Broadcast Signal Lab

Report on FM Interference and Channel Assignment Issues

Grand Cayman Island

Among its various responsibilities, the Cayman Information and Communications Technology Authority ("ICTA") administers licensed FM broadcast operations. In response to complaints received following the installation of three new FM stations, ICTA engaged Broadcast Signal Lab, LLP of Cambridge, Massachusetts to provide independent technical analysis of FM interference issues on Grand Cayman Island and provide technically valid options for addressing such issues.

In addition to the immediate problem relating to these three new stations, the same issues are present with other stations, particularly in the aftermath of Hurricane Ivan. Several stations are operating from temporary facilities until they can relocate to new towers. These temporary facilities present interference concerns because their antennas are particularly close to the ground. Also, looking to the future, with fourteen licensed FM stations on the island,[1] there is potential for an increase in the number of licensed stations. As the FM band on Grand Cayman becomes more congested with new licensees, it will be more difficult to assign new stations without causing interference.

Reception of Radio Cayman in Georgetown

The new stations in Georgetown, "Hot 104" 104.1 MHz, "Kiss 106" 106.1, and "X-107" 107.1, are operated by DMS Broadcasting Ltd. They are installed at the site of a Caymanian government tower in Georgetown. This site is also the location of the government's Radio Cayman studios. However, Radio Cayman transmits from a different government tower some eight miles to the east, in Northward. Radio Cayman operates transmitters on two frequencies, 89.9 and 105.3 MHz. Radio Cayman monitors its signals at its studios just as other listeners do, over the air using a variety of receivers.

[1] Radio Cayman 89.9 and 105.3, Hurley's Entertainment 99.9 and 101.9, DMS 104.1, 106.1 and 107.1, Paramount Media 94.9 and 98.9, Christian Communications 97.7, Cerentis Broadcasting 95.5, Panorama Productions 96.5, and (not presently operating) International College of the

503 Main Street
Medfield, Massachusetts 02052
508 359 8833

Radio Cayman noticed that when the new DMS stations were put on the air, most of its receivers were unable to provide clean reception of the Radio Cayman broadcast on 105.3. This interference did not exist prior to the operation of the DMS stations and would be eliminated in the vicinity of the Radio Cayman studios if the DMS stations were shut off. With the cooperation of DMS, Radio Cayman determined that turning off either DMS's station on 106.1 or on 107.1 resolved the problem with certain radios at the Radio Cayman studios. Turning off only 104.1 did not resolve the problem. Radio Cayman reports receiving calls from listeners experiencing interference in the same area. Several interference reports also were submitted to the ICTA by individual residents indicating Radio Cayman is not alone in experiencing interference.

"Interference"

When a receiver is unable to receive a signal in such a circumstance, it is often called "interference." Interference is easily misconstrued by the layperson. It is tempting to assume the condition is automatically the fault of the new signal source, because it is the newcomer to the scene. However, in a technical sense, there is no fault unless some element of the system fails to comply with a specification. If both the transmitter and the receiver are working as they are supposed to and interference occurs, then there is simply a lack of "Electromagnetic Compatibility" (EMC) between the transmission facility and specific receivers in specific locations. EMC is the name for a discipline that involves design for and evaluation of the compatibility of electronic devices and systems.

From a technical standpoint, the lack of compatibility between specific radios and the strong signals to which they are sometimes exposed is no more the fault of the transmitting facility than it is the fault of the radio that is not up to the task of rejecting the unwanted signals. However, the system should be built to minimize the incompatibility to the degree that is necessary and economically feasible. Thus, whenever a new radio signal is put on the air, there is a technical trade-off to be made between the provision of a new service to the community and the potential for incompatibility with some receivers. It is a public policy question, then, to determine how to address electromagnetic incompatibilities that may arise in the deployment of a broadcasting

Cayman Islands (ICCI) 101.1. Finally, a government weather station assigned to 107.9 is also not currently on the air.

service. Because of the way radios are made and sold, regulation of FM receiver design is out of the question. Instead, regulation of FM transmissions must be adopted with consideration for the degree to which they may, or should not, provoke reception problems.

Consequently, rather than simply relying on an engineering assessment of fault, the regulatory process must determine what prevention and/or remedy is most in the public interest. Is it practicable to develop the FM band in a fashion that is nearly interference free? Is it acceptable to permit new stations to overwhelm ("blanket") the reception of incumbent ones? If so, how much blanketing is tolerable? If serious blanketing is permitted to occur in densely populated areas, what are the consequences of the potential "arms race" among broadcasters who seek preferential in-town positions and power levels in order to outdo the others? Is it sufficient to allow new radio stations to respond to listener complaints of interference, or is it a detriment to the community to allow significant blanketing interference in the first place, some of which might never be resolved?

The DMS/Radio Cayman Case

The particular incompatibility in this DMS/Radio Cayman case is given this ill-defined term "blanketing interference." In a general sense, blanketing interference is the effect on radios when an undesired signal, or signals, overloads the receiver, preventing its reception of other signals.

Desensitization

In the simplest interpretation, this mechanism results in "desensitization," or "desensing." Those who have tried to view oncoming traffic with the sun shining in their eyes have experienced desensing. The pupils must contract to minimize the bright light, thereby making the scene dim and hard to see. Radios respond in the same way to very strong incoming signals at the expense of "seeing" weaker more distant signals.

Receiver-induced Intermodulation

In addition to desensing, another blanketing mechanism is the overloading of the input of the radio in a manner that forces the radio to generate its own interference. This mechanism, "intermodulation" discussed further below, may interact with the desensing mechanism to produce complex and unpredictable radio behavior.

Radio Frequency Interference

An additional factor in blanketing is the impact a strong signal has on other circuitry in the radio. Not only does the signal enter the radio through the antenna, as it should, but also a strong signal may be picked up by the power cord or through the radio chassis and consequently may be injected unpredictably into other circuits of the radio. This mechanism, called Radio Frequency Interference ("RFI") can compound the other blanketing interference mechanisms rendering some radios useless in challenging radio environments. RFI is not a subject of this report.

Receiver Manufacture not Regulated

In general, radio receivers are not regulated for quality or capability. It has been left to the marketplace to decide how susceptible to interference, how sensitive, how sturdy, and so on, a particular model of radio should be. This makes it difficult to ensure full compatibility between broadcast transmissions and all receivers. Typically, more expensive receivers are less susceptible to various kinds of interference than are less expensive ones. Automobile radios are made to be driven both near to, and far from, radio towers, so they are more likely to resist certain types of interference than the $10 walkman-style radio. Home component stereo receivers tend to be less prone to certain incompatibilities than portable boom boxes.

Blanketing in the States

Because receivers are not regulated, it is difficult to predict what conditions will be incompatible with a particular radio. Meanwhile, FM radio stations have to be put someplace in order to provide service to the entire community. In the USA, the Federal Communications Commission ("FCC") addresses potential blanketing incompatibility by establishing an area that is within an arbitrary distance of a radio station and labeling it the "blanketing area." Based only on the power of the radio station, and on no other relevant factors, the FCC defines the area and says a new broadcaster must address interference complaints within that area for one year after initiation of operations. Outside that area, any receiver incompatibility with radio transmissions is ignored. Inside that area, complaints within the first year must be addressed, but after that the listener is on his own in selecting a radio that will work well in his situation.[2]

[2] The FCC limits blanketing protection to non-mobile radios, i.e. those that plug into a wall outlet. Canada has broader protections that include mobile radios. Some advocates argue that protections

Despite the fact that the FCC has a policy for handling blanketing interference complaints, the FCC attempts to minimize the incidence of such problems. The FCC encourages the use of less-developed areas for broadcast transmitter sites (47 CFR 73.315(b)):

> The transmitter location should be chosen to maximize coverage to the city of license while minimizing interference. This is normally accomplished by locating in the least populated area available while maintaining [the coverage requirements for the city of license]… In general, the transmitting antenna of a station should be located in the most sparsely populated area available at the highest elevation available…

Impact of Blanketing

Looking more closely at the modality of the DMS blanketing interference to reception of Radio Cayman's 105.3, a few telltale characteristics emerge. When a receiver is overloaded, the various possible interference mechanisms may come into play. One of the first mechanisms to occur with increasing undesired signal levels is a mixing of several radio signals inside the radio that produces energy at frequencies that are the sums and differences of the fundamental frequencies, similar to musical overtones and undertones. They are called intermodulation products. These products are formed inside the radio and can appear on other channels on the radio, including the frequencies of other radio stations.

