different sets of the coefficient arrays (P, ABP, and DUD). All this would gain nothing. Even so, some preliminary calculations were made to note how the resulting month-hour values of F_{am} might differ from the 3-month-hour values. For the very few examples looked at, no sharp differences were noted.

The above covers the determination of the atmospheric noise F_{am} value and its statistical variation. Man-made noise and galactic noise have f_a values that also are log-normally distributed. The next section covers the estimation of the man-made noise value, its variation, and the galactic noise value and its variation. Then Section 4 covers the addition of the three noises to obtain the overall external f_a and its variation.

3. MAN-MADE AND GALACTIC NOISE

As noted in the introduction, one of the major changes in the SUBROUTINE GENOIS was to replace the current man-made noise estimates with the much more modern ones as given in CCIR Report 258-4 (1982). As will be shown, these estimates are substantially different than the ones currently used, and this, in some situations, will greatly affect the calculated signal-to-noise ratio.

Figure 5 shows the man-made noise levels from CCIR Report 258. These levels and all the associated statistics are directly from Spaulding and Disney (1974), which gives the details of the measurements and analysis giving rise to these estimates. Most of the measurements that went into the estimates were from throughout the continental U.S. The quiet rural curve is from CCIR Report 322 and is based on world-wide measurements. As noted in Report 258, numerous measurements made throughout the world since these estimates were developed generally follow them quite closely for the various areas (i.e., business, residential, etc.) and therefore the Report 258 estimates serve well throughout.

As an additional example of the applicability of the Report 258 estimates, Figure 6 shows recently analyzed noise measurements from Moscow. When the new atmospheric worldwide noise estimates were obtained (Spaulding and Washburn, 1985), some of the "new" data used was from 10 Soviet measurement locations. One of these was Moscow. For Moscow, data are available from March 1958 through December 1964. The frequencies were 12, 25, 35, 60, 100,

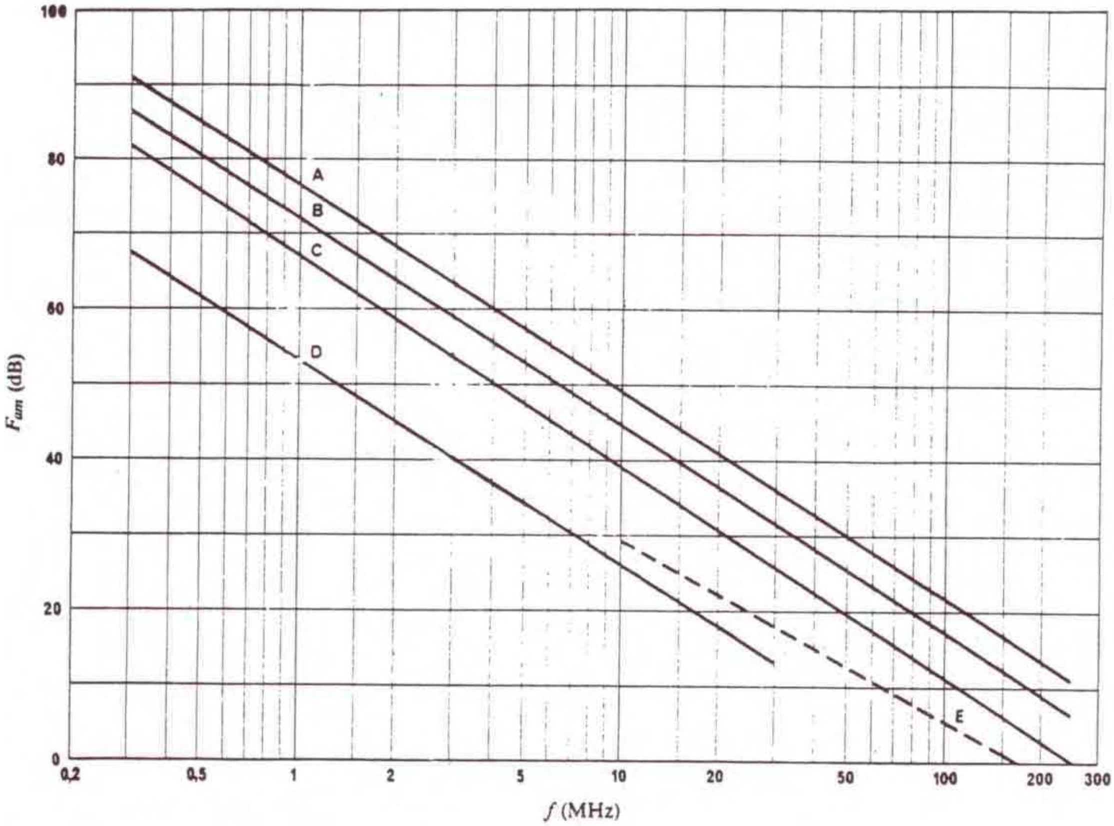

FIGURE 1 – *Median values of man-made noise power for a short vertical lossless grounded monopole antenna*

Environmental category:
A: business
B: residential
C: rural
D: quiet rural
E: galactic

Figure 5. Figure 1 from CCIR Report 258-4.

