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A Statistical Rain Attenuation Prediction Model With Application to the Advanced Communication Technology Satellite Project

II—Theoretical Development of a Dynamic Model and Application to Rain Fade Durations and Tolerable Control Delays for Fade Countermeasures

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A STATISTICAL RAIN ATTENUATION PREDICTION MODEL WITH APPLICATION TO THE ADVANCED COMMUNICATION TECHNOLOGY SATELLITE PROJECT; II - THEORETICAL DEVELOPMENT OF A DYNAMIC MODEL AND APPLICATION TO RAIN FADE DURATIONS AND TOLERABLE CONTROL DELAYS FOR FADE COUNTERMEASURES.

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SUMMARY

A dynamic rain attenuation prediction model is developed for use in obtaining the temporal characteristics, on time scales of minutes or hours, of satellite communication link availability. Analogous to the associated "static" rain attenuation model, which yields yearly attenuation predictions and is the subject of part I of this work (NASA Contractor Report #179498, Sept. 1986), this dynamic model is applicable at any location in the world that is characterized by the static rain attenuation statistics peculiar to the geometry of the satellite link and the rain statistics of the location. Such statistics are calculated by employing the formalism of part I. In fact, the dynamic model presented here is an extension of the static model and reduces to the static model in the appropriate limit. By assuming that rain attenuation is dynamically described by a first-order stochastic differential equation in time and that this random attenuation process is a Markov process, an expression for the associated transition probability is obtained by solving the related forward Kolmogorov equation. This transition probability is then used to obtain such temporal rain attenuation statistics as attenuation durations and allowable attenuation margins versus control system delay time for specified rain fade control availabilities. The time parameter that enters into the stochastic differential equation, a parameter that is taken to be a temporal characteristic of rain attenuation, is calculated from available experimental data. A coordinated propagation experiment is also specified to obtain this parameter from attenuation observations. Finally, using the attenuation statistics found in part I for 59 cities with ACTS links, the dynamic model is used to find fade durations and tolerable control delays for links in these cities.

1. INTRODUCTION

As was elaborated upon in part I of this work (ref. 1), with which familiarity by the reader is presupposed) the increasingly advanced communication satellite technology one deals with today brings with it a proportionate complexity in associated technical problems that must be solved. The Advanced Communications Technology Satellite (ACTS) program at NASA Lewis Research Center possesses a set of analysis problems never before encountered in a satellite project. The communications acquisition on a city-by-city basis afforded by the scanning beam technology on ACTS requires one to differentiate rain attenuation statistics on the same city-by-city basis for reliable communication link availability predictions. This was the major motivation of the work performed in reference 1 where a rain attenuation prediction model was developed to give communication link availability predictions on the basis of an average year. Although the model of reference 1 is applicable to any satellite link in any location, a specific application of the model was made for links from ACTS (to be placed in a geosynchronous orbit at 100° W longitude) to 59 different cities in the U.S. including Alaska and Hawaii. Also, in another publication (ref. 2), the model was applied to 33 other cities in the U.S. This model is a static one in the sense that it allows one to obtain link availability (i.e., the determination of how many minutes per year a given attenuation will be exceeded on a particular link) averaged over the time interval of a year (365.25 days), thus implicitly losing temporal descriptions of the individual rain attenuation events and their statistics that collectively are "averaged over" in the model. This is fundamentally due to the fact that the meteorological data base used to provide the rain statistics employed in reference 1 were obtainable on a yearly basis.

The present work endeavors to extend the static model (ref. 1) by theoretically adding a temporal description of rain attenuation via the introduction of a stochastic differential equation and, necessarily, a characteristic temporal parameter that describes the temporal evolution of a typical rain attenuation event over arbitrary time intervals (typically, intervals over minutes or hours).

Other than the assumption of the form used for the stochastic differential equation taken to govern the random attenuation process in time, an assumption is made that this process is a Markov random process. This allows one to obtain a forward Kolmogorov equation, the solution of which gives a transition probability of the attenuation process, i.e., a time dependent probability density for attenuation. Contact is made between the resulting dynamic model and the static one by requiring that the temporal probability density of the dynamic model reduce to the static probability density of the model in reference 1 in the limit of the time interval approaching that of a year (which, mathematically is taken to be infinity).

Such an extension of the model given (ref. 1) allows one to analyze other novel problems introduced by the ACTS system. The high data rate transmission along a typical ACTS link as well as the need to achieve the highest availability or reliability of each link dictates the use of rain fade countermeasures. One such countermeasure is that of Forward Error Correction (FEC) implementation in the digital data stream. This error correcting code, to be used when signal levels are degraded by rain attenuation, requires the use of spare time that is built into the processor controlling the data streams and spot beams within ACTS. The overall spare time that is needed on a system-wide basis for such coding is therefore dependent on how long each station or stations within the ACTS system will undergo a rain fade beyond some prescribed value. A prerequisite for such a study (ref. 3) is that one have a statistical description of rain fade durations on each link.

Another fade countermeasure that can be used is that of power control. The optimal use of power control is facilitated if one knows how long it will take for a given control threshold attenuation to be reached if one observes an attenuation level that is less than this threshold; it is intuitively obvious that the closer the observed attenuation is to the threshold attenuation at which control must be applied, the shorter the time interval is for the threshold value to be reached. Of course, this being a statistically based problem, the time intervals for given threshold values to be reached from "currently observed" values less than that of the threshold, can only be stated with an associated uncertainty. This uncertainty leads to the concept of control availability, not to be confused with link availability.

These analysis questions, as well as many others, can be answered with the formalism of the dynamic rain attenuation model to be presented here. Section 2 of this work covers the theoretical development if the temporal aspects of the rain model. Section 3 gives the applications of the work of the previous section. At the outset of section 3, value is calculated from empirical fade data for the temporal attenuation parameter that was introduced through the assumed differential equation that is taken to govern the temporal aspects of rain attenuation. This value is then used in the applications of the theory to obtain fade duration statistics and the expected times-to-threshold information for the 59 cities that were considered in part I of this work. In addition to the static statistical parameters calculated in part I for each of the cities in question, the only other parameter needed to apply the present temporal rain model is the temporal attenuation parameter previously mentioned. The importance of this parameter to the theory dictates that its characteristics, such as yearly and geographical variations, should be ascertained; such characteristics were not available in the fade duration data base used here for its calculation. An experimental design based on this dynamic theory is therefore given so that this temporal parameter can be more thoroughly studied. This is discussed in appendix C. Appendices A and B provide in-depth treatments to subjects encountered in this work. Appendix D is a compilation of the fade and control delay data generated for the 59 cities. Appendix E lists the software used to generate the results presented in section 3.

It should be noted that the form of the model presented in section 3 reproduces that which appeared in an earlier work (ref. 4). However, in reference 4, the model is presented in an ad hoc manner, it is not tied to a specified static model for attenuation, and it does not tie the models' results to empirical fade data in order to derive a value for the characteristic attenuation time parameter. The model presented in the present work satisfies these requirements and, more importantly, gives the proper formalism that will allow one to design dynamic control algorithms to counter the effects of rain attenuation on space communications links. This will form the subset of part III of this work which exists under a separate cover.

2. THE TEMPORAL ATTENUATION MODEL

Background and Initial Assumptions

As derived and discussed in reference 1, the yearly cumulative probability distribution of the attenuation due to rain incurring on an Earth-space communications link of length L and elevation angle Θ, denoted by $A(L,\Theta)$, is given by

$$P(a \geq A(L,\Theta)) = P_0(L,\Theta)P(a \geq A(L,\Theta)|\text{RAIN ON LINK}) \qquad (2.1)$$

where $P_0(L,\Theta)$ is the probability of rain occurring along the slant path. The quantity $P(a \geq A(L,\Theta)|\text{RAIN ON LINK})$ is a conditional cumulative probability that the attenuation is exceeded on the slant path, given that rain occurs along the path; the expression for this quantity is

$$P(a \geq A(L,\Theta)|\text{RAIN ON LINK}) = 1/2 \text{ erfc} \left[\frac{\ln A - \ln A_m}{(2)^{1/2} \sigma_{\ln A}}\right] \tag{2.2}$$

where $A \equiv A(L,\Theta)$, $A_m = A_m(L,\Theta)$ and $\sigma_{\ln A} \equiv \sigma_{\ln A}(L,\Theta)$ is the attenuation, mean attenuation, and standard deviation of $\ln A$, respectively, that are, in general, quantities dependent on L and Θ. The formalism developed (ref. 1) allows one to calculate the statistical parameters P_0, A_m, and $\sigma_{\ln A}$ (and hence $P(a \geq A(L,\Theta)$ for any A via equations (2.1) and (2.2)) for any location and satellite link, so long as the long-term rain statistics of that location are known.

Although the yearly availability predictions of reference 1 are sufficient for satellite system availability studies, one is also interested in knowing how the attenuation temporally evolves on time scales of seconds or minutes once it occurs on the communications link. Such a general temporal description of the attenuation process, as a function of time, should naturally transform into that of reference 1 as the time scale approaches that of a year and thus become independent of time. Stated differently, a general model is sought that yields a conditional probability density $p(A,t|\text{RAIN})$ that is a function of time t and is such that as t approaches that of a year, (as compared to a time scale based on minutes, this situation can be represented by taking the limit $t \to \infty$), one has

$$p(A|\text{RAIN}) = \lim_{t \to \infty} p(A,t|\text{RAIN}) \tag{2.3}$$

where $p(A|\text{RAIN})$ is the time independent (i.e., static) conditional probability density corresponding to equation (2.2), i.e.,

$$p(A|\text{RAIN}) = \frac{1}{(2\pi)^{1/2} \sigma_{\ln A}} \exp\left[-\frac{(\ln A - \ln A_m)^2}{2\sigma^2_{\ln A}}\right] \tag{2.4}$$

To this end, one considers the process that leads to the log-normal probability distribution of equation (2.4). Using an argument analogous to that employed in reference 1 for rainrates, one has that the attenuation process $A(t)$ is composed of a large number of random time-varying multiplicative components $A_i(t)$, i.e.,

$$A(t) = A_1(t)A_2(t)\ldots A_n(t) \tag{2.5}$$

Each of the quantities $A_i(t)$, $i=1, 2, \ldots, n$, represents a random perturbation due to a variation in some characteristic quantity of the rain attenuation process, e.g., the raindrop size distribution, raindrop canting angles, rain cell shapes, sizes, and direction of movement, etc. Taking logarithms on both sides of equation (2.5) gives

$$\ln A(t) = \ln A_1(t) + \ln A_2(t) + \ldots + \ln A_n(t)$$

By the central limit theorem, one has that for large n, the probability distribution of $\ln A(t)$ approaches a normal distribution, so long that there is no dominant component in the set $A_i(t)$. From these considerations, equation (2.4) represents the probability density of A (or $\ln A$). The temporal variations of each of the multiplicative components $A_i(t)$ can be classified in terms of the characteristic time over which they can change. For example, the factors that represent rain cell movement, raindrop size distributions and canting angles have characteristic times of change on the order of minutes, whereas the rain cell size, shape, and direction of movement have characteristic times of change on the order of hours. Thus, the attenuation process over a period of minutes could be characterized by a mean and standard deviation different from that of a process over a period of hours.

What these observations suggest is that when one is considering the temporal aspects of the overall log-normal rain attenuation process, one should consider time variations of the entire quantity

$$x(t) \equiv \frac{\ln A(t) - \ln A_m(t)}{\sigma_{\ln A}(t)} \tag{2.6}$$

where $A(t)$, $A_m(t)$ and $\sigma_{\ln A}(t)$ are now all to be taken as functions of time as well as implicit functions of L and θ.

The Dynamic Model

One must now hypothesize the functional form of the time dependence of $x(t)$. A palatable assumption borne out by casual observation of rain is that the time rate of change (decay) of rainrate is proportional to the rainrate. Thus, by the same reasoning, the rain attenuation dependent quantity $x(t)$ can be taken to be governed by the relationship

$$\frac{dx}{dt} \sim -\gamma\, x(t) \tag{2.7}$$

where γ is a characteristic decay constant. The relationship exhibited by equation (2.7) is not an equality because one must also take into account another quantity, viz., the random process that excites or drives the system. Let the random process be denoted by $\xi(t)$ and governed by the following requirements:

$$\begin{aligned} \langle \xi(t) \rangle_c &= 0 \\ \langle \xi(t)\xi(t) \rangle_c &= \delta(t_1 - t_2) \end{aligned} \tag{2.8}$$

where $\langle \ldots \rangle_c$ denotes the conditional (i.e., that it is raining) ensemble average.

The process $\xi(t)$ actually represents a change in the components that contribute to the attenuation, thus leading to the time rate of change dx/dt. That is, $\xi(t)$ is a random increment that is a result of one or more random component changes in the rain attenuation process. The specifications of equation (2.8) state that, in an ensemble of observations, $\xi(t_1)$ is uncorrelated with $\xi(t_2)$ for all t_1, t_2 where $t_1 \neq t_2$. Assuming ergodicity, an "ensemble of observations" is equivalent to observations over a long (ideally, infinite) raining time interval. Hence, what is assumed here is that changes in, e.g., the raindrop canting angle, etc., are uncorrelated (in the long term time average) with changes in, e.g., raindrop size distribution, etc. Thus one can write, using equation (2.7),

$$\frac{dx}{dt} = -\gamma x(t) + g(x,t)\xi(t) \tag{2.9}$$

where $g(x,t)$ is a deterministic function of, in general, x and t, which must remain unspecified for now.

Equation (2.9) is a special case of the more general stochastic differential equation, known as the Langevin Equation,

$$\frac{dx}{dt} = \psi(x,t) + g(x,t)\xi(t) \tag{2.10}$$

where $\psi(x,t)$ is also a deterministic function. The following problem naturally arises: Given an initial value of x at an initial time, i.e., $x = x_0$ at $t = t_0$, what will the value of x be at a later time t? Of course, equation (2.9) or (2.10) cannot be directly solved due to the occurrence of the random function $\xi(t)$. The problem can only be dealt with probabilistically. The correct forumulation of the problem is as follows: given $x = x_0$ at $t = t_0$, what is the probability that $x = x_1$ at a later time $t = t_1$? This is given by the conditional transition probability density $p(x_1,t_1|x_0,t_0)$. This density will, in part, be governed by the statistics of the random process $\xi(t)$. In appendix A, it is shown that if the random process given by equation (2.10) is a Markov process (i.e., the transition from x_0 at a time t_0, to x_1 at a time t_1, given by the density $p(x_1,t_1|x_0,t_0)$ and the transition from x_1 at a time t_1, to x_2 at a time t_2, given by the density $p(x_2,t_2|x_1,t_1)$ are completely independent from one another and thus uncorrelated), one can obtain a differential equation relating $p(x,t|x_0,t_0)$ to the deterministic functions appearing in equation (2.10). The differential equation, known as the direct Kolmogorov Equation, is given by (See appendix A.)

$$\frac{\partial p(x,t|x_0,t_0)}{\partial t} + \frac{\partial}{\partial x}\left[K_1(x,t)p(x,t|x_0,t_0)\right] - \frac{1}{2}\frac{\partial^2}{\partial x^2}\left[K_2(x,t)p(x,t|x_0,t_0)\right] = 0 \tag{2.11}$$

where

$$K_1(x,t) = \psi(x,t) \tag{2.12}$$

and

$$K_2(x,t) = g^2(x,t) \tag{2.13}$$

are known as the coefficients of, respectively, transfer (or drift) and diffusion. The form of equations (2.12) and (2.13) stem from the fact that

$$\langle \Delta x \rangle = \mathcal{O}(\Delta t)$$

and

$$\langle (\Delta x)^2 \rangle = \mathcal{O}(\Delta t)$$

whereas

$$\langle (\Delta x)^n \rangle = \mathcal{O}((\Delta t)^m), \ n > 2, \ m \geq 2$$

where

$$\Delta x = \int_{t_0}^{t_0+\Delta t} \frac{dx}{dt} \ dt$$

This is the case for the particular situation given by equation (2.9); equation (2.11) then becomes, where $K_1(x,t) = K_1(x) = \gamma x$ and $K_2(x,t) = K_2(x) = g^2(x)$ in equation (2.9),

$$\frac{\partial p}{\partial t} - \gamma \frac{\partial}{\partial x} (xp) - \frac{1}{2} \frac{\partial^2}{\partial x^2} (g^2(x)p) = 0 \tag{2.14}$$

upon comparing equations (2.10), (2.12), and (2.13) with equation (2.9) and letting $p \equiv p(x,t|x_0,t_0)$.

It now remains to determine the function $K_2(x) = g^2(x)$. The prescription leading to equation (2.3) implies that

$$\lim_{t \to \infty} \frac{\partial p}{\partial t} = 0, \tag{2.15}$$

i.e., the transition probability density becomes a stationary function of the time. Thus, equation (2.14) becomes

$$-\gamma \frac{\partial}{\partial x} (xp_{st}) = \frac{1}{2} \frac{\partial^2}{\partial x^2} \left(g^2(x) p_{st} \right) \tag{2.16}$$

where p_{st} is given by equations (2.3) and (2.4). Integrating Equation (2.16) and noting that $\lim\limits_{x \to \infty} p_{st} = \lim\limits_{x \to \infty} \dfrac{\partial p_{st}}{\partial x} = 0$, one has that

$$-2\gamma x p_{st} = \frac{1}{2} \frac{\partial}{\partial x} (g^2 p_{st}) \tag{2.17}$$

Now from equations (2.3) and (2.4), one has that

$$pst = C \exp \left(- \frac{x^2}{2} \right) \tag{2.18}$$

where

$$x = \lim_{t\to\infty} x(t) = \frac{\ln A - \ln A_m}{\sigma_{\ln A}}$$

is the stationary value of $x(t)$ and $C = 1/((2\pi)^{1/2}\,\sigma_{\ln A})$. Substituting equation (2.18) into equation (2.17) and integrating once again gives

$$-\exp(-x^2/2) + C = -\frac{1}{2\gamma}\, g^2 \exp(-x^2/2)$$

Requiring $g^2(x)$ to be a bounded function, one has that in the limit as $x \to \infty$, the integration constant is $C = 0$. Hence, one finally has

$$g^2(x) = g^2 = 2\gamma \tag{2.19}$$

which is independent of x.

It is important to note the source of the result equation (2.19); by making use of the a priori information given by equations (2.3) and (2.4), i.e., that the solution of equation (2.14) in the stationary state must be described by a Gaussian distribution. This circumstance fixes the function $K_2(x) = g^2(x)$.

Thus, the forward Kolmogorov equation giving the transition probability for the attenuation process with the characteristics given above is, via equations (2.14) and (2.19),

$$\frac{\partial p}{\partial t} - \gamma \frac{\partial}{\partial x}(xp) - \gamma \frac{\partial^2 p}{\partial x^2} = 0 \tag{2.20}$$

and the stochastic differential equation corresponding to such a process is, via equations (2.9) and (2.19),

$$\frac{dx}{dt} = -\gamma x(t) + (2\gamma)^{1/2}\,\xi(t) \tag{2.21}$$

where the random "driving" function $\xi(t)$ has the statistical characteristics given by equation (2.8). The form of equation (2.21) is convenient for use in the synthesis of dynamic control algorithms to counter rain fade events on a communications link; this will be the subject of part III of this work. The remainder of this part will be concerned with the solution of equation (2.20) and its application to the temporal aspects of rain attenuation that are of interest to the satellite communication systems designer.

Solution for the Transition Probability

To solve the linear partial differential equation given by equation (2.20) one makes the following substitution for the variable x:

$$x = ye^{-\gamma t} \tag{2.22}$$

Noting that the transition probability density p is now a function of y and t and transforming the x-derivatives via the chain rule, accounting for equation (2.22), equation (2.20) becomes

$$\frac{\partial p}{\partial t} = \gamma p + \gamma e^{2\gamma t} \frac{\partial^2 p}{\partial y^2} \tag{2.23}$$

where, as mentioned above, $p = p(y,t)$. Continuing in this fashion, one now employs the substitution

$$p = \phi e^{\gamma t} \tag{2.24}$$

in equation (2.23). This yields the parabolic differential equation

$$\frac{\partial \phi}{\partial t} = \gamma e^{2\gamma} = \frac{\partial^2 \phi}{\partial y} \tag{2.25}$$

that is of the same form as the well-known "heat equation" with a time dependent conductivity coefficient $\gamma e^{2\gamma t}$. Using the known method of solution to such an equation modified, of course, for the time dependent coefficient, one obtains,

$$\phi = \phi(y,t) = \left(\frac{1}{2\pi\kappa(t)}\right)^{1/2} \exp\left[-\frac{\left|ye^{\gamma t} - y_0\right|^2}{2\kappa(t)}\right] \tag{2.26}$$

where

$$\kappa(t) = 2\gamma \int_0^t e^{2\gamma t'}\, dt'$$

$$= e^{2\gamma t} - 1 \tag{2.27}$$

and the initial conditions used are $y = y_0$ at time $t = 0$. Solving equations (2.22) and (2.24) for y and ϕ, respectively, and substituting into equation (2.26) finally gives for the conditional transition probability density $p(x) = p(x,t|x_0,t_0)$

$$p(x) = \left(\frac{1}{2\pi\sigma(\Delta t)}\right)^{1/2} \exp\left[-\frac{\left|x - x_0 e^{-\gamma\Delta t}\right|^2}{2\sigma(\Delta t)}\right] \tag{2.28}$$

where

$$\sigma(\Delta t) = 1 - e^{-2\gamma\Delta t} \tag{2.29}$$

and

$$\Delta t = t - t_0$$

since the origin of t has been shifted from 0 (used in equation (2.27)) to t_0. To put this result in terms of the link attenuation, one substitutes equation (2.6) into equation (2.28) and, together with equation (2.29) after rearranging terms and normalizing, one has for the conditional transition probability density for an attenuation A at time t, given that the attenuation level A_0 is observed at time t_0,

$$p(A,t|A_0,t_0) = \left(\frac{1}{2\pi\sigma^2_{\ln A}(\Delta t)}\right)^{1/2} \exp\left[-\frac{(\ln A(t)-\ln A_m(\Delta t))^2}{2\sigma^2_{\ln A}(\Delta t)}\right] \tag{2.30}$$

where the time dependent mean attenuation $A_m(\Delta t)$ is given by

$$A_m(\Delta t) = A_m^{(1-e^{-\gamma\Delta t})}\, A_0^{e^{-\gamma\Delta t}} \tag{2.31}$$

and the time dependent standard deviation of $\ln A$ is given by

$$\sigma_{\ln A}(\Delta t) = \sigma_{\ln A}\,(1-e^{-2\gamma\Delta t}) \tag{2.32}$$

In equations (2.31) and (2.32), A_m and $\sigma_{\ln A}$ are, respectively, the static or yearly mean attenuation and standard deviation of $\ln A$ that were calculated in reference 1 for the 20 GHz and 30 GHz ACTS links in 59 locations in the U.S. Note that as $\Delta t \to \infty$, equations (2.31) and (2.32) give

$$\lim_{\Delta t \to \infty} A_m(\Delta t) = A_m$$

$$\lim_{\Delta t \to \infty} \sigma_{\ln A}(\Delta t) = \sigma_{\ln A}$$

i.e., the stationary yearly values. In this instance, equation (2.30) takes the form of the conditional yearly probability density given by equation (2.4), i.e.,

$$\lim_{\Delta t \to \infty} p(A,t|A_0,t_0) = p(A|\text{RAIN}),\ \Delta t \equiv t - t_0$$

These circumstances are, of course, by design via the a priori requirement of equation (2.3).

The corresponding cumulative conditional probability distribution for the temporal evolution of attenuation on a communications link can now be derived. The probability that the attenuation $a(t)$ at time t is less than or equal to some given attenuation $A(t)$ at the same time, provided an attenuation $A_0(t_0)$ at some earlier time t_0 occurred, is given by

$$P(a(t) \leq A(t)|A_0(t_0)) = \int_{-\infty}^{\ln A(t)} p(A'_0,t|A_0,t\ )\ d(\ln A'(t)) \tag{2.33}$$

Substituting equation (2.30) into this expression gives

$P(a(t) \leq A(t)|A_0(t_0))$

$$= \left(\frac{1}{2\sigma^2_{\ln A}(\Delta t)}\right)^{1/2} \int_{-\infty}^{\ln A(t)} \exp\left[-\frac{(\ln A'(t) - \ln A_m(\Delta t))^2}{2\sigma^2_{\ln}(\Delta t)}\right] d(\ln A'(t))$$

$$= \left(\frac{1}{\pi}\right)^{1/2} \int_{-\infty}^{f(A)} \exp\,(-y'^2)dy'$$

where $f(A) \equiv (\ln A(t) - \ln A_m(\Delta t))^2/(\sqrt{2}\,\sigma_{\ln A}(\Delta t))$. As in reference 1 (in particular, equations (2.12) and (2.13)), one easily evaluates this integral to yield

$$P(a(t) \leq A(t)|A_0(t_0)) = 1 - \frac{1}{2}\,\mathrm{erfc}\left[\frac{\ln A(t) - \ln A_m(\Delta t)}{\sqrt{2}\sigma_{\ln A}(\Delta t)}\right] \qquad (2.34)$$

This equation, or the complementary one, i.e.,

$$P(a(t) > A(t)|A_0(t_0)) = \frac{1}{2}\,\mathrm{erfc}\left[\frac{\ln A(t) - \ln A_m(\Delta t)}{\sqrt{2}\sigma_{\ln A}(\Delta t)}\right] \qquad (2.35)$$

forms the basis of what is to follow concerning the applications of the temporal rain attenuation model to satellite link evaluation and design.

In addition to making use of the known quantities A_m and $\sigma_{\ln A}$, the theory requires one to have a value for the temporal parameter γ. A question that has not been dealt with up to this point, other than the value of γ, has to do with whether this value is specific to each location, as is A_m or $\sigma_{\ln A}$ (although the location dependency of γ would probably not be as strong as that of A_m or $\sigma_{\ln A}$) or if it can be taken as a "universal" constant. In what is to follow it will be assumed that γ is a constant and, in the course of the development of the applications of equations (2.34) and (2.35) in the sections to follow, a value of γ will be determined using empirical fade duration data.

3. APPLICATIONS OF THE TEMPORAL RAIN ATTENUATION MODEL

Attenuation Durations and Their Statistical Description

The stationary statistical description of attenuation on a satellite link has been given on a yearly basis (ref. 1); for a specified attenuation depth, say A_0 dB, one can easily determine the availability of a particular satellite link, i.e, how many minutes per year one can expect to find A_0 dB exceeded in a 1-yr period. This total period is the sum of all the individual time intervals of rain events that occurred throughout a year where A_0 dB was exceeded. However, several satellite system design problems require one not only to know the expected <u>yearly</u> fade duration beyond a specified attenuation, but also the fade duration associated with the individual rain event beyond the specified attenuation, the total of which make up the yearly figure. Part of the solution of this problem requires a dynamic statistical description of which the model of section 2 of the present work is amenable.