In this case, the signals on 106.1 and on 107.1 penetrating the radio receiver are very strong. One of the intermodulation products that can occur is 2 x 106.1 – 107.1 = 105.1. This product on 105.1 is on the first adjacent channel to Radio Cayman's 105.3 and could interfere with reception of Radio Cayman. Recall that at the Radio Cayman studios the 105.3 signal is arriving from about eight miles away and is substantially weaker than either 106.1 or 107.1 in Georgetown. If the 105.1 intermodulation product in the receiver is strong enough it will interfere with reception of 105.3. Depending on the radio's quality, the pattern of emissions from the DMS antenna, and

should extend to non-radio devices, such as telephones, audio and video equipment, as well as other appliances. The susceptibility of these non-radio devices to radio energy is classified as Radio Frequency Interference ("RFI") and is not a subject of this report.

the received strengths of 105.3, 106.1 and 107.1 at the exact location of the receiver, this interference may occur. The probability of it occurring diminishes with distance from the DMS site. ICTA experiments with two boom boxes show that this interference, presently can extend over 2000 feet from the tower.[3]

Evidence that this is one of the interference mechanisms at Radio Cayman comes from a few sources.

- First, the DMS/Radio Cayman test shutting off one transmitter at a time reveals that both 106.1 and 107.1 transmissions are necessary for the problem to occur in certain radios at the Radio Cayman studios.

- Second, measurements taken by Broadcast Signal Lab at the site indicate that the DMS transmitter plant is not producing appreciable energy at 105.1. (Sometimes transmitter plants produce strong intermodulation and put it on the air, but that is not the case here)

- Third, ITU Recommendation BS.412-9 indicates that if the desired signal level is about -60 dBm then a pair of undesired signals at 1 MHz spacing could cause receiver-induced intermodulation interference if they are more than 15 to 25 dB stronger than the desired signal. Measurements at the site indicate the undesired signals of the DMS stations are 40 to 50 dB greater than the desired Radio Cayman signal. This shows that the DMS emissions create an environment that is very challenging to the representative sample of radios tested by the ITU.

- Fourth, in a test with an aftermarket car radio, reception of 105.3 was affected significantly more than 89.9. This is consistent with the model of intermodulation caused by blanketing. The other Radio Cayman station, on 89.9 has a moderate signal level in Georgetown, as does 105.3. However, for the most part, reception of 89.9 on this radio was not affected by the interference near the DMS tower. This indicates that this particular receiver's problem is not simply a case of raw receiver desensing from the

[3] The DMS stations were operating at 20% licensed power at the time of the experimentation, so the blanketing area would be substantially greater with 100% power. The FCC-computed blanketing area for one DMS station at full power would be in a radius of 8/10ths of a mile.

blanketing levels of the DMS signals, but receiver intermodulation resulting from the blanketing levels, possibly coupled with desensing.

Despite the clear evidence that some radios are indeed suffering from intermodulation of 106.1 and 107.1, this was not the only blanketing interference mechanism observed. In an ICTA test supervised by Broadcast Signal Lab, two boom box receivers, one name brand and one off-brand, were severely affected across the radio band by the blanketing, more than 2000 feet from the tower. The off-brand radio exhibited difficulty with most radio signals on the band, while the name brand radio was more successful at picking up some stations, while still exhibiting classic desensing and intermodulation behavior on others.

Meanwhile, other radios were largely unaffected. In particular, several original equipment manufacturer (OEM) car radios had no trouble (Honda, GM), or nearly so, being in the vicinity of the DMS transmissions. ITU tests summarized in BS.412-9 indicate that as a class, car radios are more resistant to this type of interference than other radio types.

Based on the foregoing, there are several options for dealing with the DMS/Radio Cayman blanketing issue that are discussed in detail below. They fall into two groups, blanketing remediation and blanketing prevention.

Blanketing Remediation Policy

Fix or Replace Some Radios

The least cumbersome, and potentially the least effective solution, would be to apply a blanketing remediation policy similar to that of the FCC or Industry Canada. In the USA and Canada neighbors are given one year to seek resolution to their interference problems. This policy does not remedy all blanketing interference because many listeners do not complain and simply live with the fact that they cannot receive one or more radio stations. In the long run, if there are blanketing levels in populated areas, many listeners may be unable to take advantage of the variety of programming offered on the FM band, leaving them disenfranchised from the benefits of the FM radio spectrum.

People have many media choices, so FM broadcasters would be wise to do everything they reasonably can to give listeners a positive experience throughout the island. This includes cooperating on minimizing blanketing interference and maximizing the utility of the entire FM band across the island. If employed, a policy requiring affected radios to be fixed or replaced should be accompanied by a policy that minimizes the potential for blanketing in the first place.

Reduce Station Power to Minimize Blanketing

Because of the variations in radio susceptibility, not much benefit is obtained by small increments of power reduction. A reduction by an order of magnitude, say 10 dB, will produce noticeable results. The DMS stations, which were initially operating temporarily at 6 kilowatts each before reducing to 2400 W, would be substantially more compatible with nearby radios if they were reduced from licensed power (12 kW) by about 13 dB, or to about 600 watts each. However, a 13 dB reduction in power also substantially reduces the station's coverage area, which will further compromise the ICTA goal of each station serving the entire island.

Blanketing Prevention Policy

To overcome the degradation of the quality of the FM service on Grand Cayman from blanketing interference and disparate signal levels, a cooperative approach to providing reliable FM service is recommended. If stations were to locate in less populated areas (industrial districts, less developed areas and the like) they could be consolidated in one or two common areas. In addition to constraining blanketing interference to less critical areas, this approach provides another benefit—common signal levels throughout the island. One of the characteristics that enables interference to occur is when there is a disparity in signal level between the desired signal (low level) and one or more undesired signal levels (high levels). With stations transmitting from one common area, their signals will diminish together as they propagate from the site. This way, the signal level disparity among received stations is eliminated throughout the island.

Since under their licenses all Grand Cayman broadcasters are expected to provide service to the entire island, there is no penalty in spectrum efficiency or local coverage in co-locating their facilities. On the contrary, with co-location at a suitably isolated facility, elimination of blanketing interference improves spectrum efficiency and the quality FM service to all members of the public.

DMS, and other broadcasters, could be encouraged or required to migrate to a central broadcast site designed to minimize blanketing signal levels and sited to put any such levels over a low-population area. This concept is discussed further below.

Mitigating Radio Cayman Problem Only

In lieu of the approach above in which all FM blanketing is prevented by design, there are options that could be applied specifically to the DMS/Radio Cayman case that would not provide any general benefits to the rest of the FM band on the island.

Change the DMS Antenna

DMS initially proposed a type of antenna that is intended to minimize downward emissions, called a 5-bay half-wave-spaced antenna. The installed antenna is different— a 4-bay 0.8-wave-spaced antenna, a design which is also intended to manage sidelobe intensity. The downward-emitting "sidelobes" of each antenna occur at different angles and with slightly different maximum levels.

Despite their differences in design, the difference between these two antennas' emissions on the ground close to the tower is probably not significant. Their downward emissions are of the same order of magnitude, resulting in similar impacts on the ground. A more detailed analysis is presented in Appendix 1.

With an antenna height of less than 200 feet above the ground, there is little else that can be done with antenna design to substantially reduce the blanketing emissions. There are other techniques for further reducing the downward sidelobes, however, the DMS antenna is so close to the ground that even if the sidelobes are minimized, the main horizontal lobe reaches the ground with potential blanketing levels.