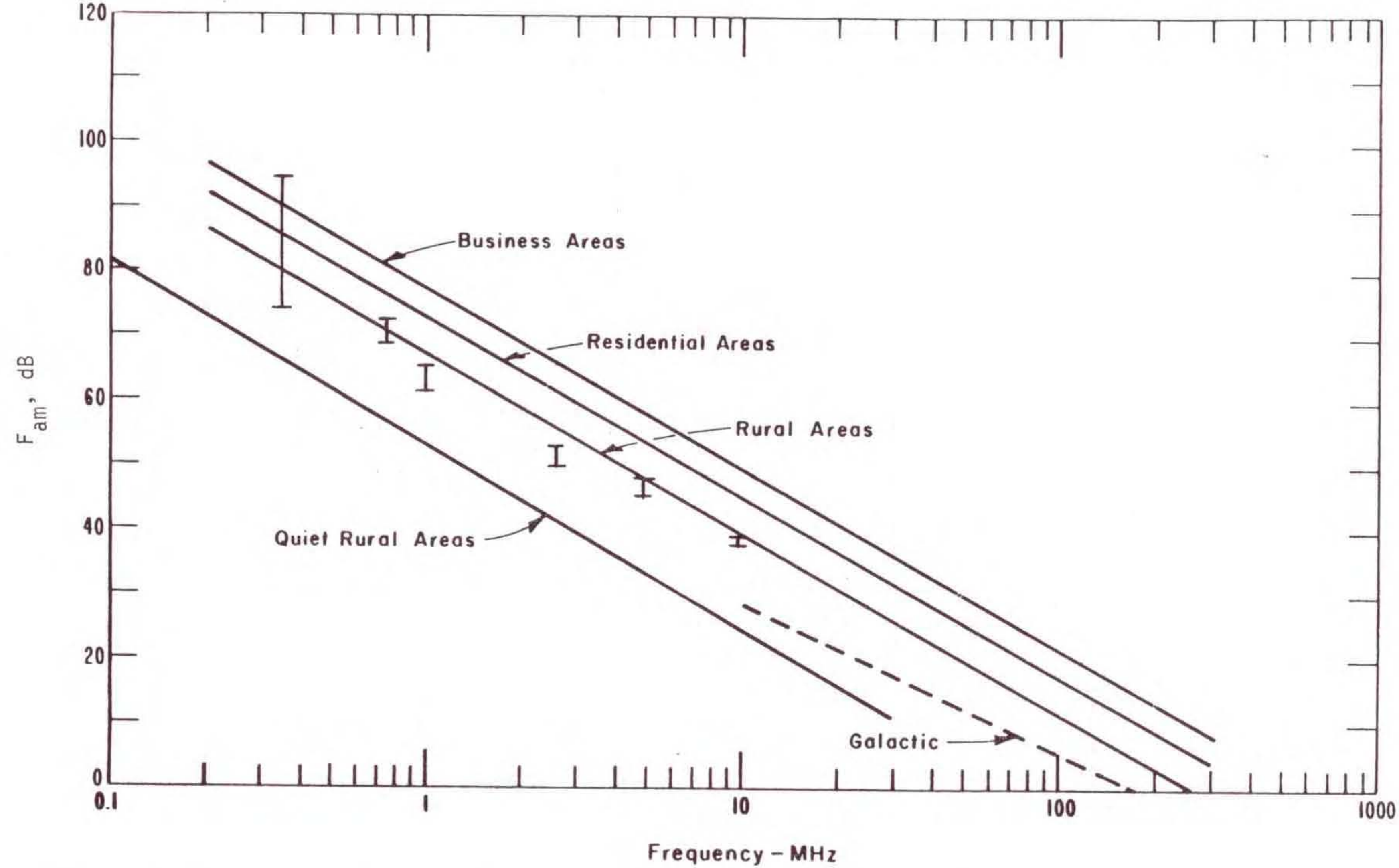

Figure 6. Figure 1 from Spaulding and Disney (1974) with Soviet Moscow noise measurements, Winter Season, 1958 - 1964.

350, 750, 1000, 2500, 5000, 7500, and 10,000 kHz. Various lower frequencies down to 3 kHz were added in October 1962. In analyzing the Soviet data, the higher frequencies were not generally analyzed as it was soon discovered that they were contaminated by man-made noise (see Spaulding and Washburn, 1985 for details). The higher frequency data for Moscow has been analyzed for the winter season (when the atmospheric noise is lowest). Figure 6 shows the range of median F_a values for each of the six 4-hour time blocks for 350, 750, 1000, 2500, 5000, and 10,000 kHz. The 350 kHz data contains atmospheric noise as shown by the large diurnal variation. However, the higher frequency measurements were, apparently, of man-made noise. Assuming that the conversion method used (Spaulding and Washburn, 1985) to obtain f_a from the parameters the Soviets measured is correct, Figure 6 indicates that the Moscow measurement location (37.3E, 55.5N) was "rural," at least in 1958 through 1964. The Soviet data at the other locations at the higher frequencies (2.5 MHz on) has not been analyzed.

In Figure 5 (or 6), the linear variations of F_{am} with frequency, including the galactic noise variations, are given by

$$F_{am} = c - d\log f, \qquad (16)$$

where f is the frequency in MHz, the constants, c and d, are given in Table 1 below. Table 1 also contains constants for other environmental categories not given in Figure 5 (e.g., parks and university campuses).

TABLE 1 -- VALUES OF THE CONSTANTS c AND d

Environmental category	c	d
Business (curve A)	76.8	27.7
Inter-state highways	73.0	27.7
Residential (curve B)	72.5	27.7
Parks and university campuses	69.3	27.7
Rural (curve C)	67.2	27.7
Quiet rural (curve D)	53.6	28.6
Galactic noise (curve E)	52.0	23.0

The next change is in the values of D_μ, D_ℓ, etc. The current IONCAP values, for all man-made noise categories, are D_μ (denoted DUM) = 9 dB, D_ℓ (DLM) = 7 dB, σ_{D_μ} (SUM) = 1.5 dB, $\sigma_{F_{am}}$ (SMM) = 3 dB and σ_{D_ℓ} (SLM) = 1.5 dB. Spaulding and Disney (1974) (and CCIR Report 258) give a separate value of D_μ, D_ℓ, and $\sigma_{F_{am}}$ for each category (business, residential, and rural) and each measurement frequency (0.25 MHz - 250 MHz). An analysis of this data has led to the conclusion that it is acceptable to use, as currently, one value for each of the parameters for all three categories and all frequencies. The values used here are designed to be acceptable at all frequencies, but most appropriate for HF frequencies. These new values are

$$D_\mu = 9.7 \text{ dB},\ D_\ell = 7 \text{ dB},\ \sigma_{D_\mu} = 1.5 \text{ dB},\ \sigma_{F_{am}} = 5.4 \text{ dB, and } \sigma_{D_\ell} = 1.5 \text{ dB}.$$

It is not completely known how appropriate these values are for the quiet rural category; however, a review of the analysis of the atmospheric noise Tech Note 18 data indicate that these should also be reasonable values for this category.

As with atmospheric noise, the variation of f_a about its median value, F_{am}, for man-made noise is well represented by two log-normal distributions, one above and one below the median. Figure 7 (from Spaulding and Disney, 1974) shows an example of this. Figure 7 shows the distribution of 10 second f_a values within an hour for Boulder, CO and 20 MHz. For this sample of data, D_μ = 10.2 dB and D_ℓ = 6.0 dB.

Galactic noise can also be represented by a log-normal distribution about its median value. The current values used are still appropriate; i.e., D_μ (denoted DUG) = 2 dB, D_ℓ (DLG), = 2 dB, σ_{D_μ} (SUG) = 0.2 dB, $\sigma_{F_{am}}$ (SMG) = 0.5 dB and σ_{D_ℓ} (SLG) = 0.2 dB. The current galactic noise representation is, however, somewhat inaccurate. The current representation corresponds to values of c and d (Table 1) of 49.5 (rather than 52) and 22.0 (rather than 23.0) respectively. The galactic noise representation has, therefore, been corrected in the new subroutine GENOIS.