The problem defined above is one of the well-known probability distribution of fades and surges. In most problems, excursions of a random process above or below a given level are called, respectively, surges and fades of the process. However, because of the terminology associated with the concept of attenuation, the situaiton is reversed; an attenuation fade is an increase in the attenuation, i.e., a fade in the signal. Thus, in what follows, attenuation fades are taken to be increases (decreases) in attenuation above (below) a given threshold.

It is therefore of interest here to consider a given time duration T_F of a fade and determine its probability distribution. The mathematical difficulties of this problem are also well-known (ref. 5) and the exact distribution of a given fade T_F is unknown for all random processes, no matter what their statistical forms are. However, for a log-normal situation such as that of attenuation, an approximate solution can be obtained. As is shown in appendix B, the probability $P_{A_0}(t_F > T_F)$ of a fade duration t_F being larger than a given value T_F above an attenuation threshold A_0 is given by

$$P_{A_0}(t_F > T_F) = P(a > A_0) \exp\left[-\gamma \frac{T_F}{F(X_0)}\right] \tag{3.1}$$

where

$$F(X_0) \equiv \pi \operatorname{erfc}\left(\frac{X_0}{\sqrt{2}}\right) \exp\left(\frac{X_0^2}{2}\right) \quad , \quad X_0 \equiv \frac{\ln A_0 - \ln A_m}{\sigma_{\ln A}} \tag{3.2}$$

and $P(a > A_0)$ is the cumulative probability of the threshold attenuation A_0 being exceeded and is given by equations (2.24) and (2.25) of reference 1, i.e.,

$$P(a > A_0) = \frac{1}{2} P_0(L,\theta) \operatorname{erfc}\left(\frac{X_0}{\sqrt{2}}\right) \tag{3.3}$$

where, as in (ref. 1), $P_0(L,\theta)$ is the probability that an attenuation event occurs on a satellite communications link of length L and elevation angle θ.

Just as $P(a > A_0)$ is dependent on the location of interest in the U.S., so are the dynamics of attenuation as shown by equation (3.2). Each location is characterized by a function $F(X_0)$ by the mean and standard deviation, A_m and $\sigma_{\ln A}$. However, as mentioned at the end of the last section, the temporal parameter γ is assumed to be a constant, independent of location. Before the results of equations (3.1) and (3.2) can be applied, or any of the other results that are yet to follow, one needs an empirical value for γ. Equations (3.1) and (3.2), in addition to some experimental data on rain attenuation fades, can be used to find a working value for γ. This determination will now be made.

A Determination of γ From the Foregoing Using Experimental Data

Recent experimental data (ref. 6) on rain fade durations at frequencies of 19 and 28 GHz recorded at Clarksburg, Maryland can be used with equations (3.1) and (3.2) to obtain a value for γ. Tables I and II display the results that were obtained from July 1976 to August 1977 on a satellite link of 21° elevation. The fade durations shown are cumulative durations, i.e., a duration shown by >3 min are those that are larger than 3 min and include those events that contribute to the duration shown by >10 min, i.e., durations larger than 10 min. Each cumulative fade duration is measured for six attenuation thresholds: 3, 6, 10, 15, 20, and 25 dB. Each duration at each threshold is characterized by the fraction of total fading time, i.e., the fraction of the total time that it rains; this time fraction is precisely given by

$$\frac{P_{A_o}(t_F > T_F)}{P(a > A_o)} = \exp\left[-\gamma \frac{T_F}{F(X_o)}\right] \tag{3.4}$$

using equation (3.1), where T_F = 3, 10, 30, and 60 min and A_o = 3, 6, 10, 15, 20, and 25 dB. One can factor out the $P(a > A_o)$ from equation (3.4) by taking the ratio of equation (3.4) at different times T_F but at the same attenuation A_o,

$$\frac{P_{A_o}(t_F > T_{F_1})}{P_{A_o}(t_F > T_{F_2})} = \exp\left[\gamma\left(\frac{T_{F_2} - T_{F_1}}{F(X_o)}\right)\right] \tag{3.5}$$

Solving this equation for γ yields

$$\gamma = \left(\frac{F(X_o)}{T_{F_2} - T_{F_1}}\right) \ln\left[\frac{P_{A_o}(t_F > T_{F_1})}{P_{A_o}(t_F > T_{F_2})}\right] \tag{3.6}$$

Since the theory does not assume a dependence of γ on frequency and level of attenuation threshold A_o, the results of the use of equation (3.6) should be independent of these quantities. To be sure, the attenuation dependence of the ratio of probabilities $P_{A_o}(t_F > T_{F_1}/P_{A_o}(t_F > T_F)$ is "deconvolved" from equation (3.6) by the factor $F(X_o)$ which itself is a function of A_o.

Applying equation (3.6) to the data in tables I and II commences with determining the quantities A_m and $\sigma_{\ln A}$ that enter into the expression for $F(X_o)$ in equation (3.2) for Clarksburg, Maryland and for a satellite link with θ = 21° at the two frequencies 19 and 28 GHz. Using the Baltimore rain data (as calculated in ref. 1, pg. 151) and employing the theory developed in reference 1 (in particular, following the flow chart of figure 5.1 of ref. 1) given that θ = 21°, one finds for this case,

19 GHz:

A_m = 1.845 dB
$\sigma_{\ln A}$ = 1.191

28 GHz:

$$A_m = 3.822 \text{ dB}$$
$$\sigma_{\ln A} = 1.151$$

Then using equation (3.6) for all possible combinations of $T_{F_2} - T_{F_1}$ for each of the six fade thresholds in tables I and II give

$$\gamma = 5.75\text{x}10^{-2} \text{ min}^{-1} \pm 2.14\text{x}10^{-2} \text{ min}^{-1}$$

for the 19 GHz data and

$$\gamma = 5.15\text{x}10^{-2} \text{ min}^{-1} \pm 2.25\text{x}10^{-2} \text{ min}^{-1}$$

for the 28 GHz data and an overall average of

$$\gamma = 5.39\text{x}10^{-2} \text{ min}^{-1} \pm 2.22\text{x}10^{-2} \text{ min}^{-1}$$

This last value will be adopted for γ in the remainder of this work; it corresponds to a characteristic time of $1/\gamma = 18.6$ min.

Of course, a more valid determination of γ as well as a check on the prevailing assumptions (i.e., is universal constancy, independent of location or any of the geometrical quantities of the satellite communications link) should be made by way of suitable propagation experiments. One such experiment, as specified by the theory developed in section 2 of the present work, is described in appendix C.

Fade Duration Statistics for Selected Cities in the U.S. Including Alaska and Hawaii

Equation (3.1) is now applied to 59 cities in the United States, including Alaska and Hawaii, that have links established with ACTS, which is assumed to be located at a longitude of 100° W in geosynchronous orbit. The frequencies of interest are 20 GHz (downlink) and 30 GHz (uplink). The required attenuation statistics for each of the cities have already been calculated in reference 1, pp. 62 - 120; thus, to use equation (3.1) one needs two sets of values A_m and $\sigma_{\ln A}$ (one set for each frequency) for each city, and, as required by equation (3.3), one also needs $P(L,\Theta)$. Using these tabulated values, equation (3.1) is evaluated for time durations T_F ranging from 1 to 100 min. The outputs, shown in the data tables contained in appendix D, are converted to minutes per year rather than stated in terms of percentage of a year. This is done using the fact that there are 525960 min in an "average" year which is taken to be 365.25 days.

For example, consider the data output for the Cleveland, Ohio ACTS terminal. From the static rain statistics calculated for this site that appear on p. 104 of reference 1, one finds that $P_o(L,\Theta) \equiv P_L = 2.097$ percent, A_m (20 GHz) = 1.319 dB, $\sigma_{\ln A}$ (20 GHz) = 1.097, A_m (30 GHz) = 2.869 dB, and $\sigma_{\ln A}$ (30 GHz) = 1.037. Using this data in equations (3.1) to (3.3) for the various values of fade duration time T_F shown, the total number of minutes per year are displayed that represents the total number of minutes that all the fades of duration equal to or greater than T_F will last, for the four attenuation thresholds shown. Thus, for a fade duration of 0 min (i.e., $T_F > 0$ min), one finds that the 3 dB fade threshold is crossed for a total of 2502.6 min/yr at 20 GHz and a total of 5325.3 min/yr at 30 GHz. Of course, by definition of $T_F \geq 0$, this data represents the total fading time for <u>any</u> fade duration at these thresholds. In other words, for a total number of 2502.6 min, a rain fade of any duration will be observed at 20 GHz. For a fade duration of 5 min, (i.e., $T_F \geq 5$ min) one finds that the total of raining periods for that will exceed 3 dB at 20 GHz for 5 min or more is 2169.6 min/yr; at 30 GHz, it is 4873 min. Consider now a fade duration of 40 min (i.e., $T_F \geq 40$ min). At 20 GHz at the 3 dB threshold, these events will subtend a total of 798.5 min/yr. However, at the 15 dB threshold, these events will only occur for a total of 16.2 min. Thus, at the 15 dB level, a fade event of $T_F \geq 40$ min never occurs; the total number of minutes per year that 15 dB is exceeded on the 20 GHz link in Cleveland is only 16.2 min.

From the fade data calculated for each city, one may also obtain the percentage of total fade time that a fade occurs; such information may be the desired format for a systems designer to work with and is independent of the absolute probability of attenuation occurrence, i.e., $P(a \geq A_0)$. This latter fact makes the percentage of total fade time a statistic that is solely dependent on the temporal aspects of rain attenuation at the location of interest since it is devoid of the static statistic represented by the probability of attenuation. These figures can easily be obtained from the data displayed by noting that the total fading time calculated for each fade depth that corresponds to a fade duration of 0 min or greater, i.e., $t_D \geq 0$, is nothing more than the total fading time that <u>any</u> fade event will occur. As mentioned earlier, fading times corresponding to fade durations larger than 0 min fade duration are fractions of the fading time at 0 min fade duration. Thus, returning to the example for Cleveland, Ohio, the total fading time at the 3 dB fade depth for 0 min fade duration is 2502.6 min. For a fade duration of 3 min, total fading time is 2297.1 min. Thus, the percentage of total fading time at the 3 dB fade depth with a duration of 3 min is 2297.1/2502.6 = 91.79 percent.

Fade Countermeasure Control Delays, Attenuation Thresholds and Controller Availability

The methods of FEC and power control are two methods of adaptive power control that can be used as a countermeasure against rain fade on a communications link. The judicious use of these schemes is required; one must not apply these countermeasures during times that they are not needed but they certainly must be in effect when the prevailing conditions dictate. In all cases, a threshold value of rain attenuation is given at which the particular control must be implemented. Thus, one can implement control at or before the time the threshold value is reached. However, the control should not be put into effect too early so as not to waste the appropriately allocated resources. It is therefore desireable to know, given a threshold attenuation A_{th} and a currently observed attenuation A_0 where $A_0 < A_{th}$, what the maximum time interval is that one can wait to implement control before the value A_{th} is attained. The calculation of this "tolerable" control delay from the dynamic rain attenuation model will now be given.

Let an attenuation A_0 be observed at a time t_0 and consider the difference $\Delta A = A_{th} - A_0 > 0$ between this observed value and a given threshold value A_{th}. Using equation (2.35), the probability that the attenuation at a time $t_0 + \Delta t$ will exceed $A_{th} = A_0 + \Delta A$ given that the attenuation A_0 occurs at t_0 is

$$P(a(t_0 + \Delta t) \geq A_0 + \Delta A | A_0(t_0)) = \frac{1}{2} \, \mathrm{erfc} \left[\frac{\ln(A_0 + \Delta A) - \ln A_m(\Delta t)}{\sqrt{2}\sigma_{\ln A}(\Delta t)} \right] \tag{3.7}$$

Thus given $A_0(t_0)$ and ΔA, equation (3.7) gives the probability that the attenuation $A_0 + \Delta A = A_{th}$ will be exceeded in a time interval Δt. Therefore, if one decides and implements control within a Δt time interval when the observed attenuation is A_0 dB, the control system will act and counter the attenuation of A_{th} dB with a probability $P = P(a(t_0 + \Delta t) \geq A_0 + \Delta A | A_0(t_0))$. In this way, the quantity P can be interpreted as the availability of the control system, i.e., the probability that the control covers the fade threshold. Hence, in addition to the values A_0 and A_{th}, if one specifies the probability P, the problem given by equation (3.7) can formally be solved for Δt, i.e., the time-to-threshold interval.

Equation (3.7) can analytically be solved for Δt using an approximation as follows. Solving equation (3.7) for the quantity ΔA gives

$$\Delta A = \exp[\ 2\sigma_{\ln A}(\Delta t)\ \mathrm{erfc}^{-1}(2P) + \ln A_m(\Delta t)] - A_0 \tag{3.8}$$

where $\mathrm{erfc}^{-1}(\ldots)$ is the inverse complementary error function. Substituting the values of $A_m(\Delta t)$ and $\sigma_{\ln A}(\Delta t)$ given, respectively, by equations (2.31) and (2.32) and using the condition $\Delta t \ll \gamma^{-1}$ satisfied by the range of values of Δt that are of interest, one obtains

$$\Delta A = A_0[\exp(2(\gamma\Delta t)^{1/2}\sigma_{\ln A}\mathrm{erfc}^{-1}(2P) - 1] \tag{3.9}$$

This relation can be solved for Δt and yields for the time to threshold interval

$$\Delta t = \frac{1}{4\gamma} \left[\frac{\ln\left(\frac{\Delta A}{A_0}\right) + 1}{\sigma_{\ln A}\mathrm{erfc}^{-1}(2P)} \right]^2 \tag{3.10}$$

explicitly in terms of the threshold attenuation $\Delta A/A_0 + 1 = (A_{th} - A_0)A_0 + 1 = A_{th}/A_0$. Thus, equation (3.10) can be written

$$\Delta t = \frac{1}{4\gamma} \left[\frac{\ln\left(\frac{A_{th}}{A_0}\right) + 1}{\sigma_{\ln A}\mathrm{erfc}^{-1}(2P)} \right]^2 \tag{3.11}$$

It is interesting to note that in this approximation, the result is independent of the mean attenuation for the location but is a rather strong function of the other static attenuation parameter, $\sigma_{\ln A}$.

Rain Attenuation Fade Control Delays for Selected Cities in the U.S. Including Alaska and Hawaii

Equation (3.10) is applied to the 59 cities considered in section 3(c). Here, only the parameter $\sigma_{\ln A}$ is needed for each link at 20 and 30 GHz. In the case of fade control on the 20 GHz downlink, a threshold of A_{th} = 3 dB is considered for four control availabilities P = 99.999, 99.99, 99.9, and 99 percent. Attenuation values A_0 of 0.5 to 2.5 dB are considered in intervals of ΔA = 0.5 dB. For the 30 GHz uplink, a threshold A_{th} = 5 dB is considered where attenuation values A_0 of 1.0 to 4.0 dB are used with an interval of ΔA = 1.0 dB. The results for each city follow those of section 3(c) in the tables that appear in appendix D. Thus, in the case of a terminal located in Cleveland, Ohio, one has that if an attenuation of 1.5 dB is observed on the 20 GHz downlink, and if a control availability of 99.999 percent is desired (i.e., 99.999 percent of the time the control system is in fact needed, it will cover the 3 dB threshold 99.999 percent of the time), one has 12.2 sec to make a decision to implement control if the attenuation level will in fact keep increasing; it may drop down to 1.0 dB thus allowing one a 30.6 sec delay. However, if the attenuation keeps increasing to 2.0 dB, the maximum allowable delay decreases to 4.2 sec. If, however, one can implement control in a time less than 0.8 sec, then one can wait until an attenuation level of 2.5 dB is reached. Note that due to the independence of the results on the mean attenuation and the similar values in $\sigma_{\ln A}$ for 20 and 30 GHz, the time to threshold delays, unlike the attenuation and fade statistics, are about the same at 30 GHz as at 20 GHz. In fact, the variability of $\sigma_{\ln A}$ from city to city as well as from 20 to 30 GHz does not compare to that of results that depend on A_m, which itself greatly varies. This circumstance may allow one to specify a "universal" set of control delay parameters.

APPENDIX A

LANGEVIN-TYPE EQUATIONS AND THEIR RELATIONSHIP TO THE FORWARD KOLMOGOROV EQUATION

Let $x(t)$ be a random function of time t whose time derivative (which, without further justification, is assumed to exist) is determined by two deterministic (i.e., nonrandom) functions $\psi(x,t)$ and $g(x,t)$ and a random function $\xi(t)$ such that

$$\frac{dx}{dt} = \psi(x,t) + g(x,t)\xi(t) \tag{A.1}$$

Equation (A.1) is a stochastic differential equation of the Langevin type. The statistics of the random process $\xi(t)$ are such that

$$\langle \xi(t) \rangle = 0$$

$$\langle \xi(t_1)\xi(t_2) \rangle = \delta(t_1 - t_2) \tag{A.2}$$

These relationships define the process $\xi(t)$ to be a "white noise" process.

A description of the temporal "evolution" of $x(t)$ as t increases must necessarily be done via a statistical approach due to the random function $\xi(t)$ operating in equation (A.1). Thus, the following problem can be formulated: Given that $x(t)$ has the value x_0 at time t_0, what is the probability (governed by the statistics of $\xi(t)$) that $x(t)$ has the value x, at a later time t_1? Let $p(x_1,t_1|x_0,t_0)$ be the conditional probability density such that $p(x_1,t_1|x_0,t_0)dx_1$ gives the probability that, given x_0 at time t_0, one finds x in the range $[x_1,x_1+dx_1]$ at a later time t_1. Now all the information that can be gleaned from what is known about the random process $x(t)$, i.e., equation (A.1), is how $x(t)$ changes over a time interval Δt where

$$\Delta x = \int_t^{t+\Delta t} \frac{dx}{dt'}\, dt'$$

$$= \int_t^{t+\Delta t} \psi(x,t')dt' + \int_t^{t+\Delta t} g(x,t')\xi(t')dt' \tag{A.3}$$

Thus, it is suggested that in order to extract information as to how $p(x_1,t_1|x_0,t_0)$ behaves or what form it takes, one should relate $p(x_1,t_1|x_0,t_0)$ at a time t_1 to $p(x_2,t_1+\Delta t|x_1,t_1)p(x_1,t_1|x_0,t_0)dx_1$; this is the probability density for the occurrence of $x(t) = x_2$ at $t = t_1 + \Delta t$ given that $x(t) = x_1 + dx_1$ at $t = t_1$, which is given by the probability $p(x_1,t_1|x_0,t_0)dx_1$ on the condition that $x(t) = x_0$ at $t = t_0$. Implicit in forming this product of conditional probabilities is that the transition from x_0 to x_1 at time t_1 and the transition from x_1 to x_2 at time $t_1 + \Delta t$ are independent, i.e., uncorrelated. Such a situation defines a continuous Markov process. Summing over all possible values of x_1 gives

$$p(x_2,t_1+\Delta t|x_0,t_0)=\int_{-\infty}^{\infty}p(x_2,t_1+\Delta t|x_1,t_1)p(x_1,t_1|x_0,t_0)dx_1 \tag{A.4}$$

for the conditional probability density that, given the fact that $x(t)=x_0$ at $t=t_0$, one has $x(t)=x_2$ at $t=t_1+\Delta t$. This relationship is known as the Chapman-Kolmogorov Equation.

It is now desired to connect the relationship exhibited by equation(A.4) with that of equation (A.1). One therefore wants an expression giving the time derivative of the conditional probability density $p(x_1,t_1|x_0,t_0)$ in terms of the deterministic functions $\psi(x,t)$ and $g(x,t)$ of equation (A.1). To this end, consider the integral

$$I\equiv\int\frac{\partial p(x_1,t_1|x_o,t_o)}{\partial t_1}R(x_1)dx_1 \tag{A.5}$$

where $R(x_1)$ is an arbitrary function which goes to zero for $x_1\rightarrow\pm\infty$ sufficiently fast. Replacing in equation (A.5) the derivative $\partial p(x_1,t_1|x_0,t_0)/\partial t_1$ by the limit of the derivative quotient, i.e.,

$$\frac{\partial p(x_1,t_1|x_o,t_o)}{\partial t}=\lim_{\Delta t\rightarrow 0}\left[\frac{p(x_1,t_1+\Delta t|x_o,t_o)-p(x_1,t_1|x_o,t_o)}{\Delta t}\right] \tag{A.6}$$

Writing equation (A.4) for $x_1=x_2$,

$$p(x_1,t_1+\Delta t|x_0,t_0)=\int_{-\infty}^{\infty}p(x_1+\Delta t|x_1,t_1)p(x_1,t_1|x_0,t_0)dx_1 \tag{A.7}$$

and substituting equation (A.7) into equation (A.6) gives

$$\frac{\partial p(x_1,t_1|x_o,t_o)}{\partial t}=\lim_{\Delta t\rightarrow 0}\left[\int_{-\infty}^{\infty}\frac{p(x_1+\Delta t|x_1',t_1)p(x_1',t_1|x_o,t_o)dx_1'-p(x_1,t_1|x_o,t_o)}{\Delta t}\right] \tag{A.8}$$

Substituting equation (A.8) into equation (A.5) gives

$$I = \lim_{\Delta t \to 0} \frac{1}{\Delta t} \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\infty} p(x_1 + \Delta t | x_1', t_1) p(x_1', t_1 | x_0, t_0) dx_1' \right] R(x_1) dx_1'$$

$$- \int_{-\infty}^{\infty} p(x_1', t_1 | x_o, t_o) R(x_1') dx_1'$$

$$= \lim_{\Delta t \to 0} \frac{1}{\Delta t} \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\infty} R(x_1) p(x_1 + \Delta t | x_1', t_1) dx_1' \right] p(x_1', t_1 | x_o, t_o) dx_1'$$

$$- \int_{-\infty}^{\infty} p(x_1', t_1 | x_o, t_o) R(x_1') dx_1' \qquad (A.9)$$

Expanding the arbitrary function $R(x_1)$ in a Taylor series about x_1', i.e.,

$$R(x_1) = R(x_1') + \frac{\partial R(x_1')}{\partial x_1'} (x_1 - x_1') + \frac{1}{2} \frac{\partial^2 R(x_1')}{\partial x_1'^2} (x_1 - x_1')^2 + \ldots$$

and inserting into equation (A.9) yields

$$I = \lim_{\Delta t \to 0} \frac{1}{\Delta t} \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\infty} R(x_1') + \frac{\partial R(x_1')}{\partial t_1'} (x_1 - x_1') p(x_1 + \Delta t | x_1', t_1) \right.$$

$$\left. + \frac{1}{2} \frac{\partial^2 R(x_1')}{\partial x_1'2} (x_1 - x_1')^2 \, p(x_1 + \Delta t | x_1', t_1) + \partial(x_1 - x_1')^3) + \ldots \right].$$

$$\cdot \, p(x_1', t_1 | x_o, t_o) dx_1' \int_{-\infty}^{\infty} p(x_1', t_1 | x_o, t_o) R(x_1') dx_1'$$

$$= \lim_{\Delta t \to 0} \frac{1}{\Delta t} \int_{-\infty}^{\infty} \left[\frac{\partial R(x_1')}{\partial x_1'} \int_{-\infty}^{\infty} (x_1 - x_1') \, p(x_1 + \Delta t | x_1', t_1) dx_1' \right.$$

$$\left. + \frac{1}{2} \frac{\partial^2 R(x_1')}{\partial x_1'^2} \int_{-\infty}^{\infty} (x_1 - x_1')^2 p(x_1 + \Delta t | x_1', t_1) dx_1' \right] p(x_1', t_1 | x_o, t_o) dx_1' \qquad (A.10)$$

Defining the conditional mean and variance, respectively, as

$$k_1(x_1',t_1 + \Delta t) = \int_{-\infty}^{\infty} (x_1 - x_1')p(x_1,t_1 + \Delta t|x_1',t)dx_1 \qquad \text{(A.11a)}$$

$$k_2(x_1',t_1 + \Delta t) = \int_{-\infty}^{\infty} (x_1 - x_1')^2 p(x_1,t_1 + \Delta t|x_1',t)dx_1 \qquad \text{(A.12a)}$$

and letting

$$K_1(x_1',t_1) = \lim_{\Delta t \to 0} \frac{k_1(x_1',t_1 + \Delta t)}{\Delta t} \qquad \text{(A.11b)}$$

$$K_2(x_1',t_1) = \lim_{\Delta t \to 0} \frac{k_2(x_1',t_1 + \Delta t)}{\Delta t} \qquad \text{(A.12b)}$$

exist (implicitly, assuming that $k_n(x_1',t_1) = \mathcal{O}(\Delta t^2) \Rightarrow 0$ for $n = 3,4\ldots$), equation (A.10) becomes

$$I = \int_{-\infty}^{\infty} \frac{\partial R(x_1')}{\partial x_1'} K_1(x_1',t_1|x_0,t_0)dx_1'$$

$$+ \frac{1}{2}\int_{-\infty}^{\infty} \frac{\partial R_2^2(x_1')}{\partial x_1'^2} K_2(x_1',t_1)p(x_1',t_1|x_0,t_0)dx_1' + \ldots \qquad \text{(A.13)}$$

Integrating the first integral by parts yields

$$\int_{-\infty}^{\infty} \frac{\partial R(x_1')}{\partial x_1'} K_1 p dx_1' = R(x_1')K_1 p \Big|_{-\infty}^{\infty} - \int_{-\infty}^{\infty} R(x_1') \frac{\partial}{\partial x_1'} (K_1 p)dx_1'$$

$$= -\int_{-\infty}^{\infty} R(x_1') \frac{\partial}{\partial x_1'} (K_1 p)dx_1' \qquad \text{(A.14)}$$

where the "surface" term gives a zero contribution due to the assumptions made about $R(x_1')$. Similarly, integrating the second integral by parts twice gives

$$\frac{1}{2}\int_{-\infty}^{\infty}\frac{\partial R^2(x_1')}{\partial x_1'^2}K_2 p dx' = \frac{1}{2}\left[\frac{\partial R(x_1')}{\partial x_1'}(K_2 p)\Big|_{-\infty}^{\infty} - \int_{-\infty}^{\infty}\frac{\partial R}{\partial x_1'}\frac{\partial}{\partial x_1'}(K_2 p)dx_1'\right]$$

$$= -\frac{1}{2}\int_{-\infty}^{\infty}\frac{\partial R}{\partial x_1'}\frac{\partial (K_2 p)}{\partial x_1'}dx'_1$$

$$= -\frac{1}{2}\left[\frac{\partial (K_2 p)}{\partial x_1'}R(x_1') - \int_{-\infty}^{\infty}\frac{\partial^2 (K_2 p)}{\partial x_1'^2}R(x_1')dx_1'\right]$$

$$= \frac{1}{2}\int_{-\infty}^{\infty}\frac{\partial^2 (K_2 p)}{\partial x_1'^2}R(x_1')dx_1' \qquad (A.15)$$

Therefore, equation (A.13) becomes, upon using equations (A.14) and (A.15),

$$I = -\int_{-\infty}^{\infty} R(x_1')\frac{\partial}{\partial x_1'}[K_1(x_1',t_1)p(x_1',t_1|x_0,t_0)]dx_1'$$

$$+\frac{1}{2}\int_{-\infty}^{\infty} R(x_1')\frac{\partial^2}{\partial x_1'^2}[K_2(x_1',t_1)p(x_1',t_1|x_0,t_0)]dx_1' \qquad (A.16)$$

Remembering the original equation, equation (A.5), one has

$$\int_{-\infty}^{\infty} R(x_1')\left[\frac{\partial p(x_1',t_1|x_0,t_0)}{\partial t_1} + \frac{\partial}{\partial x_1'}[K_1(x_1',t_1)p(x_1',t_1|x_0,t_0)]\right.$$

$$\left. -\frac{1}{2}\frac{\partial^2}{\partial x_1'^2}[K_2(x_1',t_1)p(x_1',t_1|x_0,t_0)]\right]dx_1' = 0 \qquad (A.17)$$

Since the function $R(x_1')$ appearing as a factor in the integrand of equation (A.17) is arbitrary, other than satisfying the required covergence conditions at $\pm\infty$, the other factor appearing in the integrand must be identically zero, i.e.,

$$\frac{\partial p(x_1',t_1|x_0,t_0)}{\partial t_1} + \frac{\partial}{\partial x_1'}[K_1(x_1',t_1)p(x_1',t_1|x_0,t_0)]$$

$$- \frac{1}{2}\frac{\partial^2}{\partial x^2}[K_2(x_1',t_1)p(x_1',t_1|x_0,t_0)] = 0 \qquad \text{(A.18)}$$

This is the Forward Kolmogorov Equation, also known as the Fokker-Plank Equation. It specifies the temporal dependence of $p(x'_1,t_1|x_0,t_0)$ as a function of t_1 in terms of the limit of the quotient of the conditional mean and variance K_1 and K_2 with Δt, given by equations (A.11b) and (A.12b).

