1 (89.9) radiates from an antenna that is separate from the antenna employed by Radio Cayman 105.3 and the three DMS stations sharing with 105.3. Radio Cayman 89.9 also was transmitting at modestly lower power than the other four stations. (In January 2008 the ICTA approved a power increase to 5000 watts transmitter power, which would be a 3 dB increase in operating power, over the 2500 watts emitted during the 2007 survey.) Nevertheless, the differences in power levels of 89.9 compared with the other four, particularly to the measurement points easterly of the tower, were more pronounced than the modest difference in transmitter power would suggest. We verified our antenna calibration and refined our computations before arriving at this conclusion. It may simply be a result of the broadcast antenna's pattern being distorted by interaction with the tower to which the antenna is attached. A more omnidirectional antenna arrangement would improve reception easterly of the Northward tower. It was also noted that near the Northward tower we obtained significantly stronger emissions from Radio Cayman 1 than from the other four stations on the shared antenna, possibly hinting at a difference in the antenna's vertical pattern compared to that of the shared antenna on the tower.

- *Northward Stations Emit on Aeronautical Band*

The combination of five stations at Northward, with one some 14 to 17 MHz lower in frequency than the others causes multiple interference products to be radiated on the aeronautical band around 120 MHz. Since there is no filtering present on the four-station combined antenna system, four transmitters ingest the energy of 89.9 and emit energy on the aeronautical band. Additional interference products appear in the FM band. We recommend a bandpass filter be inserted in the antenna feed line between the four-station combiner and the shared antenna. It should filter steeply enough to minimize spurious emissions as close as 1 MHz to the 104.1-107.1 group of stations.

- *George Town Stations Emit Spurs*

The three George Town stations transmitting from the GKF Industrial Park generate spurious emissions that presently do not seem to have a debilitating effect on reception of

other signals. However, some of these spurs appear on or beside signals arriving from outside of town, potentially affecting the quality of their service without necessarily creating an obvious interference effect. While 97.7 has a filter, there is a question as to whether it is as selective as necessary to minimize spurs. The other higher power station at the site, 96.5 has no filter and is generating spurs. It is recommended that these two stations install band pass filtering with sufficient selectivity to protect the spectrum from unnecessary byproducts. While 88.7 operates at such a low power level that interference products are inherently low, if 88.7 were to increase power, it should install adequate filtering as well.

- *97.7 Antenna Physically Obstructed*

The multi-bay antenna of 97.7 is leg-mounted on a tower at the GKF Industrial Park. It is positioned in close proximity to a panel antenna belonging to another tenant on the tower. The proximity of and geometry of the panel antenna is most certainly affecting the coverage of 97.7. This installation is not based on good engineering practice. The operators of 97.7 are encouraged to seek to resolve this mechanical interference issue to ensure the best coverage possible. The proximity of these two antennas may also be contributing to the interference observed in band and/or other potential interference in bands not examined in the survey.

6.2 Recommendations

The following specific actions are recommended:

- *Vibe 98.9 should repair its exciter promptly.*
- *All stations operating within a mile of any other station should have bandpass filtering that is sufficiently selective to minimize spurious emissions.* Presently the two Northward antennas lack the bandpass filtering necessary to isolate the each antenna's transmitters from those on the other antenna. Likewise, in George Town the transmitters on 96.5 and 97.7 lack sufficient filtering to suppress spurious emissions adequately. If 88.7 were to increase power, it should also install sufficient filtering.
- *An emissions mask should be adopted to provide broadcasters with regulatory certainty as to what constitutes permissible spurious emissions.* For example, US Title 47 CFR 73.317 specifies a spurious emissions limit typically about 80 dB below the power level of a 5 kW ERP station. Lower powered stations have a less restrictive mask that is inversely proportional to their power levels.
- *Each station should compute its Effective Radiated Power ("ERP") and provide the calculation to ICTA along with antenna height above ground.* ERP can then be utilized to more accurately estimate coverage and to compute the spurious emissions limits for each station. Station power levels are currently presented as transmitter output powers, which can create a false impression of coverage potential because the antenna gain and cable losses are not included in the power assessment. Directional antenna arrays (such as the 96.5 antenna array) should provide additional detail on the ERP pattern.
- *Stations on combined antenna systems should ensure their combining system design results in sufficient suppression of spurious emissions resulting from the interaction of the transmitters on the shared antenna.* The three DMS stations and Radio Cayman's Breeze operate on such a combined system. After filtering out the 89.9 energy ingress to the combined antenna system at Northward, the spectrum should be examined again to

determine whether additional filtering is necessary on individual transmitters of the four-station combining system.