Each of our three noise processes, atmospheric, man-made, and galactic is given by log-normal distributions and we need to determine the sum of these three processes. This is treated in the next section, but it is interesting to present, for the record, the "history" (as well as we can determine it) of the currently used man-made noise levels and variations and contrast them with the "new" (Figure 5) values.

The current four levels are given in GENOIS by DATA Statement XNINT and are specified in terms of dB less than 1 watt, that is, the negative of the

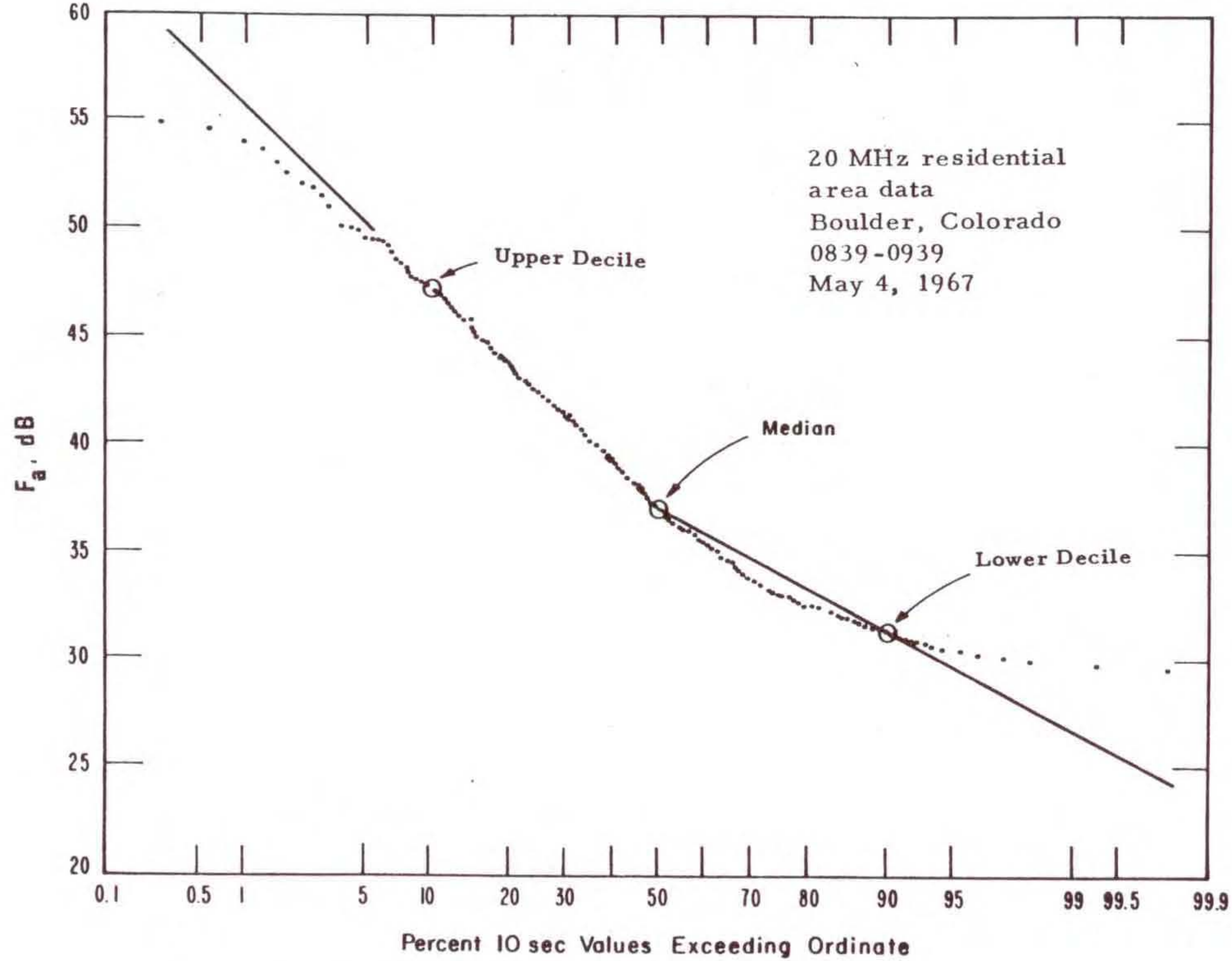

Figure 3. Distribution of F_a values for a given location.

Figure 7. Figure 3 from Spaulding and Disney (1974).

normal units dBW. The four levels are 125, 136, 148, and 164 corresponding to industrial, residential, rural, and remote unpopulous (quiet rural from CCIR 332) regions. These values are obtained from Figure 4.1 of Lucas and Haydon (1966, ITSA-1). Figure 8 shows this Figure from Lucas and Haydon (1966). The Figure supposedly relates man-made noise levels to population of a receiving area. Also the D_μ and D_ℓ values are taken to be 9 dB and 7 dB respectively. The reference to this material is Spaulding (private communication). Spaulding does not recall supplying any information in the form of Figure 8, but in any case, these estimates can be based only on very limited data. While it seems reasonable that man-made noise levels should correlate, at least broadly, with population in urban areas, attempts to correlate average noise power levels with population density, as measured in U.S. Census Bureau's standard location areas (SLA's) of 1 to 5 square miles, have not been successful (Spaulding, et al., 1971). In fact, Spaulding (1972) found no significant correlation between the average population density of an SLA (ranging from 1000 to 25,000 per square miles) to the average values of noise level taken at several locations within the SLA. The four levels (125, 136, 148, and 164) given in Figure 8 are for 3 MHz. In the original (ITSA-1) the linear slope used was 29 dB/decade of frequency versus 27.7 dB/decade (d, Table 1). In the current GENOIS, the slope (but not the 3 MHz levels) was changed to 28 dB/decade. ITSA-1 "added" the three noise processes by simply selecting the largest, using it, along with its D_μ, D_ℓ, etc. for the total. Figure 9 shows the comparison of the CCIR 258 man-made noise estimates and those currently in GENOIS.

In 1967, Spaulding and Disney prepared an estimate of the man-made radio noise expected in urban, suburban, and rural locations for the Joint Technical Advisory Committee (JTAC, 1968). These JTAC estimates are shown in Figure 10. Note the break in the JTAC curves between 10 and 20 MHz. This occurred when data were combined from measurements made by various investigators at different times, locations, and frequencies, with no one set of data covering the whole frequency range. The break seemed not unlikely at the time since between 10 and 20 MHz the predominant noise sources change from those associated with power lines to automotive ignition systems. However, the real cause was due to the incomplete frequency coverage of the measurements and the attempt to relate dissimilar parameters.