The quantities K_1 and K_2 must now be related with those of the governing stochastic differential equation, equation (A.1). From equations (A.11a) and (A.11b), one has that

$$K_1(x_1',t_1) = \lim_{\Delta t \to 0} \frac{\langle \Delta x \rangle}{\Delta t} \qquad \text{(A.19)}$$

where $\langle \Delta x \rangle$ is the average change of x in the time interval from t_1 to $t_1 + \Delta t$, i.e., $\Delta x = x_1 - x_1'$. From equations (A.3) and (A.2),

$$\langle \Delta x \rangle = \int_{t_1}^{t_1+\Delta t} \langle \psi(x_1',t) \rangle dt + \int_{t_1}^{t_1+\Delta t} \langle g(x',t)\xi(t) \rangle dt$$

$$\int_{t_1}^{t_1+\Delta t} \psi(x_1',t)dt$$

since $\psi(x,t)$ and $g(x,t)$ are deterministic and $\langle \xi(t) \rangle = 0$. For small Δt, one has

$$\int_{t_1}^{t_1+\Delta t} \psi(x_1',t_1)dt \approx \psi(x_1',t_1)\Delta t$$

and equation (A.19) becomes

$$K_1(x_1',t_1) = \lim_{\Delta t \to 0} \frac{\psi(x_1',t_1)\Delta t}{\Delta t} = \psi(x_1',t_1) \qquad \text{(A.20)}$$

From equations (A.12a) and (A.12b), one has

$$K_2(x_1',t_1) = \lim_{\Delta t \to 0} \frac{\langle (\Delta x)^2 \rangle}{\Delta t} \qquad \text{(A.21)}$$

where $\langle(\Delta x)^2\rangle$ is the variance of x in a time interval Δt. Again, from equations (A.3) and (A.2),

$$\langle(\Delta x)^2\rangle = \int_{t_1}^{t_1+\Delta t} \psi(x_1',t)dt + \int_{t_1}^{t_1+\Delta t} g(x_1',t)\xi(t)dt$$

$$\int_{t_1}^{t_1+\Delta t} \psi(x_1',t')dt + \int_{t_1}^{t_1+\Delta t} g\,(x_1',t')\xi(t')dt'$$

$$= \int_{t_1}^{t_1+\Delta t} \int_{t_1}^{t_1+\Delta t} \psi(x_1',t)\psi(x_1',t')dtdt' + \int_{t_1}^{t_1+\Delta t} g^2\,(x_1',t)\partial t$$

which is also derived by noting the determinacity of ψ and g and using the statistics, $\langle\xi(t)\rangle = 0$ and $\langle\xi(t_1)\xi(t_2)\rangle = \delta(t_1-t_2)$. Again, letting Δt be small, one has that

$$\langle(\Delta x)^2\rangle = \psi^2(x_1',t)(\Delta t)^2 + g^2(x_1',t)\Delta t$$

Using equation (A.21), one has

$$K_2(x_1',t_1) = g^2(x_1',t_1) \qquad \text{(A.22)}$$

Rewriting equation (A.1) in terms of the results of equations (A.20) and (A.22), one can summarize the results of this appendix as follows: given the stochastic process governed by the differential equation

$$\frac{dx}{dt} = K_1(x,t) + (K_2(x,t))^{1/2}\,\xi(t) \qquad \text{(A.23)}$$

with the statistics of $\xi(t)$ given by equation (A.2), and taking this process to be a Markov process given by the conditional probability density $p(x,t|x_0,t_0)$, one has that this probability density must satisfy the Fokker-Plank Equation

$$\frac{\partial p\,(x,t|x_o,t_o)}{\partial t} + \frac{\partial}{\partial x}[K_1(x,t)p(x,t|x_0,t_0)]$$

$$- \frac{1}{2}\frac{\partial^2}{\partial x}\,[K_2(x,t)p(x,t|x_0,t_0)] = 0 \qquad \text{(A.24)}$$

APPENDIX B

DERIVATION OF ATTENUATION FADE STATISTICS

Following reference 7, a derivation leading to equations (3.1) and (3.2) will be given. Let $y(t)$ be a stationary random process and let t_Y be the time (as measured from an arbitrary origin) that the magnitude of y exceeds the level Y, i.e., $y(t_Y) > Y$. One can define the following problem: given that $y(t_Y) > Y$, what is the conditional probability that $y(t) > Y$ for the times $t_Y < t < t_Y + \tau$? Let this conditional probability be given by $P(y(t_Y + \tau) > Y|y(t_Y) > Y)$. It will be expediant to divide the time internal τ into n such intervals such that

$$\tau = n\Delta\tau \tag{B.1}$$

One can approximately write the probability of the single event that $y(t) > Y$ for $t_Y < t < t_Y + \tau$ as a joint probability that the n events $y_n(t) > Y$ occur, each for one of the subintervals Δt, i.e., $y_n(t) > Y$ for t such that $t = t_Y + n\Delta\tau$. Thus, one has

$$P(y(t_Y + \tau) \geq Y|y(t_Y) \geq Y)$$

$$\approx P(y(t_Y + \Delta\tau) \geq Y, y(t_Y + 2\Delta\tau) \geq Y, y(t_Y + n\Delta\tau) \geq Y|y(t_Y) \geq Y) \tag{B.2}$$

Using the notation $y(t_Y + i\Delta\tau) \equiv y_i$, and employing the theorem (ref. 8) of joint probability, equation (B.2) can be written as

$$P(y(t_Y + \tau) \geq Y|y(t_Y) \geq Y) \approx P(y_1 \geq Y, y_2 \geq Y, \ldots y_n \geq Y|y_0 \geq Y)$$

$$\approx \frac{P(y_0 \geq Y, y_1 \geq Y, y_2 \geq Y, \ldots y_n \geq Y)}{P(y_0 \geq Y)} \tag{B.3}$$

Equation (B.3) becomes an equality in the limit $n \to \infty$ where, necessarily, $\Delta\tau \to 0$, i.e.,

$$P(y(t_Y + \tau) \geq Y|y(t_Y) \geq Y) = \frac{1}{P(y_0 \geq Y)} \lim_{\substack{n\to\infty \\ (\Delta\tau\to\infty)}} P(y_0 \geq Y, y_1 \geq Y, \ldots y_n \geq Y) \tag{B.4}$$

Since the values of y_i, $i = 0, \ldots n$ are taken to exceed the level Y during the time interval τ, then the point at which this level Y is crossed where $y_i(t_i) < Y$ will occur at some time $t_i \geq t_Y + \tau$. Therefore, the probability $P(y(t_Y + \tau \geq Y|y(t_Y) \geq Y)$ can be taken to be that of the time interval τ that the random process y remains above some fixed level Y. Thus, letting $P_Y(t \geq \tau|y > Y)$ denote the conditional probability that a level Y is exceeded for a time interval t that is larger than some given value τ (such an event is called a surge above the level Y), one has

$$P_Y(t \geq \tau|y \geq Y) = p(y(t + \tau) \geq Y|y(t) \geq Y) \tag{B.5}$$

In order to determine this function, it is necessary to find the value of the limit required by equation (B.4). Thus, one needs an expression that describes the general n dimensional distribution function for the y_i quantities. However, in the simplest case of a normal process (which will be dealt with here) such an expression becomes unwieldy even for $n \geq 3$. The following approximate solution must therefore be employed.

The right-hand side of equation (B.3) can be written as

$$\frac{P(y_0 \geq Y, y_1 \geq Y, \ldots y_n \geq Y)}{P(y_0 \geq Y)} = P(1|0)P(2|1,0)\ldots P(n|n-1,\ldots 1,0) \tag{B.6}$$

where $P(i|i-1,\ldots 1,0)$ is the conditional probability that the event $y_i \geq Y$ occurs, given that the events $y_{i-1} \geq Y, \ldots y_0 > Y$ have occurred. Taking into account that

$$P(i|i-1,\ldots 1,0) \leq P(i|i-1) \tag{B.7}$$

one has, from equation (B.6)

$$\frac{P(y_0 \geq Y, y_1 \geq Y, \ldots y_n \geq Y)}{P(y_0 \geq Y)} \leq P^n(i|i-1) = P^n(y(t+\tau/n) \geq Y|y(t) \geq Y) \tag{B.8}$$

and, using equations (B.4) and (B.5),

$$P_Y(t \geq \tau|y \geq Y) = \lim_{n\to\infty} P\left[y\left(t+\frac{\tau}{n}\right) \geq Y|y(t) \geq Y\right]^n$$

$$= \lim_{n\to\infty} \frac{\left[y\left(t+\frac{\tau}{n}\right) \geq Y|y(t) \geq Y\right]^n}{P\left[y|(t) \geq Y\right]} \tag{B.9}$$

where the last line follows from application of the theorem of joint probabilities. Equation (B.9) represents a solution to the problem of the probability of the time interval τ that a random process y remains above some given level Y. This solution essentially estimates an n-dimensional distribution by the nth power of a one-dimensional distribution based on $n - 1$ conditions; in the limit as $n\to\infty$, the distribution of $P_Y(t \geq \tau|y \geq Y)$ is obtained. The statistics peculiar to the process $y(t)$ enters into the problem through the expression for the joint probability distribution $P(y(t + \tau/n) \geq Y, y(t) \geq Y)$. In the case considered here, the process is the attenuation due to rain that occurs on a communications link and the governing statistics are, as discussed in reference 1), log-normal. What is the same thing, the process $y(t)$ can be taken to be the logarithm of attenuation and the statistics are normally distributed. In this latter case, one can write, using the well known equation for the bivariate normal distribution (ref. 9) and making the identifications $y(t) = \ln A(t)$ and $Y \equiv \ln A_0$, one has

$$P\left[a\left(t+\frac{\tau}{n}\right)\geq A_0, a(t)\geq A_0\right] = P_0(L,\theta)P\left[a\left(t+\frac{\tau}{n}\right)\geq A_0, a(t)\geq A_0 | \text{RAIN ON LINK}\right]$$

$$= P_0(L,\theta)\left(\frac{1}{2\pi\sigma_{\ln A}^2\left[1-R^2(\Delta\tau)\right]^{1/2}}\right)$$

$$\int_{\ln A_0}^{\infty}\int_{\ln A_0}^{\infty} \exp\left[\frac{(x_1-a)^2-2R(\Delta\tau)(x_1-a)(x_2-a)+(x_2-a)^2}{2\sigma_{\ln A}^2[1-R^2(\Delta\tau)]}\right]dx_1dx_2 \qquad (B.10)$$

where $R(\Delta\tau)$ is the termporal correlation coefficient of the attenuation process that, in general, can be a function of the time interval $\Delta\tau = \tau/n$ and all the other parameters have been previously defined in reference 1). If $\Delta\tau$ is small, the conditional joint probability $P_c(\Delta\tau) \equiv P[a(t+\Delta\tau) \geq A_0, a(t) \geq A_0|\text{RAIN ON LINK}]$ can be expanded about the point $R(0)$ in a Taylor Series, i.e.,

$$P_c(\Delta\tau) = P_c(0) + \left[\frac{dP_c(\Delta\tau)}{dR(\Delta\tau)}\frac{dR(\Delta\tau)}{d(\Delta\tau)}\right]_{\Delta\tau=0}\Delta\tau + \ldots$$

Performing the required calculations, simplifying, and noting that $P_c(0) = P[a(t) \geq A_0, a(t) \geq A_0|\text{RAIN ON LINK}] = P[a(t) \geq A_0|\text{RAIN ON LINK}]$, one obtains

$$P_c(\Delta\tau) \approx P[a(t) \geq A_0|\text{RAIN ON LINK}] +$$

$$+ \frac{(-R''(0))^1}{2\pi}\exp\left[\frac{(\ln A_0 - \ln A_m)^2}{2\sigma_{\ln A}^2}\right]\Delta\tau \qquad (B.11)$$

where R'' denotes the second time derivative of $R(t)$. Substituting equation (B.11) into (B.9) and noting the first line of equation (B.10) gives

$$P_{A_0}(t \geq \tau | a \geq A_0)$$

$$= \lim_{n\to\infty}\left\{\frac{P[a(t)\geq A_0] + P_0(L,\theta)\frac{(-R''(0))^{1/2}}{2\pi}\exp\left[-\frac{(\ln A_0 - \ln A_m)^2}{2\sigma_{\ln A}^2}\right]\Delta\tau}{P[a(t)\geq A_0]}\right\}$$

$$= \lim\left[1-\alpha\frac{\tau}{n}\right]^n = \exp(-\alpha\tau) \qquad (B.12)$$

where

$$\alpha \equiv \frac{P_0(L,\theta)(-R''(0))^{1/2} \exp\left[\frac{\left(-\ln A_0 - \ln A_m\right)^2}{2\sigma_{\ln A}^2}\right]}{2\pi\ P[a(t) \geq A_0]} \tag{B.13}$$

since one has that $P[a(t) \geq A_0) = P_0(L,\theta)P(a(t) \geq A_0|\text{RAIN ON LINK}]$ where, as shown in reference 1),

$$P[a(t) \geq A_0|\text{RAIN ON LINK}] = \frac{1}{2}\ \text{erfc}\left(\frac{\ln A_0 - \ln A_m}{\sqrt{2}\sigma_{\ln A}}\right)$$

Equation (B.13) can be written

$$\alpha = \frac{(-R''(0))^{1/2} \exp\left[\frac{\left(-\ln A_0 - \ln A_m\right)^2}{2\sigma_{\ln A}^2}\right]}{\pi\ \text{erfc}\left(\frac{\ln_0 - \ln A_m}{\sqrt{2}\sigma_{\ln A}}\right)} \tag{B.14}$$

It now remains to find the value for the second derivative of $R(\Delta\tau)$ evaluated at $\Delta\tau = 0$. For this, one must go back to the stochastic differential equation (eq. (2.21)), viz.,

$$\frac{dx}{dt} = -\gamma x(t) + (2\gamma)^{1/2}\xi(t) \tag{B.15}$$

where

$$x(t) = \frac{\ln A(t) - \ln A_m}{\sigma_{\ln A}} \tag{B.16}$$

Finding the correlation function of the process defined by equation (B.15), one makes use of the Wiener-Khintchine Theorem which states that correlation function is the Fourier transform of the normalized power spectrum of the random process in question (ref. 10). Taking the temporal Fourier transform of equation (B.15), forming the normalized power spectrum and inverse transforming this result yields

$$R(\Delta\tau) = e^{-\gamma(\Delta\tau)} \tag{B.17}$$

Following the prescription given in reference 11 for obtaining the second derivative of equation (B.17) and setting $\Delta\tau = 0$ finally gives

$$R''(0) = -\gamma^2$$

Substituting this result into equation (B.14) and using the definition of equation (B.16) yields

$$\alpha = \frac{\gamma}{F(X_0)} \tag{B.18}$$

where

$$F(X_0) \equiv \pi \operatorname{erfc}\left(\frac{X_0}{\sqrt{2}}\right) \exp\left(\frac{X_0^{\,2}}{2}\right)$$

and

$$X_0 \equiv \frac{\ln A_0 - \ln A_m}{\sigma_{\ln A}} \tag{B.19}$$

Combining equations (B.12) and (B.18) gives

$$P_{A_0}(t \geq \tau | a \geq A_0) = \exp\left(-\frac{\gamma\tau}{F(X_0)}\right) \tag{B.20}$$

It now remains to multiply this conditional probability by the cumulative probability $P(a \geq A_0)$ to obtain the desired results of equations (3.1) to (3.3) for fade times $\tau \equiv T_F$.

APPENDIX C

EXPERIMENTAL DETERMINATION OF THE TEMPORAL PARAMETER γ

An experimental procedure to obtain empirical values for γ from actual rain attenuation events occurring on a communications link is suggested by a relation derives in appendix A, equation (A.22). This expression relates the conditional variance $K(X,t)$ of the quantity

$$X(t) = \frac{\ln A(t) - \ln A_m}{\sigma_{\ln A}} \tag{C.1}$$

to the parameter γ, viz

$$K_2(X,t) = g^2(X,t) = 2\gamma \tag{C.2}$$

where use was also made of equation (2.19). From equation (A.21), the conditional variance can be given by

$$K_2(X,t) = \lim_{\Delta t \to 0} \left(\frac{\langle (X|t + \Delta t) - X(t))^2 \rangle}{\Delta t} \right) \tag{C.3}$$

where $\langle (X(t + \Delta t) - X(t))^2 \rangle$ is the variance of $X(t)$ over the time interval Δt; the esemble averaging $\langle \ldots \rangle$ is, by ergodicity; time averaging over all realizations of $(X(t - \Delta t) - X(t))^2$. Using equation (C.1) and letting $A(t) \equiv A_0$ and $A(t+\Delta t) \equiv A$, one has

$$X(t + \Delta t) - X(t) = \frac{\ln A - \ln A_0}{\sigma_{\ln A}}$$

$$= \frac{\ln\left(\frac{A}{A_0}\right)}{\sigma_{\ln A}} \tag{C.4}$$

Letting $A = A_0 + \Delta A$ where $A_0 \geq \Delta A$, the $\ln(A/A_0)$ factor of equation (C.4) can be expanded to yield

$$\gamma = 1/2 \lim_{\Delta t \to 0} \frac{\langle (\Delta A)^2 \rangle}{A_0^2 \, \sigma_{\ln A}^2 \, \Delta t} \tag{C.6}$$

Equation (C.6) easily lends itself to experimental implementation. In discrete form, carefully noting the time dependencies of the particular attenuation values $A_0 \equiv A(t)$ and $\Delta A = A - A \equiv A(T + \Delta t) - A(t)$, one has

$$\gamma \approx \frac{\langle [A(t_{i+1}) - A(t_i)]^2 \rangle}{2\sigma_{\ln A}^2 \, A^2(t_i) \, \Delta t} \tag{C.7}$$

where $\Delta t \equiv t_{i+1} - t_i$ is the ith sampling interval. As can be seen, a record of attenuation samples must first be built. Only after this has been done over many samples, one can form the variance, $\langle[A(t_{i+1}) - A(t_i)]^2\rangle/(A^2(t_i)\Delta t)$. So as not to bias the result, the value for σ_{lnA} must also be derived from the observations rather than the values calculated in reference 1). Running estimates of equation (C.7) can continually be made throughout the lifetime of the experiment which, of course, should be as long as possible. These measurements should be made at various locations throughout the country verify or refute the assumption made in this work that γ is independent of location. The data should also be placed in class intervals according to month of year so as to ascertain possible variations throughout the year.

APPENDIX D

FADE STATISTICS AND CONTROL DELAY DATA FOR ACTS COMMUNICATIONS LINKS FOR 59 CITIES IN THE U.S.

LOCATION OF TERMINAL: JUNEAU, AK

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 37.308 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.103 dB; @ 30 GHz: 0.282 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.124; @ 30 GHz: 1.030

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	266.6	54.5	10.6	0.9	2129.3	514.4	113.9	11.2
1	248.5	50.3	9.7	0.8	2011.9	481.3	105.6	10.2
2	231.5	46.4	8.9	0.8	1900.9	450.4	97.9	9.4
3	215.8	42.9	8.2	0.7	1796.1	421.4	90.8	8.6
4	201.1	39.6	7.5	0.6	1697.1	394.3	84.2	7.9
5	187.4	36.6	6.8	0.6	1603.5	369.0	78.1	7.2
10	131.7	24.5	4.4	0.3	1207.6	264.7	53.5	4.6
15	92.5	16.5	2.8	0.2	909.5	189.9	36.7	3.0
20	65.0	11.1	1.8	0.1	684.9	136.2	25.1	1.9
30	32.1	5.0	0.8	0.0	388.4	70.1	11.8	0.8
40	15.9	2.2	0.3	0.0	220.3	36.1	5.5	0.3
50	7.8	1.0	0.1	0.0	124.9	18.6	2.6	0.1
60	3.9	0.5	0.1	0.0	70.9	9.5	1.2	0.1
70	1.9	0.2	0.0	0.0	40.2	4.9	0.6	0.0
80	0.9	0.1	0.0	0.0	22.8	2.5	0.3	0.0
90	0.5	0.0	0.0	0.0	12.9	1.3	0.1	0.0
100	0.2	0.0	0.0	0.0	7.3	0.7	0.1	0.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	77.6	102.3	147.5	259.9
1.0	29.2	38.5	55.5	97.7
1.5	11.6	15.3	22.1	38.9
2.0	4.0	5.2	7.6	13.3
2.5	0.8	1.1	1.5	2.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	74.6	98.3	141.8	249.8
2.0	24.2	31.9	46.0	81.0
3.0	7.5	9.9	14.3	25.2
4.0	1.4	1.9	2.7	4.8

LOCATION OF TERMINAL: PHOENIX, AZ

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION; 0.931 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.412 dB; @ 30 GHz: 0.903 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.381; @ 30 GHz: 1.335

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	368.6	173.1	77.7	22.6	901.9	489.2	250.3	86.4
1	353.9	165.1	73.6	21.3	874.3	471.1	239.5	82.0
2	339.9	157.4	69.8	20.0	847.6	453.6	229.1	77.7
3	326.3	150.1	66.1	18.8	821.7	436.8	219.2	73.7
4	313.4	143.2	62.7	17.6	796.5	420.6	209.8	69.9
5	300.9	136.6	59.4	16.5	772.1	405.1	200.7	66.3
10	245.7	107.8	45.4	12.1	661.0	335.4	160.9	50.8
15	200.6	85.0	34.6	8.8	565.9	277.7	129.1	39.0
20	163.8	67.1	26.5	6.5	484.4	229.9	103.5	29.9
30	109.2	41.8	15.4	3.5	355.0	157.6	66.5	17.6
40	72.8	26.0	9.0	1.8	260.2	108.1	42.8	10.4
50	48.5	16.2	5.3	1.0	190.7	74.1	27.5	6.1
60	32.3	10.1	3.1	0.5	139.8	50.8	17.7	3.6
70	21.6	6.3	1.8	0.3	102.4	34.8	11.4	2.1
80	14.4	3.9	1.0	0.1	75.1	23.9	7.3	1.2
90	9.6	2.4	0.6	0.1	55.0	16.4	4.7	0.7
100	6.4	1.5	0.4	0.0	40.3	11.2	3.0	0.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	51.3	67.7	97.6	172.0
1.0	19.3	25.4	36.7	64.6
1.5	7.7	10.1	14.6	25.7
2.0	2.6	3.5	5.0	8.8
2.5	0.5	0.7	1.0	1.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	44.3	58.5	84.3	148.5
2.0	14.4	18.9	27.3	48.1
3.0	4.5	5.9	8.5	15.0
4.0	0.9	1.1	1.6	2.9

LOCATION OF TERMINAL: FRESNO, CA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 15.842 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.016 dB; @ 30 GHz: 0.048 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.835; @ 30 GHz: 1.704

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	173.6	69.5	28.1	7.6	633.1	265.9	111.2	31.1
1	162.2	64.6	26.0	7.0	596.7	249.1	103.7	28.7
2	151.5	60.0	24.0	6.4	562.4	233.4	96.6	26.6
3	141.6	55.8	22.2	5.9	530.0	218.7	90.0	24.6
4	132.3	51.8	20.5	5.4	499.5	204.9	83.9	22.7
5	123.6	48.2	19.0	5.0	470.7	191.9	78.1	21.0
10	88.0	33.4	12.8	3.2	350.0	138.6	54.9	14.2
15	62.7	23.1	8.6	2.1	260.2	100.0	38.5	9.6
20	44.6	16.0	5.8	1.4	193.5	72.2	27.1	6.5
30	22.6	7.7	2.7	0.6	106.9	37.6	13.4	3.0
40	11.5	3.7	1.2	0.2	59.1	19.6	6.6	1.4
50	5.8	1.8	0.6	0.1	32.7	10.2	3.2	0.6
60	3.0	0.8	0.3	0.0	18.1	5.3	1.6	0.3
70	1.5	0.4	0.1	0.0	10.0	2.8	0.8	0.1
80	0.8	0.2	0.1	0.0	5.5	1.4	0.4	0.1
90	0.4	0.1	0.0	0.0	3.1	0.8	0.2	0.0
100	0.2	0.0	0.0	0.0	1.7	0.4	0.1	0.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	29.1	38.3	55.3	97.4
1.0	10.9	14.4	20.8	36.6
1.5	4.4	5.7	8.3	14.6
2.0	1.5	2.0	2.8	5.0
2.5	0.3	0.4	0.6	1.0

