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May 1, 2011

Storey County Commissioners
Storey County, Nevada

Reference: Taormina Towers Comments #3

Dear Storey County Commissioners,

This is regarding Tom and Midge Taormina's application for a Special Use Permit Case No. 2011-010. Please put this in the permanent public file for the issue.

I agree with the recommendations of the Planning Commission "to maintain the four (4) existing amateur ham radio antenna towers applicable to this SUP in accordance with the limitations set forth hereby and deny installation of any additional towers on the property located at 370 Panamint Road (APN 003-431-18), Highland Ranches, Storey County, Nevada and to include all applicable conditions presented in the addendum (See Planning Commission Minutes dated 3/3/11)."

I urge you to adopt their recommendation.

I am sending this letter to support their recommendation. Because of the amount of material I am splitting up my comments into several letters. This is letter #3.

This is about the Noise part of Signal-to-Noise used by Tom's Expert in the calculations performed by the VOACAP program.

Noise

When you are considering Signal-to-Noise Ratio (SNR) you have to ask, "How much noise is there?"

Tom's main interest is in High Frequencies (HF). The primary sources of noise at HF are atmospheric, man-made, and galactic (really).

The contribution of galactic noise is small, so the main sources are atmospheric and man-made.

The VOACAP program makes general assumptions about the noise. Some of them don't apply to Tom's case.

I will be quoting from George Lane's book. George Lane is one of the contributors to VOACAP. (See http://www.voacap.com/overview.html). He is the "Lane G." cited as the author or co-author in the references that Hopengarten listed in his Yahoo Group message that I discussed in my previous letters.

George Lane wrote the book on signal-to noise predictions using VOACAP.

Indeed, it's called **Signal-to-Noise Predictions Using VOACAP - A User's Guide**, by George Lane, published by Rockwell Collins, Copyright 2000, 2001. (It's available for $5 on CD from Rockwell Collins through http://greg-hand.com/pc_hf/rockwell/ .)

The following quotes from Lane come from the section **3. NOISE POWER PREDICTIONS**. I have reproduced the section in Exhibit 1.

> ***3.1 General Discussion***
>
> In the HF band, noise power present at a radio receiver is expressed in dB relative to 1 watt (dBW) and for a noise power bandwidth of 1 Hz. It is generally assumed that the controlling radio noise is external to the radio. The 3 major sources of radio noise at HF are atmospheric, man-made and galactic noise (Horner 1962) (CCIR Report 322 1964). Atmospheric radio noise usually predominates during the nighttime and at frequencies typically at 10 MHz or lower. Man-made sources are usually the controlling source of radio noise during the daytime and for frequencies above 10 MHz at night. Galactic radio noise is only detectable near 30 MHz in very quiet regions of the earth. We, again, must remember that the prediction of the radio noise power is just as critical as the prediction of the signal power when it comes to correctly estimating the signal-to-noise ratio that will be available to the receiver.

Yes, the prediction of the noise is just as critical as the prediction of the signal.

> Noise power measurements were made using short vertical antennas over a fairly extensive ground screen (Chindahpom and Younker 1968). Models of radio noise currently in use do not have a direction of arrival for the noise source although in reality there is generally an azimuthal dependency. Noise tends to have a fairly low angle of arrival in the vertical plane. Atmospheric noise is assumed to arrive via skywave propagation, whereas man-made noise fields generally propagate by groundwave or line-of-sight. Galactic radio noise results from the collection of RF emitting sources in our galaxy.
>
> The noise power models used in VOACAP do not consider the directivity of the specified receive antenna. If the user-specified antenna is one which has an associated frequency dependent efficiency terms, then the noise power is reduced by the efficiency factor of the receive antenna at each of the operating frequencies under consideration. It is assumed that receive antenna is immersed in an omni-directional noise field and that the noise power pickup by the antenna is that of the integrated power pattern (i.e., 3 dBi for an antenna over perfect earth).
>
> The actual noise power calculation in VOACAP assumes that the noise power is slightly higher than that received by the isotropic receive antenna over perfect earth. The data is normalized to the noise power available from a short, lossless vertical monopole. This accommodates the fact that most radio noise arrives at low elevation angles. There is some disagreement as to whether a horizontal half-wave dipole is as susceptible to radio noise power as a monopole antenna. The error seems to be small (2 to 3 dB) and VOACAP uses the higher noise power value which makes the signal-to-noise ratio prediction slightly conservative.