In 1969, the HF propagation program, HFMUFES, was developed (Barghausen,

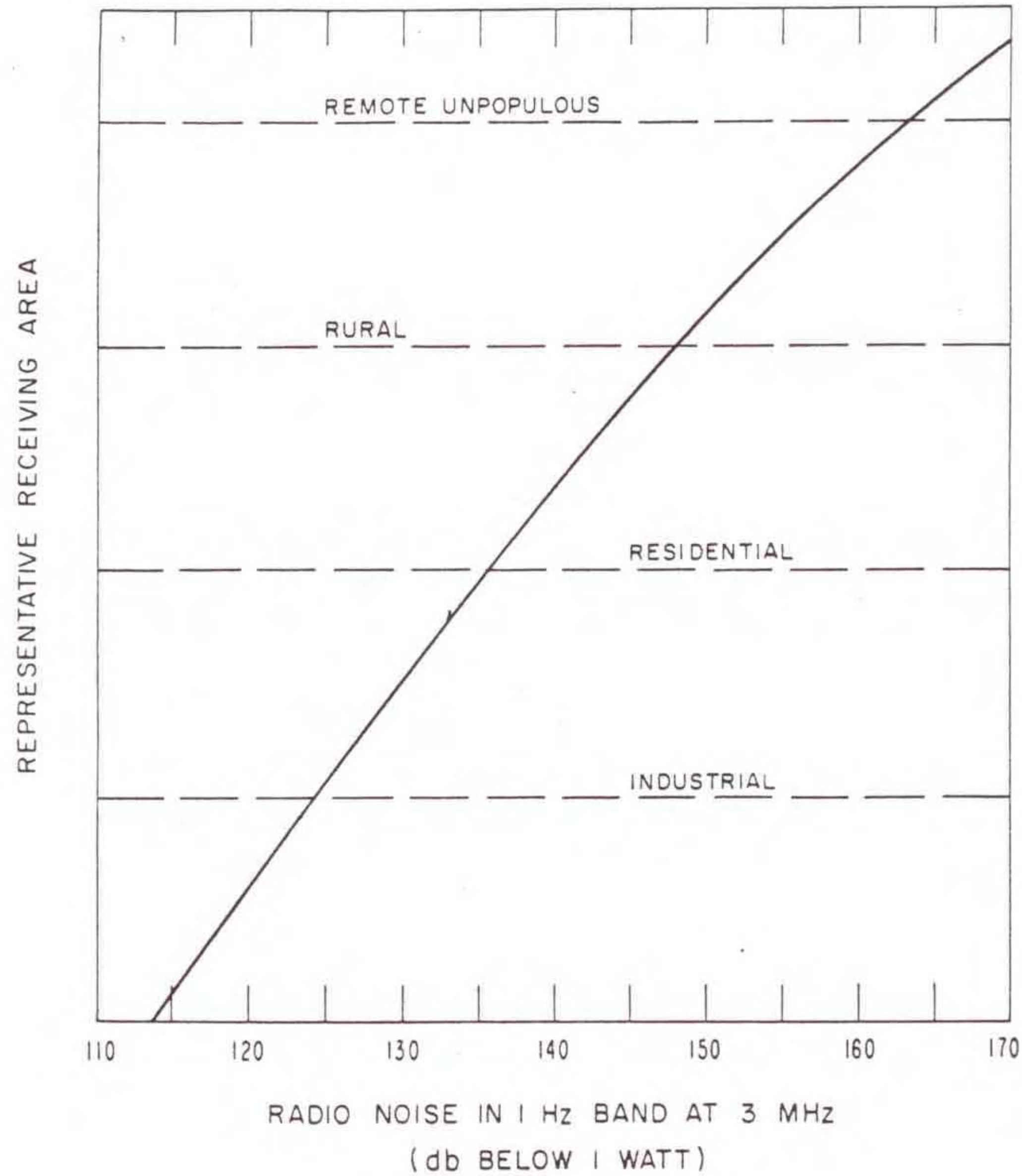

Figure 4.1. Typical Man-Made Noise Relative to Population of Receiving Area.

Figure 8. Figure 4.1 from Lucas and Haydon (1966).