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	27.2	35.9	51.8	91.2
2.0	8.8	11.6	16.8	29.6
3.0	2.7	3.6	5.2	9.2
4.0	0.5	0.7	1.0	1.8

LOCATION OF TERMINAL: LOS ANGELES, CA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.915 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.512 dB; @ 30 GHz: 1.187 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.126; @ 30 GHz: 1.066

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	584.8	215.8	73.4	13.5	1937.0	893.8	370.4	87.4
1	560.2	205.0	69.2	12.6	1878.7	859.7	353.4	82.5
2	536.6	194.7	65.2	11.8	1822.1	826.8	337.1	77.8
3	514.0	184.9	61.4	11.0	1767.3	795.3	321.6	73.4
4	492.4	175.6	57.9	10.2	1714.1	764.9	306.9	69.2
5	471.7	166.8	54.5	9.5	1662.5	735.7	292.8	65.3
10	380.4	128.9	40.5	6.7	1426.9	605.5	231.4	48.8
15	306.8	99.7	30.0	4.7	1224.6	498.4	182.9	36.4
20	247.5	77.0	22.3	3.3	1051.1	410.2	144.5	27.2
30	161.0	46.0	12.3	1.6	774.2	277.9	90.3	15.2
40	104.7	27.5	6.8	0.8	570.3	188.3	56.4	8.5
50	68.1	16.4	3.7	0.4	420.1	127.6	35.2	4.7
60	44.3	9.8	2.1	0.2	309.5	86.4	22.0	2.6
70	28.8	5.9	1.1	0.1	228.0	58.5	13.8	1.5
80	18.8	3.5	0.6	0.0	167.9	39.7	8.6	0.8
90	12.2	2.1	0.3	0.0	123.7	26.9	5.4	0.5
100	7.9	1.3	0.2	0.0	91.1	18.2	3.4	0.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	77.3	102.0	147.0	259.0
1.0	29.1	38.3	55.3	97.4
1.5	11.6	15.3	22.0	38.8
2.0	4.0	5.2	7.5	13.3
2.5	0.8	1.1	1.5	2.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	69.5	91.7	132.2	233.0
2.0	22.5	29.7	42.9	75.5
3.0	7.0	9.2	13.3	23.5
4.0	1.3	1.8	2.5	4.5

LOCATION OF TERMINAL: SAN DIEGO, CA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.364 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.471 dB; @ 30 GHz: 1.065 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.254; @ 30 GHz: 1.202

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	501.9	213.9	85.8	20.7	1395.9	711.6	335.4	99.7
1	481.6	203.7	81.1	19.4	1354.0	685.2	320.7	94.4
2	462.2	194.0	76.7	18.2	1313.5	659.8	306.6	89.4
3	443.5	184.8	72.5	17.0	1274.1	635.3	293.1	84.6
4	425.6	176.0	68.6	15.9	1235.9	611.7	280.2	80.1
5	408.4	167.6	64.8	14.9	1198.8	589.0	267.9	75.8
10	332.3	131.3	49.0	10.7	1029.6	487.5	214.0	57.6
15	270.3	102.8	37.0	7.7	884.3	403.5	170.9	43.8
20	220.0	80.6	28.0	5.6	759.5	334.0	136.5	33.3
30	145.6	49.4	16.0	2.9	560.2	228.8	87.1	19.2
40	96.4	30.3	9.1	1.5	413.2	156.8	55.5	11.1
50	63.8	18.6	5.2	0.8	304.8	107.4	35.4	6.4
60	42.2	11.4	3.0	0.4	224.8	73.6	22.6	3.7
70	28.0	7.0	1.7	0.2	165.8	50.4	14.4	2.1
80	18.5	4.3	1.0	0.1	122.3	34.5	9.2	1.2
90	12.3	2.6	0.6	0.1	90.2	23.7	5.9	0.7
100	8.1	1.6	0.3	0.0	66.6	16.2	3.7	0.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	62.3	82.2	118.5	208.8
1.0	23.4	30.9	44.6	78.5
1.5	9.3	12.3	17.7	31.2
2.0	3.2	4.2	6.1	10.7
2.5	0.6	0.9	1.2	2.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	54.7	72.1	104.0	183.2
2.0	17.7	23.4	33.7	59.4
3.0	5.5	7.3	10.5	18.5
4.0	1.1	1.4	2.0	3.5

LOCATION OF TERMINAL: SAN FRANSICSO, CA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.895 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.517 dB; @ 30 GHz: 1.224 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.072; @ 30 GHz: 1.002

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	768.7	261.0	80.8	12.8	2823.6	1218.8	463.9	94.2
1	735.4	247.5	76.0	11.9	2737.4	1171.1	441.9	88.6
2	703.6	234.7	71.4	11.0	2653.9	1125.2	420.9	83.4
3	673.1	222.5	67.1	10.3	2572.9	1081.1	400.9	78.5
4	644.0	210.9	63.1	9.5	2494.4	1038.8	381.9	73.8
5	616.1	200.0	59.3	8.9	2418.2	998.1	363.8	69.5
10	493.7	153.2	43.6	6.1	2071.0	817.4	285.2	51.3
15	395.7	117.4	32.0	4.3	1773.7	669.4	223.7	37.9
20	317.1	90.0	23.5	2.9	1519.0	548.1	175.4	27.9
30	203.7	52.8	12.7	1.4	1114.1	367.6	107.8	15.2
40	130.8	31.0	6.8	0.7	817.2	246.5	66.3	8.3
50	84.0	18.2	3.7	0.3	599.4	165.3	40.8	4.5
60	54.0	10.7	2.0	0.2	439.6	110.9	25.1	2.5
70	34.7	6.3	1.1	0.1	322.4	74.4	15.4	1.3
80	22.3	3.7	0.6	0.0	236.5	49.9	9.5	0.7
90	14.3	2.2	0.3	0.0	173.5	33.4	5.8	0.4
100	9.2	1.3	0.2	0.0	127.2	22.4	3.6	0.2

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS			
	99.999%	99.99%	99.9%	99%
0.5	85.2	112.4	162.1	285.6
1.0	32.0	42.3	60.9	107.4
1.5	12.8	16.8	24.3	42.7
2.0	4.4	5.8	8.3	14.6
2.5	0.9	1.2	1.7	3.0

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS			
	99.999%	99.99%	99.9%	99%
1.0	78.8	103.9	149.8	263.9
2.0	25.5	33.7	48.6	85.5
3.0	7.9	10.5	15.1	26.6
4.0	1.5	2.0	2.9	5.1

LOCATION OF TERMINAL: DENVER, CO

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 3.019 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.135 dB; @ 30 GHz: 0.342 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.449; @ 30 GHz: 1.350

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	257.6	101.0	38.6	9.2	856.1	373.0	155.3	40.5
1	244.1	95.1	36.1	8.5	819.5	354.5	146.6	37.9
2	231.4	89.5	33.8	7.9	784.5	337.0	138.4	35.5
3	219.3	84.3	31.6	7.3	751.0	320.3	130.7	33.2
4	207.8	79.3	29.6	6.8	718.9	304.4	123.4	31.0
5	196.9	74.6	27.7	6.3	688.2	289.4	116.5	29.0
10	150.6	55.2	19.8	4.3	553.2	224.5	87.4	20.8
15	115.1	40.8	14.2	3.0	444.7	174.2	65.6	14.9
20	88.0	30.1	10.1	2.0	357.4	135.1	49.2	10.7
30	51.5	16.4	5.2	1.0	231.0	81.3	27.7	5.5
40	30.1	9.0	2.7	0.4	149.2	48.9	15.6	2.8
50	17.6	4.9	1.4	0.2	96.4	29.5	8.8	1.4
60	10.3	2.7	0.7	0.1	62.3	17.7	4.9	0.7
70	6.0	1.5	0.4	0.0	40.3	10.7	2.8	0.4
80	3.5	0.8	0.2	0.0	26.0	6.4	1.6	0.2
90	2.1	0.4	0.1	0.0	16.8	3.9	0.9	0.1
100	1.2	0.2	0.0	0.0	10.9	2.3	0.5	0.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	46.6	61.5	88.7	156.2
1.0	17.5	23.1	33.3	58.7
1.5	7.0	9.2	13.3	23.4
2.0	2.4	3.1	4.5	8.0
2.5	0.5	0.6	0.9	1.6

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	43.4	57.2	82.5	145.3
2.0	14.1	18.5	26.7	47.1
3.0	4.4	5.8	8.3	14.6
4.0	0.8	1.1	1.6	2.8

LOCATION OF TERMINAL: HARTFORD, CT

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.591 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.687 dB; @ 30 GHz: 3.635 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.014; @ 30 GHz: 0.960

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	20GHz 5dB	20GHz 8dB	20GHz 15dB	30GHz 3dB	30GHz 5dB	30GHz 8dB	30GHz 15dB
0	3886.3	1935.6	850.8	212.6	7894.6	5040.7	2801.5	951.9
1	3788.0	1870.8	815.5	201.4	7780.9	4931.3	2719.3	913.5
2	3692.3	1808.2	781.8	190.8	7668.8	4824.3	2639.5	876.5
3	3598.9	1747.7	749.4	180.8	7558.3	4719.5	2562.1	841.1
4	3507.9	1689.3	718.3	171.3	7449.3	4617.1	2487.0	807.1
5	3419.2	1632.8	688.5	162.3	7342.0	4516.9	2414.0	774.5
10	3008.3	1377.3	557.2	123.9	6828.1	4047.4	2080.2	630.1
15	2646.8	1161.8	450.9	94.6	6350.1	3626.8	1792.5	512.6
20	2328.7	980.1	364.9	72.2	5905.6	3249.8	1544.6	417.0
30	1802.6	697.4	239.0	42.1	5107.7	2609.4	1146.9	276.0
40	1395.4	496.2	156.5	24.5	4417.7	2095.2	851.6	182.7
50	1080.2	353.1	102.5	14.3	3820.8	1682.4	632.4	120.9
60	836.2	251.3	67.1	8.3	3304.6	1350.8	469.5	80.0
70	647.3	178.8	44.0	4.9	2858.2	1084.6	348.7	53.0
80	501.0	127.2	28.8	2.8	2472.0	870.9	258.9	35.1
90	387.8	90.5	18.9	1.6	2138.0	699.3	192.2	23.2
100	300.2	64.4	12.4	1.0	1849.2	561.5	142.7	15.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	95.2	125.6	181.1	319.1
1.0	35.8	47.2	68.1	120.0
1.5	14.3	18.8	27.1	47.8
2.0	4.9	6.4	9.3	16.3
2.5	1.0	1.3	1.9	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	85.8	113.2	163.2	287.5
2.0	27.8	36.7	52.9	93.2
3.0	8.6	11.4	16.4	29.0
4.0	1.6	2.2	3.1	5.5

LOCATION OF TERMINAL: WASHINGTON, D. C.

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.488 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.470 dB; @ 30 GHz: 4.895 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.109; @ 30 GHz: 1.083

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3369.4	2054.3	1132.4	406.5	5279.2	3852.5	2544.0	1177.9
1	3303.9	2000.2	1094.7	389.0	5218.9	3785.9	2484.1	1139.2
2	3239.7	1947.5	1058.3	372.3	5159.3	3720.5	2425.6	1101.8
3	3176.7	1896.2	1023.1	356.2	5100.4	3656.2	2368.6	1065.6
4	3115.0	1846.2	989.1	340.9	5042.2	3593.1	2312.8	1030.6
5	3054.5	1797.6	956.2	326.2	4984.6	3531.0	2258.4	996.8
10	2769.0	1572.9	807.4	261.8	4706.5	3236.4	2004.9	843.5
15	2510.2	1376.3	681.8	210.1	4443.8	2966.3	1779.9	713.8
20	2275.5	1204.3	575.7	168.6	4195.9	2718.8	1580.1	604.1
30	1870.1	922.0	410.5	108.6	3740.7	2284.0	1245.3	432.6
40	1536.8	706.0	292.7	69.9	3334.9	1918.7	981.4	309.8
50	1263.0	540.5	208.7	45.0	2973.1	1611.9	773.4	221.9
60	1037.9	413.8	148.8	29.0	2650.6	1354.1	609.5	158.9
70	853.0	316.8	106.1	18.7	2363.0	1137.5	480.4	113.8
80	701.0	242.6	75.6	12.0	2106.7	955.6	378.6	81.5
90	576.1	185.7	53.9	7.7	1878.1	802.8	298.4	58.4
100	473.4	142.2	38.5	5.0	1674.4	674.4	235.1	41.8

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	79.6	105.0	151.4	266.8
1.0	29.9	39.5	56.9	100.3
1.5	11.9	15.7	22.7	39.9
2.0	4.1	5.4	7.8	13.7
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	67.4	88.9	128.2	225.9
2.0	21.9	28.8	41.6	73.2
3.0	6.8	9.0	12.9	22.8
4.0	1.3	1.7	2.5	4.3

LOCATION OF TERMINAL: JACKSONVILLE, FL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.070 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 4.926 dB; @ 30 GHz: 9.104 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.108; @ 30 GHz: 1.098

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	3785.1	2782.8	1861.2	885.8	4748.1	3979.7	3076.7	1826.8
1	3741.7	2735.0	1817.8	857.2	4719.3	3938.3	3029.1	1783.8
2	3698.8	2688.0	1775.5	829.4	4690.6	3897.3	2982.3	1741.8
3	3656.3	2641.7	1734.2	802.6	4662.0	3856.8	2936.2	1700.8
4	3614.4	2596.3	1693.8	776.6	4633.7	3816.7	2890.8	1660.7
5	3572.9	2551.7	1654.3	751.5	4605.5	3777.0	2846.1	1621.6
10	3372.7	2339.7	1470.5	637.6	4467.2	3584.7	2632.8	1439.5
15	3183.6	2145.4	1307.0	540.9	4333.0	3402.2	2435.5	1277.8
20	3005.2	1967.2	1161.8	458.9	4202.8	3229.0	2253.0	1134.3
30	2677.7	1654.0	917.9	330.3	3954.1	2908.6	1928.0	893.8
40	2386.0	1390.6	725.2	237.8	3720.2	2620.0	1649.9	704.3
50	2126.0	1169.2	572.9	171.1	3500.0	2360.0	1411.8	555.0
60	1894.4	983.1	452.7	123.2	3292.9	2125.8	1208.2	437.3
70	1688.0	826.5	357.6	88.7	3098.0	1914.8	1033.9	344.6
80	1504.0	694.9	282.6	63.8	2914.7	1724.8	884.7	271.6
90	1340.2	584.3	223.2	45.9	2742.2	1553.7	757.1	214.0
100	1194.1	491.3	176.4	33.1	2580.0	1399.5	647.9	168.6

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	79.8	105.2	151.7	267.3
1.0	30.0	39.6	57.0	100.5
1.5	11.9	15.7	22.7	40.0
2.0	4.1	5.4	7.8	13.7
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	65.5	86.4	124.6	219.5
2.0	21.2	28.0	40.4	71.1
3.0	6.6	8.7	12.6	22.1
4.0	1.3	1.7	2.4	4.2

LOCATION OF TERMINAL: MIAMI, FL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.992 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 6.062 dB; @ 30 GHz: 11.273 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.021; @ 30 GHz: 1.009

TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS

FADE DURATION (Minutes)	20GHz 3dB	20GHz 5dB	20GHz 8dB	20GHz 15dB	30GHz 3dB	30GHz 5dB	30GHz 8dB	30GHz 15dB
0	3937.5	2999.5	2050.4	978.1	4723.3	4120.9	3303.0	2027.6
1	3902.4	2955.9	2007.7	948.4	4704.4	4088.7	3261.1	1985.0
2	3867.5	2912.9	1965.9	919.6	4685.5	4056.7	3219.6	1943.4
3	3833.0	2870.5	1925.0	891.6	4666.8	4024.9	3178.7	1902.6
4	3798.8	2828.7	1884.9	864.5	4648.1	3993.5	3138.3	1862.7
5	3764.9	2787.5	1845.7	838.2	4629.5	3962.2	3098.4	1823.6
10	3599.8	2590.5	1661.4	718.3	4537.6	3809.7	2906.4	1640.1
15	3442.0	2407.4	1495.5	615.6	4447.6	3663.0	2726.4	1475.1
20	3291.1	2237.3	1346.1	527.5	4359.3	3522.0	2557.5	1326.6
30	3008.9	1932.2	1090.7	387.4	4188.0	3256.0	2250.4	1073.1
40	2750.9	1668.7	883.8	284.5	4023.4	3010.1	1980.2	868.0
50	2515.0	1441.2	716.1	208.9	3865.3	2782.7	1742.4	702.1
60	2299.3	1244.7	580.2	153.5	3713.4	2572.6	1533.2	567.9
70	2102.1	1074.9	470.1	112.7	3567.5	2378.3	1349.1	459.4
80	1921.8	928.4	380.9	82.8	3427.3	2198.7	1187.1	371.6
90	1757.0	801.8	308.6	60.8	3292.6	2032.6	1044.6	300.6
100	1606.3	692.4	250.1	44.6	3163.2	1879.1	919.1	243.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	94.0	123.9	178.7	314.8
1.0	35.3	46.6	67.2	118.4
1.5	14.1	18.5	26.7	47.1
2.0	4.8	6.3	9.2	16.1
2.5	1.0	1.3	1.9	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	77.6	102.3	147.6	260.0
2.0	25.2	33.2	47.8	84.3
3.0	7.8	10.3	14.9	26.2
4.0	1.5	2.0	2.8	5.0

LOCATION OF TERMINAL: TAMPA, FL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.144 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 4.075 dB; @ 30 GHz: 7.942 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.040; @ 30 GHz: 1.013

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3706.5	2540.2	1554.7	632.6	5006.2	4069.3	2992.2	1595.6
1	3657.4	2490.1	1513.4	609.4	4973.8	4023.0	2941.0	1553.7
2	3609.0	2440.9	1473.2	587.2	4941.5	3977.3	2890.7	1513.0
3	3561.1	2392.7	1434.1	565.7	4909.5	3932.1	2841.2	1473.3
4	3514.0	2345.5	1396.0	545.0	4877.7	3887.4	2792.6	1434.7
5	3467.4	2299.2	1358.9	525.1	4846.1	3843.2	2744.8	1397.1
10	3243.7	2081.1	1187.8	435.9	4691.1	3629.7	2518.0	1223.2
15	3034.4	1883.6	1038.3	361.9	4541.1	3428.0	2309.8	1071.0
20	2838.6	1704.9	907.6	300.4	4395.9	3237.6	2118.9	937.8
30	2484.1	1396.7	693.4	207.0	4119.3	2887.8	1783.1	718.9
40	2173.9	1144.3	529.8	142.7	3860.0	2575.9	1500.5	551.2
50	1902.4	937.4	404.8	98.3	3617.1	2297.6	1262.6	422.5
60	1664.8	768.0	309.3	67.8	3389.5	2049.4	1062.5	323.9
70	1456.9	629.2	236.3	46.7	3176.2	1828.0	894.1	248.3
80	1275.0	515.4	180.6	32.2	2976.3	1630.5	752.4	190.4
90	1115.8	422.3	138.0	22.2	2789.0	1454.4	633.2	146.0
100	976.4	345.9	105.4	15.3	2613.5	1297.3	532.8	111.9

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	90.6	119.4	172.2	303.4
1.0	34.0	44.9	64.7	114.1
1.5	13.6	17.9	25.8	45.4
2.0	4.6	6.1	8.8	15.5
2.5	0.9	1.2	1.8	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	77.0	101.6	146.5	258.0
2.0	25.0	32.9	47.5	83.6
3.0	7.8	10.2	14.8	26.0
4.0	1.5	2.0	2.8	5.0

LOCATION OF TERMINAL: ATLANTA, GA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.974 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.190 dB; @ 30 GHz: 4.644 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.008; @ 30 GHz: 0.952

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3917.4	2141.6	1030.5	291.7	7027.7	4869.4	2946.2	1130.9
1	3833.5	2078.9	992.3	277.7	6948.0	4781.4	2871.6	1090.0
2	3751.3	2018.0	955.5	264.3	6869.2	4695.0	2798.8	1050.5
3	3671.0	1958.9	920.0	251.6	6791.3	4610.2	2727.8	1012.5
4	3592.4	1901.5	885.9	239.5	6714.3	4526.9	2658.7	975.9
5	3515.4	1845.8	853.0	228.0	6638.2	4445.1	2591.3	940.5
10	3154.8	1590.9	706.1	178.2	6270.3	4057.8	2279.2	782.2
15	2831.1	1371.2	584.4	139.2	5922.7	3704.2	2004.6	650.6
20	2540.6	1181.8	483.8	108.8	5594.5	3381.4	1763.1	541.1
30	2046.0	877.9	331.5	66.4	4991.5	2817.8	1363.9	374.3
40	1647.7	652.1	227.1	40.6	4453.5	2348.1	1055.1	258.9
50	1326.9	484.4	155.6	24.8	3973.5	1956.7	816.2	179.1
60	1068.6	359.9	106.6	15.1	3545.2	1630.6	631.4	123.9
70	860.6	267.3	73.0	9.2	3163.1	1358.8	488.5	85.7
80	693.1	198.6	50.0	5.6	2822.2	1132.3	377.9	59.3
90	558.1	147.5	34.3	3.4	2518.0	943.6	292.3	41.0
100	449.5	109.6	23.5	2.1	2246.6	786.3	226.1	28.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	96.5	127.2	183.4	323.1
1.0	36.3	47.8	69.0	121.5
1.5	14.4	19.0	27.5	48.4
2.0	4.9	6.5	9.4	16.5
2.5	1.0	1.3	1.9	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	87.3	115.1	166.0	292.4
2.0	28.3	37.3	53.8	94.8
3.0	8.8	11.6	16.7	29.5
4.0	1.7	2.2	3.2	5.6

LOCATION OF TERMINAL: HONOLULU, HI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 3.174 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.032 dB; @ 30 GHz: 2.076 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.363; @ 30 GHz: 1.343

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3622.0	2063.2	1111.0	414.3	6544.2	4279.7	2629.6	1175.0
1	3518.0	1991.2	1065.6	393.9	6407.7	4165.7	2544.6	1127.6
2	3417.1	1921.7	1022.0	374.6	6274.1	4054.6	2462.3	1082.1
3	3319.0	1854.6	980.2	356.2	6143.2	3946.6	2382.6	1038.4
4	3223.8	1789.8	940.2	338.7	6015.1	3841.4	2305.6	996.5
5	3131.3	1727.4	901.8	322.1	5889.6	3739.0	2231.0	956.3
10	2707.1	1446.2	732.0	250.4	5300.5	3266.7	1892.8	778.3
15	2340.4	1210.8	594.1	194.7	4770.3	2854.0	1605.9	633.4
20	2023.3	1013.7	482.3	151.4	4293.1	2493.4	1362.5	515.5
30	1512.3	710.5	317.7	91.5	3477.2	1903.2	980.7	341.4
40	1130.3	498.0	209.3	55.3	2816.3	1452.7	705.9	226.2
50	844.8	349.1	137.9	33.4	2281.1	1108.9	508.1	149.8
60	631.4	244.7	90.9	20.2	1847.5	846.4	365.7	99.2
70	471.9	171.5	59.9	12.2	1496.4	646.1	263.3	65.7
80	352.7	120.2	39.4	7.4	1212.0	493.1	189.5	43.5
90	263.6	84.3	26.0	4.5	981.7	376.4	136.4	28.8
100	197.0	59.1	17.1	2.7	795.1	287.3	98.2	19.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	52.7	69.5	100.2	176.6
1.0	19.8	26.1	37.7	66.4
1.5	7.9	10.4	15.0	26.4
2.0	2.7	3.6	5.1	9.0
2.5	0.5	0.7	1.0	1.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	43.8	57.8	83.4	146.9
2.0	14.2	18.7	27.0	47.6
3.0	4.4	5.8	8.4	14.8
4.0	0.8	1.1	1.6	2.8

LOCATION OF TERMINAL: CAIRO, IL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.629 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.802 dB; @ 30 GHz: 5.751 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.949; @ 30 GHz: 0.908

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	4038.5	2320.7	1152.1	330.1	6538.4	4808.7	3069.2	1248.2
1	3965.8	2260.5	1112.8	315.1	6481.8	4736.6	3001.1	1206.7
2	3894.5	2201.8	1075.0	300.7	6425.6	4665.6	2934.6	1166.7
3	3824.4	2144.7	1038.4	287.0	6370.0	4595.6	2869.5	1128.0
4	3755.6	2089.0	1003.0	273.9	6314.8	4526.7	2805.9	1090.5
5	3688.0	2034.8	968.9	261.4	6260.1	4458.9	2743.7	1054.4
10	3368.0	1784.2	814.9	207.0	5993.8	4134.5	2452.8	890.6
15	3075.8	1564.4	685.3	164.0	5738.7	3833.8	2192.7	752.3
20	2808.9	1371.7	576.4	129.9	5494.5	3554.9	1960.2	635.5
30	2342.6	1054.6	407.7	81.4	5036.8	3056.6	1566.5	453.5
40	1953.7	810.8	288.4	51.1	4617.3	2628.1	1251.9	323.6
50	1629.4	623.3	204.0	32.0	4232.7	2259.6	1000.5	230.9
60	1358.9	479.2	144.3	20.1	3880.1	1942.9	799.5	164.8
70	1133.3	368.4	102.1	12.6	3556.9	1670.5	639.0	117.6
80	945.2	283.2	72.2	7.9	3260.7	1436.3	510.6	83.9
90	788.3	217.8	51.1	5.0	2989.1	1234.9	408.1	59.9
100	657.4	167.4	36.1	3.1	2740.1	1061.8	326.1	42.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	108.8	143.5	206.9	364.5
1.0	40.9	53.9	77.8	137.0
1.5	16.3	21.5	31.0	54.5
2.0	5.6	7.3	10.6	18.7
2.5	1.1	1.5	2.1	3.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	95.8	126.3	182.1	320.8
2.0	31.0	40.9	59.0	104.0
3.0	9.6	12.7	18.3	32.3
4.0	1.8	2.4	3.5	6.2

LOCATION OF TERMINAL: CHICAGO, IL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.599 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.624 dB; @ 30 GHz: 3.421 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.090; @ 30 GHz: 1.041