DMS Frequency Change to Move Receiver Induced Intermodulation

First, resolving the receiver-generated intermodulation product on 105.1 will address only those receivers that are suffering intermodulation without suffering more complete overload. For these radios, moving the intermodulation product off 105.1 might improve their performance. This could be accomplished, say, by moving DMS's "X107" from 107.1 to 107.5. This moves the intermodulation product from 105.1 to 104.7—away from 105.3 and closer to 104.1. Such a move would, however, waste spectrum by forcing the government weather radio station on 107.9 off its channel.

Alternatively, weather and X107 could swap channels, placing X107 at 107.9. This moves the receiver-induced intermodulation product to 104.3, which is adjacent to DMS's 104.1. Since 104.1 is as strong as 106.1 and X107, the intermodulation product on 104.3 is less likely to be a problem for DMS as it presently is for Radio Cayman.

However, while these options might improve reception of 105.3 on certain radios, they will not relieve interference to other receivers in the area that now experience blanketing more severely.

Bring Radio Cayman to Georgetown

Another solution would be to relocate Radio Cayman's 105.3 transmitter to the DMS tower. This improves the relationship between the received signal level of 105.3 and the levels of the DMS signals. A reduction in blanketing induced intermodulation problems may occur for some radios. However since the area is already a blanketing area, the addition of yet another signal to this site will only exacerbate the reception problems of those receivers that are already or nearly overloaded.

Further, as a government operated radio station, loss of coverage to the more sparsely populated eastern region of the island may not be satisfactory. The current Radio Cayman transmission site in Northward is about eight miles east of Georgetown and obtains probably the best all-island coverage of any of the current FM sites. The low antenna height and the westerly location of the Georgetown tower conspire against good coverage in the eastern areas.

Best Solution to DMS Problem

The solution most beneficial to Radio Cayman and, perhaps more importantly, to residents, workers, and travelers near the DMS transmitter site, would be to relocate DMS to a less objectionable site. It could be done as part of a larger plan to improve FM service island-wide, discussed further below.

Other Coverage and Blanketing Concerns

Three primary factors affect a radio's ability to receive a signal reliably— sufficient signal strength, no blanketing overload of the receiver, and a suitable ratio between the desired signal and other undesired signals. Signal levels are measured in two primary ways: field strength, the measure of the signal's electric field (or equivalent) in the air, and received signal level, the measure of the power of the received signal on the antenna terminals of the radio. Field strength is presented in volts per meter, or in this case, decibels with respect to one microvolt per meter per meter (dBμ). Receiver input levels are reported as power levels such as decibels with respect to one miliwatt (dBm).

The International Telecommunications Union Radiocommunications Sector ("ITU-R") has among its many recommendations specifications for a reference receiver (BS.704), minimum performance for low cost receivers (BS.415-2), and FM facility planning (BS.412-9). The ITU publishes recommendations that are adopted by international consensus. Recommendations are not binding regulations, but are techniques and specifications that member nations may choose to adopt for their own purposes or to employ in the formation of treaties with neighboring countries.

Sensitivity

The ITU reference receiver is intended to represent the desired minimum performance of a medium priced radio. The desired minimum sensitivity of the reference receiver describes its ability to pick up a weak signal with satisfactory audio quality. For a stereo receiver this minimum sensitivity is 50 dB microvolts per meter (50 dBμ). For FM planning purposes the ITU recommends FM stations should project levels slightly higher than receiver minimum stereo sensitivity into rural areas (54 dBμ) and levels substantially higher into urban areas (66 dBμ) to improve penetration of buildings. To serve the entire island with at least 54 dBμ, a station antenna at 200 feet above ground in Georgetown would have difficulty providing full coverage even with 50,000 watts. (This is shown in more detail in Appendix 2)

Blanketing Levels

With minimum signal levels established, the other end of the range must be considered, the maximum useable signal level. Combining ITU BS.704(3.2) and (4), a receiver should be able to handle a -40 dBm (about 85 dBµ) desired signal in the presence of a 110 dBµ undesired signal with no significant degradation of performance. In comparison, the FCC uses a rough threshold of 115 dBµ as the threshold for mitigating blanketing complaints. Hence, it is possible that a medium-price radio would suffer overload at levels lower than the 115 dBµ target used by the FCC.

Desired-to-Undesired Ratios

So far, the reference radio specifications discussed refer to the radio's ability to receive a useable desired signal at these minimum and maximum levels. The next level of complexity in the evaluation of radios is how they handle desired signals in the presence of undesired ones. The desired-to-undesired ratios are expressed in dB. A negative value indicates the desired signal is weaker than the undesired signal. In Georgetown, the level of Radio Cayman's signal on 105.3 has a deeply negative D-U ratio to the DMS signals.

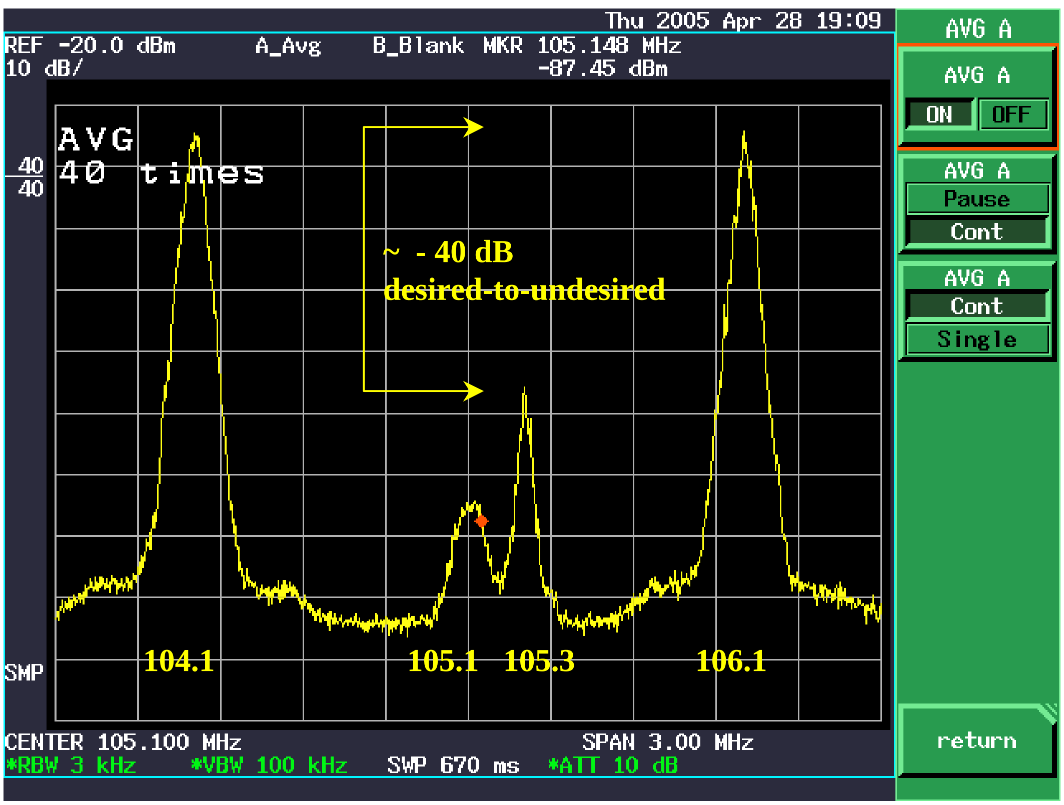

Figure 1
Signal Levels at Radio Cayman Studios

ITU recommends[4] that radios be able to handle stations on the fourth and higher adjacent channels[5] that are at least 40 dB stronger than the desired signal (-40 dB desired-to-undesired ratio). Figure 1 is a spectrum analyzer image showing the relative power levels of several radio signals arriving at the Radio Cayman studios.

DMS stations 104.1 and 106.1 appear as the higher signals on the left and right ends of the trace. Just about 40 dB below these signals is the signal of Radio Cayman's 105.3. An ITU reference radio tuning 105.3 would just barely be able to receive it. Even if not blanketed by the high power of the DMS signals, some receivers could have difficulty selecting 105.3 due to this large difference in signal levels between desired and undesired signals. Figure 1 was taken with a test antenna placed on the second floor balcony of the Radio Cayman studios.