The noise power measurements that VOACAP bases its calculations on were made using vertical antennas without considering directionality (“direction of arrival”).

Tom uses mostly Yagi antennas with a horizontal polarization. More importantly, Tom’s Yagi antennas are directional. The way antennas produce gain is by taking signal from where you don’t want it and putting it where you do want it. In other words, antennas produce gain by becoming more directional. Most of the time hams want the directionality to be around the azimuth. So do most AM Broadcasters. However, most FM and TV Broadcasters want an omnidirectional pattern. When they use antennas systems that produce gain the pattern is narrowed all around with respect to the horizon. As a result they send less signal at the ground and up into Space. (Those who might listen to the station off-planet are less likely to buy the products advertised on the station or to contribute to NPR’s pledge drives anyway.)

I have read Tom’s documents and I do not see useful information about the Yagis such as gain, model numbers, or if he built them himself.

To continue.

Atmospheric noise at HF is caused mostly by lightening strikes, even lightening strikes on the other side of the planet.

> ### 3.2 Atmospheric Radio Noise
>
> Atmospheric radio noise is generally the summation of all the radiation released from thunderstorm activity around the world. A single lightning strike can send a noise spike that can be detected up to 8 times as it circles the world via ionospheric propagation. In the 1940s, when scientists were trying to map the worldwide occurrence of atmospheric radio noise, there were very few observation points. Although the data were well controlled and the National Bureau of Standards (NBS) calibrated the noise measurement devices that were used, there were not enough stations to allow for world mapping. The NBS (Crichlow et al. 1955) prepared the first set of atmospheric radio noise maps using the noise measurement data and world weather maps showing the probability of a lightning strike (WMO 1956). Worldwide atmospheric noise factor contours at 1 MHz were hand drawn. In 1963, after several revisions, these maps were approved by the International Telecommunications Union (CCIR Report 322 1964). Later, with the advent of computers, these maps were regenerated using mathematical contouring (Lucas and Harper 1965). However, they still retained the judgement used by Herb Crichlow in determining where noise peaks and valleys would occur based on lightning-activity maps when actual noise measurement data was not available. Crichlow's contribution is still used in the current noise model in VOACAP.

Atmospheric noise is also affected by solar activity.

> There are several other points that we should consider when using the atmospheric radio noise predictions. The dependence on sunspot number has never been determined although the data is slanted toward the years with higher sunspot numbers. The time variation of the noise data is based on the day-to-day variation over 4-hour time blocks and 3 months. The resolution of noise data for a given hour and month is poor at best. Also, noise collection procedures tended to average the noise over a period of a few minutes. Actual noise spikes may be much greater than indicated by the maps.

And then there is man-made noise.

> The history of man-made radio noise measurements and their levels would fill a book. Let it be said that most of the controversy was dispelled in 1974 (Disney and Spaulding 1974). The CCIR in Report 258-4 (1986) unanimously recommended these median values, but then added on a number of possible statistical distribution methods with no recommendation as to which one should be used.
>
> Under the sponsorship of the Voice of America, the National Telecommunications and Information Administration - Institute for Telecommunication Sciences (NTIA - ITS) was asked to review the man-made noise issue one more time. The recommendation of this review (Spaulding and Stewart 1987) was

a statistical model for man-made radio noise which is now included in the VOACAP radio noise model. The equation given for the manmade noise factor is:

$F_{AM} = C - D \, Log_{10} f$

where: f is the frequency in MHz and
C and D are reference values

In Table 3.1. Values of C and D Needed to Compute the Radio Noise Factor, F_{AM}, as a Function of the Frequency, f, in MHz, we will find the reference values needed to compute the median level of man-made noise factor, F_{AM}.