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2411.0	1270.4	603.0	173.8	4627.4	3008.5	1742.8	654.3
1	2350.2	1228.7	578.8	165.0	4556.4	2941.8	1691.8	628.5
2	2291.0	1188.4	555.5	156.7	4486.4	2876.5	1642.4	603.7
3	2233.2	1149.5	533.2	148.8	4417.6	2812.7	1594.4	579.9
4	2176.9	1111.8	511.8	141.3	4349.8	2750.3	1547.7	557.1
5	2122.0	1075.3	491.2	134.2	4283.0	2689.2	1502.5	535.1
10	1867.7	910.2	400.1	103.6	3964.3	2403.8	1295.3	437.6
15	1643.8	770.4	325.9	79.9	3669.3	2148.7	1116.7	357.9
20	1446.8	652.1	265.5	61.7	3396.2	1920.7	962.8	292.7
30	1120.7	467.2	176.2	36.8	2909.6	1534.7	715.6	195.7
40	868.2	334.7	116.9	21.9	2492.6	1226.2	531.9	130.9
50	672.5	239.8	77.6	13.0	2135.4	979.8	395.3	87.5
60	521.0	171.8	51.5	7.8	1829.4	782.8	293.8	58.5
70	403.6	123.1	34.2	4.6	1567.3	625.5	218.4	39.2
80	312.6	88.2	22.7	2.8	1342.7	499.8	162.3	26.2
90	242.2	63.2	15.0	1.6	1150.3	399.3	120.6	17.5
100	187.6	45.3	10.0	1.0	985.5	319.1	89.7	11.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	82.5	108.8	156.9	276.4
1.0	31.0	40.9	59.0	103.9
1.5	12.3	16.3	23.5	41.4
2.0	4.2	5.6	8.0	14.2
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	73.0	96.2	138.7	244.4
2.0	23.6	31.2	45.0	79.2
3.0	7.3	9.7	14.0	24.6
4.0	1.4	1.8	2.7	4.7

LOCATION OF TERMINAL: PEORIA, IL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.146 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.521 dB; @ 30 GHz: 4.953 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.074; @ 30 GHz: 1.052

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2624.7	1577.2	849.8	291.3	4116.7	2991.0	1953.4	879.6
1	2574.2	1535.6	821.3	278.5	4070.8	2939.8	1907.4	850.5
2	2524.6	1495.1	793.8	266.4	4025.5	2889.4	1862.4	822.3
3	2476.0	1455.7	767.2	254.7	3980.6	2839.9	1818.5	795.0
4	2428.4	1417.3	741.4	243.6	3936.3	2791.2	1775.7	768.6
5	2381.6	1379.9	716.6	233.0	3892.4	2743.4	1733.8	743.1
10	2161.1	1207.2	604.2	186.4	3680.3	2516.3	1539.0	627.8
15	1960.9	1056.1	509.5	149.1	3479.8	2308.0	1366.0	530.4
20	1779.3	924.0	429.6	119.2	3290.1	2117.0	1212.4	448.1
30	1465.0	707.2	305.5	76.3	2941.3	1781.0	955.2	319.8
40	1206.3	541.3	217.2	48.8	2629.5	1498.4	752.5	228.3
50	993.2	414.3	154.4	31.2	2350.8	1260.6	592.9	162.9
60	817.8	317.1	109.8	20.0	2101.5	1060.5	467.1	116.3
70	673.3	242.7	78.1	12.8	1878.7	892.2	368.0	83.0
80	554.4	185.8	55.5	8.2	1679.6	750.6	289.9	59.2
90	456.5	142.2	39.5	5.2	1501.5	631.5	228.4	42.3
100	375.8	108.8	28.1	3.3	1342.3	531.3	179.9	30.2

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	85.0	112.1	161.6	284.7
1.0	31.9	42.1	60.8	107.0
1.5	12.7	16.8	24.2	42.6
2.0	4.4	5.7	8.3	14.6
2.5	0.9	1.2	1.7	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	71.5	94.3	135.9	239.5
2.0	23.2	30.6	44.1	77.6
3.0	7.2	9.5	13.7	24.1
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: SPRINGFIELD, IL

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.203 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.306 dB; @ 30 GHz: 4.607 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.082; @ 30 GHz: 1.053

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2554.9	1500.1	791.1	263.9	4163.6	2966.8	1898.0	828.9
1	2502.8	1458.7	763.6	252.0	4113.9	2913.2	1851.3	800.5
2	2451.7	1418.4	737.0	240.7	4064.9	2860.6	1805.7	773.0
3	2401.7	1379.2	711.4	229.9	4016.4	2808.9	1761.3	746.5
4	2352.7	1341.1	686.7	219.5	3968.5	2758.1	1717.9	720.9
5	2304.7	1304.1	662.8	209.7	3921.2	2708.3	1675.6	696.2
10	2078.9	1133.7	555.2	166.6	3693.0	2472.3	1479.3	584.7
15	1875.2	985.6	465.2	132.4	3478.0	2256.8	1306.0	491.1
20	1691.5	856.8	389.7	105.2	3275.5	2060.2	1153.0	412.4
30	1376.3	647.5	273.5	66.5	2905.3	1716.8	898.7	290.9
40	1119.9	489.4	191.9	42.0	2576.9	1430.6	700.5	205.2
50	911.2	369.8	134.7	26.5	2285.6	1192.1	546.0	144.7
60	741.4	279.5	94.5	16.7	2027.3	993.4	425.5	102.1
70	603.3	211.2	66.4	10.6	1798.2	827.8	331.7	72.0
80	490.9	159.6	46.6	6.7	1594.9	689.8	258.5	50.8
90	399.4	120.7	32.7	4.2	1414.6	574.8	201.5	35.8
100	325.0	91.2	22.9	2.7	1254.7	479.0	157.1	25.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.7	110.4	159.2	280.5
1.0	31.5	41.5	59.9	105.4
1.5	12.5	16.5	23.8	42.0
2.0	4.3	5.7	8.2	14.4
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	71.3	94.1	135.7	239.0
2.0	23.1	30.5	44.0	77.5
3.0	7.2	9.5	13.7	24.1
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: EVANSVILLE, IN

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.197 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 3.201 dB; @ 30 GHz: 6.242 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.024; @ 30 GHz: 1.004

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3307.6	2088.2	1168.4	414.0	4831.0	3699.0	2534.1	1204.8
1	3254.1	2039.6	1132.8	397.1	4789.8	3646.7	2482.2	1168.5
2	3201.5	1992.2	1098.2	380.8	4748.9	3595.1	2431.4	1133.2
3	3149.7	1945.9	1064.7	365.2	4708.4	3544.2	2381.6	1099.0
4	3098.8	1900.6	1032.2	350.2	4668.2	3494.1	2332.9	1065.9
5	3048.7	1856.4	1000.7	335.9	4628.4	3444.6	2285.2	1033.7
10	2810.1	1650.4	857.1	272.5	4434.2	3207.7	2060.7	886.9
15	2590.2	1467.2	734.0	221.0	4248.2	2987.1	1858.3	761.0
20	2387.4	1304.4	628.7	179.3	4070.1	2781.6	1675.8	652.9
30	2028.3	1030.9	461.1	118.0	3735.8	2412.1	1362.8	480.7
40	1723.3	814.8	338.2	77.7	3429.0	2091.7	1108.2	353.9
50	1464.1	643.9	248.1	51.1	3147.3	1813.8	901.2	260.5
60	1243.9	508.9	182.0	33.6	2888.8	1572.9	732.9	191.8
70	1056.8	402.2	133.5	22.1	2651.6	1364.0	596.0	141.2
80	897.8	317.9	97.9	14.6	2433.8	1182.8	484.6	103.9
90	762.8	251.2	71.8	9.6	2233.9	1025.7	394.1	76.5
100	648.1	198.6	52.7	6.3	2050.4	889.4	320.5	56.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	93.4	123.2	177.6	312.9
1.0	35.1	46.3	66.8	117.6
1.5	14.0	18.4	26.6	46.8
2.0	4.8	6.3	9.1	16.0
2.5	1.0	1.3	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	78.4	103.3	149.0	262.5
2.0	25.4	33.5	48.3	85.1
3.0	7.9	10.4	15.0	26.4
4.0	1.5	2.0	2.9	5.0

LOCATION OF TERMINAL: FORT WAYNE, IN

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.624 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.711 dB; @ 30 GHz: 3.599 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.043; @ 30 GHz: 0.997

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2522.0	1298.7	595.1	160.0	4890.1	3167.5	1806.9	650.3
1	2459.4	1256.2	571.0	151.8	4818.5	3098.8	1754.5	624.5
2	2398.3	1215.0	547.9	144.0	4748.0	3031.7	1703.6	599.8
3	2338.8	1175.3	525.8	136.6	4678.6	2966.0	1654.2	576.0
4	2280.7	1136.8	504.5	129.6	4610.1	2901.7	1606.3	553.2
5	2224.1	1099.6	484.1	123.0	4542.7	2838.8	1559.7	531.2
10	1961.4	931.1	393.8	94.6	4220.0	2544.2	1346.3	434.0
15	1729.7	788.4	320.3	72.7	3920.2	2280.2	1162.1	354.5
20	1525.4	667.5	260.6	55.9	3641.7	2043.6	1003.2	289.6
30	1186.3	478.6	172.4	33.0	3142.6	1641.5	747.5	193.3
40	922.6	343.1	114.1	19.5	2711.9	1318.5	556.9	129.0
50	717.5	246.0	75.5	11.5	2340.3	1059.0	415.0	86.1
60	558.0	176.4	50.0	6.8	2019.6	850.6	309.2	57.4
70	434.0	126.4	33.1	4.0	1742.8	683.3	230.4	38.3
80	337.5	90.7	21.9	2.4	1504.0	548.8	171.7	25.6
90	262.5	65.0	14.5	1.4	1297.9	440.8	127.9	17.1
100	204.1	46.6	9.6	0.8	1120.0	354.1	95.3	11.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	90.0	118.7	171.1	301.5
1.0	33.8	44.6	64.3	113.3
1.5	13.5	17.8	25.6	45.1
2.0	4.6	6.1	8.8	15.4
2.5	0.9	1.2	1.8	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	79.5	104.8	151.2	266.3
2.0	25.8	34.0	49.0	86.3
3.0	8.0	10.6	15.2	26.8
4.0	1.5	2.0	2.9	5.1

LOCATION OF TERMINAL: INDIANAPOLIS, IN

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.386 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.470 dB; @ 30 GHz: 4.997 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.015; @ 30 GHz: 0.982

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3092.2	1775.8	899.8	275.1	5092.1	3643.8	2302.7	958.0
1	3031.4	1727.4	868.3	262.5	5037.7	3581.7	2247.6	925.2
2	2971.8	1680.2	838.0	250.5	4983.9	3520.8	2193.8	893.5
3	2913.3	1634.4	808.7	239.0	4930.7	3460.9	2141.3	862.9
4	2856.0	1589.8	780.5	228.1	4878.1	3402.0	2090.1	833.3
5	2799.9	1546.4	753.2	217.6	4826.0	3344.1	2040.1	804.7
10	2535.2	1346.6	630.6	172.2	4573.9	3069.0	1807.5	676.0
15	2295.5	1172.7	527.9	136.3	4335.0	2816.6	1601.4	567.8
20	2078.5	1021.2	441.9	107.8	4108.5	2584.9	1418.8	476.9
30	1704.1	774.4	309.7	67.5	3690.4	2177.2	1113.7	336.5
40	1397.2	587.2	217.1	42.3	3314.9	1833.8	874.2	237.4
50	1145.5	445.3	152.1	26.5	2977.6	1544.5	686.2	167.5
60	939.2	337.7	106.6	16.6	2674.6	1300.9	538.6	118.2
70	770.0	256.1	74.7	10.4	2402.4	1095.7	422.8	83.4
80	631.3	194.2	52.4	6.5	2157.9	922.9	331.9	58.8
90	517.6	147.2	36.7	4.1	1938.4	777.3	260.5	41.5
100	424.4	111.7	25.7	2.5	1741.1	654.7	204.5	29.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	95.2	125.5	181.0	318.8
1.0	35.8	47.2	68.0	119.8
1.5	14.2	18.8	27.1	47.7
2.0	4.9	6.4	9.3	16.3
2.5	1.0	1.3	1.9	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	82.0	108.2	156.0	274.8
2.0	26.6	35.1	50.6	89.1
3.0	8.3	10.9	15.7	27.7
4.0	1.6	2.1	3.0	5.3

LOCATION OF TERMINAL: LEXINGTON, KY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.682 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.511 dB; @ 30 GHz: 5.185 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.941; @ 30 GHz: 0.900

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3761.2	2053.9	965.2	254.3	6444.9	4566.8	2787.3	1052.9
1	3687.4	1996.6	930.2	242.1	6382.1	4491.6	2720.5	1015.8
2	3615.0	1941.0	896.6	230.5	6319.9	4417.6	2655.4	979.9
3	3544.1	1886.9	864.2	219.5	6258.4	4344.9	2591.7	945.3
4	3474.5	1834.3	832.9	209.0	6197.4	4273.3	2529.6	912.0
5	3406.3	1783.1	802.8	198.9	6137.0	4202.9	2469.0	879.8
10	3084.8	1548.0	667.7	155.6	5843.8	3868.0	2187.1	735.1
15	2793.7	1344.0	555.4	121.7	5564.6	3559.8	1937.4	614.2
20	2530.1	1166.8	461.9	95.2	5298.7	3276.1	1716.2	513.2
30	2075.1	879.4	319.6	58.3	4804.5	2774.8	1346.6	358.3
40	1701.9	662.8	221.1	35.6	4356.4	2350.2	1056.6	250.1
50	1395.9	499.6	152.9	21.8	3950.1	1990.6	829.1	174.6
60	1144.9	376.5	105.8	13.3	3581.6	1686.0	650.6	121.9
70	939.0	283.8	73.2	8.2	3247.6	1428.0	510.5	85.1
80	770.1	213.9	50.6	5.0	2944.7	1209.5	400.6	59.4
90	631.6	161.2	35.0	3.1	2670.0	1024.4	314.3	41.5
100	518.0	121.5	24.2	1.9	2421.0	867.6	246.6	29.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	110.7	145.9	210.4	370.7
1.0	41.6	54.9	79.1	139.4
1.5	16.6	21.8	31.5	55.5
2.0	5.7	7.5	10.8	19.0
2.5	1.1	1.5	2.2	3.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	97.5	128.6	185.5	326.7
2.0	31.6	41.7	60.1	105.9
3.0	9.8	13.0	18.7	32.9
4.0	1.9	2.5	3.6	6.3

LOCATION OF TERMINAL: LOUISVILLE, KY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.610 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.452 dB; @ 30 GHz: 5.046 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.006; @ 30 GHz: 0.964

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3561.8	2027.9	1016.1	304.4	5972.3	4267.2	2679.9	1095.4
1	3491.3	1972.2	980.3	290.4	5909.8	4195.2	2615.8	1057.6
2	3422.2	1917.9	945.8	277.0	5848.0	4124.3	2553.3	1021.2
3	3354.4	1865.2	912.5	264.2	5786.8	4054.7	2492.3	986.0
4	3288.0	1813.9	880.3	252.0	5726.2	3986.3	2432.7	952.1
5	3223.0	1764.0	849.3	240.4	5666.3	3919.0	2374.6	919.3
10	2916.4	1534.5	709.9	189.8	5376.0	3599.1	2104.1	771.5
15	2638.9	1334.8	593.4	149.9	5100.5	3305.4	1864.4	647.5
20	2387.9	1161.1	496.1	118.3	4839.2	3035.7	1652.0	543.4
30	1955.2	878.6	346.6	73.8	4356.0	2560.4	1297.1	382.8
40	1600.9	664.8	242.2	46.0	3921.1	2159.6	1018.4	269.6
50	1310.8	503.0	169.2	28.7	3529.6	1821.5	799.6	189.9
60	1073.3	380.6	118.2	17.9	3177.1	1536.3	627.8	133.8
70	878.8	288.0	82.6	11.1	2859.9	1295.8	492.9	94.2
80	719.5	217.9	57.7	7.0	2574.3	1092.9	387.0	66.4
90	589.1	164.9	40.3	4.3	2317.3	921.8	303.9	46.7
100	482.4	124.8	28.2	2.7	2085.9	777.5	238.6	32.9

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	96.7	127.5	183.9	324.0
1.0	36.4	47.9	69.2	121.8
1.5	14.5	19.1	27.5	48.5
2.0	5.0	6.5	9.4	16.6
2.5	1.0	1.3	1.9	3.4

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	85.0	112.1	161.6	284.7
2.0	27.5	36.3	52.4	92.3
3.0	8.6	11.3	16.3	28.7
4.0	1.6	2.2	3.1	5.5

LOCATION OF TERMINAL: NEW ORLEANS, LA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.088 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 5.914 dB; @ 30 GHz: 11.271 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.961; @ 30 GHz: 0.941

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	4349.8	3258.4	2155.2	951.9	5267.3	4614.4	3675.7	2178.3
1	4311.7	3210.4	2108.9	921.7	5249.1	4580.7	3630.1	2131.9
2	4273.9	3163.1	2063.7	892.5	5231.0	4547.3	3585.0	2086.5
3	4236.5	3116.5	2019.4	864.1	5212.9	4514.1	3540.4	2042.1
4	4199.4	3070.6	1976.1	836.7	5194.9	4481.2	3496.5	1998.6
5	4162.6	3025.4	1933.7	810.1	5176.9	4448.5	3453.0	1956.1
10	3983.5	2809.0	1735.1	689.5	5088.0	4288.5	3243.8	1756.5
15	3812.1	2608.2	1556.8	586.8	5000.7	4134.3	3047.3	1577.3
20	3648.1	2421.6	1396.9	499.4	4914.9	3985.6	2862.7	1416.4
30	3341.0	2087.7	1124.6	361.7	4747.6	3704.1	2526.4	1142.1
40	3059.7	1799.8	905.4	261.9	4586.0	3442.5	2229.5	921.0
50	2802.0	1551.6	728.9	189.7	4429.9	3199.4	1967.6	742.6
60	2566.1	1337.6	586.8	137.4	4279.1	2973.4	1736.4	598.8
70	2350.1	1153.1	472.4	99.5	4133.5	2763.4	1532.4	482.9
80	2152.2	994.1	380.3	72.1	3992.8	2568.2	1352.3	389.4
90	1971.0	857.0	306.2	52.2	3856.9	2386.8	1193.4	314.0
100	1805.0	738.8	246.5	37.8	3725.7	2218.3	1053.2	253.2

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	106.1	139.9	201.8	355.5
1.0	39.9	52.6	75.9	133.6
1.5	15.9	20.9	30.2	53.2
2.0	5.4	7.2	10.3	18.2
2.5	1.1	1.4	2.1	3.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	89.3	117.8	169.9	299.3
2.0	29.0	38.2	55.1	97.0
3.0	9.0	11.9	17.1	30.2
4.0	1.7	2.3	3.3	5.8

LOCATION OF TERMINAL: BALTIMORE, MD

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.844 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.085 dB; @ 30 GHz: 4.319 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.087; @ 30 GHz: 1.043

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3578.2	2041.8	1047.9	336.9	6176.0	4308.5	2688.7	1127.1
1	3500.4	1982.4	1009.9	321.3	6098.2	4226.9	2619.7	1087.1
2	3424.3	1924.8	973.2	306.4	6021.4	4146.8	2552.5	1048.4
3	3349.8	1868.9	937.9	292.1	5945.5	4068.3	2487.0	1011.2
4	3277.0	1814.6	903.9	278.6	5870.6	3991.2	2423.2	975.2
5	3205.7	1761.9	871.1	265.7	5796.7	3915.6	2361.1	940.6
10	2871.9	1520.4	724.2	209.5	5440.7	3558.5	2073.4	784.9
15	2572.9	1312.0	602.0	165.1	5106.5	3234.0	1820.7	655.0
20	2305.0	1132.2	500.5	130.2	4792.9	2939.1	1598.9	546.6
30	1850.0	843.1	345.9	80.9	4222.3	2427.4	1233.0	380.6
40	1484.9	627.8	239.0	50.3	3719.6	2004.9	950.8	265.1
50	1191.8	467.5	165.2	31.3	3276.7	1655.9	733.2	184.6
60	956.5	348.1	114.2	19.4	2886.6	1367.6	565.4	128.5
70	767.7	259.2	78.9	12.1	2542.9	1129.6	436.0	89.5
80	616.2	193.0	54.5	7.5	2240.2	932.9	336.2	62.3
90	494.5	143.8	37.7	4.7	1973.5	770.5	259.3	43.4
100	396.9	107.0	26.0	2.9	1738.5	636.4	200.0	30.2

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	82.9	109.3	157.6	277.7
1.0	31.2	41.1	59.3	104.4
1.5	12.4	16.4	23.6	41.6
2.0	4.2	5.6	8.1	14.2
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	72.7	95.9	138.3	243.6
2.0	23.6	31.1	44.8	79.0
3.0	7.3	9.7	13.9	24.5
4.0	1.4	1.8	2.7	4.7

LOCATION OF TERMINAL: BOSTON, MA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.762 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.628 dB; @ 30 GHz: 3.527 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.989; @ 30 GHz: 0.935

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3898.4	1864.8	781.3	180.1	8260.4	5149.5	2768.5	883.6
1	3796.7	1800.4	747.9	170.3	8138.5	5034.6	2684.9	846.8
2	3697.8	1738.2	715.9	161.1	8018.5	4922.2	2603.8	811.5
3	3601.4	1678.3	685.3	152.3	7900.2	4812.3	2525.1	777.7
4	3507.5	1620.3	656.0	144.1	7783.7	4704.9	2448.8	745.3
5	3416.1	1564.4	627.9	136.3	7668.8	4599.9	2374.9	714.2
10	2993.5	1312.4	504.7	103.1	7119.7	4109.1	2037.2	577.3
15	2623.2	1101.0	405.7	78.1	6609.9	3670.6	1747.5	466.6
20	2298.7	923.7	326.0	59.1	6136.5	3278.8	1499.0	377.2
30	1765.1	650.1	210.6	33.8	5289.1	2616.4	1103.1	246.4
40	1355.4	457.5	136.1	19.4	4558.8	2087.8	811.7	161.0
50	1040.8	322.0	87.9	11.1	3929.2	1665.9	597.3	105.2
60	799.2	226.6	56.8	6.4	3386.7	1329.3	439.5	68.7
70	613.7	159.5	36.7	3.6	2919.0	1060.8	323.4	44.9
80	471.2	112.3	23.7	2.1	2515.9	846.4	238.0	29.3
90	361.9	79.0	15.3	1.2	2168.5	675.4	175.1	19.2
100	277.9	55.6	9.9	0.7	1869.0	539.0	128.8	12.5

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	100.1	132.0	190.4	335.3
1.0	37.6	49.6	71.6	126.1
1.5	15.0	19.8	28.5	50.2
2.0	5.1	6.8	9.7	17.2
2.5	1.0	1.4	2.0	3.5

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	90.4	119.1	171.8	302.7
2.0	29.3	38.6	55.7	98.1
3.0	9.1	12.0	17.3	30.5
4.0	1.7	2.3	3.3	5.8

LOCATION OF TERMINAL: ALPINA, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 3.417 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.521 dB; @ 30 GHz: 1.232 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.223; @ 30 GHz: 1.141

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	1370.3	580.1	229.9	54.2	3909.2	1970.2	906.5	255.1
1	1316.0	552.8	217.5	50.7	3797.1	1899.0	867.2	241.6
2	1263.9	526.9	205.7	47.5	3688.3	1830.4	829.6	228.7
3	1213.8	502.1	194.6	44.5	3582.6	1764.3	793.7	216.5
4	1165.7	478.5	184.1	41.7	3479.9	1700.6	759.3	205.0
5	1119.5	456.0	174.2	39.0	3380.1	1639.1	726.4	194.1
10	914.6	358.4	132.0	28.1	2922.7	1363.7	582.2	147.6
15	747.2	281.7	100.0	20.3	2527.2	1134.5	466.6	112.3
20	610.5	221.4	75.8	14.6	2185.2	943.9	373.9	85.4
30	407.5	136.8	43.5	7.6	1633.8	653.3	240.1	49.4
40	272.0	84.5	25.0	3.9	1221.5	452.2	154.2	28.6
50	181.5	52.2	14.3	2.0	913.3	313.0	99.1	16.6
60	121.2	32.3	8.2	1.1	682.8	216.6	63.6	9.6
70	80.9	19.9	4.7	0.6	510.5	150.0	40.9	5.5
80	54.0	12.3	2.7	0.3	381.7	103.8	26.2	3.2
90	36.0	7.6	1.6	0.1	285.4	71.8	16.9	1.9
100	24.1	4.7	0.9	0.1	213.4	49.7	10.8	1.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	65.4	86.3	124.4	219.2
1.0	24.6	32.4	46.8	82.4
1.5	9.8	12.9	18.6	32.8
2.0	3.4	4.4	6.4	11.2
2.5	0.7	0.9	1.3	2.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	60.8	80.1	115.5	203.6
2.0	19.7	26.0	37.5	66.0
3.0	6.1	8.1	11.6	20.5
4.0	1.2	1.5	2.2	3.9

LOCATION OF TERMINAL: DETROIT, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.883 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.265 dB; @ 30 GHz: 2.737 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.102; @ 30 GHz: 1.047

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2146.5	1052.4	467.1	123.2	4605.9	2796.8	1512.6	515.4
1	2084.9	1014.1	446.6	116.5	4522.0	2725.7	1463.2	493.2
2	2025.1	977.2	427.0	110.2	4439.7	2656.5	1415.4	472.0
3	1966.9	941.6	408.3	104.3	4358.9	2589.0	1369.1	451.6
4	1910.5	907.3	390.4	98.6	4279.5	2523.2	1324.4	432.2
5	1855.7	874.2	373.2	93.3	4201.6	2459.1	1281.1	413.6
10	1604.2	726.1	298.2	70.6	3832.9	2162.2	1085.0	331.9
15	1386.8	603.2	238.3	53.4	3496.4	1901.1	919.0	266.4
20	1198.9	501.0	190.4	40.4	3189.6	1671.6	778.3	213.8
30	896.0	345.7	121.6	23.2	2654.2	1292.3	558.3	137.7
40	669.6	238.5	77.6	13.3	2208.8	999.0	400.5	88.7
50	500.4	164.5	49.5	7.6	1838.0	772.3	287.3	57.1
60	374.0	113.5	31.6	4.4	1529.6	597.1	206.1	36.8
70	279.5	78.3	20.2	2.5	1272.8	461.6	147.8	23.7
80	208.9	54.0	12.9	1.4	1059.2	356.9	106.0	15.3
90	156.1	37.3	8.2	0.8	881.4	275.9	76.1	9.8
100	116.7	25.7	5.3	0.5	733.5	213.3	54.6	6.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	80.6	106.3	153.3	270.0
1.0	30.3	40.0	57.6	101.5
1.5	12.1	15.9	22.9	40.4
2.0	4.1	5.4	7.9	13.8
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	72.2	95.1	137.2	241.7
2.0	23.4	30.8	44.5	78.4
3.0	7.3	9.6	13.8	24.4
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: GRAND RAPIDS, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.615 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.755 dB; @ 30 GHz: 3.669 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.035; @ 30 GHz: 0.992