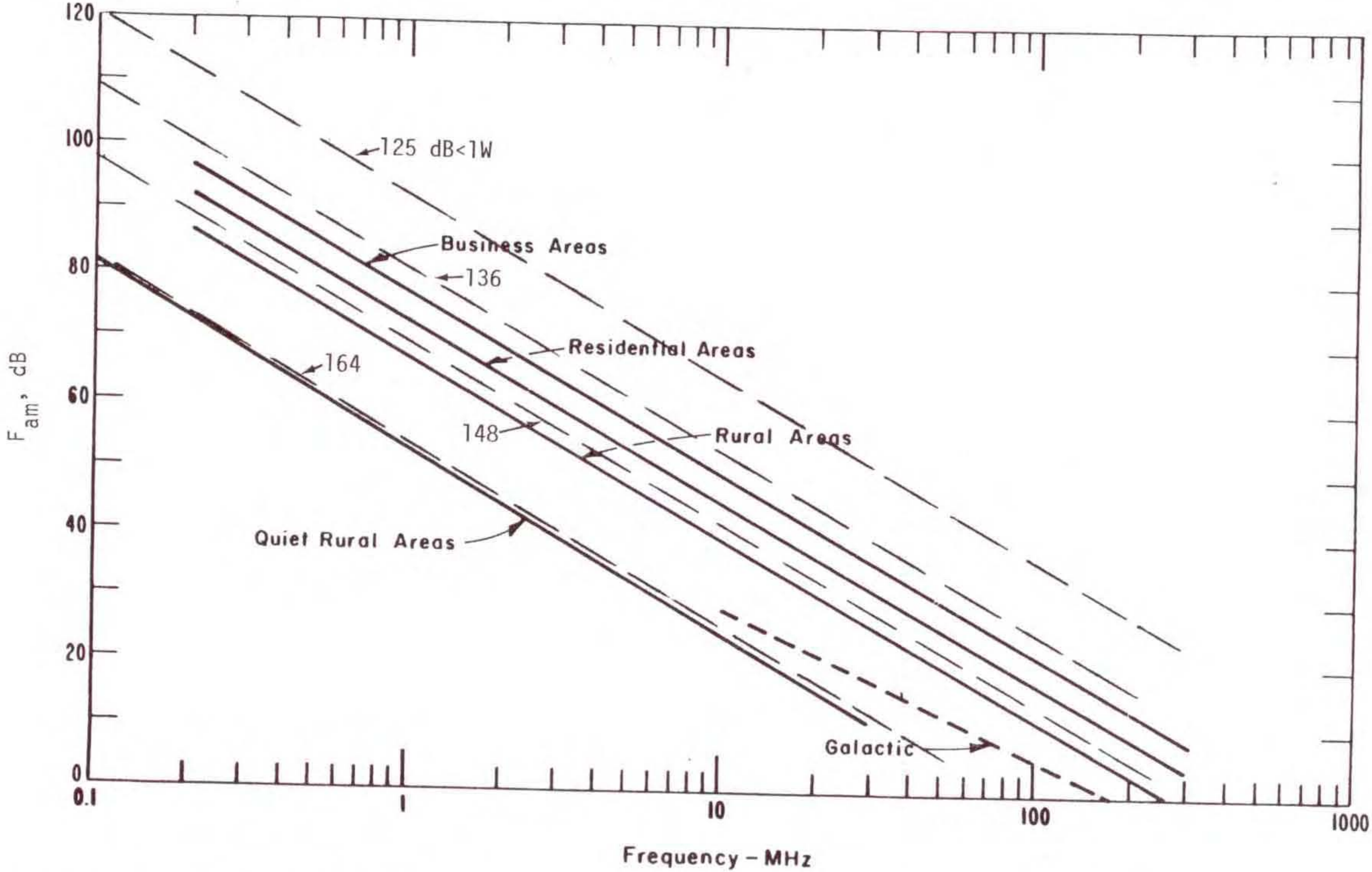

Figure 9. Comparison of the CCIR Report 258 man-made noise estimates and those currently used in GENOIS of IONCAP.

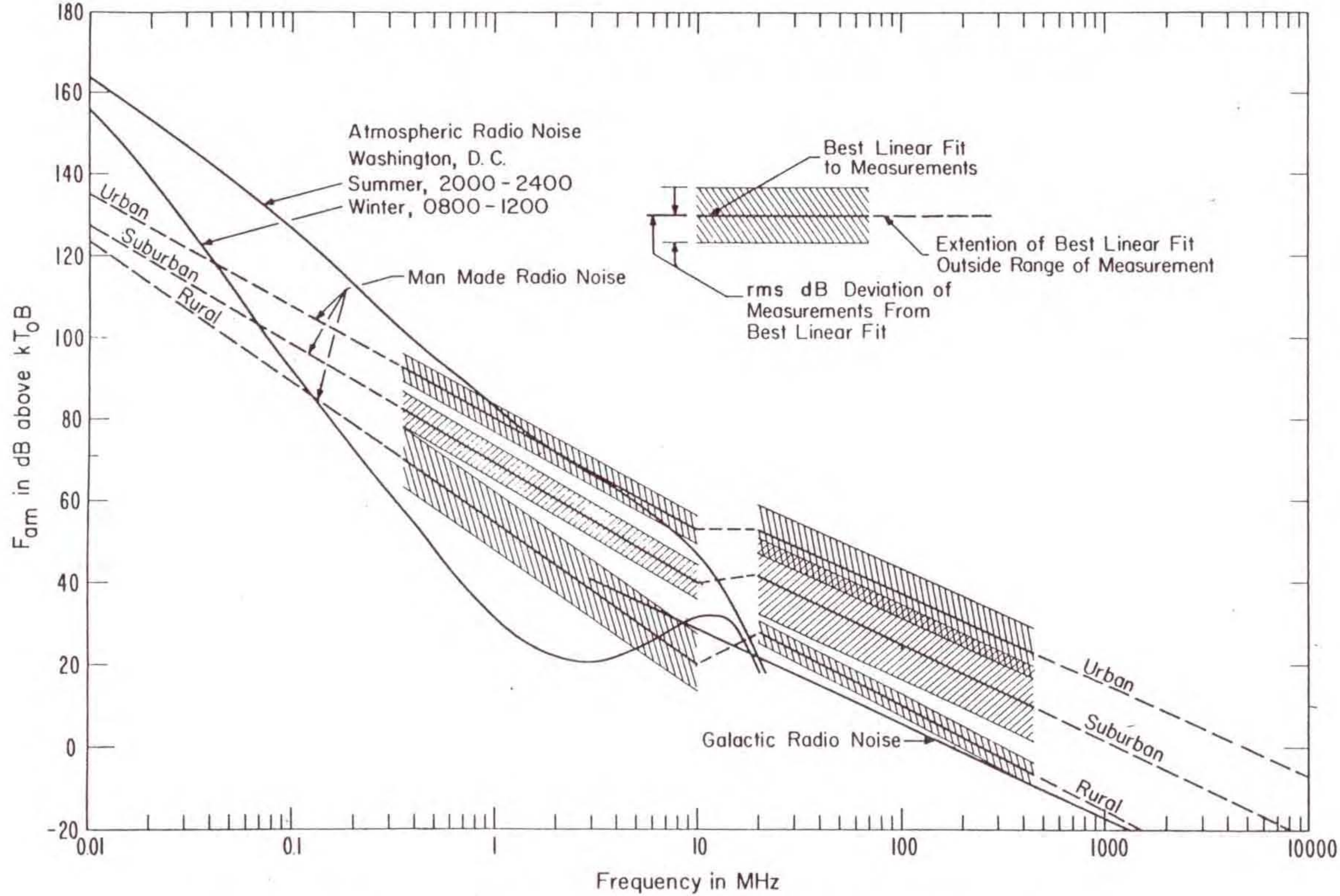

Fig. 3. Median Values of Radio Noise Power (Omnidirectional Antenna Near Surface)

Figure 10. The JTAC (1968) man-made noise radio estimates.

et al., 1969). This program uses the JTAC man-made noise estimates (Figure 10) in its noise routines. As in IONCAP, HFMUFES used linear interpolation to obtain a 3 month/1-hour F_{am}, etc. values for atmospheric noise using GENFAM and NOISY. The overall noise level is calculated in SUBROUTINE RELBIL. For man-made noise, the JTAC curves are used, with three frequency ranges $f < 10$ MHz, $10 < f < 20$, and $f > 20$ MHz. For each of these frequency ranges, and for each environmental category, urban, suburban, and rural, a different D_μ is used. Also D_ℓ is set equal to D_μ (see Table 4.1, Barghausen, et al., 1969). A $\sigma_{F_{am}} = 3.0$ dB and $\sigma_{D_\ell} = \sigma_{D_\mu} = 1.5$ dB are used. The three noise processes, atmospheric, man-made, and galactic are ordered in magnitude (median values) and either 0, 1.0, 1.8, 2.4, 3.0, 3.5, 4.0, or 4.8 dB is added to the largest value depending on the various differences between the highest noise source, second highest, and third highest (see Table 4.2 of Barghausen, et al., 1969). The D_μ and D_ℓ (= D_μ) for the highest noise source is then used for the "sum" of the noise processes. Figure 11, from Spaulding and Disney (1974) shows the comparison of the JTAC man-made noise estimates and the current CCIR Report 258 estimates.