Table 3.1. Values of C and D Needed to Compute the Radio Noise Factor, F_{AM}, as a Function of the Frequency, f, in MHz

Environmental Category	**C**	**D**	**P_N at 3 MHz**
Business	76.8	27.7	-140.4 (dBW/Hz)
Residential	72.5	27.7	-144.7
Rural	67.2	27.7	-150.0
Quiet Rural	53.6	28.6	-164.0
Galactic Noise	52.0	23.0	-163.0

and

> Man-made radio noise was primarily measured where noise levels were rather high. In industrial settings, the measurements were made inside the grounds of the factory, one employing electromechanical devices. City and residential measurements were made near stop lights on busy streets where cars would queue waiting for the light to change. The one general complaint expressed most often is that the reference man-made radio noise levels are too high. Again, the VOACAP user must exercise judgement when selecting the manmade noise environment for use in the predictions. <u>It must be kept in mind that the accuracy of the noise prediction is just as important as the accuracy in the signal prediction when it comes to calculating the signal-to-noise ratio</u>.

{Emphasis added}

And, finally, galactic noise.

> Galactic radio noise is included in VOACAP so that noise power cannot go essentially to 0. However, noise arriving on earth from the Milky Way is hardly a factor in the HF band anymore with the huge increase in RF noise pollution. The original model for galactic noise is taken from ITSA-1 (Lucas and Haydon 1966) and is attributed to an extrapolation of data measured by Cottony and Johler (1952) and later verified by measurement (Chchlow and Spaulding 1965). The same source is quoted in CCIR Report 322 (1964); however, the noise is slightly higher at the 1 MHz intercept 52 rather than 49.5 dB, and the slope with frequency is -23 rather than 22.

Tom has lived here for a number of years.

He could have done some rudimentary measurements of the noise environment.

There is no evidence that he has done that.

Instead, he is relying on data that is general in nature and is also admittedly flawed. I am referring to the VOACAP model assuming a non-directional vertical antenna, while Tom is using mostly horizontally polarized directional antennas.

Conclusion

VOACAP appears to be a marvelous tool for predicting radio propagation under different conditions.

However:

1. It is only a prediction.

2. It assumes that all of the parameters are correct and are entered correctly.

From: http://www.voacap.com/overview.html

> VOACAP is an improved and corrected version of **IONCAP**, retaining all of the theory as put forth by **John Lloyd**, **George Haydon**, **Donald Lucas** and **Larry Teters** in the 1975-1985 time-frame with modifications which were suggested/approved by **George Lane**, **Donald Lucas**, **George Haydon** and **A. D. Spaulding** (a world authority on HF radio noise predictions).
>
> Take a look at the VOACAP evolution chart (courtesy of George Lane, Lane Consultant).
>
> Major improvements in efficiency, coding corrections and ease of understanding the IONCAP program were made by **Franklin Rhoads** of the U.S. Navy Research Laboratory under the sponsorship of the **Voice of America** (1985-1996). Many of the newer features in VOACAP and VOAAREA were designed and implemented by **Gregory Hand** at the Institute for Telecommunication Sciences who created VOAAREA and made many significant improvements to VOACAP.

Although Gregory Hand is now retired he still provides support for the program. And from his Web site http://greg-hand.com/hf.html

> ## High Frequency Propagation Models - ICEPAC, VOACAP, REC533
>
> ---
>
> **Disclaimer: The software contained within was developed by an agency of the U.S. Government. NTIA/ITS has no objection to the use of this software for any purpose since it is not subject to copyright protection in the U.S.**
>
> **No warranty, expressed or implied, is made by NTIA/ITS or the U.S. Government as to the**

> **accuracy, suitability and functioning of the program and related material, nor shall the fact of distribution constitute any endorsement by the U.S. Government.**

Let me emphasize the part that says, **“**No warranty, expressed or implied, is made by NTIA/ITS or the U.S. Government as to the accuracy, suitability and functioning of the program and related material, …”