- *If the license requirement of providing universal service to the entire island remains a policy priority, then all stations should be encouraged or required to increase power to provide at least a rural monophonic signal (48 dBμ) to the entire island or nearly the entire island (such as 90% of the land mass or population). Presently George Town stations do not serve the entire island. Among the stations near Newlands, Spin 94.9 is least compliant and Vibe 98.9 is close to compliant but essentially not compliant with an island-wide mandate. With the recently approved power increase for Radio Cayman 1 we can expect a 3 dB increase in received signal levels at all locations. However this may not be enough to overcome the apparent inefficiency of the station's transmissions.*
- *The interaction of the 97.7 antenna and the other antenna mounted close to it should be further examined. The two antennas' proximity can negatively affect the coverage patterns of each antenna and can inject unwanted energy from each source into the other system, potentially causing spurious emissions.*
- *The issue regarding whether to move the three remaining stations in George Town is a policy matter. We observed the improved interference climate in George Town with the removal of the three DMS stations to Northward and observed that interference is still occurring to a degree with 97.7 and 96.5 still operating from George Town. A requirement to move the remaining George Town stations to Northward or Newlands and operate at island-serving power levels would be consistent with the desire to a) centralize blanketing interference to one (or two) locations on the island and b) to achieve island-wide universal service for each station. The potential detriment of such a move and power requirement is the risk of the loss of economic viability of one or more stations due to either the one-time cost of moving and upgrading equipment or the increased operational cost of operating a higher power facility at a distant site.*
- *An evaluation of the antenna pattern of Radio Cayman 1 on 89.9 is recommended. Interaction with the tower may be limiting coverage, especially to the east, and the*

antenna may be projecting far more energy toward the ground than necessary. Proper antenna element phasing and vertical spacing should also be confirmed.

- *Field surveys subsequent to the 2007 survey are recommended on an as-needed basis, with a suggested annual review cycle to determine whether a consultative visit is required.* It may be desirable to perform follow-on work to confirm the resolution of current emissions issues. This will ensure that each licensee is unencumbered by interference from other licensees and is likewise not polluting the spectrum at the potential expense of fellow licensees. Also, as new stations are licensed and incumbent stations relocate or increase power, it is advisable to verify clean operation of the facilities. If the island-wide service mandate is a priority, a field survey of new or modified facilities can verify each licensee's degree of compliance. As has occurred over the past three years, it appears that the roughly annual attention to the stakeholders provided by bringing in an FM consultant is beneficial. Not only are specific interference and performance issues identified and addressed with field visits, but also it is an opportunity for the stakeholders to engage in dialogue on the technical and regulatory issues facing them.

David Maxson

Managing Partner

Broadcast Signal Lab

February 2008

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Appendix 1
Discussion of Reception Quality Report Table Terms

Discussion of Reception Quality Report Table Terms

Table 1-A in Section 2 is the key to the terms contained in the Reception Quality Report Table. This section discusses each term in more detail. Ideal reception is sometimes referred to as “full quieting.” This occurs when the desired signal is strong enough to produce audio that is as noise-free as the receiver can deliver. The “OK” designation on the table indicates full quieting, or nearly full quieting.

The *Noisy1* designation indicates that there was audible background noise (usually “white noise” sometimes called “hiss”). This noise was at a level that some listeners might tolerate, especially if the listener is strongly invested in hearing the current program on the station. *Noisy2* is a higher level of the noise, a level that might be tolerated by a determined listener only for a limited time. *Noisy3* is an even higher level of noise that most listeners would find unacceptable for listening to at all.

Mild Multipath indicates a noise that varies with program audio modulation of the signal. This is characteristic of reception where the arriving signal is accompanied by reflections of the signal that bounced off of distant surfaces. This is a time-varying and often tolerable but unpleasant condition. It is not caused by the presence of other stations or interfering signals in the spectrum. It indicates that there may be terrain or structures preventing a strong signal arriving directly from the transmitting antenna site.

The designations *Crosstalk*, *Hard to Tune in*, and *Will Not Lock* are consequences of other radio signals compromising the receiver’s ability to tune in the desired signal. Strong undesired signals can affect the operation of a receiver in a variety of ways.

Crosstalk is a result of unintended mixing of signals in the receiver’s front end. More than one station is audible on the channel. Strong signals that overload the front end of the receiver can produce phantom frequencies the way two musical notes can create additional undertones and overtones to the human ear.

Hard to Tune In applies to the analog tuner of the clock radio and not to the digital tuning of the in-dash radio. The ability of an inexpensive analog tuner to resolve signals is limited. The quality of a received signal may depend on whether the user tuned to the channel from a higher

frequency or a lower frequency (tuning down or up the dial). The ability to find the desired signal may also be dependent on speed at which the dial is adjusted. The “sweet spot” where the tuner can lock in the desired signal may be diminished by interference.

