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Update the Loo Model in Equatorial zone

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Abstract. In this paper, the statistical characteristics of rain attenuation in the equatorial zone are investigated. A more reasonable Fixed satellite and LMS channel model incorporating weather impairment is proposed and compared of the weather-affected Ka-band channel model suggested by Loo. The Amplitude received signal derived from Loo's model and new model from the weather-affected was compare. A statistic model from Loo model developed by new model is described in detail, as well as its extension to modeling Fixed and LMS communications at Ka-Band This was accomplished by including a Gaussian probability density function to account for weather conditions. Finally, the influence of weather impairments under various weather conditions, which shows in the new model.

Keywords: Ka-Band, Broadband satellite, rain drop size distribution

I. INTRODUCTION

The congestion of radio spectrum in L/S band (1/2GHz) and maturing of Ka-band (30/20 GHz) Technologies stimulate strong industrial interests in Ka-band, which is referred as "Ka-Band Rush" [1]. The next generation LEO Satellite system like Teledesic will use this frequency band as primary links to implements multimedia communications.[2]. However, Ka-band propagation is more susceptible to weather impairments and shadowing compared tom lower frequency bands. At Ka-band, moderates rain and shadowing may cause complete failure of communications especially in the equatorial zone where high rainfall are often experienced. Ka-band propagation studies show that when weather effects are not considered, the L/S band Fixed satellite and LMS channel model may also be suitable for Ka-band [3],[4],[5].However the available L/S Fixed satellite and LMS channel models which ignore weather impairments are not applicable to Ka-band where the propagation is severely affected by weather impairments. Although extensive work associated with Ka-band propagation measurements and channel modeling have been reported in the literature, they only consider atmospheric impairments as in GEO satellite system and fixed satellite, or only consider the fades due to mobile environment as in land mobile satellite system operating at lower frequency band. The only exceptions is Loo's model work [4].which considered weather impairments for Ka-band Fixed satellite and LMS channel model.In this paper we focus on narrowband model, where Loo's model us used as the basis to establish the new Ka-band weather-affected Fixed satellite and LMS channel model The numerical results show that by employing the proposed channel model, the effects of weather impairments like rain attenuation are successfully accounted for.

This paper is organized as follows. In section II Statistical model for Ka-Band (20GHz) Channel Loo's model .In sec III, rain Attenuation Factor in Broadband Satellite Channel. The new weather-affected immurements for in this paper and sec IV, the model analysis and , Section V, Results compare amplitude received signal between Loo's model and new model. Conclusions are presented in the last section.

II. Statistical model for Ka-Band (20GHz) Channel

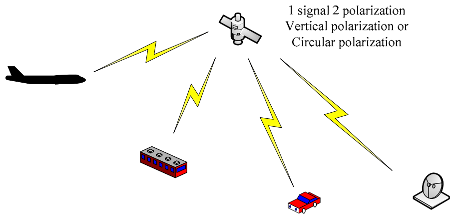

Figure.1 Principle of satellite links

For a fixed satellite communications channel whose characteristics depend on weather conditions, the results show that the signal envelop and signal phase can be modeled as Gaussian, and their expressions by

$$p_W(r)= 1 \Big/ (\sqrt{2\pi}).\exp\left[-(r-m_W)^2/2\sigma^2{}_W\right] \quad (1)$$

The signal phase and signal envelop caused by weather conditions are given in table 1 and 2, respectively. Modeling parameters for shadowing and multipath fading under several representative rural areas are given in table 3 and 4 for signal envelop and signal phase

Table1. Fixed Satellite channel Phase model –ka-band

Weather conditions	Mean	Variance
Clear sky	0.0072	0.00357
Intermittent light rain	0.0088	0.00546
Thunder shower	0.0068	0.00414
rain	0.0089	0.03077

Table2.Fixed Satellite channel –Envelope model ka-band

Weather conditions	Mean	Variance
Clear sky	0.413	0.00087
Intermittent light rain	0.483	0.00003
Thunder shower	0.436	0.01386
rain	0.662	0.0200