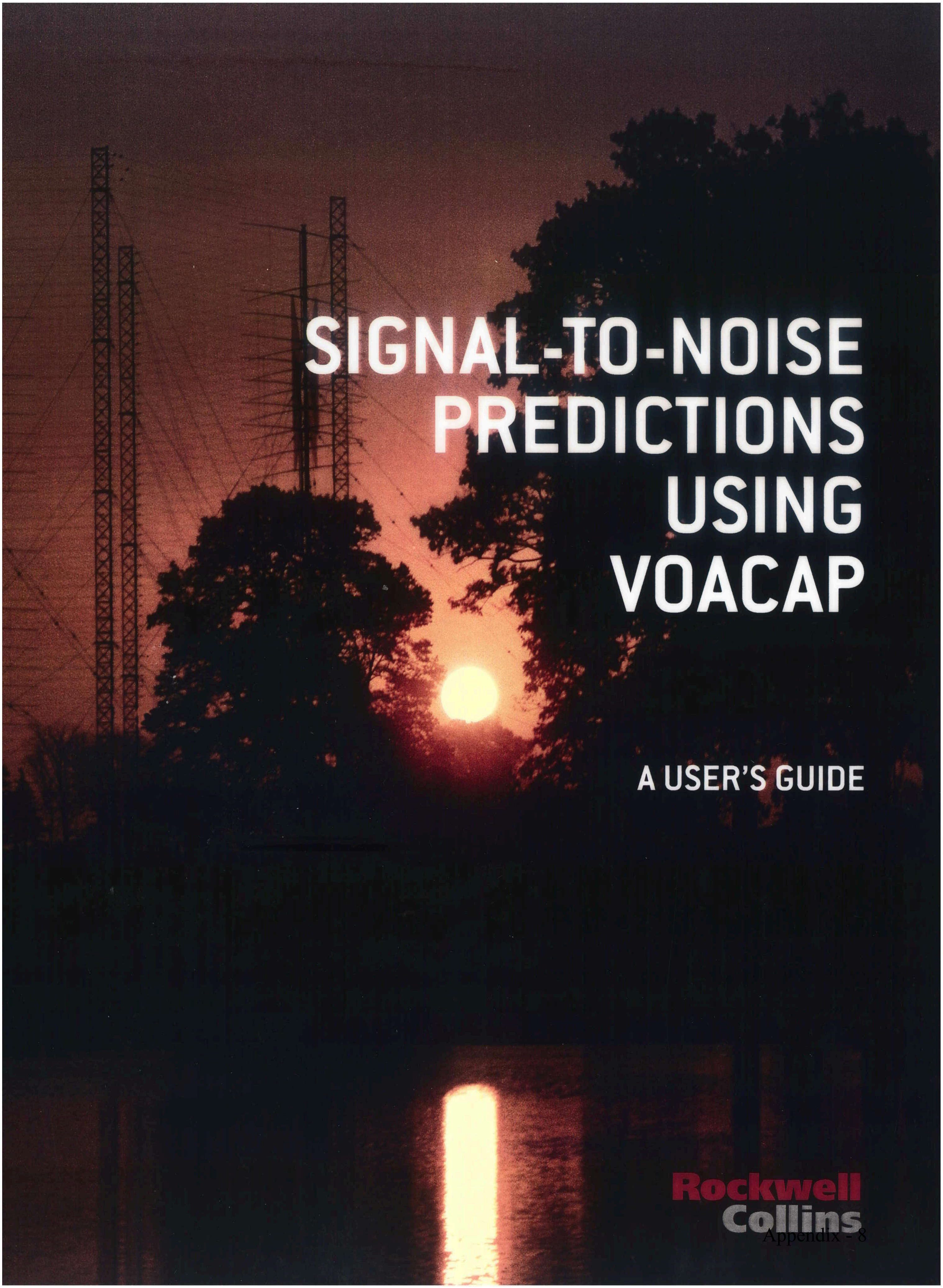
I doubt that the many people who spent so much of their time and energy creating and expanding this program intended for it to be used to settle a legal dispute.