Figure 1 also shows what happens inside a receiver that is blanketed. The input level to the analyzer is deliberately overloading it to simulate blanketing interference. Note the receiver-induced intermodulation product on 105.1. If this were a radio, the intermodulation product might be strong enough to cause interference because it is close in level to that of 105.3.

To remove the cause of the blanketing interference to the analyzer, a filter was inserted that passed 105.1 energy without changing its level and reduced the levels of the strong signals. The analyzer is no longer creating a large intermodulation product on 105.1 because the other signals are reduced. Figure 2 shows the result of inserting the filter.

Figure 2 shows that the amount of intermodulation energy emanating from the DMS transmitters conforms to good engineering practice because it is more than 75 dB below the reference level of the DMS transmissions (reference level is the peak levels of 104.1 and 106.1 in figure 1).

[4] ITU-R BS.412-9 Planning standards for terrestrial FM sound broadcasting at VHF

[5] It is customary to avoid assigning radio stations in the same city to frequencies that are less than four channels apart. First-, second- and, to some degree, third-adjacent channel stations cannot be distinguished clearly by some consumer radios. The focus of this discussion therefore begins at the fourth-adjacency. 106.1 is fourth adjacent to 105.3.

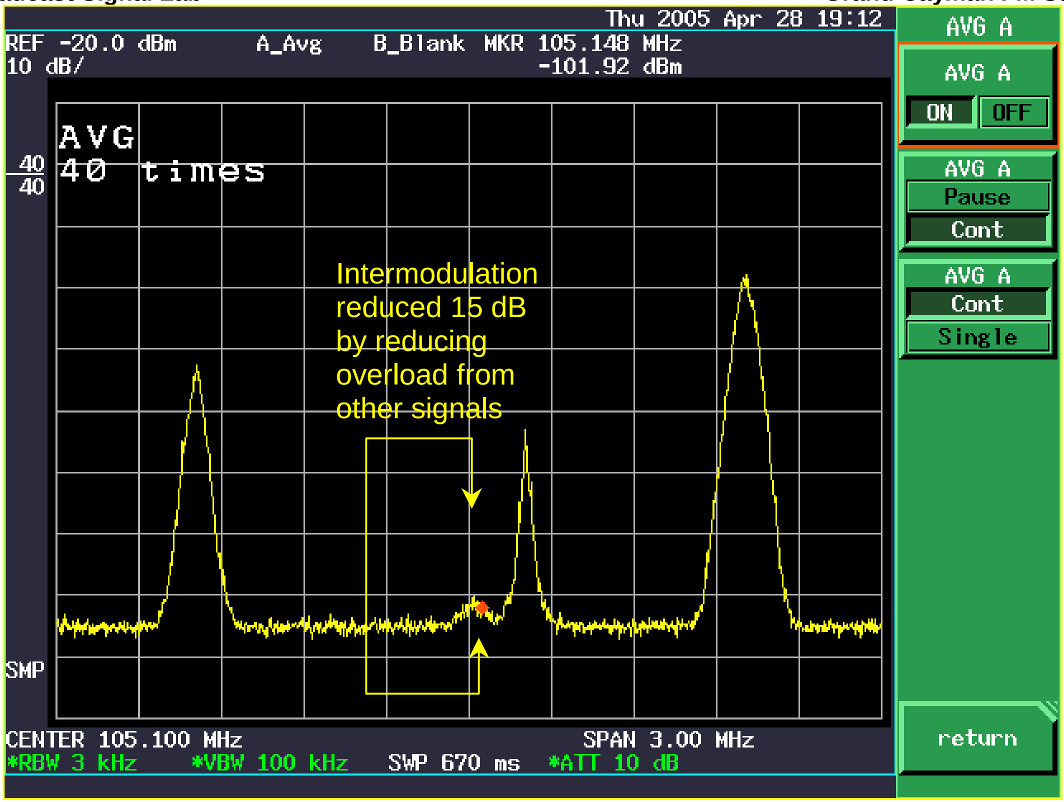

Figure 2
Signal Levels at Radio Cayman Studios
Filter Attenuates all Signals but 105.1

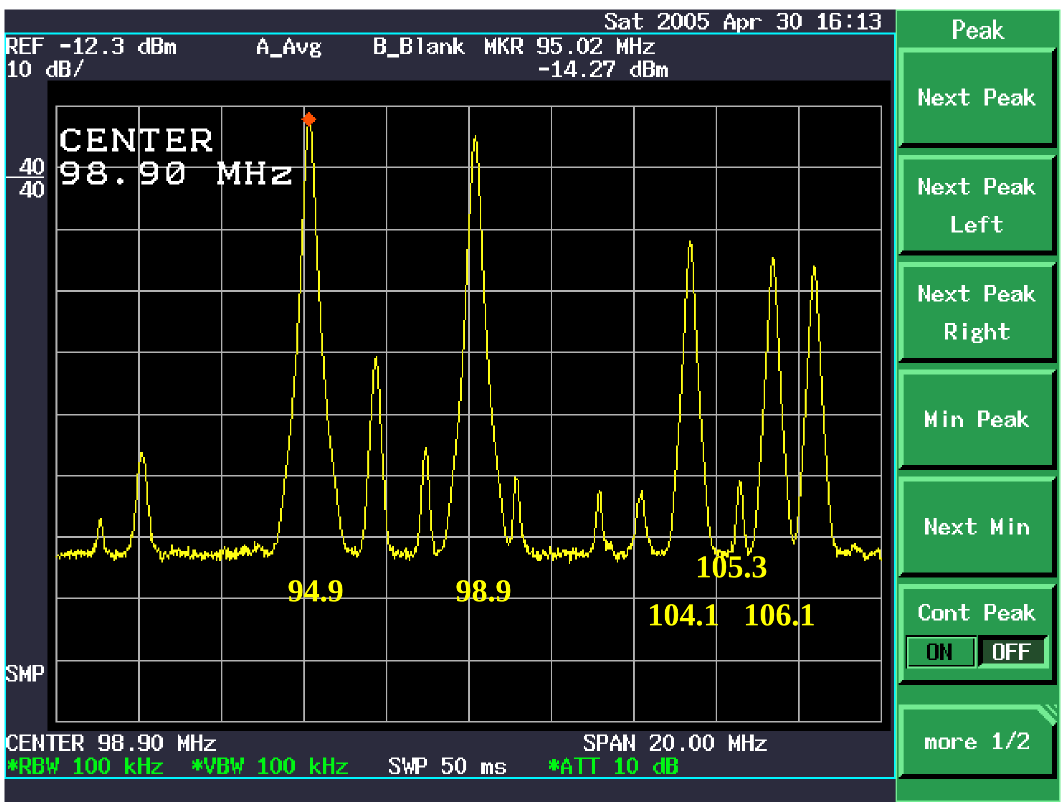

Figure 3
Signal Levels Near Paramount Antennas
Fort St, Georgetown

Spectrum images were taken near other transmitter sites for comparison to the DMS site. Figure 3 shows the levels of all stations received on Fort Street, Georgetown near the rooftop-mounted antennas belonging to Paramount. This is a post-Ivan temporary location. Here Paramount's 98.9 and 94.9 dominate the spectrum. Blanketing was experienced in the vicinity of this antenna site. The two boom boxes were susceptible to a distance of about 700 feet. The operating power levels of the Paramount stations are not known. Radio Cayman levels at this location are substantially lower than the Paramount signals, which implies Radio Cayman reception will be among the first affected by the Paramount blanketing.