As noted above, the original subroutine GENOIS simply selected the largest noise source and its statistics for the "sum". Later GENOIS was changed to attempt to add the three noise processes to obtain the "sum" process. However, the (inappropriate) man-made noise levels were retained, although, as noted above, the linear slope was modified. The next section, then, covers the addition of the three processes.

Finally, the current IONCAP allows the user to enter his own man-made noise value (in dB > 1 watt) at 3 MHz. This feature has been maintained in the new GENOIS and functions exactly as before. (Of course, the new D_μ and D_ℓ etc. values now apply).

4. COMBINATION OF THE THREE NOISES

In this section we want to detail the changes made in GENOIS as to the technique used to find the total external noise and its distribution. As noted in the last section, the original GENOIS in ITSA-1 simply selected the largest of the three noises (atmospheric, man-made, and galactic) and used its median value and decile values for the total. Later, HFMUFES did much the same in that it used the decile and sigmas of the largest noise source, but increased the largest noise source median value by various amounts ranging from 0 to

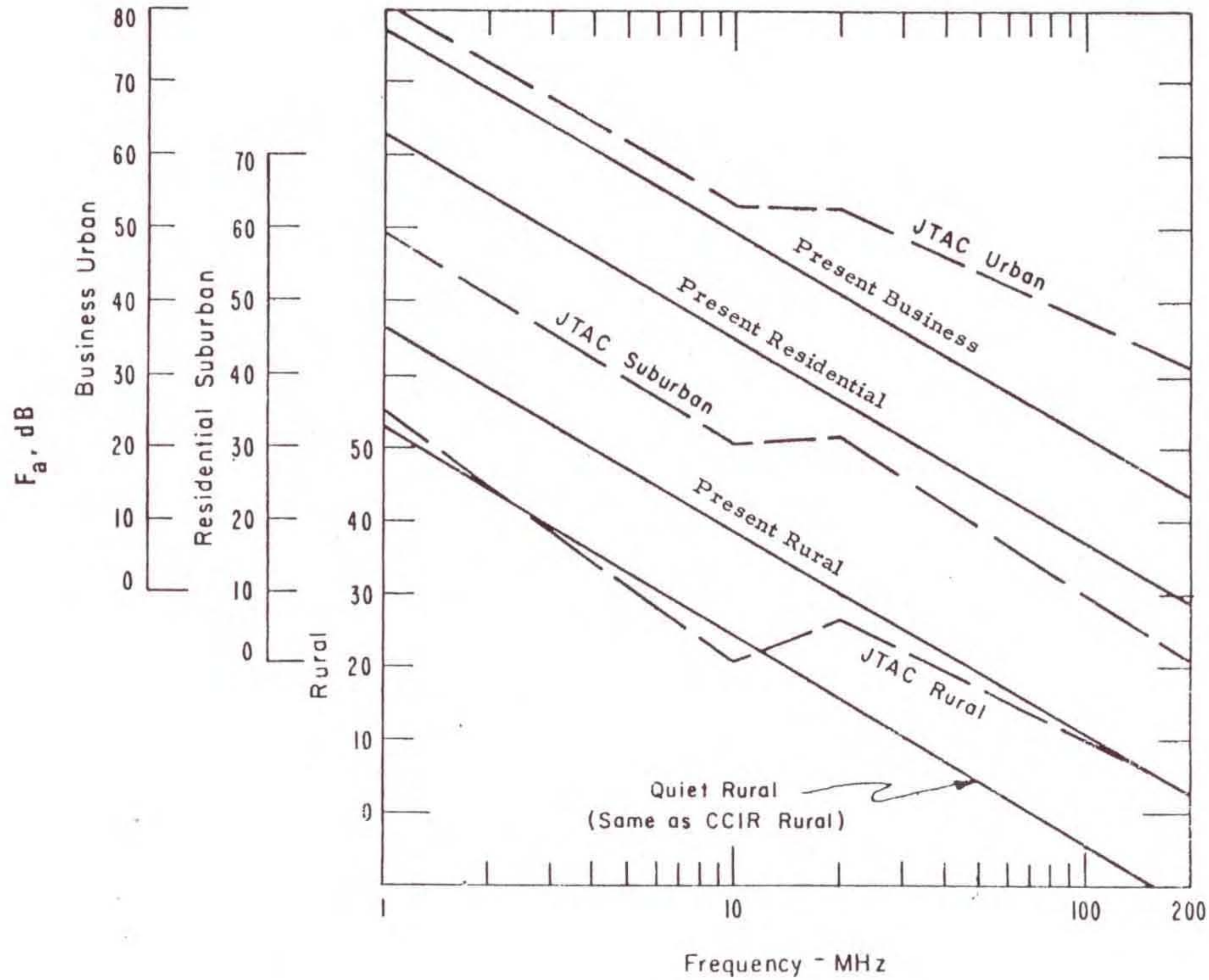

Figure 11. Comparison of present estimates with JTAC (1968) estimates.

4.8 dB, depending on the differences between the largest, next largest, etc. The current GENOIS attempts to find the sum noise process and its statistics as summarized, and commented on, below.

In the current GENOIS, the three noise median values are given by ATNOS for atmopsheric noise, GNOS for galactic noise, and XNOIS for man-made noise. The previous sections of this report detailed how these values are obtained. All three noise processes are represented by log-normal distributions. The median value of the total is obtained by summing the three individual medians, after converting to watts (ATNOS, GNOS, and XNOIS are in dBW). That is, the sum, XRNSE, is given by

$$XRNSE = 10\log\left(10^{\frac{ATNOS}{10}} + 10^{\frac{GNOIS}{10}} + 10^{\frac{XNOIS}{10}}\right). \qquad (17)$$

First, the procedure is not strictly correct, since only the mean values add, and for log-normal distributions, the median value and the mean value are different. As we shall see, using (17) still is reasonably accurate for most cases arising in practice.