73,

Jed Margolin
WA2VEW

Exhibit 1

Exhibit 1



SIGNAL-TO-NOISE PREDICTIONS USING VOACAP

A USER'S GUIDE

Rockwell
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Rockwell
Collins

Signal-to-Noise Predictions Using VOACAP, Including VOAAREA

A User's Guide

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Lane Consultant
Silver Spring, MD

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with
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3. NOISE POWER PREDICTIONS

3.1 General Discussion

In the HF band, noise power present at a radio receiver is expressed in dB relative to 1 watt (dBW) and for a noise power bandwidth of 1 Hz. It is generally assumed that the controlling radio noise is external to the radio. The 3 major sources of radio noise at HF are atmospheric, man-made and galactic noise (Horner 1962) (CCIR Report 322 1964). Atmospheric radio noise usually predominates during the nighttime and at frequencies typically at 10 MHz or lower. Man-made sources are usually the controlling source of radio noise during the daytime and for frequencies above 10 MHz at night. Galactic radio noise is only detectable near 30 MHz in very quiet regions of the earth. We, again, must remember that the prediction of the radio noise power is just as critical as the prediction of the signal power when it comes to correctly estimating the signal-to-noise ratio that will be available to the receiver.

Noise power measurements were made using short vertical antennas over a fairly extensive ground screen (Chindahporn and Younker 1968). Models of radio noise currently in use do not have a direction of arrival for the noise source although in reality there is generally an azimuthal dependency. Noise tends to have a fairly low angle of arrival in the vertical plane. Atmospheric noise is assumed to arrive via skywave propagation, whereas man-made noise fields generally propagate by groundwave or line-of-sight. Galactic radio noise results from the collection of RF emitting sources in our galaxy.

The noise power models used in VOACAP do not consider the directivity of the specified receive antenna. If the user-specified antenna is one which has an associated frequency dependent efficiency terms, then the noise power is reduced by the efficiency factor of the receive antenna at each of the operating frequencies under consideration. It is assumed that receive antenna is immersed in an omni-directional noise field and that the noise power pickup by the antenna is that of the integrated power pattern (i.e., 3 dBi for an antenna over perfect earth).

The actual noise power calculation in VOACAP assumes that the noise power is slightly higher than that received by the isotropic receive antenna over perfect earth. The data is normalized to the noise power available from a short, lossless vertical monopole. This accommodates the fact that most radio noise arrives at low elevation angles. There is some disagreement as to whether a horizontal half-wave dipole is as susceptible to radio noise power as a monopole antenna. The error seems to be small (2 to 3 dB) and VOACAP uses the higher noise power value which makes the signal-to-noise ratio prediction slightly conservative.

WARNING: The VOACAP user should ascertain what the likely noise sources are for the HF system being modeled. The adequacy of the existing noise models should be determined and adjustments made to compensate for any discrepancies (Cummins et al. 1979). Things that could create problems are: systems with large bandwidths (Spaulding et al. 1962) (Disney and Spaulding 1970); excessive interference by other signals, such as in the broadcast bands; cheap receivers with high levels of internal set or thermal noise; high probability of local thunderstorms or heat lightning; precipitation static caused by flying through clouds and blowing ice particles or sand striking the antenna; high levels of audio noise, such as cockpit noise in a jet fighter or helicopter which can exceed the RF noise for voice communications; and height-gain for airborne systems which can see more of the radio horizon than ground-based systems (Roy 1981). These are just some of the examples of things the modeler must be aware of when using the noise model in VOACAP. Also see the discussion in Chapter 9, Section 9.5.

3.2 Atmospheric Radio Noise

Atmospheric radio noise is generally the summation of all the radiation released from thunderstorm activity around the world. A single lightning strike can send a noise spike that can be detected up to 8 times as it circles the world via ionospheric propagation. In the 1940s, when scientists were trying to map the worldwide occurrence of atmospheric radio noise, there were very few observation points. Although the data were well controlled and the National Bureau of Standards (NBS) calibrated the noise measurement devices that were used, there were not enough stations to allow for world mapping. The NBS (Crichlow et al. 1955) prepared the first set of atmospheric radio noise maps using the noise measurement data and world weather maps showing the probability of a lightning strike (WMO 1956). Worldwide atmospheric noise factor contours at 1 MHz were hand drawn. In 1963, after several revisions, these maps were approved by the International Telecommunications Union (CCIR Report 322 1964). Later, with the advent of computers, these maps were regenerated using mathematical contouring (Lucas and Harper 1965). However, they still retained the judgement used by Herb Crichlow in determining where noise peaks and valleys would occur based on lightning-activity maps when actual noise measurement data was not available. Crichlow's contribution is still used in the current noise model in VOACAP.