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2566.1	1323.0	605.5	161.8	4929.2	3206.1	1834.3	661.3
1	2503.2	1280.0	581.1	153.5	4858.3	3137.4	1781.5	635.3
2	2441.8	1238.5	557.7	145.7	4788.5	3070.3	1730.3	610.2
3	2381.9	1198.3	535.3	138.2	4719.7	3004.5	1680.6	586.2
4	2323.5	1159.4	513.7	131.2	4651.8	2940.2	1632.3	563.0
5	2266.5	1121.8	493.1	124.5	4585.0	2877.2	1585.3	540.8
10	2002.0	951.1	401.5	95.8	4264.8	2582.1	1370.2	442.3
15	1768.3	806.4	327.0	73.7	3967.0	2317.3	1184.3	361.7
20	1561.9	683.8	266.3	56.7	3689.9	2079.6	1023.6	295.8
30	1218.6	491.6	176.6	33.6	3192.6	1674.9	764.6	197.9
40	950.7	353.4	117.1	19.9	2762.3	1348.9	571.2	132.3
50	741.7	254.1	77.7	11.8	2389.9	1086.4	426.7	88.5
60	578.7	182.7	51.5	7.0	2067.8	875.0	318.7	59.2
70	451.5	131.3	34.2	4.1	1789.1	704.7	238.1	39.6
80	352.2	94.4	22.7	2.4	1547.9	567.5	177.9	26.5
90	274.8	67.9	15.0	1.4	1339.3	457.1	132.9	17.7
100	214.4	48.8	10.0	0.9	1158.8	368.1	99.3	11.8

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	91.5	120.7	174.0	306.6
1.0	34.4	45.4	65.4	115.3
1.5	13.7	18.1	26.0	45.9
2.0	4.7	6.2	8.9	15.7
2.5	0.9	1.2	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	80.3	105.9	152.8	269.1
2.0	26.0	34.3	49.5	87.2
3.0	8.1	10.7	15.4	27.1
4.0	1.5	2.0	2.9	5.2

LOCATION OF TERMINAL: HOUGHTON, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.645 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.298 dB; @ 30 GHz: 2.765 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.048; @ 30 GHz: 1.003

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	1834.1	856.9	357.5	84.4	4045.2	2399.4	1251.9	396.9
1	1781.0	825.1	341.4	79.7	3971.9	2337.8	1210.2	379.4
2	1729.4	794.4	326.0	75.3	3899.9	2277.9	1170.0	362.6
3	1679.3	764.9	311.4	71.1	3829.2	2219.5	1131.1	346.6
4	1630.6	736.5	297.4	67.1	3759.8	2162.5	1093.4	331.3
5	1583.4	709.2	284.0	63.3	3691.7	2107.1	1057.1	316.7
10	1367.0	587.0	225.6	47.5	3369.1	1850.4	892.6	252.7
15	1180.1	485.8	179.2	35.6	3074.7	1625.0	753.7	201.7
20	1018.8	402.1	142.3	26.7	2806.0	1427.0	636.4	161.0
30	759.3	275.4	89.8	15.0	2337.0	1100.5	453.8	102.5
40	565.9	188.6	56.7	8.5	1946.4	848.7	323.6	65.3
50	421.8	129.2	35.8	4.8	1621.1	654.6	230.7	41.6
60	314.4	88.5	22.6	2.7	1350.2	504.8	164.5	26.5
70	234.3	60.6	14.2	1.5	1124.5	389.3	117.3	16.9
80	174.6	41.5	9.0	0.8	936.6	300.2	83.6	10.7
90	130.1	28.4	5.7	0.5	780.0	231.5	59.6	6.8
100	97.0	19.5	3.6	0.3	649.7	178.6	42.5	4.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	89.2	117.6	169.7	298.9
1.0	33.5	44.2	63.8	112.4
1.5	13.4	17.6	25.4	44.7
2.0	4.6	6.0	8.7	15.3
2.5	0.9	1.2	1.8	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	78.6	103.6	149.4	263.3
2.0	25.5	33.6	48.4	85.3
3.0	7.9	10.4	15.1	26.5
4.0	1.5	2.0	2.9	5.1

LOCATION OF TERMINAL: LANSING, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.564 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.462 dB; @ 30 GHz: 3.086 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.082; @ 30 GHz: 1.036

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2083.2	1051.6	477.6	129.0	4202.9	2638.2	1472.1	522.3
1	2027.3	1015.3	457.5	122.2	4132.9	2575.7	1426.5	500.7
2	1973.0	980.2	438.3	115.8	4064.1	2514.6	1382.4	480.0
3	1920.1	946.3	419.8	109.7	3996.5	2455.0	1339.7	460.2
4	1868.7	913.6	402.2	103.9	3930.0	2396.7	1298.2	441.2
5	1818.6	882.0	385.2	98.5	3864.6	2339.9	1258.1	423.0
10	1587.6	739.8	310.7	75.2	3553.5	2075.3	1075.2	342.6
15	1385.9	620.5	250.6	57.4	3267.4	1840.6	918.9	277.5
20	1209.9	520.4	202.1	43.8	3004.4	1632.5	785.3	224.7
30	922.1	366.1	131.5	25.6	2540.2	1284.2	573.6	147.4
40	702.7	257.6	85.5	14.9	2147.7	1010.2	419.0	96.7
50	535.5	181.2	55.6	8.7	1815.8	794.6	306.0	63.4
60	408.1	127.5	36.2	5.1	1535.3	625.1	223.5	41.6
70	311.0	89.7	23.6	3.0	1298.1	491.7	163.3	27.3
80	237.0	63.1	15.3	1.7	1097.5	386.8	119.2	17.9
90	180.7	44.4	10.0	1.0	927.9	304.3	87.1	11.7
100	137.7	31.2	6.5	0.6	784.5	239.3	63.6	7.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.8	110.4	159.3	280.6
1.0	31.5	41.5	59.9	105.5
1.5	12.5	16.5	23.8	42.0
2.0	4.3	5.7	8.2	14.4
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	73.6	97.1	140.0	246.7
2.0	23.9	31.5	45.4	80.0
3.0	7.4	9.8	14.1	24.9
4.0	1.4	1.9	2.7	4.7

LOCATION OF TERMINAL: SAULT STE. MARIE, MI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.977 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.366 dB; @ 30 GHz: 2.942 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.005; @ 30 GHz: 0.954

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2253.1	1021.0	407.8	88.6	5113.3	3006.3	1530.7	456.4
1	2188.4	983.0	389.3	83.6	5024.9	2930.8	1480.1	436.1
2	2125.6	946.4	371.6	78.9	4938.0	2857.3	1431.1	416.7
3	2064.6	911.2	354.7	74.4	4852.6	2785.6	1383.8	398.2
4	2005.3	877.3	338.6	70.2	4768.7	2715.6	1338.0	380.5
5	1947.8	844.6	323.2	66.2	4686.3	2647.5	1293.8	363.5
10	1683.8	698.7	256.2	49.4	4294.9	2331.5	1093.5	289.5
15	1455.6	578.0	203.0	36.9	3936.3	2053.2	924.3	230.6
20	1258.3	478.2	160.9	27.5	3607.6	1808.1	781.2	183.7
30	940.4	327.3	101.1	15.3	3030.2	1402.2	558.1	116.5
40	702.8	224.0	63.5	8.6	2545.3	1087.5	398.7	73.9
50	525.2	153.3	39.9	4.8	2137.9	843.4	284.8	46.9
60	392.5	104.9	25.1	2.7	1795.8	654.0	203.5	29.7
70	293.3	71.8	15.7	1.5	1508.4	507.2	145.4	18.9
80	219.2	49.1	9.9	0.8	1267.0	393.4	103.8	12.0
90	163.8	33.6	6.2	0.5	1064.2	305.1	74.2	7.6
100	122.4	23.0	3.9	0.3	893.9	236.6	53.0	4.8

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	97.1	128.0	184.6	325.2
1.0	36.5	48.1	69.4	122.3
1.5	14.5	19.2	27.6	48.7
2.0	5.0	6.6	9.5	16.7
2.5	1.0	1.3	1.9	3.4

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	86.8	114.4	165.0	290.8
2.0	28.1	37.1	53.5	94.2
3.0	8.7	11.5	16.6	29.3
4.0	1.7	2.2	3.2	5.6

LOCATION OF TERMINAL: KANSAS CITY, MO

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.154 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.231 dB; @ 30 GHz: 4.484 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.082; @ 30 GHz: 1.050

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2380.6	1383.4	722.2	237.4	3941.0	2785.3	1765.3	759.6
1	2331.0	1344.5	696.7	226.6	3892.9	2733.9	1721.1	733.2
2	2282.4	1306.7	672.1	216.3	3845.4	2683.6	1678.0	707.7
3	2234.8	1270.0	648.3	206.5	3798.4	2634.1	1636.0	683.0
4	2188.2	1234.3	625.5	197.1	3752.1	2585.6	1595.1	659.3
5	2142.5	1199.6	603.4	188.1	3706.3	2537.9	1555.2	636.3
10	1928.3	1040.3	504.1	149.1	3485.5	2312.5	1370.0	533.1
15	1735.4	902.1	421.2	118.1	3277.9	2107.2	1207.0	446.6
20	1561.9	782.3	351.9	93.6	3082.6	1920.0	1063.3	374.2
30	1265.1	588.2	245.7	58.8	2726.3	1594.1	825.2	262.6
40	1024.7	442.3	171.5	36.9	2411.2	1323.6	640.5	184.3
50	830.0	332.6	119.7	23.2	2132.5	1098.9	497.1	129.4
60	672.3	250.1	83.6	14.6	1886.0	912.4	385.8	90.8
70	544.5	188.1	58.4	9.1	1668.0	757.5	299.4	63.7
80	441.1	141.4	40.7	5.7	1475.2	629.0	232.4	44.7
90	357.3	106.4	28.4	3.6	1304.7	522.2	180.3	31.4
100	289.4	80.0	19.9	2.3	1153.9	433.6	140.0	22.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.7	110.3	159.1	280.3
1.0	31.5	41.5	59.8	105.4
1.5	12.5	16.5	23.8	41.9
2.0	4.3	5.6	8.1	14.4
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	71.7	94.5	136.3	240.1
2.0	23.2	30.6	44.2	77.8
3.0	7.2	9.5	13.7	24.2
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: OMAHA, NEB

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.569 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.371 dB; @ 30 GHz: 2.938 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.106; @ 30 GHz: 1.051

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	1976.9	999.0	457.0	125.9	4062.2	2529.5	1405.1	498.4
1	1922.5	963.9	437.6	119.3	3992.0	2468.0	1360.8	477.6
2	1869.6	930.0	419.0	113.0	3923.0	2408.0	1318.0	457.7
3	1818.2	897.3	401.2	107.0	3855.3	2349.4	1276.5	438.6
4	1768.2	865.8	384.1	101.4	3788.6	2292.2	1236.3	420.3
5	1719.6	835.4	367.8	96.0	3723.2	2236.4	1197.4	402.7
10	1495.9	698.6	296.0	73.3	3412.5	1977.3	1020.4	325.4
15	1301.2	584.3	238.2	55.9	3127.7	1748.2	869.5	262.9
20	1131.9	488.6	191.7	42.6	2866.7	1545.6	741.0	212.5
30	856.5	341.7	124.2	24.8	2408.2	1208.2	538.1	138.7
40	648.1	239.0	80.4	14.4	2023.0	944.4	390.8	90.6
50	490.4	167.2	52.1	8.4	1699.5	738.3	283.8	59.1
60	371.1	116.9	33.7	4.9	1427.7	577.1	206.1	38.6
70	280.8	81.8	21.9	2.8	1199.3	451.1	149.7	25.2
80	212.5	57.2	14.2	1.7	1007.5	352.6	108.7	16.5
90	160.8	40.0	9.2	1.0	846.4	275.6	78.9	10.7
100	121.7	28.0	5.9	0.6	711.0	215.5	57.3	7.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	80.1	105.6	152.3	268.4
1.0	30.1	39.7	57.3	100.9
1.5	12.0	15.8	22.8	40.2
2.0	4.1	5.4	7.8	13.7
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	71.6	94.4	136.2	239.9
2.0	23.2	30.6	44.1	77.7
3.0	7.2	9.5	13.7	24.2
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: TRENTON, NJ

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.737 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.386 dB; @ 30 GHz: 4.827 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.055; @ 30 GHz: 1.023

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3783.9	2207.4	1148.9	371.8	6204.2	4443.0	2838.7	1222.9
1	3708.1	2147.0	1109.0	355.0	6134.3	4365.4	2770.2	1181.2
2	3633.8	2088.2	1070.5	339.0	6065.1	4289.1	2703.3	1140.9
3	3561.1	2031.0	1033.3	323.7	5996.7	4214.1	2638.0	1102.0
4	3489.7	1975.3	997.4	309.1	5929.1	4140.5	2574.3	1064.5
5	3419.8	1921.2	962.8	295.2	5862.3	4068.1	2512.2	1028.2
10	3090.8	1672.2	806.8	234.3	5539.1	3724.9	2223.2	864.5
15	2793.4	1455.4	676.1	186.0	5233.8	3410.6	1967.5	726.9
20	2524.6	1266.7	566.6	147.7	4945.3	3122.8	1741.1	611.2
30	2062.2	959.6	397.9	93.1	4415.2	2618.0	1363.6	432.1
40	1684.5	726.9	279.4	58.6	3941.9	2194.8	1067.9	305.5
50	1375.9	550.7	196.2	37.0	3519.3	1840.0	836.4	216.0
60	1123.9	417.1	137.8	23.3	3142.1	1542.6	655.0	152.7
70	918.0	316.0	96.8	14.7	2805.2	1293.3	513.0	107.9
80	749.9	239.4	67.9	9.2	2504.5	1084.2	401.8	76.3
90	612.5	181.3	47.7	5.8	2236.0	909.0	314.6	53.9
100	500.3	137.4	33.5	3.7	1996.3	762.0	246.4	38.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	88.0	116.1	167.4	294.9
1.0	33.1	43.6	62.9	110.9
1.5	13.2	17.4	25.1	44.1
2.0	4.5	5.9	8.6	15.1
2.5	0.9	1.2	1.7	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	75.5	99.6	143.6	253.1
2.0	24.5	32.3	46.6	82.0
3.0	7.6	10.0	14.5	25.5
4.0	1.5	1.9	2.8	4.9

LOCATION OF TERMINAL: ALBANY, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.804 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.862 dB; @ 30 GHz: 3.825 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.082; @ 30 GHz: 1.047

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3127.4	1713.5	843.6	255.2	5613.2	3785.7	2282.1	910.8
1	3054.5	1660.7	811.4	242.8	5534.5	3707.8	2219.5	876.7
2	2983.2	1609.5	780.4	231.1	5457.0	3631.4	2158.6	843.9
3	2913.6	1559.9	750.6	219.9	5380.5	3556.7	2099.4	812.3
4	2845.6	1511.8	721.9	209.2	5305.1	3483.4	2041.7	781.9
5	2779.2	1465.2	694.4	199.1	5230.8	3411.7	1985.7	752.6
10	2469.7	1252.9	571.6	155.3	4874.4	3074.7	1727.8	621.9
15	2194.7	1071.4	470.5	121.1	4542.2	2770.9	1503.4	513.9
20	1950.3	916.1	387.3	94.5	4232.8	2497.1	1308.2	424.7
30	1540.1	669.9	262.5	57.5	3675.6	2028.1	990.4	290.0
40	1216.2	489.8	177.8	35.0	3191.8	1647.2	749.9	198.0
50	960.4	358.2	120.5	21.3	2771.7	1337.8	567.8	135.2
60	758.4	261.9	81.7	13.0	2406.9	1086.5	429.9	92.3
70	598.9	191.5	55.3	7.9	2090.0	882.4	325.5	63.0
80	473.0	140.0	37.5	4.8	1814.9	716.7	246.4	43.0
90	373.5	102.4	25.4	2.9	1576.0	582.1	186.6	29.4
100	294.9	74.9	17.2	1.8	1368.6	472.7	141.2	20.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.7	110.4	159.2	280.4
1.0	31.5	41.5	59.8	105.4
1.5	12.5	16.5	23.8	42.0
2.0	4.3	5.7	8.2	14.4
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	72.0	95.0	137.0	241.3
2.0	23.4	30.8	44.4	78.2
3.0	7.3	9.6	13.8	24.3
4.0	1.4	1.8	2.6	4.6

LOCATION OF TERMINAL: BINGHAMTON, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.799 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.757 dB; @ 30 GHz: 3.685 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.030; @ 30 GHz: 0.987

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2855.6	1467.1	668.2	177.0	5511.2	3581.3	2043.9	732.4
1	2785.6	1419.4	641.3	167.9	5432.4	3504.7	1985.1	703.5
2	2717.3	1373.2	615.4	159.3	5354.7	3429.8	1928.1	675.7
3	2650.6	1328.6	590.6	151.1	5278.0	3356.5	1872.7	649.0
4	2585.6	1285.4	566.8	143.4	5202.5	3284.8	1818.8	623.4
5	2522.1	1243.6	543.9	136.1	5128.1	3214.6	1766.6	598.8
10	2227.6	1054.2	442.7	104.6	4771.6	2885.5	1526.9	489.6
15	1967.4	893.6	360.4	80.4	4439.9	2590.0	1319.7	400.3
20	1737.7	757.5	293.4	61.8	4131.3	2324.8	1140.6	327.2
30	1355.5	544.3	194.4	36.5	3576.8	1873.1	852.1	218.7
40	1057.4	391.1	128.8	21.6	3096.8	1509.2	636.5	146.2
50	824.8	281.0	85.3	12.8	2681.2	1216.0	475.5	97.7
60	643.4	201.9	56.5	7.5	2321.4	979.7	355.2	65.3
70	501.9	145.1	37.5	4.5	2009.9	789.4	265.4	43.7
80	391.5	104.3	24.8	2.6	1740.1	636.0	198.2	29.2
90	305.4	74.9	16.4	1.6	1506.6	512.4	148.1	19.5
100	238.2	53.8	10.9	0.9	1304.4	412.9	110.6	13.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	92.3	121.7	175.5	309.2
1.0	34.7	45.7	66.0	116.2
1.5	13.8	18.2	26.3	46.3
2.0	4.7	6.2	9.0	15.8
2.5	1.0	1.3	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	81.2	107.0	154.4	271.9
2.0	26.3	34.7	50.0	88.1
3.0	8.2	10.8	15.6	27.4
4.0	1.6	2.1	3.0	5.2

LOCATION OF TERMINAL: BUFFALO, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.760 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.119 dB; @ 30 GHz: 2.495 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.037; @ 30 GHz: 0.973

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2480.5	1081.1	420.3	89.5	6168.4	3447.3	1677.2	473.3
1	2402.5	1038.1	400.2	84.2	6047.3	3352.1	1617.5	451.1
2	2327.0	996.7	381.0	79.3	5928.5	3259.6	1559.9	429.9
3	2253.8	957.0	362.8	74.6	5812.1	3169.6	1504.3	409.8
4	2182.9	918.9	345.4	70.2	5698.0	3082.2	1450.8	390.5
5	2114.3	882.3	328.9	66.1	5586.1	2997.1	1399.2	372.2
10	1802.1	720.0	257.3	48.8	5058.7	2605.7	1167.2	292.7
15	1536.0	587.5	201.3	36.0	4581.2	2265.4	973.7	230.1
20	1309.3	479.5	157.5	26.6	4148.7	1969.6	812.3	181.0
30	951.2	319.3	96.4	14.5	3402.4	1488.7	565.4	111.9
40	691.0	212.6	59.0	7.9	2790.3	1125.3	393.5	69.2
50	502.0	141.6	36.1	4.3	2288.4	850.6	273.8	42.8
60	364.7	94.3	22.1	2.3	1876.7	642.9	190.6	26.5
70	265.0	62.8	13.5	1.3	1539.1	486.0	132.6	16.4
80	192.5	41.8	8.3	0.7	1262.2	367.3	92.3	10.1
90	139.9	27.9	5.1	0.4	1035.2	277.6	64.2	6.3
100	101.6	18.5	3.1	0.2	848.9	209.9	44.7	3.9

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	91.1	120.1	173.2	305.1
1.0	34.2	45.1	65.1	114.7
1.5	13.6	18.0	25.9	45.7
2.0	4.7	6.1	8.9	15.6
2.5	0.9	1.2	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	83.5	110.1	158.8	279.8
2.0	27.1	35.7	51.5	90.7
3.0	8.4	11.1	16.0	28.2
4.0	1.6	2.1	3.1	5.4

LOCATION OF TERMINAL: NEW YORK, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.040 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.110 dB; @ 30 GHz: 4.387 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.032; @ 30 GHz: 0.990

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3932.2	2162.7	1054.5	307.8	6967.8	4800.6	2918.0	1149.7
1	3846.3	2098.7	1015.3	293.1	6882.8	4710.2	2842.5	1107.9
2	3762.3	2036.7	977.5	279.0	6798.9	4621.6	2768.9	1067.6
3	3680.1	1976.5	941.2	265.7	6716.0	4534.6	2697.2	1028.8
4	3599.7	1918.1	906.2	252.9	6634.1	4449.2	2627.3	991.4
5	3521.1	1861.4	872.5	240.8	6553.2	4365.5	2559.3	955.4
10	3153.0	1602.1	721.8	188.3	6163.3	3969.7	2244.7	793.9
15	2823.4	1378.9	597.2	147.3	5796.5	3609.9	1968.7	659.7
20	2528.3	1186.8	494.0	115.2	5451.6	3282.7	1726.7	548.2
30	2027.3	879.1	338.2	70.5	4822.2	2714.5	1328.2	378.6
40	1625.6	651.2	231.5	43.1	4265.4	2244.7	1021.7	261.4
50	1303.5	482.4	158.4	26.4	3772.9	1856.2	785.9	180.5
60	1045.3	357.4	108.4	16.1	3337.2	1535.0	604.6	124.7
70	838.2	264.7	74.2	9.9	2951.9	1269.3	465.1	86.1
80	672.1	196.1	50.8	6.0	2611.1	1049.6	357.7	59.4
90	538.9	145.3	34.8	3.7	2309.6	868.0	275.2	41.1
100	432.1	107.6	23.8	2.3	2042.9	717.7	211.7	28.3

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	91.9	121.2	174.9	308.0
1.0	34.6	45.6	65.7	115.8
1.5	13.8	18.1	26.2	46.1
2.0	4.7	6.2	9.0	15.8
2.5	1.0	1.3	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	80.6	106.3	153.4	270.2
2.0	26.1	34.5	49.7	87.6
3.0	8.1	10.7	15.4	27.2
4.0	1.6	2.0	2.9	5.2

LOCATION OF TERMINAL: ROCHESTER, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.415 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.876 dB; @ 30 GHz: 3.755 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.106; @ 30 GHz: 1.082

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2497.0	1396.8	706.1	223.9	4331.5	2943.8	1802.9	746.4
1	2439.3	1354.3	679.6	213.3	4269.5	2882.8	1753.6	718.8
2	2383.0	1313.2	654.1	203.1	4208.3	2823.1	1705.6	692.2
3	2328.0	1273.3	629.5	193.5	4148.1	2764.6	1658.9	666.6
4	2274.2	1234.6	605.9	184.3	4088.7	2707.3	1613.6	641.9
5	2221.7	1197.1	583.1	175.5	4030.1	2651.2	1569.4	618.2
10	1976.8	1026.0	481.6	137.5	3749.7	2387.7	1366.2	511.9
15	1758.9	879.3	397.7	107.8	3488.8	2150.4	1189.3	424.0
20	1565.0	753.6	328.5	84.5	3246.1	1936.7	1035.3	351.1
30	1239.0	553.5	224.0	51.9	2810.1	1570.8	784.6	240.8
40	980.9	406.6	152.8	31.9	2432.7	1274.1	594.6	165.2
50	776.5	298.6	104.2	19.6	2105.9	1033.4	450.6	113.3
60	614.8	219.4	71.1	12.0	1823.1	838.2	341.4	77.7
70	486.7	161.1	48.5	7.4	1578.2	679.9	258.8	53.3
80	385.3	118.3	33.1	4.5	1366.2	551.4	196.1	36.6
90	305.0	86.9	22.5	2.8	1182.7	447.3	148.6	25.1
100	241.5	63.8	15.4	1.7	1023.9	362.8	112.6	17.2

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	80.0	105.5	152.2	268.2
1.0	30.1	39.7	57.2	100.8
1.5	12.0	15.8	22.8	40.1
2.0	4.1	5.4	7.8	13.7
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	67.5	89.0	128.3	226.1
2.0	21.9	28.8	41.6	73.3
3.0	6.8	9.0	12.9	22.8
4.0	1.3	1.7	2.5	4.3

LOCATION OF TERMINAL: SYRACUSE, NY

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.365 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.453 dB; @ 30 GHz: 3.147 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.048; @ 30 GHz: 0.991

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3039.7	1480.5	643.2	160.8	6459.2	3983.6	2155.9	716.4
1	2956.9	1428.3	615.5	152.1	6353.5	3889.0	2088.4	686.2
2	2876.3	1377.8	589.0	143.9	6249.5	3796.7	2023.1	657.3
3	2798.0	1329.2	563.6	136.1	6147.3	3706.6	1959.8	629.6
4	2721.7	1282.3	539.3	128.8	6046.7	3618.7	1898.5	603.0
5	2647.6	1237.0	516.1	121.9	5947.7	3532.8	1839.1	577.6
10	2306.0	1033.6	414.0	92.4	5476.7	3133.0	1568.8	465.7
15	2008.5	863.6	332.2	70.0	5043.0	2778.5	1338.3	375.5
20	1749.4	721.6	266.5	53.1	4643.6	2464.0	1141.7	302.7
30	1327.2	503.8	171.6	30.5	3937.3	1937.9	830.8	196.8
40	1006.8	351.7	110.4	17.5	3338.4	1524.1	604.6	127.9
50	763.8	245.6	71.1	10.1	2830.6	1198.7	440.0	83.2
60	579.5	171.4	45.8	5.8	2400.0	942.7	320.2	54.1
70	439.6	119.7	29.5	3.3	2034.9	741.4	233.0	35.1
80	333.5	83.6	19.0	1.9	1725.4	583.1	169.5	22.8
90	253.0	58.3	12.2	1.1	1462.9	458.6	123.4	14.9
100	191.9	40.7	7.9	0.6	1240.4	360.7	89.8	9.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	89.2	117.7	169.7	299.0
1.0	33.6	44.2	63.8	112.4
1.5	13.4	17.6	25.4	44.7
2.0	4.6	6.0	8.7	15.3
2.5	0.9	1.2	1.8	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	80.4	106.1	153.0	269.5
2.0	26.1	34.4	49.6	87.3
3.0	8.1	10.7	15.4	27.1
4.0	1.5	2.0	2.9	5.2