For land mobile satellite communications modeling at Ka-band, one needs to take weather conditions into account, as well as fading and shadowing. With this in mind, it is reasonable to assume that the two fading processes, one caused by weather conditions and the other due to fading and shadowing, are independent. The combined signal envelope probability function $p_T(r)$ is given by

$$p_T(r)=p_W(r).p(r) \quad (5)$$

With $p_W(r)$ and $p(r)$ given by respectively. Similarly, for the combined signal phase mode, is given by

$$p_T(\phi)=p(\phi_W+\phi_m) \quad (6)$$

There have been several hardware and software channel simulator developed for the land mobile channel the emphasis of this subsection is one computer generated channel model and, in particular, on the one developed at CRC. All computer models for the fading channel described in this subsection are based on the manipulation of a white Gaussian random process. This process is approximated by a sum of sinusoid with random phase angle. An expression for the Gaussian random process $a(t)$ is given below [6]

$$a = \mathrm{Re} \sum_{k=-N/2}^{N/2} V_k \exp[j2\pi(f_c + kf_o)t + j\lambda_k] \qquad (7)$$

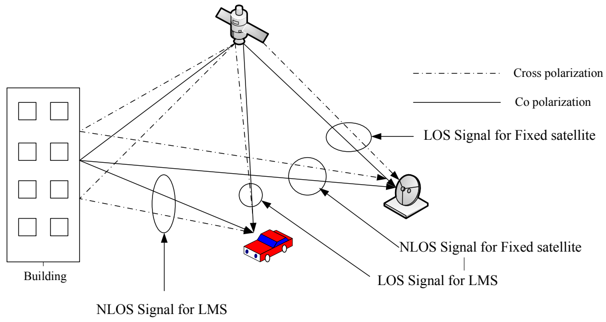

Figure 2. Polarization LOS, NLOS in Fixed satellite and LMS

Where V_k is the amplitude and λ_k is a random phase angel uniformly distribution between 0 and 2π .N is the number of sinusoid, $(f_c + kf_o)$ is the sinusoidal frequency, and Re denote the "real part of"

$$a = \mathrm{Re}\{[a_c(t) + ja_s(t)]\exp(j2\pi f_c t)\} \qquad (8)$$

Where $$a_c(t) = \mathrm{Re} \sum_{k=-N/2}^{N/2} V_k \exp[j(2\pi kf_o + \lambda_k) \qquad (9)$$

$$a_s(t) = \mathrm{Im} \sum_{k=-N/2}^{N/2} V_k \exp[j(2\pi kf_o + \lambda_k) \qquad (10)$$

Denotes "the imaginary part of" $a_c(t)$ and $a_s(t)$ can be easily obtained using the FFT algorithm forgiven V_k and λ_k

1).Rayleigh Fading Channel: By definition [7] the envelope r of the two narrow-band Gaussian random process is Rayleigh, and its phase ϕ is uniform. Therefore

$$r = \sqrt{a^2{}_c(t) + a^2{}_s(t)} \qquad (11)$$

is Rayleigh and

$$\phi = \tan^{-1}\left(\frac{a_s(t)}{a_c(t)}\right) \qquad (12)$$

Is uniform

2).Rician Fading Channel; When a fading process has a LOS component A_c together with multipath fading, the channel is model as Rician[8]. The Rice process is given by

$$a_r(t) = \mathrm{Re}\{[A_c + a_c(t)] + ja_s(t)]\exp[j2\pi f_c t]\} \qquad (13)$$

And it's envelop r and ϕ are given by

$$r = \sqrt{[A_C + a_c(t)]^2 + a_s{}^2(t)} \qquad (14)$$

$$\phi = \tan^{-1}\left(\frac{a_s}{A_c + a_s}\right) \qquad (15)$$

3).Log-Normal Fading Channel: Local mean variation of cellular mobile channel and shadowing caused by foliage attenuation are usually modeled as a log-normal fading process.[9] [10] .[11] There are two methods of generating a log-normal fading process: one for slow fading and the other for fast fading

a).Slow fading log-normal process: The statistic of a log-normal process is generated from a normal (Gaussian) random process. For the slow-fading case, the normal random variate is generated from a nonlinear transformation of a uniform distribution [12] and is given by

$$x_p = \sqrt{-2\ln u}\cos(2\pi v) \qquad (16)$$

Where u and v are uniform distribution between zero and one. x_p is a Gaussian variate with zero mean and unity variance .To convert this variate to actual mean and variance, the following transformation is required

$$x=\sqrt{d_o x_p}+\mu \qquad (17)$$

Where μ and d_o are the mean and variance, respectively. The slow-fading log-normal process is given by