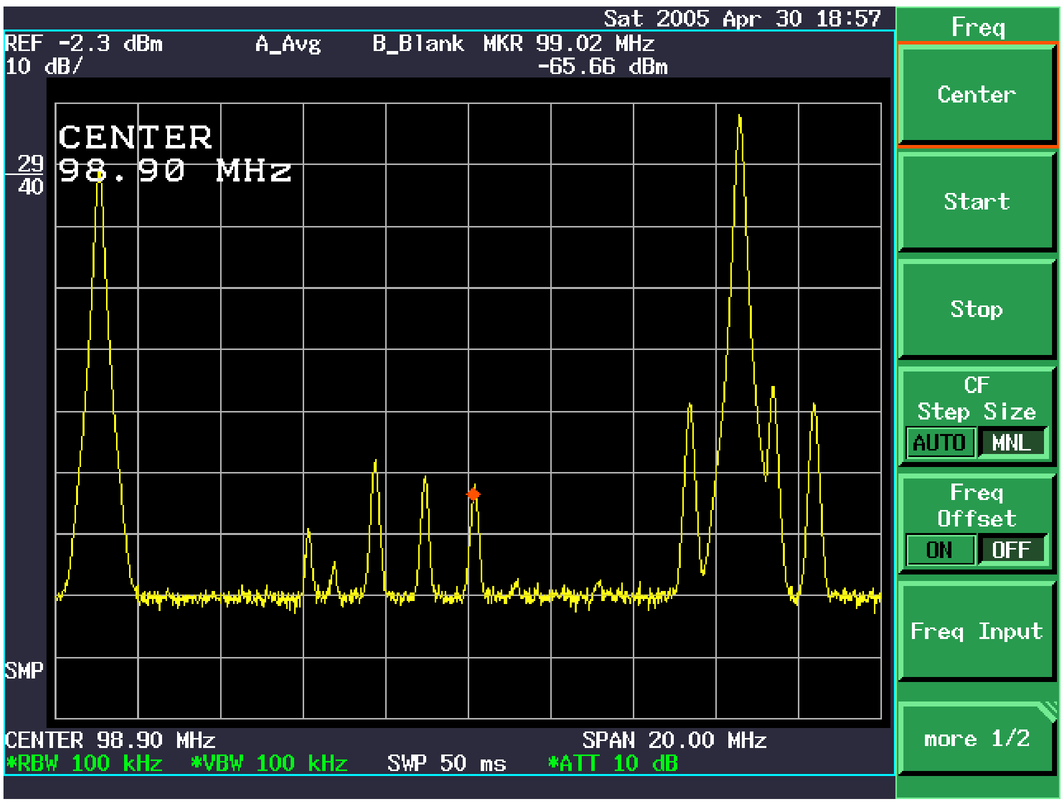

Figure 4
Signal Levels at Radio Cayman Tower,
Northward

Figure 4 shows the contrasting signal levels near the Radio Cayman antennas in Northward. This area is adjacent to the prison, and is in a sparsely developed area. Clearly, the Radio Cayman signals dominate here. No radio listening testing was performed here.

Table 1 Field Strengths of FM Signals Measured at each Transmitter Site

Location		Radio Cayman studios	Fort Street	Northward	Crewe	Home Depot	Gateway of India Restaurant
		2nd Floor Balcony	1 block away	End of driveway	Parking lot	Parking lot	Beside building with antenna
Nearest Transmitters		DMS	Temporary site Paramount	Radio Cayman	Temporary site Hurley	Christian & Panorama	Temporary site Cerentis
Radial Distance to Antenna (yds)		56	82	92	36	236	28
Antenna Height above ground (yds)		60	20 est	75	10 est	93 & 62	10 est
Frequency				Measured Signal Levels (dBµ)			
(2 dB below licensed power)	89.9	60	64	**99**	62	60	61
?	94.9	96	**128**	*49*	72	87	62
(10 dB below licensed power)	95.5	96	*49*	*42*	*	*51*	**123**
	96.5	100	90	61	95	**110**	62
(8 dB below licensed power)	97.7	93	74	57	93	**105**	54
?	98.9	92	**125**	55	*	95	68
(11 dB below licensed power)	99.9	79	70	*40*	**125**	82	*
(11 dB below licensed power)	101.9	79	69	*39*	**126**	85	*
(7 dB below licensed power)	104.1	**109**	107	67	101	106	78
(1 dB below licensed power)	105.3	66	69	**115**	67	77	74
(7 dB below licensed power)	106.1	**114**	104	69	101	99	73
(7 dB below licensed power)	107.1	**116**	103	67	101	106	74

107.9 and 101.1 not on air

RED BOLD indicates signals from nearest tower

BLUE ITALIC indicates weak signals below 54 dBµ

* Signal too low to measure (noise floor or D-U issue)

FCC blanketing Level is 115 dBµ

ITU expects radios to be functional at 85 dBµ in presence of unwanted 110 dBµ

ITU Rural signal should be at least 54 dBµ

The reference levels displayed on the spectrum analyzer plots are not adjusted for the test bed configuration at each site. External level adjustments were made to drive the analyzer with appropriate signal levels. Correcting for these adjustments, and for antenna factors, Table 1 displays the measured field strengths of the signals at each site.

The temporary facilities of Hurley, Cerentis, and Paramount are each quite close to the ground, producing very strong blanketing levels close to them. To improve island-wide coverage and reduce the blanketing levels, these facilities should be promptly restored to appropriate antenna heights.

All facilities produce FCC blanketing levels to some degree. Power levels, antenna designs, antenna heights, and concentration of residences and workplaces affect the degree of interference experienced near each of the facilities.

Design Opportunity

The process of assigning FM channels and power levels on Grand Cayman Island does not need to follow precisely mainland customs. The ideal spacing by frequency to maximize spectrum efficiency would be every fourth channel.[6] Utilizing a channel spacing of 200 kHz, there are 100 channels available on the FM band. The method of allocating channels on the mainland involves geographically distributing channel use and power levels to provide interlocking service areas for radio stations on each channel. On Grand Cayman Island this geographic diversity is a moot issue as there are no surrounding states or municipalities requiring frequency coordination.

Based on the foregoing, Grand Cayman has an opportunity to maximize spectrum efficiency and minimize interference. If each station must serve the entire island, then the best way to do so is to have a tower of suitable height that meets the following criteria:

- Close enough to the population center to provide reasonably strong signals
- Placed in an area not heavily populated
- Placed fairly centrally to the island, but favoring the population density on the western portion.

[6] Third adjacent channel spacing could be assigned instead, but the concept would require further testing to be certain that less expensive radios have the selectivity necessary to discriminate between third adjacent channel signals.

- Tall enough to provide three benefits
    - Minimize blanketing interference around the facility
    - Provide island-wide coverage
    - Reduce power requirements
- Capable of supporting multiple transmitter facilities

This approach addresses the three reception issues outlined above: minimum signal strength, maximum signal strength (blanketing), and desired-to-undesired signal ratio. Optimum siting provides sufficient signal to the entire island, avoids blanketing interference as much as possible, and provides a rare opportunity for all FM stations to have the same signal level (a perfect desired-to-undesired ratio) from the point of transmission to the entire island.

Frequency planning is also simplified. Issues of receiver-induced intermodulation are essentially eliminated because of the reduced blanketing interference and the balancing of all signal levels. Coordination of frequencies with adjacent municipalities is not a factor because the island is treated as a single municipality. Hence, up to 25 channels could be made available with full frequency planning. Currently there are fourteen assigned frequencies. All frequency separations are fourth adjacent or greater, except the spacing between 94.9 and 95.5, which is third adjacent. Plotting the available frequencies for future licenses, assuming fourth adjacent spacing, there are eight more frequencies, for a total of 22. Three frequencies cannot be assigned without forcing third adjacent separations or moving current stations' frequencies.

If a more aggressive approach were taken by applying third adjacent separations, the maximum possible licensed frequencies would be 34. Without changing current station frequencies, 16 additional frequencies could be assigned, for a total of 30. Four frequencies could not be assigned without moving existing stations' frequencies.

Station Power

The present ICTA protocol for frequency and power assignment requires applicants to examine the spectrum and rationalize their proposed frequencies, power levels, and locations. Their licenses require that each station provide service to the entire island.

With its limited resources, ICTA relies upon the applicant's due diligence to comply with technical criteria, including the full-coverage policy.

Taking into account the fact that several stations are operating temporary facilities at reduced antenna heights, the originally licensed facilities of many stations may not be capable of providing 54 dBμ service to the entire island.