If the receiver *Will Not Lock* on the desired signal, it is the result of strong unwanted signals or mixing products falling very close to the desired channel, but not directly on it. The receiver has trouble latching on to the desired station’s frequency. This is typically the result of the undesired signal energy affecting the receiver’s automatic frequency control (“AFC”) and/or automatic gain control (“AGC”).

If a station is marked *Barely Audible*, it is most likely due to a weak incoming signal. The receiver produces noise within which the desired station’s audio is just detectable. In some cases undesired signals may also not be audible but may still help provoke the desired station’s poor audibility.

Not Receivable indicates that there is no sign of the desired signal on the receiver. This is usually due to the presence of strong unwanted signals and a weak desired signal. In cases where there is no strong undesired signal, the desired signal is so weak as to be effectively nonexistent.

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Appendix 2
Table of Spectrum Analyzer Measurements

Appendix 2 Table of Spectrum Analyzer Measurements

25 Nov - 30 Nov 2007

Anritsu MS2721A

Use Anritsu Master Software to Read .spa Files. Images from .spa files converted to .jpg with same file names.

2007

Site#	Filename	Location
10	cayman_1	Owen Roberts Dr. @ Dorcy Rd. by Airport Post Office
3	cayman_1(1)	Hirst Rd. @North Sound
20	cayman_1(2)	Hirst Rd. @Avcom Tower Driveway (Style Vibe)
4	cayman_1(3)	Tangelo Rd.
6	cayman_1(4)	John McLean Rd.
7	cayman_1(5)	Turnpipe Lane
8	cayman_1(6)	Sunnyfield Rd.
9	cayman_1(7)	Rum Point
9	cayman_1(8)	Rum Point
2	cayman_2	Alissta
11	cayman_3	GKF Industrial Park, beside Christian Communications Studios (Building 90D, Map 28)
11	cayman_3(1)	GKF Industrial Park, beside Christian Communications Studios (Building 90D, Map 28)
12	cayman_3(2)	Washington Rd. and Grackle Rd. (near GKF sites)
13	cayman_3(3)	Woodpecker Close, Cypros Rd., Brushy Ave. (near GKF sites)
13	cayman_4	Woodpecker Close, Cypros Rd., Brushy Ave. (near GKF sites)
14	cayman_4(1)	End of Greenwood (near GKF sites)
15	cayman_5	Kirk Home Centre - Bodden Rd @ Eastern Ave.
16	cayman_6	Northward Tower Site

2006

Site#	Date	Notes
No	11/25/2007	max hold, peak detector
3	11/25/2007	
3	11/25/2007	20 dB att.
4	11/25/2007	10 dB att., Site 5 skipped to save time - not critical.
6	11/25/2007	10 dB att.
7	11/25/2007	
8	11/25/2007	
9	11/25/2007	
9	11/25/2007	Internal preamp on
2	11/26/2007	20 dB att.
No	11/26/2007	20 dB att.
No	11/26/2007	10 dB att.
No	11/26/2007	10 dB att.
No	11/26/2007	
No	11/26/2007	10 dB att.
No	11/26/2007	10 dB att.
No	11/27/2007	20 dB att.

16	cayman_6(1)	Northward Tower Site	No	11/27/2007	10 dB att., Repeat measurement after adjusting averaging.
16	cayman_6(2)	Northward Tower Site	No	11/27/2007	10 dB att., Aircraft Band
17	cayman_6(3)	Northward Rd. and Shamrock Rd. (map p. 68)	No	11/27/2007	Aircraft Band
17	cayman_6(4)	Northward Rd. and Shamrock Rd. (map p. 68)	No	11/27/2007	
1	cayman_7	Boatswain's Day @ Dunlop Rd.	1	11/27/2007	
18	cayman_8	L. Gould Driveway, West Bay	No	11/27/2007	20 dB att., 94.3 on
18	cayman_8(1)	L. Gould Driveway, West Bay	No	11/27/2007	94.3 off, preamp on
2	cayman_9	Alissta		11/28/2007	3 dB splitter in line
19	cayman_9(1)	Marriott Courtyard Parking Lot, 7-Mile Beach	No	11/29/2007	Potomac dipole, vertical
19	cayman_9(2)	Marriott Courtyard Parking Lot, 7-Mile Beach	No	11/29/2007	Potomac dipole, horizontal
3	cayman_10	Exciter of 94.9		11/28/2007	30 dB att.

- All Measurements taken with 1/4-wavelength Maxrad magnetic roof mount whip, unless otherwise indicated.

- *att.* = internal attenuation (note: displayed values on analyzer files are corrected for internal attenuation settings. Hence a reading on a -10 dBm signal that was measured with 10 dB internal attenuation worked like this: the signal entered the attenuator at -10 dBm, lost 10 dB to hit the mixer at -20 dBm, was measured internally as -20 dBm and the instrument corrected the measured level to display it at -10 dBm)

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Appendix 3

Signal Strengths at Various Locations