$$A_c=\exp[x] \qquad (18)$$

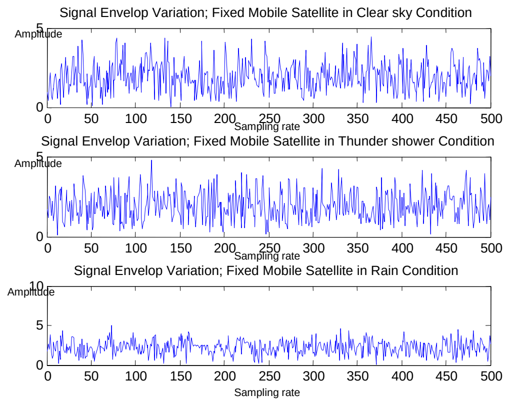

Figure 3 signal Envelop for Fixed Satellite

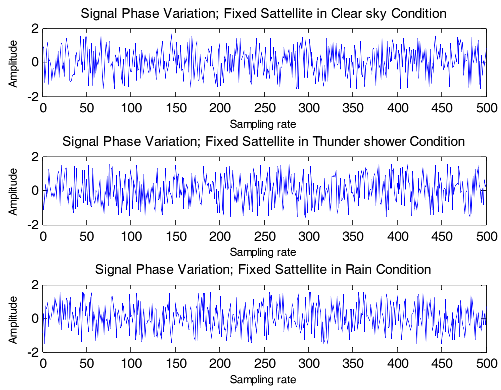

Figure 5 signal Phase for Fixed Satellite

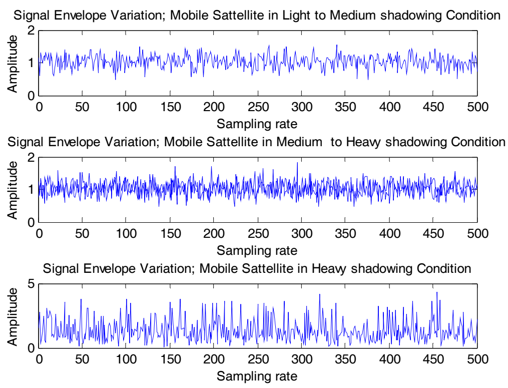

Figure 4 signal Envelop for LMS Satellite

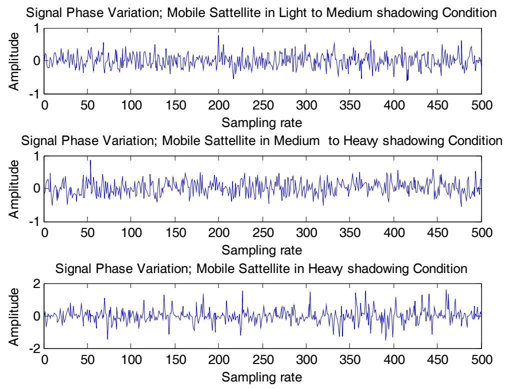

Figure 6 signal Phase for LMS Satellite

b).Fast-fading log-normal process: For the fast-fading log-normal model, the normal (Gaussian) process is approximation by a sum of *sinusoid* with random phase angle. The effect of the fading bandwidth is included. The fast log-normal model is given by

$$A(t)=\exp[\mu+\sqrt{d_o}\,x_c(t)+j\sqrt{d_o x_s}\,x(t)] \qquad (19)$$

Where $x_c(t)$ and $x_s(t)$ are narrow-band Gaussian random process, which can be obtained using expression given in [13],[14] and with appropriate amplitude and phase

Table3. LMS Satellite channel Phase model –ka-band

Channel condition	μ	$\sqrt{d}$	b_o
Light to medium shadowing	-0.230	0.0115	0.1585
Medium to heavy shadowing	-2.30	0.046	0.10
Heavy shadowing	-1.95	0.46	0.0398

Table4.LMS Satellite channel –Envelope model ka-band

Channel condition	**Mean**	**Variance**
Light to medium shadowing	0.0068	0.0262
Medium to heavy shadowing	-0.01447	0.1124
Heavy shadowing	-0.0111	0.1934

B. Land Mobile Satellite Fading Channel: This channel model [4] assume*s* that the LOS component under shadowing is log-normal distribution and that the multipath effect is Rayleigh distribution. The two process are additive. Thus, the channel model is given by the combination of log-normal and Rayleigh model described previously. As given below

$$a(t)=\mathrm{Re}\{[y_c(t)+a_c(t)+j(y_s(t)+a_s(t))]\exp[j2\pi f_c t]\} \quad (20)$$

And $a_c(t)$ and $a_s(t)$ are Gaussian random process whose magnitude is related to the input sinusoid amplitude V_k of [13] and[14] , which ,in turn, is related to the multipath power b_o as

$$b_o=\sum_{k=1}^{N} V^2{}_k/2 \qquad (21)$$

Similarly, $y_c(t)$ and $y_s(t)$ are log-normal random processes whose values are related in the following way. From [15] $A(t)$ can be rewritten as

$$A(t) = y_c(t) + jy_s(t)$$
$$= \exp[\mu\sqrt{d_o}\, x_c(t).[\cos(\sqrt{d_o}\, x_c(t)) + j\sin(\sqrt{d_o}\, x_s(t))] \quad (22)$$