Next, GENOIS states (via a comment statement) that "equation 37, page 29 of The Theory of Errors by Yardly Beers, McGraw Hill" is used to calculate the deciles and variance. Equation 37 of Beers is the standard relation that if a random variable V is given by a function of two random variables x and y,

$$V = V(x,y), \qquad (18)$$

then the variance of V is given by

$$\sigma_V^2 = \left(\frac{\partial V}{\partial x}\right)^2 \sigma_x^2 + \left(\frac{\partial V}{\partial y}\right)^2 \sigma_y^2 + \rho_{xy}\left(\frac{\partial V}{\partial x}\right)\left(\frac{\partial V}{\partial y}\right) \sigma_x \sigma_y . \qquad (19)$$

Result (19) is for two variables, but is the "same" for any number of variables. We assume independent noise sources, so that the cross correlations, $\rho_{xy} = 0$, etc. The relation (19) is, of course, an approximation for non-linear functions, but is an arbitrarily close approximation for sufficiently small σ's ,since $D_\mu = 1.282\sigma$, (19) also could be used for decile values. GENOIS does not use (19) for the computation of the deciles, but uses it only for the computation of SIGM, the standard deviation of the "total" median. If (19) is used for the calculation of deciles (as was once suggested by Rosich, private communication), a very inaccurate result is obtained. This is due to the incorrect relation for the sum (17) and to the σ's (or D_μ's) for the three variables (ATNOS, GNOIS, and XNOIS) not being small. The decile values for the sum process are calculated instead by

$$DU = 10 \log \left(10^{\frac{ATNOS + DUA}{10}} + 10^{\frac{GNOIS + DUG}{10}} + 10^{\frac{XNOIS + DUM}{10}} \right) - XRNSE, \quad (20)$$

and

$$DL = 10 \log \left(10^{\frac{ATNOS + DLA}{10}} + 10^{\frac{GNOIS + DLG}{10}} + 10^{\frac{XNOIS + DLM}{10}} \right) - XRNSE. \quad (21)$$

The rational behind (20) is obvious, (20) simply adds the powers (watts) at the 10% level of the noise sources, converts back to dB and then subtacts the median, XRNSE, computed by (17). If this same rational was followed for DL (21), then this would require ATNOS - DLA rather than ATNOS + DLA, etc. The plus DLA etc. was probably used so that if only one noise source is considered, then (21) returns DL = DLA, for example, and would not if the minus sign was used. While not theoretically correct, both (20) and (21) do give reasonable estimates for most cases of interest.

The next parameter calculated is SIGM, the standard deviation of the median of the sum noise process. GENOIS uses (19) for this calculation. The three required partial derivatives are termed QPA, QPG, and QPM, and from (17)

$$QPA = \frac{\partial XRNSE}{\partial ATNOS} = 10^{\frac{ATNOS - XRNSE}{10}}, \text{ etc.} \quad (22)$$

Therefore, using (19),

$$SIGM^2 = (QPA \times SMA)^2 + (QPG \times SMG)^2 + (QPM \times SMM)^2 \quad (23)$$

In the computation of the standard deviations for DU and DL, as given by (20) and (21), (19) was not used (although it should have been). From (20), DU is a function of <u>six</u> variables, ATNOS, DUA, GNOIS, DUG, XNOIS, and DUM. If (19) had been used, the required partial derivatives are

$$\frac{\partial DU}{\partial DUA} = QPA \times 10^{\frac{DUA - DU}{10}}, \quad (24)$$

$$\frac{\partial DU}{\partial ATNOS} = QPA \times \left(10^{\frac{DUA - DU}{10}} - 1\right), \text{ etc.} \qquad (25)$$

Instead of using (19) with the six partial derivatives given by (24) and (25), the current GENOIS estimates the standard deviations of DU and DL by

$$SIGU^2 = \left(\frac{DUA \times SUA \times QPA^2}{DU}\right)^2 + \left(\frac{DUG \times SUG \times QPG^2}{DU}\right)^2 + \left(\frac{DUM \times SUM \times QPM^2}{DU}\right)^2, \qquad (26)$$

with a similar expression for SIGL. These expressions for SIGL and SIGU (the standard deviation for DU and DL) provide very poor estimates (as we shall see) and their origin is a mystery.

We now proceed with the addition and variance estimation methods used in the updated GENOIS. We start in a fairly general way. Suppose we have N noise sources, each with their f_a values log-normally distributed. We require the distribution of the sum of the N sources. It turns out that if N is large, the distribution of the sum is closely represented by another log-normal distribution. Also, if one of the N sources dominates the others, the resulting distribution cannot be far from log-normal. However, we are interested in a relatively small N (3 here) and, quite often, with sources of similar size. The resulting distribution for the sum is now definitely not log-normal and can be determined by convolution. [The current procedures in IONCAP, of course, assume the sum is log-normal.] Such convolutions of log-normal pdf's (probability density function) have been performed in the past with, for our purposes, some quite interesting results. It turns out that the method presented below will give quite accurate results for the larger noise levels (i.e., the small percentage points of the result and distribution) and appears to be most acurate around the 10% point. [For an indication of the truth of this conjecture, see Norton et al., (1952); and Appendix A of Gierhart et al., (1970)]. The method below simply determines the log-normal distribution that best approximates the true distribution of the sum.

The pdf for our i-th noise source, N_i is

$$p_{N_i}(x_i) = \frac{4.343}{x_i\sqrt{2\pi\sigma_i^2}}\, e^{-1/2\left(\frac{10\log x_i - \mu_i}{\sigma_i}\right)^2} \qquad 0<x_i<\infty \qquad (27)$$

and for the variable $y_i = 10 \log x_i = 4.343 \ln x_i$,

$$p_{Y_i}(y_i) = \frac{1}{\sigma\sqrt{2\pi}} e^{-1/2\left(\frac{y_i - \mu_i}{\sigma_i}\right)^2}, \qquad -\infty < y_i < \infty, \qquad (28)$$

that is, a normal distribution with mean μ_i(dB) and standard deviation, σ_i(dB).