Other atmospheric radio mapping routines have been produced. Some generated noise contours using only the noise power measurements. This often places noise "valleys" where noise "peaks" should occur. One notable example is the noise model in early versions of the US Navy Prophet program which had a noise valley over the Amazon river basin where it is well known that atmospheric radio noise is so high that it makes the AM band unusable during the nighttime.

The Voice of America has chosen to use the CCIR Worldwide Atmospheric Noise Maps in CCIR Report 322-3 (1986). These maps retain the original insight of where thunderstorm and lightning activities are located and include some additional measurements made in the former USSR and Thailand (Spaulding and Washburn 1985). In the original noise-data collection these areas were poorly represented. There is some controversy over which of the CCIR maps are best (Sailors 1995) (Lane 1994) (Bradley 1999).

One point that is very important for us to understand about any of the CCIR worldwide atmospheric radio-noise maps is that the measured values were excluded when a local thunderstorm was present. Local noise bursts propagated either by line-of-sight or groundwave were so great that they saturated the detector instrumentation. Therefore, the noise power predictions derived from these maps are for conditions when there are no local thunder storms. In areas such as the Southeastern USA, where heat lightning is nearly an every night occurrence during the summertime, actual noise power spikes may greatly exceed the CCIR-predicted atmospheric noise at the location, time and season,

There are several other points that we should consider when using the atmospheric radio noise predictions. The dependence on sunspot number has never been determined although the data is slanted toward the years with higher sunspot numbers. The time variation of the noise data is based on the day-to-day variation over 4-hour time blocks and 3 months. The resolution of noise data for a given hour and month is poor at best. Also, noise collection procedures tended to average the noise over a period of a few minutes. Actual noise spikes may be much greater than indicated by the maps.

The atmospheric radio noise data is adequate for long term planning. However, the engineer should be aware that, during certain months of high probability of local thunderstorm activity, actual conditions can be much worse than predicted. Ionospherically propagated atmospheric radio noise tends to be vertically polarized and tends to arrive at the receiver at relatively low angles, below 10°. In the CCIR models of noise power, it is assumed that the noise arrives omni-directionally and that the noise power delivered to the receiver by any actual antenna is the same as that which would be delivered by an short lossless whip antenna over perfect earth.

The amplitude probability distribution of the atmospheric noise can be wider than that of man-made radio noise. One must remember that, when planning for 90% reliability, the upper decile of the noise distribution applies. When we begin planning for the HF system, we should always consult the CCIR Report 322 to see how severe the atmospheric noise is in the receive areas by looking at the median maps and the upper decile, D_U, found on the figure adjacent to the world map.

Example for Estimating Atmospheric Radio Noise Using the CCIR Atlas: Let us assume that we are planning to place a receiver in Brasilia (16S; 48W) for operation on 5 MHz in October at 18 LT (21 UT). First, we need to remember that October is a spring month in the Southern Hemisphere. Go to the appropriate map in CCIR 322-3 (1986) and look up the value of F_{AM} at 1 MHz. We should see a value of about 84 dB at Brasilia. Next we need to convert this to the noise factor at 5 MHz. This requires us to look at the Figure of Variation of radio noise with frequency (spring 1600-2000 h). Find the intersection of 5 MHz and the curve that would approximate $F_{AM} = 84$. The corrected F_{AM} is found by looking at where that intersection falls on the vertical axis of the figure. In this case, we find F_{AM} at 5 MHz = 57 dB (Note: Noise Power = F_{AM} – 204 dBW/Hz). Subtracting 204 from this F_{AM} value yields a median noise power of –147 dBW/Hz. The ratio of the upper decile to the median value of F_{AM} is found on the adjacent figure (data on noise variability and character spring 1600 – 2000 h). Here we locate the intersection of 5 MHz with the D_U curve. Again, looking where this intersection falls on the vertical (dB) axis, we find the D_U at 5 MHz = 13 dB. That means that 10% of the time we can expect the noise power to be as high as -134 dBW/Hz. If we are wanting a circuit reliability of 90%, then we must realize that we will need to protect our system by this additional 13 dB just to account for the variability in noise power. This is a significant design consideration.