Licensees should review their station designs to determine whether their facilities comply with ICTA requirements to serve the entire island. It is advisable that ICTA look more closely at station coverage as licenses are assigned or renewed.

David Maxson
Managing Partner
Broadcast Signal Lab
May 6, 2005

Appendix 1

Discussion of antenna characteristics

Antenna emissions plots were submitted by Mr. Kiron of the Cayman Government and CMBE on behalf of DMS. The government representative's analysis was satisfactory as a first pass at considering antenna patterns. It showed the characteristic difference between the classes of antennas under discussion—the half-wave antenna proposed and the 0.8 wave antenna installed. CMBE's presentation added another important layer of detail to the analysis. In addition to the antenna pattern itself, the FCC software CMBE used makes adjustments to the emitted power of the antenna to account for the radial distance from the antenna to the ground. CMBE's results indicate predicted power density at the ground based on the antenna pattern.

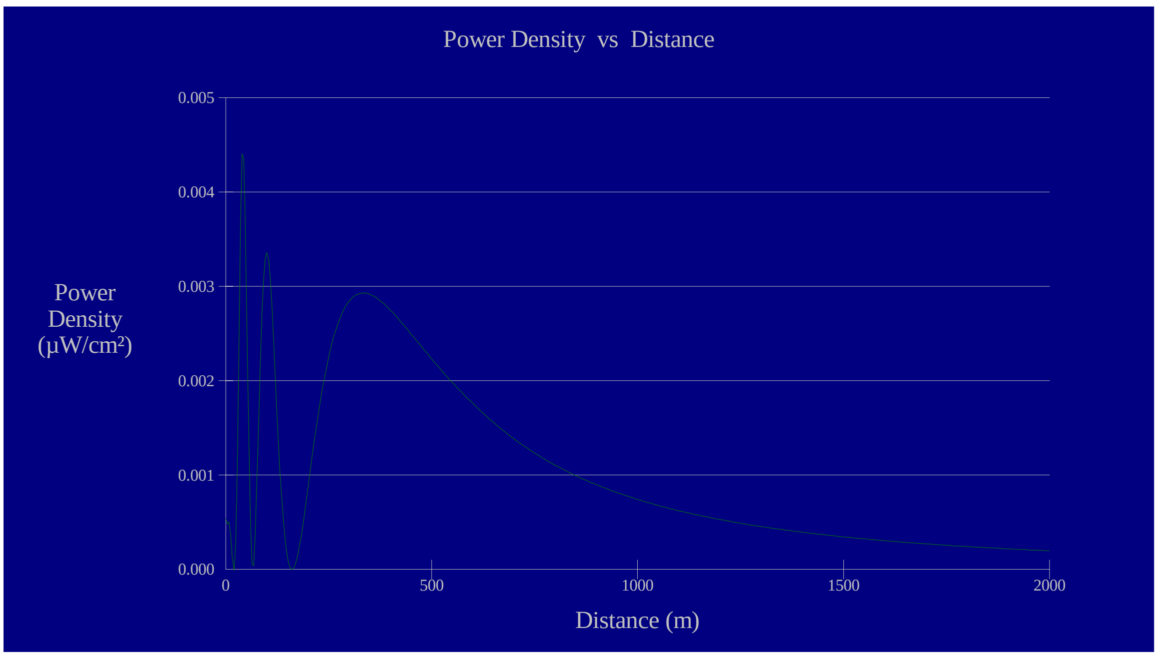

Figure A1-1

Replica of CMBE's plot of the installed DMS antenna emissions with scale error

Unfortunately, both sets of submitted data employ linear vertical scales. Radio signal levels vary so widely that it is more helpful to present the graphs with a log scale. Linear scales tend to exaggerate minor differences. Further, CMBE's plots appear to have been performed using 12 watts effective power rather than the licensed value of 12,425 watts. This presents a systematic error of a factor of 1000. The shapes of the curves for the two antenna models, proposed and installed, are still correct and can be compared. However, the resulting power density levels are off by the factor of 1000. When it comes to comparing the predicted power densities to receiver performance, the error must be resolved.