For the log-normal distribution (27), by using the moment generating function for the normal distribution, it is easily shown that

$$E\left[X_i\right] = \exp\left[\mu_i/c + \frac{1}{2}\sigma_i^2/c^2\right], \qquad (29)$$

and

$$E\left[X_i^2\right] = \exp\left[2\mu_i/c + 2\sigma_i^2/c^2\right], \qquad (30)$$

where c = 4.343. In (29) and (30), $E[x_i]$ is the mean value (watts or kT_0's) and the μ_i and σ_i are dB values (dBW or dB>1kT_0). For atmospheric noise, say, the μ_i is ATNOS (F_{am}) and σ_i is given by DUA/1.282 (or by DLA/1.282 for the log-normal distribution representing atmospheric noise below the median level). If the calculations are carried out in terms of f_a, the dB values are for f_a and the "real" units are kTo's or if the calculations are carried out in terms of watts,the dB values are dBW and the "real" units are watts. Of course, dBW = F_a - 204 for a 1 Hz bandwidth. As we shall see, it is better numerically to carry out the computations in terms of f_a's. If we let α_i denote the mean value and β_i denote the variance, then from (29) and (30),

$$\alpha_i = E[X_i], \text{ and}$$

$$\beta_i = E[X_i^2] - E[X_i]^2$$

$$\beta_i = \alpha_i^2 \left[\exp(\sigma_i^2/c^2) - 1\right]. \qquad (31)$$

The above (29), (30), and (31) can be solved to give

$$\sigma_i^2 = c^2 \ln(1 + \beta_i/\alpha_i^2), \text{ and} \tag{32}$$

$$\mu_i = c(\ln\alpha_i - \frac{1}{2}\sigma_i^2/c^2). \tag{33}$$

Since our N log-normally distributed noise processes are independent, the mean α_T, and the variances, β_T, of the sum are given by:

$$\alpha_T = \sum_{i=1}^{N} \alpha_i, \text{ and} \tag{34}$$

$$\beta_T = \sum_{i=1}^{N} \beta_i. \tag{35}$$

Then these α_T and β_T can be used in (32) and (33) to obtain σ_T and μ_T, with the resulting pdf then given by

$$p_{Y_T}(y) = \frac{1}{\sqrt{2\pi\sigma_T^2}} e^{-1/2\left(\frac{y - \mu_T}{\sigma_T}\right)^2}, \tag{36}$$

where Y_T is the sum (in dB) of our N (3 in our case here) noise processes. Note that (29) gives the actual mean value of the distribution in watts which is different than the median value in dB converted to watts as is currently done in GENOIS (17). Also, the estimate of the variance (and therefore D_μ and D_ℓ) via (35) is a much better estimate, in general, than the procedure currently used in (20).

GENOIS has been modified to sum the three noise processes via (34) and (35). The median value and D_μ value are calculated using the three medians and three D_μ's. The D_ℓ value for the sum is calculated using the three D_ℓ's. As the next section shows, for most cases of interest in practice in IONCAP, the XRNSE, DL, and DU calculated by the current GENOIS are not substantially different than the "new" ones calculated by the new GENOIS. Some significant differences will be noted however in the SIGU (26) and SIGL. While the new GENOIS does not change XRNSE, DL, and DU significantly for the example cases shown, it does provide better estimates in general, and stands on firm theoretical ground.

The three mean values and the three variances are computed from (29) and (31) and added (34, 35). The totals are then used in (32) and (33) to obtain the new median (dB) of the overall distribution. That is, the new variance (see new GENOIS in Appendix) is given by

$$\sigma^2/c^2 = \text{SIGTSQ} = \ln\left(1 + \frac{\text{VU}}{\text{AU}^2}\right), \tag{37}$$

where VU denotes β_T and AU denotes σ_T, and the new overall median is

$$\text{XRNSE} = 4.34294(\ln\text{AU} - \text{SIGTSQ}/2)-204, \quad \text{(dBW)} \tag{38}$$

and the new overall D_μ is

$$\text{DU} = 5.568\sqrt{\text{SIGTSQ}}. \tag{39}$$

The last item is to calculate the "new" $\sigma_{F_{am}}$ (SIGM), σ_{D_μ} (SIGU), and σ_{D_ℓ} (SIGL) for the overall distribution.

If (19) is used directly on (38), using (29) and (31) for each of the three means and variances giving AU (the total in watts) and SIGTSQ (the total in watts squared), very extensive mathematical (and computational) complexities arise due to the interactions between the individual means and variances (29, for example). Relation (19) (which is in itself an approximation) has been used directly and it turns out that appropriate approximations are in order for the required partial derivatives. For example, we use

$$\frac{\partial\text{XRNSE}}{\partial\text{ATNOS}} = \exp[(\text{ATNOS} - \text{XRNSE})/c], \text{ etc.} \tag{40}$$

The approximation (40) is identical to QPA (22) and amounts to ignoring the σ_i's in (29). It is easy to show that using (40) (with corresponding expressions for the galactic and man-made noise contributions) greatly simplifies the calculation of $\sigma_{F_{am}}$ and still produces an acceptably accurate result. Thus, $\sigma_{F_{am}}$ (SIGM) is calculated via (23), but of course, using the XRNSE calculated by (38).

In the computation of σ_{D_μ} and σ_{D_ℓ}, as noted earlier, six partial derivatives are required, since the variations of the individual median values as well as the individual decile values are important. It turns out, although it is more difficult to show, that the partials given by (24) and (25) serve as good approximations. Therefore, the σ_{D_μ} (SIGU) is given by

$$SIGU^2 = \left(\frac{\partial DU}{\partial DUA} SUA\right)^2 + \left(\frac{\partial DU}{\partial DUG} SUG\right)^2 + \left(\frac{\partial DU}{\partial DUM} SUM\right)^2 + \left(\frac{\partial DU}{\partial ATNOS} SMA\right)^2 + \left(\frac{\partial DU}{\partial GNOIS} SMG\right)^2 + \left(\frac{\partial DU}{\partial XNOIS} SMM\right)^2, \tag{41}$$

with a corresponding expression for σ_{D_ℓ} (SIGL).

The next section gives a few examples (paths) using IONCAP with and without the new GENOIS and with and without the new atmospheric noise and man-made noise estimates.

5. COMPARISONS AND CONCLUSIONS

As detailed in the previous sections, three major changes have been made in the noise portion of IONCAP via subroutine GENOIS: the replacement of the worldwide atmospheric radio noise estimates with the current, much improved estimates of CCIR Report 322-3; the replacement of the man-made noise estimates with the much more modern estimates of CCIR Report 258-4; and the means of summing the three noise contributions and determining the noise overall distribution and its statistical variations has been updated. While an unlimited number of examples to indicate the various changes due to the new GENOIS could be run, we show only a few here to indicate the kind of differences produced.

Table 2 shows the magnitude and direction of change between the old man-made noise model and the new man-made noise model (Figure 9). As we can see, the most significant difference is in the Business category and the difference decreases to a relatively small value in the quiet rural category. The correction in galactic noise is also displayed in Table 2 and shows a small increase from the old galactic noise values. To demonstrate the most significant effect of the changes in the man-made and galactic noise, IONCAP was run with both the old and new values and the results are displayed in Tables 3 to 6. For the Business category and the circuit shown in Tables 3 and 4, there is a significant increase in the reliability figures (REL), also the power