LOCATION OF TERMINAL: OKLAHOMA CITY, OK

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.852 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.848 dB; @ 30 GHz: 5.466 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.113; @ 30 GHz: 1.096

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2156.1	1373.0	791.4	303.4	3171.0	2384.7	1630.9	799.6
1	2118.1	1339.6	766.9	291.1	3138.1	2346.7	1595.1	774.8
2	2080.7	1307.0	743.0	279.2	3105.5	2309.3	1560.1	750.8
3	2044.0	1275.2	719.9	267.8	3073.3	2272.6	1525.9	727.6
4	2007.9	1244.2	697.6	256.9	3041.4	2236.3	1492.4	705.1
5	1972.5	1213.9	675.9	246.5	3009.8	2200.7	1459.7	683.3
10	1804.5	1073.3	577.2	200.2	2856.9	2030.9	1306.5	583.9
15	1650.9	948.9	493.0	162.7	2711.7	1874.2	1169.3	498.9
20	1510.3	839.0	421.0	132.1	2573.9	1729.6	1046.6	426.3
30	1264.0	655.9	307.0	87.2	2318.9	1473.0	838.4	311.3
40	1057.9	512.7	223.9	57.6	2089.2	1254.5	671.6	227.3
50	885.4	400.8	163.3	38.0	1882.3	1068.3	538.0	166.0
60	741.0	313.3	119.1	25.1	1695.8	909.8	431.0	121.2
70	620.2	244.9	86.9	16.5	1527.8	774.9	345.3	88.5
80	519.0	191.4	63.4	10.9	1376.5	659.9	276.6	64.6
90	434.4	149.7	46.2	7.2	1240.1	562.0	221.6	47.2
100	363.6	117.0	33.7	4.8	1117.3	478.6	177.5	34.5

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	79.1	104.3	150.4	265.0
1.0	29.7	39.2	56.5	99.6
1.5	11.8	15.6	22.5	39.7
2.0	4.1	5.3	7.7	13.6
2.5	0.8	1.1	1.6	2.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	65.8	86.8	125.1	220.4
2.0	21.3	28.1	40.6	71.4
3.0	6.6	8.7	12.6	22.2
4.0	1.3	1.7	2.4	4.2

LOCATION OF TERMINAL: CLEVELAND, OH

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.097 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.319 dB; @ 30 GHz: 2.869 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.098; @ 30 GHz: 1.037

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2503.6	1238.9	554.1	147.5	5326.2	3267.1	1781.0	611.3
1	2433.1	1194.4	530.1	139.5	5232.5	3186.1	1723.8	585.3
2	2364.6	1151.6	507.1	132.1	5140.4	3107.1	1668.6	560.4
3	2298.1	1110.2	485.2	125.0	5050.0	3030.1	1615.0	536.6
4	2233.4	1070.4	464.1	118.3	4961.1	2955.0	1563.2	513.8
5	2170.5	1032.0	444.0	111.9	4873.9	2881.8	1513.1	492.0
10	1881.7	859.7	355.8	84.9	4459.9	2541.9	1285.5	396.0
15	1631.4	716.1	285.1	64.5	4081.2	2242.2	1092.2	318.7
20	1414.3	596.5	228.4	48.9	3734.6	1977.8	927.9	256.5
30	1063.0	413.9	146.6	28.2	3127.2	1538.8	669.8	166.2
40	799.0	287.2	94.2	16.2	2618.6	1197.3	483.5	107.6
50	600.5	199.3	60.4	9.4	2192.7	931.5	349.0	69.7
60	451.3	138.3	38.8	5.4	1836.0	724.8	251.9	45.2
70	339.2	96.0	24.9	3.1	1537.4	563.9	181.8	29.3
80	255.0	66.6	16.0	1.8	1287.4	438.8	131.3	18.9
90	191.6	46.2	10.3	1.0	1078.0	341.4	94.7	12.3
100	144.0	32.1	6.6	0.6	902.7	265.6	68.4	8.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	81.3	107.2	154.7	272.4
1.0	30.6	40.3	58.1	102.4
1.5	12.2	16.0	23.1	40.8
2.0	4.2	5.5	7.9	14.0
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	73.4	96.8	139.7	246.0
2.0	23.8	31.4	45.3	79.7
3.0	7.4	9.8	14.1	24.8
4.0	1.4	1.9	2.7	4.7

LOCATION OF TERMINAL: COLUMBUS, OH

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.502 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.159 dB; @ 30 GHz: 4.426 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.020; @ 30 GHz: 0.984

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2951.3	1621.2	786.8	226.8	5163.3	3560.2	2162.5	848.7
1	2887.7	1573.7	757.7	216.0	5101.0	3493.6	2106.7	817.9
2	2825.4	1527.5	729.6	205.6	5039.5	3428.2	2052.3	788.2
3	2764.5	1482.6	702.5	195.7	4978.7	3364.1	1999.3	759.6
4	2704.9	1439.1	676.5	186.4	4918.6	3301.1	1947.7	732.0
5	2646.5	1396.9	651.4	177.4	4859.3	3239.4	1897.4	705.4
10	2373.3	1203.6	539.3	138.8	4573.1	2947.4	1664.9	586.2
15	2128.2	1037.0	446.5	108.6	4303.8	2681.8	1460.8	487.2
20	1908.4	893.5	369.6	84.9	4050.4	2440.1	1281.8	404.9
30	1534.6	663.3	253.3	51.9	3587.4	2020.1	986.8	279.7
40	1234.1	492.5	173.6	31.8	3177.3	1672.4	759.8	193.2
50	992.3	365.6	119.0	19.4	2814.1	1384.6	584.9	133.4
60	798.0	271.4	81.6	11.9	2492.5	1146.3	450.3	92.2
70	641.7	201.5	55.9	7.3	2207.6	949.0	346.7	63.7
80	516.0	149.6	38.3	4.5	1955.2	785.7	266.9	44.0
90	414.9	111.0	26.3	2.7	1731.7	650.4	205.5	30.4
100	333.7	82.4	18.0	1.7	1533.8	538.5	158.2	21.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	94.1	124.1	179.0	315.4
1.0	35.4	46.7	67.3	118.6
1.5	14.1	18.6	26.8	47.2
2.0	4.8	6.4	9.2	16.1
2.5	1.0	1.3	1.9	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	81.6	107.6	155.2	273.4
2.0	26.5	34.9	50.3	88.6
3.0	8.2	10.8	15.6	27.5
4.0	1.6	2.1	3.0	5.3

LOCATION OF TERMINAL: PORTLAND, OR

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 18.209 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.117 dB; @ 30 GHz: 0.314 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.277; @ 30 GHz: 1.177

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	529.6	156.8	44.9	6.9	2650.1	898.6	285.8	49.1
1	498.0	146.3	41.6	6.3	2522.3	848.1	267.7	45.5
2	468.3	136.4	38.5	5.8	2400.6	800.5	250.7	42.1
3	440.4	127.3	35.6	5.3	2284.8	755.6	234.8	39.0
4	414.1	118.8	33.0	4.9	2174.6	713.2	219.9	36.2
5	389.4	110.8	30.6	4.5	2069.7	673.1	205.9	33.5
10	286.3	78.3	20.8	2.9	1616.4	504.3	148.3	22.9
15	210.5	55.3	14.2	1.9	1262.4	377.7	106.8	15.6
20	154.8	39.1	9.7	1.2	985.9	283.0	77.0	10.7
30	83.7	19.5	4.5	0.5	601.4	158.8	39.9	5.0
40	45.3	9.8	2.1	0.2	366.8	89.1	20.7	2.3
50	24.5	4.9	1.0	0.1	223.7	50.0	10.7	1.1
60	13.2	2.4	0.4	0.0	136.5	28.1	5.6	0.5
70	7.2	1.2	0.2	0.0	83.2	15.7	2.9	0.2
80	3.9	0.6	0.1	0.0	50.8	8.8	1.5	0.1
90	2.1	0.3	0.0	0.0	31.0	5.0	0.8	0.1
100	1.1	0.2	0.0	0.0	18.9	2.8	0.4	0.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	60.1	79.2	114.2	201.2
1.0	22.6	29.8	42.9	75.6
1.5	9.0	11.9	17.1	30.1
2.0	3.1	4.1	5.8	10.3
2.5	0.6	0.8	1.2	2.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	57.0	75.2	108.5	191.1
2.0	18.5	24.4	35.2	61.9
3.0	5.7	7.6	10.9	19.3
4.0	1.1	1.4	2.1	3.7

LOCATION OF TERMINAL: HARRISBURG, PA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.315 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.463 dB; @ 30 GHz: 3.173 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.082; @ 30 GHz: 1.023

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3086.0	1559.1	708.8	191.7	6352.7	3997.3	2228.4	785.1
1	3003.3	1505.2	679.0	181.7	6249.3	3903.8	2160.1	752.8
2	2922.8	1453.3	650.4	172.1	6147.6	3812.5	2093.8	721.8
3	2844.6	1403.1	623.1	163.1	6047.5	3723.3	2029.6	692.1
4	2768.3	1354.6	596.9	154.5	5949.0	3636.2	1967.4	663.6
5	2694.2	1307.8	571.8	146.4	5852.2	3551.2	1907.0	636.3
10	2352.1	1097.0	461.2	111.8	5391.1	3154.8	1632.0	515.7
15	2053.5	920.2	372.1	85.4	4966.3	2802.7	1396.6	418.0
20	1792.8	771.9	300.1	65.2	4575.0	2489.9	1195.2	338.8
30	1366.5	543.1	195.3	38.0	3882.4	1965.2	875.3	222.6
40	1041.5	382.1	127.1	22.2	3294.7	1551.0	641.0	146.2
50	793.9	268.9	82.7	12.9	2796.0	1224.1	469.4	96.0
60	605.1	189.2	53.8	7.5	2372.7	966.1	343.8	63.1
70	461.2	133.1	35.0	4.4	2013.5	762.5	251.8	41.4
80	351.5	93.7	22.8	2.6	1708.7	601.8	184.4	27.2
90	267.9	65.9	14.8	1.5	1450.1	475.0	135.0	17.9
100	204.2	46.4	9.6	0.9	1230.6	374.9	98.9	11.8

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.6	110.3	159.1	280.2
1.0	31.4	41.5	59.8	105.3
1.5	12.5	16.5	23.8	41.9
2.0	4.3	5.6	8.1	14.3
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	75.5	99.5	143.6	252.9
2.0	24.5	32.3	46.5	82.0
3.0	7.6	10.0	14.5	25.5
4.0	1.5	1.9	2.8	4.9

LOCATION OF TERMINAL: MEMPHIS, TN

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.145 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.246 dB; @ 30 GHz: 4.780 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.963; @ 30 GHz: 0.907

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	4308.7	2289.9	1055.4	274.1	7855.5	5418.2	3216.5	1169.8
1	4217.1	2222.4	1015.6	260.6	7771.1	5322.3	3135.2	1126.9
2	4127.6	2156.9	977.3	247.8	7687.7	5228.2	3055.9	1085.6
3	4039.9	2093.3	940.5	235.6	7605.1	5135.7	2978.6	1045.8
4	3954.0	2031.6	905.1	224.0	7523.4	5044.9	2903.3	1007.4
5	3870.0	1971.7	871.0	213.0	7442.6	4955.7	2829.9	970.4
10	3476.1	1697.7	718.8	165.4	7051.3	4532.7	2489.7	805.1
15	3122.2	1461.8	593.2	128.5	6680.6	4145.8	2190.5	667.9
20	2804.3	1258.6	489.5	99.8	6329.4	3792.0	1927.2	554.0
30	2262.4	933.1	333.4	60.3	5681.5	3172.3	1491.7	381.3
40	1825.2	691.8	227.0	36.4	5099.8	2653.9	1154.7	262.4
50	1472.5	512.9	154.6	21.9	4577.7	2220.2	893.8	180.6
60	1188.0	380.2	105.3	13.2	4109.1	1857.4	691.8	124.3
70	958.4	281.9	71.7	8.0	3688.4	1553.8	535.5	85.5
80	773.2	209.0	48.8	4.8	3310.8	1299.9	414.5	58.9
90	623.8	154.9	33.3	2.9	2971.9	1087.5	320.8	40.5
100	503.3	114.9	22.7	1.8	2667.6	909.8	248.3	27.9

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	105.7	139.3	200.9	354.0
1.0	39.7	52.4	75.5	133.1
1.5	15.8	20.9	30.1	53.0
2.0	5.4	7.1	10.3	18.1
2.5	1.1	1.4	2.1	3.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	96.1	126.7	182.7	321.8
2.0	31.1	41.1	59.2	104.3
3.0	9.7	12.8	18.4	32.4
4.0	1.8	2.4	3.5	6.2

LOCATION OF TERMINAL: NASHVILLE, TN

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.400 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 3.310 dB; @ 30 GHz: 6.625 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 0.973; @ 30 GHz: 0.940

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	3977.9	2472.9	1342.1	443.7	5891.7	4547.2	3096.1	1416.8
1	3915.6	2415.9	1300.9	425.1	5847.6	4487.2	3034.9	1374.1
2	3854.2	2360.1	1260.9	407.4	5803.8	4428.0	2974.8	1332.8
3	3793.8	2305.6	1222.2	390.4	5760.3	4369.6	2915.9	1292.7
4	3734.3	2252.4	1184.6	374.1	5717.2	4312.0	2858.2	1253.8
5	3675.8	2200.5	1148.2	358.4	5674.3	4255.1	2801.6	1216.0
10	3396.7	1958.0	982.4	289.6	5465.0	3981.7	2535.1	1043.7
15	3138.7	1742.3	840.5	234.0	5263.4	3725.8	2293.9	895.8
20	2900.3	1550.3	719.1	189.0	5069.2	3486.5	2075.7	768.9
30	2476.5	1227.5	526.4	123.4	4702.0	3052.8	1699.5	566.4
40	2114.7	971.9	385.3	80.6	4361.5	2673.1	1391.5	417.3
50	1805.7	769.5	282.0	52.6	4045.6	2340.7	1139.4	307.4
60	1541.8	609.3	206.4	34.3	3752.6	2049.5	932.9	226.4
70	1316.5	482.4	151.1	22.4	3480.8	1794.6	763.8	166.8
80	1124.1	382.0	110.6	14.6	3228.7	1571.4	625.4	122.9
90	959.9	302.4	81.0	9.5	2994.9	1376.0	512.1	90.5
100	819.6	239.5	59.3	6.2	2778.0	1204.8	419.3	66.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS			
	99.999%	99.99%	99.9%	99%
0.5	103.4	136.4	196.7	346.5
1.0	38.9	51.3	73.9	130.3
1.5	15.5	20.4	29.4	51.9
2.0	5.3	7.0	10.1	17.7
2.5	1.1	1.4	2.0	3.6

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS			
	99.999%	99.99%	99.9%	99%
1.0	89.4	117.8	169.9	299.4
2.0	29.0	38.2	55.1	97.0
3.0	9.0	11.9	17.1	30.2
4.0	1.7	2.3	3.3	5.8

LOCATION OF TERMINAL: AUSTIN, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.809 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 3.341 dB; @ 30 GHz: 6.406 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.119; @ 30 GHz: 1.100

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2289.7	1528.4	925.7	382.0	3210.4	2505.7	1786.1	933.9
1	2253.7	1494.6	899.2	367.5	3181.8	2470.3	1750.7	907.2
2	2218.2	1461.5	873.4	353.5	3153.4	2435.5	1716.0	881.3
3	2183.3	1429.2	848.4	340.0	3125.3	2401.2	1682.0	856.2
4	2148.9	1397.6	824.1	327.1	3097.4	2367.3	1648.6	831.7
5	2115.1	1366.7	800.5	314.6	3069.8	2334.0	1616.0	808.0
10	1953.9	1222.0	692.2	259.1	2935.3	2174.0	1462.1	699.1
15	1804.9	1092.7	598.5	213.4	2806.7	2025.1	1322.8	604.8
20	1667.3	977.0	517.6	175.8	2683.8	1886.3	1196.9	523.3
30	1422.7	781.2	387.0	119.2	2453.8	1636.6	979.7	391.7
40	1214.0	624.6	289.4	80.9	2243.5	1420.0	802.0	293.2
50	1036.0	499.4	216.4	54.9	2051.3	1232.1	656.5	219.5
60	884.0	399.3	161.8	37.2	1875.5	1069.0	537.4	164.3
70	754.4	319.2	121.0	25.2	1714.7	927.5	440.0	123.0
80	643.7	255.2	90.4	17.1	1567.8	804.8	360.1	92.0
90	549.3	204.1	67.6	11.6	1433.4	698.3	294.8	68.9
100	468.7	163.2	50.6	7.9	1310.6	605.8	241.3	51.6

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	78.2	103.1	148.7	262.0
1.0	29.4	38.8	55.9	98.5
1.5	11.7	15.4	22.3	39.2
2.0	4.0	5.3	7.6	13.4
2.5	0.8	1.1	1.5	2.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	65.3	86.2	124.3	218.9
2.0	21.2	27.9	40.3	71.0
3.0	6.6	8.7	12.5	22.1
4.0	1.3	1.7	2.4	4.2

LOCATION OF TERMINAL: DALLAS, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.939 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.615 dB; @ 30 GHz: 5.152 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.116; @ 30 GHz: 1.089

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2228.5	1386.6	781.3	290.1	3410.1	2524.5	1695.2	806.8
1	2186.8	1351.3	756.0	277.9	3372.8	2482.5	1656.6	781.0
2	2145.9	1316.9	731.6	266.3	3335.9	2441.2	1618.9	756.1
3	2105.8	1283.3	708.0	255.1	3299.5	2400.5	1582.0	731.9
4	2066.4	1250.6	685.1	244.4	3263.4	2360.6	1546.0	708.5
5	2027.8	1218.7	663.0	234.1	3227.8	2321.3	1510.8	685.9
10	1845.2	1071.1	562.6	188.9	3055.2	2134.5	1346.3	583.1
15	1679.0	941.4	477.4	152.5	2891.9	1962.7	1199.8	495.7
20	1527.8	827.4	405.2	123.0	2737.3	1804.7	1069.3	421.4
30	1265.0	639.1	291.8	80.1	2452.4	1525.9	849.2	304.6
40	1047.4	493.6	210.1	52.2	2197.2	1290.1	674.4	220.1
50	867.2	381.3	151.3	34.0	1968.5	1090.8	535.6	159.1
60	718.0	294.5	109.0	22.1	1763.7	922.3	425.4	115.0
70	594.5	227.5	78.5	14.4	1580.2	779.8	337.8	83.1
80	492.3	175.7	56.5	9.4	1415.7	659.3	268.3	60.1
90	407.6	135.7	40.7	6.1	1268.4	557.4	213.1	43.4
100	337.5	104.9	29.3	4.0	1136.4	471.3	169.2	31.4

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	78.7	103.8	149.7	263.6
1.0	29.6	39.0	56.3	99.1
1.5	11.8	15.5	22.4	39.5
2.0	4.0	5.3	7.7	13.5
2.5	0.8	1.1	1.5	2.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	66.6	87.8	126.7	223.1
2.0	21.6	28.5	41.1	72.3
3.0	6.7	8.8	12.8	22.5
4.0	1.3	1.7	2.4	4.3

LOCATION OF TERMINAL: EL PASO, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.642 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.630 dB; @ 30 GHz: 1.353 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.245; @ 30 GHz: 1.203

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	354.6	162.3	69.6	18.4	857.8	468.0	235.6	76.8
1	341.6	155.2	66.1	17.3	834.9	452.2	226.1	73.0
2	329.1	148.4	62.7	16.3	812.5	437.0	216.9	69.3
3	317.1	142.0	59.6	15.3	790.8	422.2	208.2	65.9
4	305.5	135.7	56.6	14.4	769.6	408.0	199.7	62.6
5	294.3	129.8	53.7	13.5	749.0	394.3	191.7	59.5
10	244.3	103.8	41.5	9.9	654.0	332.1	155.9	46.1
15	202.8	83.0	32.0	7.3	571.0	279.8	126.8	35.7
20	168.4	66.4	24.7	5.4	498.6	235.7	103.2	27.7
30	116.0	42.5	14.7	2.9	380.1	167.3	68.3	16.6
40	79.9	27.1	8.8	1.6	289.8	118.7	45.2	10.0
50	55.1	17.4	5.2	0.8	220.9	84.2	29.9	6.0
60	38.0	11.1	3.1	0.5	168.4	59.8	19.8	3.6
70	26.2	7.1	1.9	0.2	128.4	42.4	13.1	2.2
80	18.0	4.5	1.1	0.1	97.9	30.1	8.7	1.3
90	12.4	2.9	0.7	0.1	74.6	21.4	5.7	0.8
100	8.6	1.9	0.4	0.0	56.9	15.2	3.8	0.5

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	63.2	83.3	120.1	211.6
1.0	23.8	31.3	45.2	79.6
1.5	9.5	12.5	18.0	31.7
2.0	3.2	4.3	6.2	10.8
2.5	0.7	0.9	1.2	2.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	54.6	72.1	103.9	183.1
2.0	17.7	23.4	33.7	59.3
3.0	5.5	7.3	10.5	18.4
4.0	1.1	1.4	2.0	3.5

LOCATION OF TERMINAL: FORT WORTH, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.910 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.736 dB; @ 30 GHz: 5.354 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.097; @ 30 GHz: 1.075

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	2232.0	1393.5	784.5	289.0	3373.2	2513.5	1695.0	807.8
1	2191.5	1358.6	759.5	276.9	3337.9	2472.9	1657.2	782.2
2	2151.7	1324.6	735.3	265.4	3303.0	2432.9	1620.2	757.5
3	2112.7	1291.5	711.8	254.3	3268.4	2393.6	1584.0	733.6
4	2074.3	1259.2	689.1	243.7	3234.2	2354.9	1548.6	710.5
5	2036.6	1227.7	667.1	233.5	3200.3	2316.8	1514.0	688.0
10	1858.4	1081.7	567.3	188.7	3036.3	2135.5	1352.4	586.0
15	1695.7	953.1	482.4	152.5	2880.7	1968.4	1208.0	499.2
20	1547.2	839.7	410.2	123.2	2733.1	1814.4	1079.1	425.2
30	1288.2	651.9	296.6	80.4	2460.1	1541.6	861.0	308.5
40	1072.5	506.0	214.5	52.5	2214.4	1309.8	686.9	223.8
50	893.0	392.8	155.1	34.3	1993.3	1112.8	548.1	162.4
60	743.5	305.0	112.1	22.4	1794.2	945.5	437.3	117.8
70	619.0	236.7	81.1	14.6	1615.0	803.3	348.9	85.5
80	515.4	183.8	58.6	9.5	1453.7	682.5	278.4	62.0
90	429.1	142.7	42.4	6.2	1308.5	579.9	222.1	45.0
100	357.2	110.7	30.7	4.1	1177.8	492.7	177.2	32.6

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	81.4	107.4	154.9	272.8
1.0	30.6	40.4	58.2	102.6
1.5	12.2	16.1	23.2	40.8
2.0	4.2	5.5	7.9	14.0
2.5	0.8	1.1	1.6	2.8

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	68.5	90.3	130.2	229.3
2.0	22.2	29.3	42.2	74.3
3.0	6.9	9.1	13.1	23.1
4.0	1.3	1.7	2.5	4.4

LOCATION OF TERMINAL: HOUSTON, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.966 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 4.571 dB; @ 30 GHz: 8.811 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.022; @ 30 GHz: 0.998

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3351.4	2361.7	1482.6	621.6	4366.3	3630.3	2735.0	1508.6
1	3311.7	2318.7	1445.5	599.9	4342.0	3593.4	2692.0	1471.3
2	3272.4	2276.5	1409.4	578.9	4317.9	3556.9	2649.6	1434.8
3	3233.5	2235.1	1374.2	558.6	4293.9	3520.7	2608.0	1399.3
4	3195.1	2194.4	1339.9	539.1	4270.0	3484.9	2566.9	1364.7
5	3157.2	2154.4	1306.4	520.2	4246.3	3449.5	2526.6	1330.9
10	2974.2	1965.3	1151.3	435.3	4129.6	3277.7	2334.0	1174.2
15	2801.9	1792.8	1014.5	364.3	4016.1	3114.5	2156.1	1036.0
20	2639.5	1635.4	894.0	304.8	3905.7	2959.4	1991.8	914.0
30	2342.4	1360.9	694.2	213.4	3694.0	2672.0	1699.8	711.4
40	2078.8	1132.4	539.1	149.5	3493.8	2412.6	1450.5	553.7
50	1844.8	942.3	418.6	104.7	3304.4	2178.3	1237.9	431.0
60	1637.2	784.2	325.1	73.3	3125.2	1966.7	1056.4	335.5
70	1452.9	652.5	252.4	51.3	2955.8	1775.7	901.5	261.1
80	1289.4	543.0	196.0	35.9	2795.6	1603.3	769.3	203.3
90	1144.3	451.8	152.2	25.2	2644.0	1447.6	656.5	158.2
100	1015.5	376.0	118.2	17.6	2500.7	1307.0	560.3	123.1

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	93.8	123.7	178.5	314.4
1.0	35.3	46.5	67.1	118.2
1.5	14.0	18.5	26.7	47.0
2.0	4.8	6.3	9.1	16.1
2.5	1.0	1.3	1.8	3.3

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	79.3	104.6	150.8	265.7
2.0	25.7	33.9	48.9	86.1
3.0	8.0	10.5	15.2	26.8
4.0	1.5	2.0	2.9	5.1

LOCATION OF TERMINAL: SAN ANTONIO, TX

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 0.984 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.498 dB; @ 30 GHz: 5.085 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.074; @ 30 GHz: 1.035