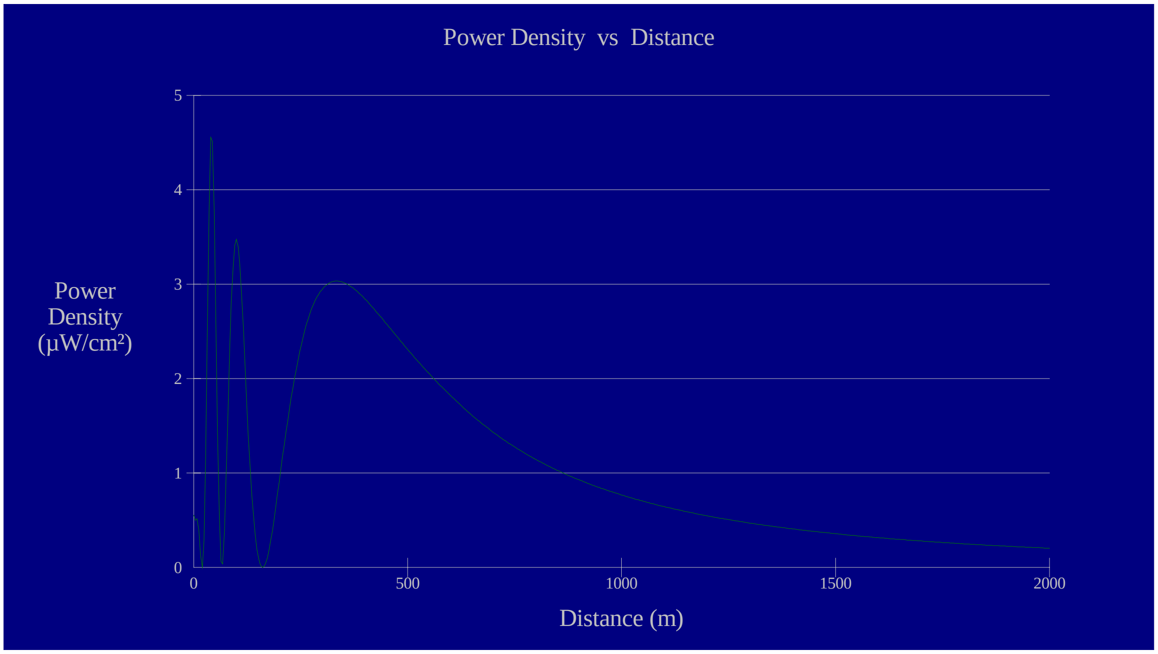

Figure A1-2

Linear plot of on-ground power densities of installed antenna at 12,425 W ERP

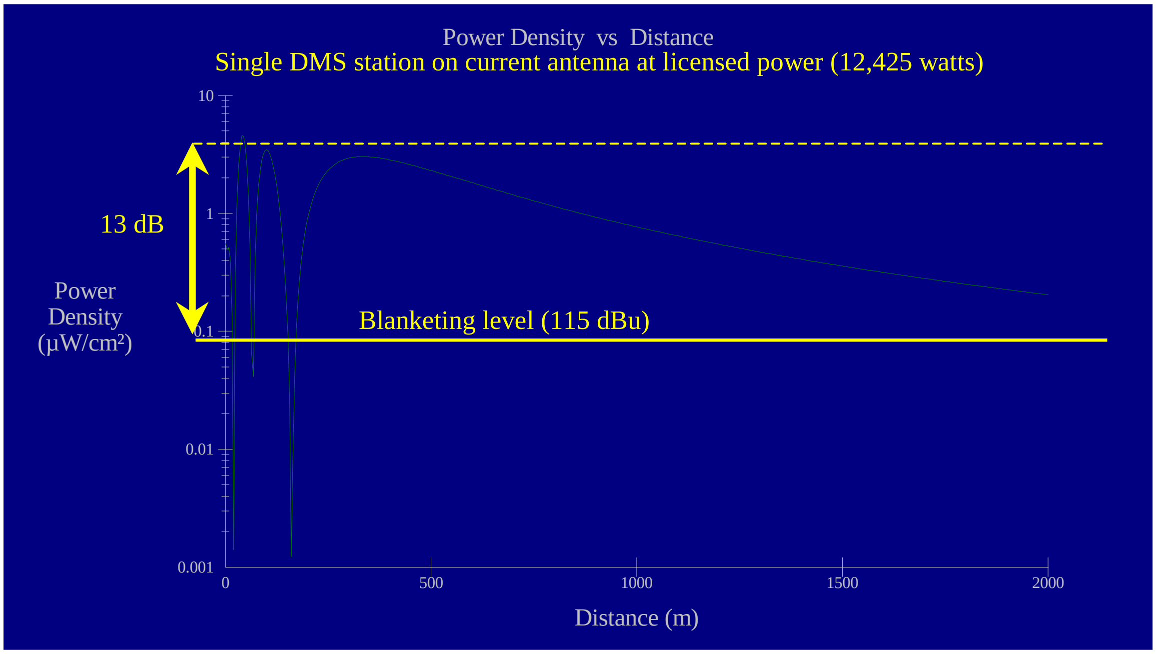

Figure A1-3 Logarithmic plot of on-ground power densities of installed antenna at 12,425 W ERP. FCC Blanketing level shown

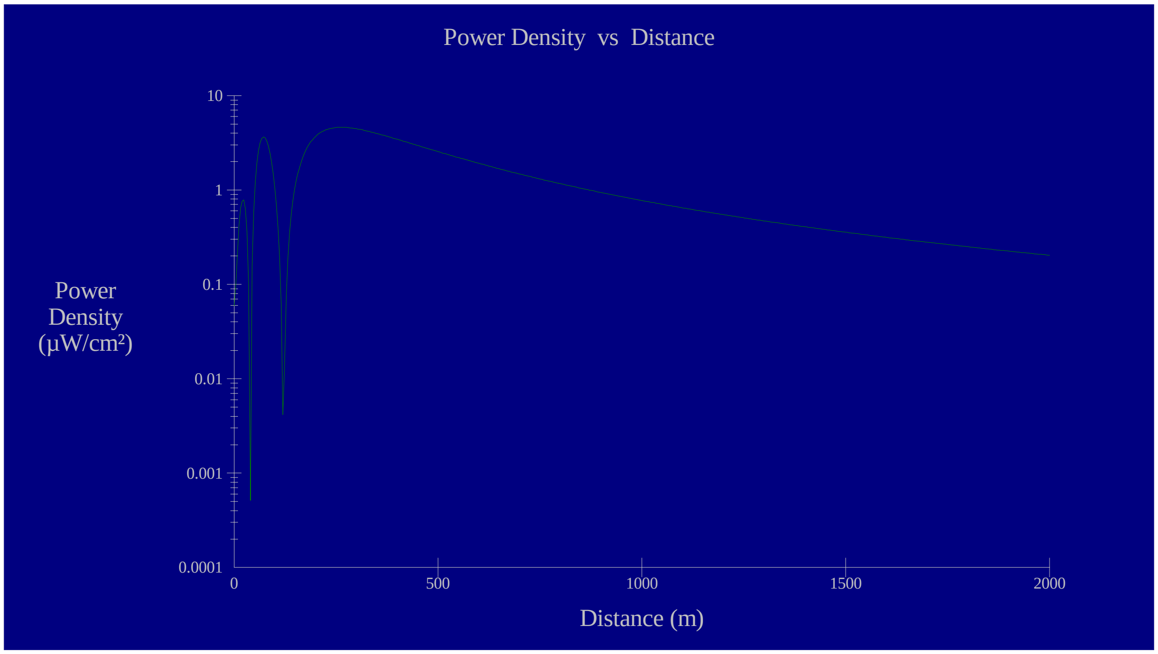

Figure A1-4 Logarithmic plot of on-ground power densities of proposed half-wave antenna at 12,425 W ERP

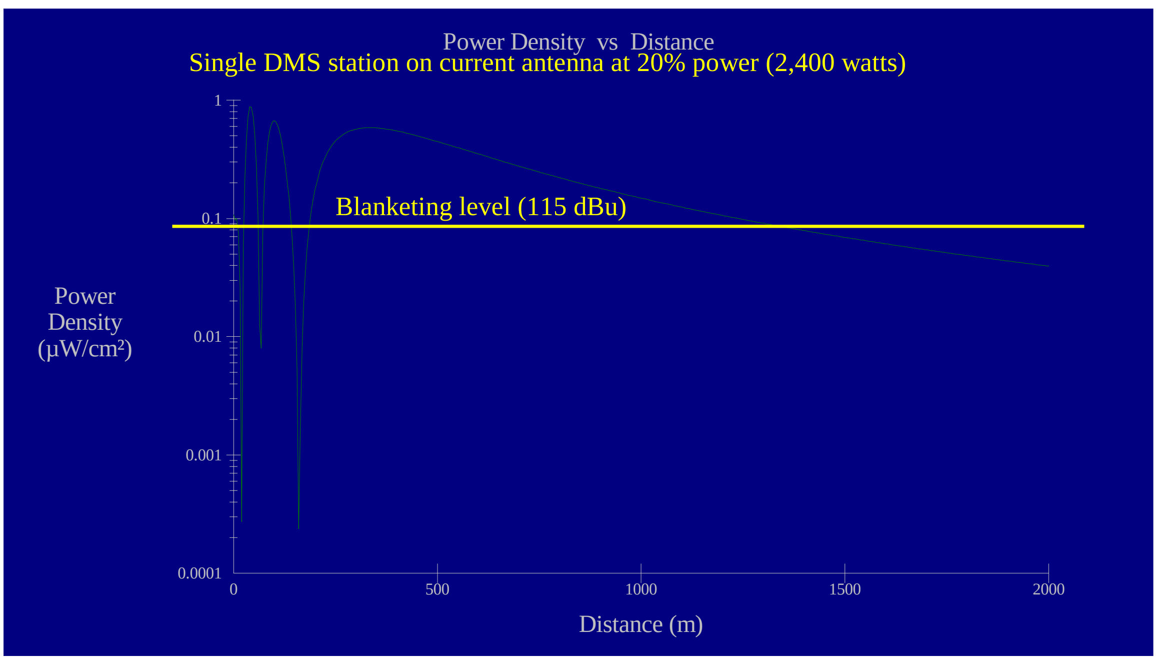

Figure A1-5 Logarithmic plot of on-ground power densities of installed antenna at 20% power. FCC Blanketing level shown

Broadcast Signal Lab recreated the original CMBE plots, adjusted them for the correct power levels and converted the scales to logarithmic presentation. At licensed power, the installed antenna puts FCC blanketing levels on the ground beginning at the tower and extending more than 2000 feet distance. At 20% power, the official blanketing level extends to about 1300 feet. (As previously noted, actual blanketing interference may occur at lower signal levels and greater distances)

Figure A1-3 indicates that a 13 dB reduction from licensed power would bring each individual DMS station's signal level on the ground to be almost entirely below the FCC blanketing threshold of 115 dBu. While this level is not guaranteed to be compatible with all radios, there would be a significant reduction in receiver-induced interference. A 13 dB reduction results in a reduction to about 5% of the original power level, or about 600 watts.

Because these charts are only generalized approximations, power reductions could be performed experimentally and measured around the site to determine the exact behavior of the antenna array in its particular context (the configuration of tower and buildings). The measurements performed at the site roughly confirm the charts.

It is also important to note that the total energy from all FM channels entering the radio's antenna is a factor in receiver overload, and the presence of three equally powered stations potentially requires an additional power reduction of 5 dB per station. That is, if 600 watts total power is the limit, then it would be 200 watts per station to prevent crossing the blanketing threshold.

Appendix 2

Coverage Analysis of Various Transmitter Configurations

This Appendix presents estimated coverage distances for various transmitter configurations. Longley Rice propagation modeling was performed over level terrain for a receiver at two meters height above ground. A 6 dB loss factor was added to estimate the losses expected from Grand Cayman's nearly level terrain and low vegetation.