3.3 Man-Made Radio Noise

The history of man-made radio noise measurements and their levels would fill a book. Let it be said that most of the controversy was dispelled in 1974 (Disney and Spaulding 1974). The CCIR in Report 258-4 (1986) unanimously recommended these median values, but then added on a number of possible statistical distribution methods with no recommendation as to which one should be used.

Under the sponsorship of the Voice of America, the National Telecommunications and Information Administration - Institute for Telecommunication Sciences (NTIA - ITS) was asked to review the man-made noise issue one more time. The recommendation of this review (Spaulding and Stewart 1987) was a statistical model for man-made radio noise which is now included in the VOACAP radio noise model. The equation given for the man-made noise factor is:

$$F_{AM} = C - D\ \mathrm{Log}_{10} f$$

where: f is the frequency in MHz and
C and D are reference values

In Table 3.1. Values of C and D Needed to Compute the Radio Noise Factor, F_{AM}, as a Function of the Frequency, f, in MHz, we will find the reference values needed to compute the median level of man-made noise factor, F_{AM}.

Table 3.1. Values of C and D Needed to Compute the Radio Noise Factor, F_{AM}, as a Function of the Frequency, f, in MHz

Environmental Category	**C**	**D**	**P_N at 3 MHz**
Business	76.8	27.7	–140.4 (dBW/Hz)
Residential	72.5	27.7	–144.7
Rural	67.2	27.7	–150.0
Quiet Rural	53.6	28.6	–164.0
Galactic Noise	52.0	23.0	–163.0

The noise power at the receiver for a 1-Hz noise power bandwidth expressed in dBW is given by:

$$P_N\,(\mathrm{dBW/Hz}) = F_{AM} - 204$$

For some reason buried nearly half a century ago, reference man-made radio noise values were and are still given for a reference frequency of 3 MHz, whereas, atmospheric noise was referenced to 1 MHz. The reference levels at 3 MHz for the international categories of man-made radio noise are shown in the last column of Table 3.1.

Man-made radio noise was primarily measured where noise levels were rather high. In industrial settings, the measurements were made inside the grounds of the factory, one employing electromechanical devices. City and residential measurements were made near stop lights on busy streets where cars would queue waiting for the light to change. The one general complaint expressed most often is that the reference man-made radio noise levels are too high. Again, the VOACAP user must exercise judgement when selecting the man-made noise environment for use in the predictions. It must be kept in mind that the accuracy of the noise prediction is just as important as the accuracy in the signal prediction when it comes to calculating the signal-to-noise ratio.

Man-made noise is the controlling source in most cases during the daytime when the D-layer absorption diminishes the level of skywave atmospheric radio noise. Even at night, man-made sources can predominate. Examples of this are receivers located in close proximity to arc welders (especially bad in the plastics industry of third-world countries), hospitals with diathermy equipment, cities with many unregulated blinking neon signs, power lines in arid climates (grounding wires on the poles lose their connectivity with the ground), saturation of the receiver by antenna pick up of too many out-of-band and nearby CB transmissions, just to name a few.

Actual measurements in the 1980s in Germany showed that both rural and residential man-made radio noise values were about −154 dBW/Hz. Even measurements made near electrical cranes and electrical railroads did not exceed this value at 3 MHz. However, areas in Germany that appeared to be remote rural were not because of noise being propagated along nearby power lines. The noise source was actually a city several miles away, but the power lines offered a means to conduct the city noise level into remote rural areas where it was reradiated from the power lines.