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2238.6	1341.8	721.2	246.4	3598.2	2622.3	1712.2	765.7
1	2195.3	1306.3	696.9	235.6	3559.4	2578.3	1672.3	740.4
2	2152.8	1271.6	673.5	225.3	3521.0	2535.0	1633.4	716.0
3	2111.1	1237.9	650.8	215.4	3483.1	2492.4	1595.3	692.3
4	2070.2	1205.1	628.9	206.0	3445.5	2450.6	1558.1	669.5
5	2030.1	1173.2	607.7	196.9	3408.4	2409.4	1521.9	647.3
10	1841.0	1025.7	512.1	157.4	3228.6	2213.8	1352.7	547.3
15	1669.5	896.7	431.5	125.8	3058.3	2034.1	1202.3	462.7
20	1514.0	784.0	363.6	100.6	2896.9	1868.9	1068.7	391.2
30	1245.1	599.3	258.2	64.3	2599.4	1577.8	844.3	279.6
40	1023.9	458.1	183.3	41.1	2332.3	1332.0	667.0	199.8
50	842.1	350.2	130.2	26.2	2092.8	1124.5	527.0	142.8
60	692.5	267.7	92.4	16.8	1877.8	949.3	416.3	102.1
70	569.5	204.6	65.6	10.7	1684.9	801.4	328.9	73.0
80	468.3	156.4	46.6	6.8	1511.8	676.6	259.8	52.2
90	385.2	119.5	33.1	4.4	1356.5	571.2	205.3	37.3
100	316.8	91.4	23.5	2.8	1217.2	482.2	162.2	26.6

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	84.9	112.0	161.5	284.4
1.0	31.9	42.1	60.7	106.9
1.5	12.7	16.8	24.2	42.6
2.0	4.3	5.7	8.3	14.6
2.5	0.9	1.2	1.7	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	73.8	97.3	140.4	247.3
2.0	23.9	31.6	45.5	80.2
3.0	7.4	9.8	14.1	24.9
4.0	1.4	1.9	2.7	4.8

LOCATION OF TERMINAL: SALT LAKE CITY, UT

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 3.704 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.151 dB; @ 30 GHz: 0.382 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.298; @ 30 GHz: 1.207

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz				30GHz			
	3dB	5dB	8dB	15dB	3dB	5dB	8dB	15dB
0	205.6	67.6	21.4	3.8	853.3	321.9	114.0	22.9
1	194.2	63.4	19.9	3.5	815.3	305.1	107.2	21.3
2	183.5	59.4	18.6	3.2	779.0	289.2	100.9	19.8
3	173.3	55.7	17.3	3.0	744.4	274.1	94.9	18.5
4	163.7	52.2	16.1	2.7	711.2	259.8	89.3	17.2
5	154.7	48.9	15.0	2.5	679.6	246.3	84.0	16.0
10	116.4	35.4	10.4	1.7	541.2	188.4	61.9	11.2
15	87.6	25.6	7.3	1.1	431.0	144.2	45.6	7.8
20	65.9	18.6	5.1	0.7	343.3	110.3	33.6	5.5
30	37.3	9.7	2.5	0.3	217.7	64.6	18.2	2.7
40	21.1	5.1	1.2	0.1	138.1	37.8	9.9	1.3
50	11.9	2.7	0.6	0.1	87.6	22.1	5.4	0.6
60	6.8	1.4	0.3	0.0	55.5	13.0	2.9	0.3
70	3.8	0.7	0.1	0.0	35.2	7.6	1.6	0.2
80	2.2	0.4	0.1	0.0	22.3	4.4	0.9	0.1
90	1.2	0.2	0.0	0.0	14.2	2.6	0.5	0.0
100	0.7	0.1	0.0	0.0	9.0	1.5	0.3	0.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	58.2	76.7	110.6	194.9
1.0	21.9	28.8	41.6	73.3
1.5	8.7	11.5	16.6	29.2
2.0	3.0	3.9	5.7	10.0
2.5	0.6	0.8	1.1	2.0

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	54.3	71.6	103.2	181.9
2.0	17.6	23.2	33.5	58.9
3.0	5.5	7.2	10.4	18.3
4.0	1.0	1.4	2.0	3.5

LOCATION OF TERMINAL: NORFOLK, VA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 2.099 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.134 dB; @ 30 GHz: 4.486 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.023; @ 30 GHz: 0.974

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	4078.6	2235.4	1083.2	312.0	7286.9	5030.0	3050.9	1189.2
1	3990.0	2169.4	1042.9	297.0	7200.5	4936.8	2972.5	1146.0
2	3903.3	2105.4	1004.1	282.7	7115.1	4845.3	2896.1	1104.4
3	3818.5	2043.3	966.7	269.1	7030.7	4755.5	2821.7	1064.4
4	3735.6	1983.0	930.7	256.2	6947.3	4667.3	2749.3	1025.7
5	3654.4	1924.5	896.1	243.9	6864.9	4580.8	2678.6	988.5
10	3274.4	1656.8	741.3	190.6	6467.3	4171.8	2351.8	821.7
15	2933.9	1426.4	613.2	149.0	6092.7	3799.2	2064.9	683.0
20	2628.7	1228.0	507.3	116.5	5739.9	3460.0	1813.0	567.7
30	2110.4	910.2	347.2	71.2	5094.3	2869.6	1397.6	392.2
40	1694.3	674.6	237.6	43.5	4521.3	2380.0	1077.3	271.0
50	1360.2	500.0	162.6	26.6	4012.8	1973.9	830.5	187.2
60	1092.0	370.6	111.3	16.2	3561.4	1637.1	640.2	129.4
70	876.7	274.7	76.1	9.9	3160.8	1357.8	493.5	89.4
80	703.8	203.6	52.1	6.1	2805.3	1126.1	380.4	61.8
90	565.0	150.9	35.7	3.7	2489.8	934.0	293.3	42.7
100	453.6	111.9	24.4	2.3	2209.7	774.6	226.1	29.5

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	93.7	123.5	178.1	313.8
1.0	35.2	46.4	67.0	118.0
1.5	14.0	18.5	26.7	47.0
2.0	4.8	6.3	9.1	16.1
2.5	1.0	1.3	1.8	3.2

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	83.2	109.7	158.3	278.8
2.0	27.0	35.6	51.3	90.4
3.0	8.4	11.1	15.9	28.1
4.0	1.6	2.1	3.0	5.4

LOCATION OF TERMINAL: RICHMOND, VA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.629 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 2.610 dB; @ 30 GHz: 5.267 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.053; @ 30 GHz: 1.019

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	3831.9	2299.3	1230.6	414.2	6079.3	4457.6	2919.5	1303.4
1	3759.7	2239.4	1189.6	396.1	6016.5	4384.8	2852.8	1260.8
2	3688.9	2181.0	1149.9	378.8	5954.4	4313.2	2787.5	1219.5
3	3619.5	2124.2	1111.6	362.2	5892.9	4242.8	2723.7	1179.6
4	3551.3	2068.8	1074.5	346.4	5832.1	4173.5	2661.4	1141.0
5	3484.4	2014.9	1038.7	331.3	5771.9	4105.4	2600.6	1103.7
10	3168.5	1765.6	876.8	265.0	5480.1	3781.0	2316.5	934.6
15	2881.2	1547.2	740.1	212.0	5203.0	3482.2	2063.4	791.4
20	2620.0	1355.8	624.7	169.5	4940.0	3207.0	1838.0	670.1
30	2166.4	1041.1	445.1	108.5	4453.1	2720.2	1458.3	480.5
40	1791.4	799.5	317.1	69.4	4014.2	2307.3	1157.1	344.5
50	1481.3	613.9	225.9	44.4	3618.5	1957.1	918.1	247.0
60	1224.8	471.4	161.0	28.4	3261.9	1660.0	728.4	177.1
70	1012.8	362.0	114.7	18.2	2940.4	1408.0	578.0	127.0
80	837.5	278.0	81.7	11.6	2650.6	1194.3	458.6	91.1
90	692.5	213.5	58.2	7.4	2389.3	1013.0	363.8	65.3
100	572.6	163.9	41.5	4.8	2153.8	859.2	288.7	46.8

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	88.4	116.5	168.1	296.1
1.0	33.2	43.8	63.2	111.3
1.5	13.2	17.4	25.2	44.3
2.0	4.5	6.0	8.6	15.2
2.5	0.9	1.2	1.7	3.1

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	76.1	100.4	144.8	255.1
2.0	24.7	32.5	46.9	82.7
3.0	7.7	10.1	14.6	25.7
4.0	1.5	1.9	2.8	4.9

LOCATION OF TERMINAL: SEATTLE, WA

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 53.498 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 0.031 dB; @ 30 GHz: 0.090 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.435; @ 30 GHz: 1.326

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	20GHz 5dB	20GHz 8dB	20GHz 15dB	30GHz 3dB	30GHz 5dB	30GHz 8dB	30GHz 15dB
0	195.5	53.6	14.7	2.2	1149.2	343.8	100.2	16.0
1	181.5	49.4	13.4	2.0	1078.4	320.1	92.7	14.7
2	168.4	45.5	12.3	1.8	1012.0	298.1	85.7	13.4
3	156.3	42.0	11.2	1.6	949.7	277.6	79.2	12.3
4	145.1	38.7	10.3	1.5	891.3	258.6	73.3	11.3
5	134.7	35.6	9.4	1.4	836.4	240.8	67.8	10.3
10	92.8	23.7	6.1	0.8	608.7	168.7	45.8	6.7
15	63.9	15.7	3.9	0.5	443.0	118.1	31.0	4.3
20	44.0	10.5	2.5	0.3	322.4	82.8	20.9	2.8
30	20.9	4.6	1.0	0.1	170.8	40.6	9.6	1.1
40	9.9	2.0	0.4	0.0	90.5	19.9	4.4	0.5
50	4.7	0.9	0.2	0.0	47.9	9.8	2.0	0.2
60	2.2	0.4	0.1	0.0	25.4	4.8	0.9	0.1
70	1.1	0.2	0.0	0.0	13.4	2.4	0.4	0.0
80	0.5	0.1	0.0	0.0	7.1	1.2	0.2	0.0
90	0.2	0.0	0.0	0.0	3.8	0.6	0.1	0.0
100	0.1	0.0	0.0	0.0	2.0	0.3	0.0	0.0

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	47.6	62.8	90.5	159.5
1.0	17.9	23.6	34.0	59.9
1.5	7.1	9.4	13.5	23.9
2.0	2.4	3.2	4.6	8.2
2.5	0.5	0.6	0.9	1.7

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	45.0	59.3	85.5	150.6
2.0	14.6	19.2	27.7	48.8
3.0	4.5	6.0	8.6	15.2
4.0	0.9	1.1	1.6	2.9

LOCATION OF TERMINAL: MILWAUKEE, WI

PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: 1.653 %
MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: 1.435 dB; @ 30 GHz: 3.053 dB
STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: 1.083; @ 30 GHz: 1.033

FADE DURATION (Minutes)	TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS 20GHz 3dB	5dB	8dB	15dB	30GHz 3dB	5dB	8dB	15dB
0	2155.5	1082.6	489.5	131.4	4405.5	2751.5	1526.2	536.2
1	2097.1	1044.9	468.7	124.5	4331.5	2685.8	1478.7	513.9
2	2040.4	1008.5	448.9	117.9	4258.8	2621.6	1432.6	492.5
3	1985.2	973.4	429.9	111.7	4187.4	2558.9	1388.0	472.1
4	1931.4	939.5	411.7	105.8	4117.1	2497.8	1344.8	452.5
5	1879.1	906.8	394.2	100.2	4048.0	2438.1	1302.9	433.7
10	1638.2	759.5	317.5	76.4	3719.5	2160.4	1112.3	350.7
15	1428.2	636.1	255.7	58.3	3417.7	1914.4	949.5	283.7
20	1245.1	532.8	206.0	44.4	3140.3	1696.3	810.6	229.5
30	946.3	373.7	133.6	25.8	2651.3	1331.9	590.8	150.1
40	719.2	262.2	86.7	15.0	2238.5	1045.8	430.5	98.2
50	546.7	183.9	56.2	8.7	1889.9	821.1	313.8	64.2
60	415.5	129.0	36.5	5.1	1595.6	644.7	228.7	42.0
70	315.8	90.5	23.7	3.0	1347.2	506.2	166.7	27.5
80	240.0	63.5	15.4	1.7	1137.4	397.5	121.5	18.0
90	182.4	44.5	10.0	1.0	960.3	312.1	88.5	11.8
100	138.6	31.2	6.5	0.6	810.8	245.1	64.5	7.7

FADE CONTROL ON 20 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
0.5	83.5	110.1	158.8	279.8
1.0	31.4	41.4	59.7	105.2
1.5	12.5	16.5	23.8	41.9
2.0	4.3	5.6	8.1	14.3
2.5	0.9	1.1	1.6	2.9

FADE CONTROL ON 30 GHz LINK

IF ATTENUATION LEVEL (IN dB) IS	THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS 99.999%	99.99%	99.9%	99%
1.0	74.0	97.6	140.8	248.1
2.0	24.0	31.6	45.6	80.4
3.0	7.5	9.8	14.2	25.0
4.0	1.4	1.9	2.7	4.8

APPENDIX E

RAIN FADE DISTRIBUTION AND FADE CONTROL DELAY CALCULATION

ALGORITHM FOR SATELLITE LINKS

The following program E.1, is the "Microsoft" basic program used to generate the temporal rain statistics that appear in appendix D. The program carries out the calculation of equations (3.1) to (3.3) and equation (3.11) using as inputs the quantities $P_0(L,\theta)$, $\ln A_m$, and $\sigma_{\ln A}$ for 20 and 30 GHz as calculated in part 1 of this work. The value of $\gamma = 5.39 \times 10^{-2}$ $\min^{-1}$ is used for the "universal" attenuation time parameter.

```
REM
REM RAIN FADE DISTRIBUTION  AND FADE CONTROL DELAY CALCULATION
REM
REM SEPTEMBER 3, 1987
REM
REM THIS PROGRAM CALCULATES THE NUMBER OF MINUTES IN A YEAR THAT
REM GIVEN FADE DURATIONS WILL BE EXCEEDED FOR GIVEN FADE DEPTHS.
REM IT THEN DETERMINES, FOR A GIVEN CONTROL SYSTEM AVAILABILITY,
REM WHAT THE TIME INTERVAL IN WHICH A DECISION MUST BE MADE TO
REM IMPLEMENT CONTROL FOR SELECTED VALUES OF FADE MARGINS.
REM
DIM PT20(15),PT30(15),I1(17),I2(4),DT20(5),DT30(5)
FOR J=1 TO 17
READ I1(J)
NEXT J
FOR J=1 TO 4
READ I2(J)
NEXT J
100 CLS
PRINT"CITY, STATE WHERE SITE IS LOCATED: "
LINE INPUT CTY$
REM
REM INPUT PROBABILITY OF ATTENUATION FOR THIS LOCATION THAT IS
REM   SPECIFIC TO ACTS AS CALCULATED IN THE STATIC RAIN MODEL.
REM
INPUT"ENTER PROBABILITY (IN %) OF ATTENUATION FOR THIS ACTS LINK :";P0
REM
REM INPUT 20 GHz STATISTICS
REM
INPUT"ENTER MEAN ATTENUATION FOR 20 GHz :";AM20
INPUT"ENTER STANDARD DEV. OF 20 GHz ATTENUATION :";SA20
REM
REM INPUT 30 GHz STATISTICS
REM
INPUT"ENTER MEAN ATTENUATION FOR 30 GHz :";AM30
INPUT"ENTER STANDARD DEV. OF 30 GHz ATTENUATION :";SA30
REM
REM  PRINT OUT INTERMEDIATE RESULTS
REM
LPRINT
LPRINT TAB(7)"LOCATION OF TERMINAL: ";CTY$
LPRINT
LPRINT TAB(7)"PROBABILITY OF ATTENUATION ON AN ACTS LINK AT THIS LOCATION: ";P0;"%"
LPRINT TAB(7)"MEAN ATTENUATION ON AN ACTS LINK; @ 20 GHz: ";AM20;"dB;";" @ 30 GHz: ";AM30;"dB
"
LPRINT TAB(7)"STNDRD. DEVIATION OF ATTENUATION; @ 20 GHz: ";SA20;"dB;";" @ 30 GHz: ";SA30;"dB
"
```

PROGRAM E.1

```
LPRINT
LPRINT
LPRINT
LPRINT"     FADE          TOTAL FADING TIME (IN MINUTES) ACROSS FADE DEPTHS"
LPRINT"    DURATION          20GHz                         30GHz"
LPRINT"    (Minutes)  3dB    5dB    8dB    15dB   3dB    5dB    8dB    15dB"
LPRINT
REM
REM
REM    CALCULATE FADE DURATIONS
REM
REM
REM CALCULATE ATTENUATION DEPENDENT COEFFICIENTS FOR FOUR
REM  VALUES OF FADE DEPTHS
REM
B=.0539 'Inverse Minutes. (UNIVERSAL ATTENUATION TIME PARAMETER)
REM
REM    BEGIN LOOP
REM
REM         STEP THRU TIME
REM
FOR JJ=1 TO 17
T=I1(JJ)
REM
REM         STEP THRU ATTENUATION
REM
FOR KK=1 TO 4
A=I2(KK)
REM         20 GHz
X020=(LOG(A)-LOG(AM20))/SA20
ARG=X020/SQR(2)
GOSUB ERRORFUNC
FX020=3.14159*ERFC*EXP(ARG^2)
REM  CALCULATE CUMULATIVE PROBABILITY OF A AT 20 GHz
PA20=(P0/2)*ERFC
REM         30 GHz
X030=(LOG(A)-LOG(AM30))/SA30
ARG=X030/SQR(2)
GOSUB ERRORFUNC
FX030=3.14159*ERFC*EXP(ARG^2)
REM  CALCULATE CUMULATIVE PROBABILITY OF A AT 30 GHz
PA30=(P0/2)*ERFC
REM
REM CALCULATE CUMULATIVE PROBABILITY DISTRIBUTION FOR 20 AND 30 GHz
REM
PT20(A)=(PA20/100)*EXP(-B*T/FX020) ' Minutes/Year
PT30(A)=(PA30/100)*EXP(-B*T/FX030) ' Minutes/Year
```

PROGRAM E.1 (cont'd)

```
NEXT KK
LPRINT TAB(10);USING"###";T;
LPRINT TAB(18); USING"######.#";PT20(3)*525960!;
LPRINT USING"#######.#";PT20(5)*525960!;
LPRINT USING"#######.#";PT20(8)*525960!;
LPRINT USING"#######.#";PT20(15)*525960!;
LPRINT USING"#######.#";PT30(3)*525960!;
LPRINT USING"#######.#";PT30(5)*525960!;
LPRINT USING"#######.#";PT30(8)*525960!;
LPRINT USING"#######.#";PT30(15)*525960!
NEXT JJ
DATA 0,1,2,3,4,5,10,15,20,30,40,50,60,70,80,90,100
DATA 3,5,8,15
REM
REM
REM   CONTROL DELAY CALCULATION
REM
REM
INVERFC59=3.02' INVERSE ERROR FUNC CORRESPONDING TO 2*PAVIL, PAVIL=.99999
INVERFC49=2.63' INVERSE ERROR FUNC CORRESPONDING TO 2*PAVIL, PAVIL=.9999
INVERFC39=2.19' INVERSE ERROR FUNC CORRESPONDING TO 2*PAVIL, PAVIL=.999
INVERFC29=1.65' INVERSE ERROR FUNC CORRESPONDING TO 2*PAVIL, PAVIL=.99
Ath20=3'dB; CONTROL THRESHOLD FOR 20 GHz.
Ath30=5'dB; CONTROL THRESHOLD FOR 30 GHz.
LPRINT
LPRINT
LPRINT
LPRINT
LPRINT TAB(35);"FADE CONTROL ON 20 GHz LINK"
LPRINT
LPRINT TAB(8);" IF ATTENUATION";
LPRINT TAB(30);"THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL"
LPRINT TAB(8);" LEVEL (IN dB)";
LPRINT TAB(27);"WITH 3 dB THRESHOLD AT GIVEN AVAILABILITY IS "
LPRINT TAB(13);"IS";
LPRINT TAB (30);"99.999%";
LPRINT TAB(44);"99.99%";
LPRINT TAB(58);"99.9%";
LPRINT TAB(72);"99%"
LPRINT
REM
REM   STEP THRU ATTENUATION VALUES
REM
FOR LL=1 TO 5
AC=LL/2
DT20(5)=(60/(4*B))*(LOG(Ath20/AC)/(SA20*INVERFC59))^2
IF LOG(Ath20/AC)<0 THEN DT20(5)=0
```

PROGRAM E.1 (cont'd)

```
DT20(4)=(60/(4*B))*(LOG(Ath20/AC)/(SA20*INVERFC49))^2
IF LOG(Ath20/AC)<0 THEN DT20(4)=0
DT20(3)=(60/(4*B))*(LOG(Ath20/AC)/(SA20*INVERFC39))^2
IF LOG(Ath20/AC)<0 THEN DT20(3)=0
DT20(2)=(60/(4*B))*(LOG(Ath20/AC)/(SA20*INVERFC29))^2
IF LOG(Ath20/AC)<0 THEN DT20(2)=0
LPRINT TAB(13);USING"*.*";AC;
LPRINT TAB(30); USING"***.*";DT20(5);
LPRINT TAB(44);USING"***.*";DT20(4);
LPRINT TAB(58);USING"***.*";DT20(3);
LPRINT TAB(70);USING"***.*";DT20(2)
NEXT LL
LPRINT
LPRINT
LPRINT TAB(35);"FADE CONTROL ON 30 GHz LINK"
LPRINT
LPRINT TAB(8);" IF ATTENUATION";
LPRINT TAB(27);"THEN MAXIMUM TIME (IN SECONDS) TO IMPLEMENT CONTROL"
LPRINT TAB(8);" LEVEL (IN dB)";
LPRINT TAB(30);"WITH 5 dB THRESHOLD AT GIVEN AVAILABILITY IS "
LPRINT TAB(13);"IS";
LPRINT TAB (30);"99.999%";
LPRINT TAB(44);"99.99%";
LPRINT TAB(58);"99.9%";
LPRINT TAB(72);"99%"
LPRINT
REM
REM  STEP THRU ATTENUATION VALUES
REM
FOR AC=1 TO 4
DT30(5)=(60/(4*B))*(LOG(Ath30/AC)/(SA30*INVERFC59))^2
IF LOG(Ath30/AC)<0 THEN DT30(5)=0
DT30(4)=(60/(4*B))*(LOG(Ath30/AC)/(SA30*INVERFC49))^2
IF LOG(Ath30/AC)<0 THEN DT30(4)=0
DT30(3)=(60/(4*B))*(LOG(Ath30/AC)/(SA30*INVERFC39))^2
IF LOG(Ath30/AC)<0 THEN DT30(3)=0
DT30(2)=(60/(4*B))*(LOG(Ath30/AC)/(SA30*INVERFC29))^2
IF LOG(Ath30/AC)<0 THEN DT30(20)=0
LPRINT TAB(13);USING"*.*";AC;
LPRINT TAB(30); USING"***.*";DT30(5);
LPRINT TAB(44);USING"***.*";DT30(4);
LPRINT TAB(58);USING"***.*";DT30(3);
LPRINT TAB(70);USING"***.*";DT30(2)
NEXT AC
150 INPUT"CONTINUE WITH ANOTHER LOCATION ? (YES/NO):";ANS$
IF ANS$="YES" THEN GOTO 100
IF ANS$="NO" THEN GOTO 200
```

PROGRAM E.1 (cont'd)

```
GOTO 150
200 END

ERRORFUNC:
TOL=.00001
IF ARG<0 THEN LET K1=-1
IF ARG>0 THEN LET K1=1
IF ARG=0 THEN GOTO 1000
ARG=K1*ARG
ARG2=ARG^2
IF (ARG>1.5) THEN GOTO 1100
T0=ARG
T1=ARG
J=0
REM   BEGIN LOOP
1200 J=J+1
T2=T0
T1=2*T1*ARG2/(1+2*J)
T0=T1+T2
IF (T1>TOL*T0) THEN GOTO 1200
ERF=K1*2*T0*EXP(-ARG2)/SQR(3.14159)
ERFC=1-ERF
GOTO 1300
1000 ERF=0
ERFC=1
GOTO 1300
REM   COMPLEMENTARY ERROR FUNCTION
1100 T3=12
V=.5/ARG2
U=1+V*(T3+1)
FOR J=T3 TO 1 STEP -1
T0=1+J*V/U
U=T0
NEXT J
ERFC=EXP(-ARG2)/(ARG*T0*SQR(3.14159))
ERF=1-ERFC
IF K1=1 THEN GOTO 1300
ERF=-ERF
ERFC=1-ERF
1300 RETURN
```

PROGRAM E.1 (cont'd)

C-2

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TABLE I. - ANNUAL ATTENUATION DURATION STATISTICS

[Frequency: 19.04 GHz (horizontal polarization; elevation angle: 21°; time period: July 1976 to August 1977; Location: Clarksburg, Maryland.]

Fade duration, min	Fraction of total fading time, percent, across fade levels					
	Decibels					
	3	6	10	15	20	25
> 3	95.7	91.9	91.1	93.6	91.2	89.7
>10	81.6	72.4	69.7	71.4	85.6	78.4
>30	53.8	29.0	39.6	17.0	38.1	----
>60	17.5	6.1	-----	-----	--	----
Total fading time, min	2196	1024	514	297	114	24
Total number of fades	183	125	66	43	12	7

TABLE 2. - ANNUAL ATTENUATION DURATION STATISTICS

[Frequency: 28.56 GHz (vertical polarization; elevation angle: 21°; time period: July 1976 to August 1977; Location: Clarksburg, Maryland.]

Fade duration, min	Fraction of total fading time, percent, across fade levels					
	Decibels					
	3	6	10	15	20	25
> 3	96.9	95.6	92.6	89.3	93.1	91.1
>10	86.1	76.2	71.6	68.9	69.6	81.2
>30	68.7	56.0	35.4	40.2	35.4	18.3
>60	57.1	45.5	5.6	11.2	19.6	----
Total fading time, min	5366	2391	1188	511	310	167
Total number of fades	333	220	141	79	37	24

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16. Abstract

A dynamic rain attenuation prediction model is developed for use in obtaining the temporal characteristics, on time scales of minutes or hours, of satellite communication link availability. Analogous to the associated "static" rain attenuation model, which yields yearly attenuation predictions and is the subject of Part I of this work (NASA Contractor Report CR-179498, Sept. 1986), this dynamic model is applicable at any location in the world that is characterized by the static rain attenuation statistics peculiar to the geometry of the satellite link and the rain statistics of the location. Such statistics are calculated by employing the formalism of Part I. In fact, the dynamic model presented here is an extension of the static model and reduces to the static model in the appropriate limit. By assuming that rain attenuation is dynamically described by a first-order stochastic differential equation in time and that this random attenuation process is a Markov process, an expression for the associated transition probability is obtained by solving the related forward Kolmogorov equation. This transition probability is then used to obtain such temporal rain attenuation statistics as attenuation durations and allowable attenuation margins versus control system delay time for specified rain fade control availabilities.

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