DMS coverage is estimated in the first two images at licensed power and at the current 20% power, respectively (Figures A2-1 & A2-2). Figure A2-3 shows the extent of coverage with 50,000 watts at about the same height, 200 feet. Finally, 2000-watt coverage from a greater antenna height (400 feet) is shown for comparison (A2-3).

An approximation of the island's outline is superimposed on each plot for illustration. Its scale accuracy is not guaranteed. Similarly, the positioning of the plot's center with respect to the outline is only approximate.

The concentric circles represent 2-mile increments. Yellow (light grey) coverage is ITU urban signal strength (66 dBμ or stronger). Green (dark grey) coverage is ITU rural signal strength (54 dBμ to 65 dBμ).

Based on this analysis, stations in Georgetown are probably non-compliant with their license requirements to serve the entire island. Further study of the actual coverage of each station would be necessary to verify this concern. The hypothetical 400-foot high antenna more central to the island, at a fraction of the DMS power, would reach more of the island than Georgetown sites do.

Figure A2-1

Licensed DMS coverage: 12.4kW @185 ft

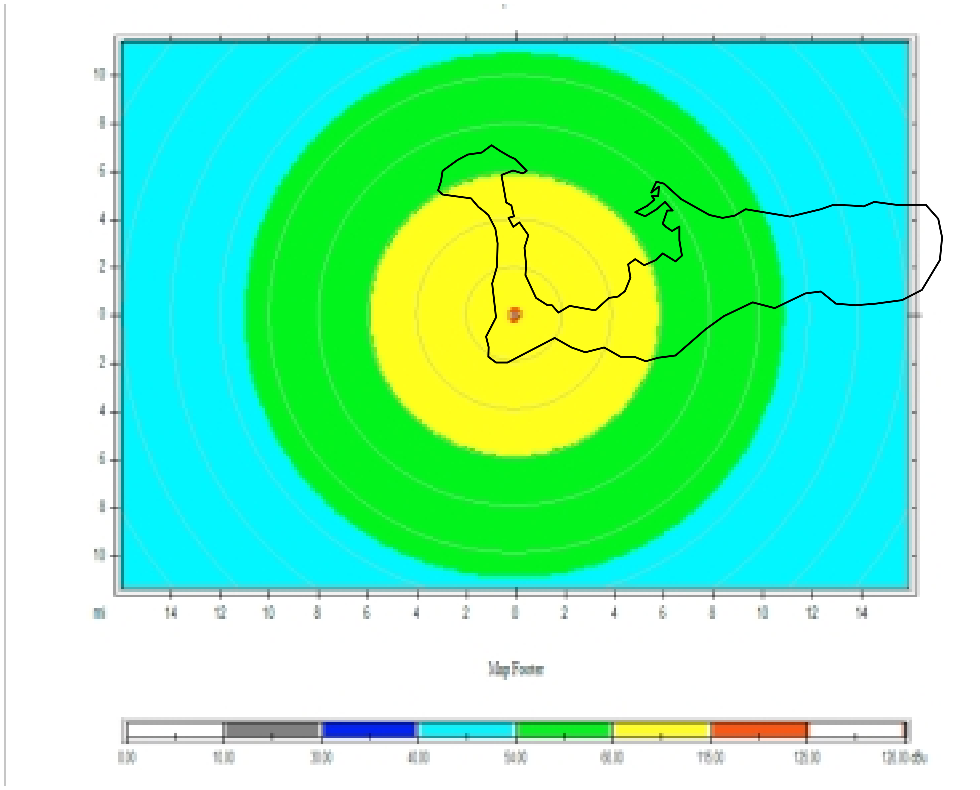

Figure A2-2

Operating DMS coverage 2.4 kW @185 ft

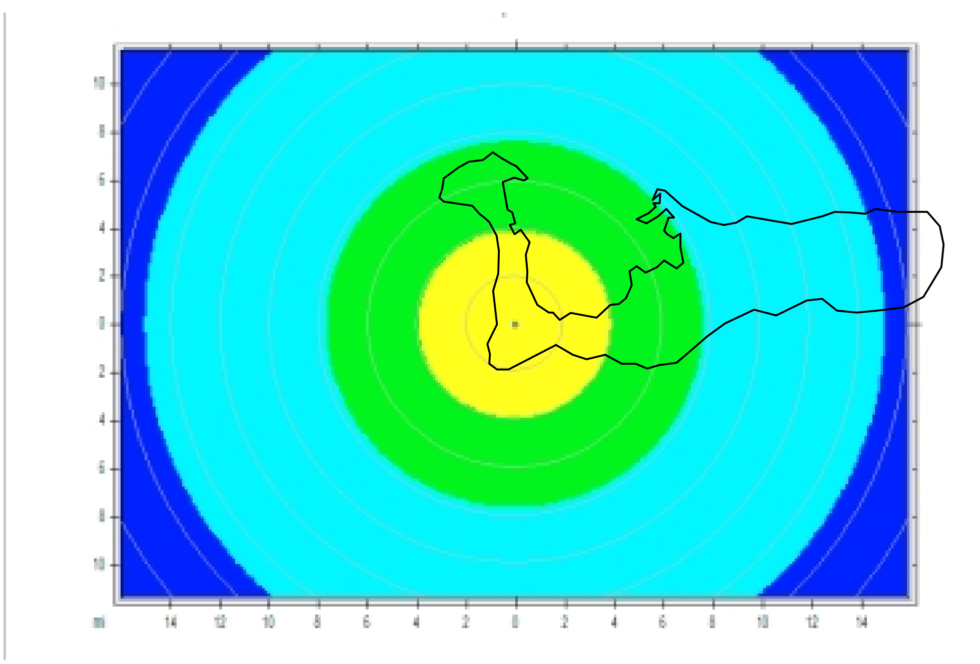

Figure A2-3

50 kW at 200 ft

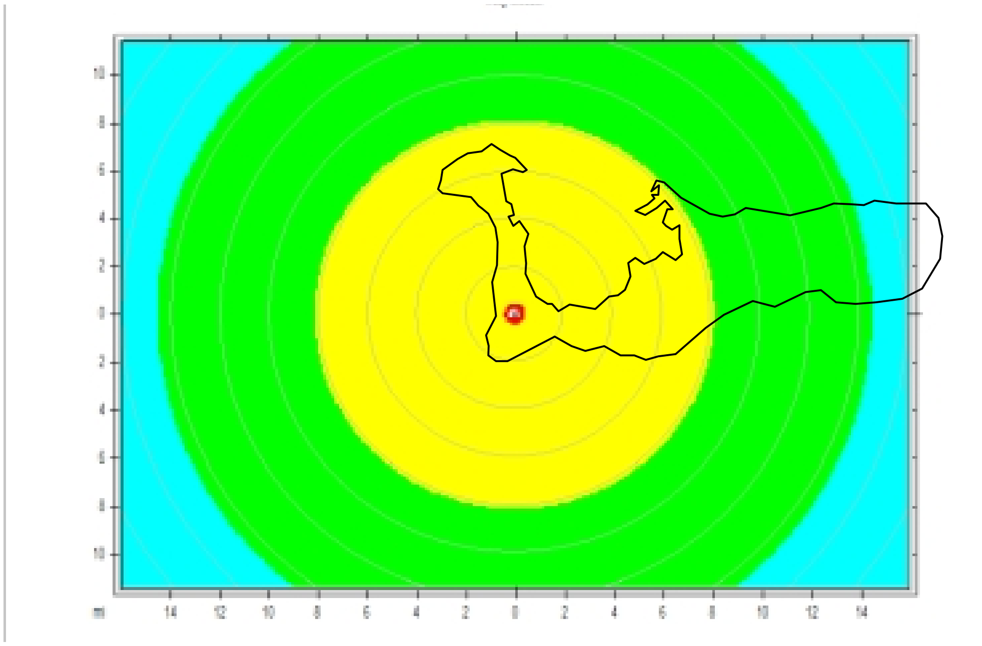

Figure A2-4

2kW @ 400 ft (placed more centrally on island)