In Washington, DC, measurements made with a roof-top antenna on a 6-story office building yielded noise power values consistent with residential areas except during rush hour. When traffic levels were high, the radio bands became clogged with emergency radio calls, taxi dispatch messages and truck-driver use of CB radios. The combined power of these extraneous transmissions collected by the roof-top antenna was sufficient to saturate the receiver. At these times, it was better to model the noise power at the business level rather than the residential level.

On Taiwan, throughout the entire island, man-made radio noise levels mysteriously rose by 20 dB in a matter of a few years. It was found that the home industry of making plastic tubing with a small arc welder was the primary source of the increased noise. The problem was resolved by requiring, under the penalty of law, that each arc welder must have an inexpensive but effective RF suppressor installed. Within months of vigorous enforcement of this law, the RF noise level on Taiwan fell back to the previous level.

Voice of America found that, due to congestion in the International Shortwave bands, they needed about 1 mV/m signal strength to be competitive with co-channel and adjacent channel interference. A man-made radio noise level of −145 dBW/Hz at 3 MHz was selected to model the listening environment since at the prime bands of 9 and 11 MHz this noise level required field strengths of 1 mV/m or more in order to achieve 90% reliability at a required signal-to-noise (density) ratio of 73 dB•Hz (Lane and Toia 1985).

Each situation the modeler faces is different and great care needs to be exercised when selecting the reference level of the man-made noise power to be used in VOACAP. So far, we have only addressed the median man-made noise value and its dependence on frequency. Measurements have shown that there is a location as well as a time variability to man-made noise (Disney and Spaulding 1974) and (CCIR Report 258-4 1986). In 1987, A. D. Spaulding recommended to the Voice of America that it is acceptable to use one value for each of the statistical parameters for all 4 categories of man-made noise (Spaulding and Stewart 1987). Subsequently, a typographical error was found in that report and at the request of A. D. Spaulding a correction was published (Lane 1995). The correct values, according to Spaulding, are a lower decile range of 6 dB and an upper decile range of 9.7 dB. These are the values currently used in VOACAP and are approximately the same ranges as recommended for use in IONCAP (Lloyd et al. 1978).

Example: Again let's look at the previous example used for the atmospheric noise discussion. We had computed the median and upper decile of the noise power at 5 MHz in Brasilia for October in the early evening. If we assume that the receive location is in a residential area of the city, then the reference level from Table 3.1 is –144.7 dBW/Hz at 3 MHz. Adjusting this value for 5 MHz using the frequency dependence equation given previously, we obtain a median man-made noise power of –150.9 dBW/Hz. The critical parameter which will effect the reliability is the range to the upper decile (i.e., 9.7 dB). Thus, 10% of the time, the man-made noise power will not exceed a value of –141.2 dBW/Hz. Although this value is 8 dB lower than the value we calculated for the upper decile range of the atmospheric radio noise, it is a significant level for quieter parts of the day and seasons with less thunderstorm activity.

3.4 Galactic Radio Noise

Galactic radio noise is included in VOACAP so that noise power cannot go essentially to 0. However, noise arriving on earth from the Milky Way is hardly a factor in the HF band anymore with the huge increase in RF noise pollution. The original model for galactic noise is taken from ITSA-1 (Lucas and Haydon 1966) and is attributed to an extrapolation of data measured by Cottony and Johler (1952) and later verified by measurement (Crichlow and Spaulding 1965). The same source is quoted in CCIR Report 322 (1964); however, the noise is slightly higher at the 1 MHz intercept 52 rather than 49.5 dB, and the slope with frequency is –23 rather than 22.

This discrepancy was noted by Spaulding and Stewart (1987) and the new galactic noise model for IONCAP/VOACAP was changed to that recommended by the CCIR Report 258-4 (1986) which is attributed to CCIR Report 322 (1964) and is shown in Table 3.1 of this chapter. The reason for the discrepancy is not clear and the parties who might know are deceased. The variation of the galactic noise has remained the same throughout this period at ±2 dB at the decile range.

As noted earlier, our discussion of galactic noise is mostly historical. Galactic radio noise does not effect most HF radio systems except under rare circumstances as will be discussed in Section 3.5, Controlling Noise.