The values of $x_c(t)$ and $x_s(t)$ are related to the amplitude v_k of the sin wave of and [13] and [14] with the *x* replacing the *a.* For this case, however the power of the sum of the sine wave is normalizes to unity

$$\sum_{k=1}^{N} V^2{}_k \ /2=1 \quad (23)$$

The signal envelope and signal phase are given by[16] and[17], respectively

$$r(t)=\sqrt{[y_c(t)+a_c(t)]^2+[y_s(t)+a_s(t)]^2} \quad (24)$$

$$\phi(t)=\tan^{-1}\left(\frac{y_s(t)+a_s(t)}{y_c(t)+a_c(t)}\right) \quad (25)$$

5).Shaping of the Fading Spectrum: Two spectral shaping filters are used to shape the fading spectrum of the computer-generated model. One shaping filter is based on the land cellular mobile channel [10] and [11] and the other has a Butterworth frequency response in the pass band [18]

III. Rain Attenuation Factor in Broadband Satellite Channel

This paper considered rain attenuation from rain drop size distribution and the specific attenuation A in dB/km due to rain. This is calculated by integrating over all of the drop size as

$$A=4.343\int Q(D,\lambda,m)N(D)dD \quad (22)$$

Q is the attenuation cross section which is a function of the drop diameter. D is the wavelength of the radio wave λ and the complex refractive index of the water drop, which is a function of the function and temperature. And N(D) is the drop size distribution. The attenuation cross section Q is found by applying the classical scattering theory of Mie's for a plane wave impinging upon a spherical absorbing particle. N(D) for Gamma distribution can be written

$$N(D)=N_T A^{n+1} D^n \exp[-AD/\Gamma(n+1)] \ (m^{-3}.mm^{-1}) \quad (23)$$

N(D) for Log normal distribution can be written

$$N(D)=\frac{N_T}{\sigma D\sqrt{2\pi}}.\exp\left[-\frac{1}{2}\left(\frac{\ln(D)-\mu^2}{\sigma}\right)\right] \ (m^{-3}.mm^{-1}) \quad (24)$$

Consider in Log normal distribution terms and forms

$$P=F(\ln A)=\int_{\ln A}^{\alpha}\frac{1}{\delta\sqrt{2\pi}}.\exp\left[\frac{-\left(x-\mu^2\right)}{2\delta^2}\right].dx=Q\left(\frac{\ln A-\mu}{\delta}\right)$$

And (22), (23),(24) [19], [20], [21]

$$A=4.343\int Q(D,\lambda,m).N(D)dD$$

The cross section Q is expended as

$$Q(D,\lambda,m)=\frac{\lambda^2}{2\pi}.\sum_{n=1}^{\alpha}(2n+1)\operatorname{Re}\left[a_n+b_n\right] \quad A=(4.343)\left(\frac{\lambda^2}{2\pi}\right).\sum_{n=1}^{\alpha}(2n+1)\operatorname{Re}\left[a_n+b_n\right].\frac{N_T}{\sigma D\sqrt{2\pi}}.\exp\left[-\frac{1}{2}\left(\frac{\ln D-\mu^2}{\delta}\right)\right] \qquad (25)$$

a_n and b_n are the Mie scattering coefficients and analysis in Bessel function [22], [23], which are the complex function of m, D and λ. In the equation (22), A is rain attenuation analysis in rain drop size distribution having log normal distribution term. We can find N(D) for log normal distribution[24] and it can be written as

$$N(D)=\frac{N_T}{D(2\pi)^{\frac{1}{2}}\ln\sigma}.e^{-\left[\ln\left(\frac{D}{D_M}\right)/2\ln\sigma\right]^2}$$

Case 1 (Showers) $5\langle R\langle 50mm/hr$

$N_T = 40R^{0.64}$

$D_M = 1.14 + 0.18\ln R$

$\sigma = e^{0.29-0.001R}$

Case 2 (Showers) $5\langle R\langle 50mm/hr$

$N_T = 46R^{0.55}$

$D_M = 0.222 + 0.397\ln R$

$\sigma = e^{0.5--.0035R}$

Case 3 (Thunderstorms) $50\langle R\langle 200mm/hr$

$N_T = 8.8^R$

$D_M = 1.76 + (7.33*10^{-4}).\ln R$

$\sigma = 1.37$

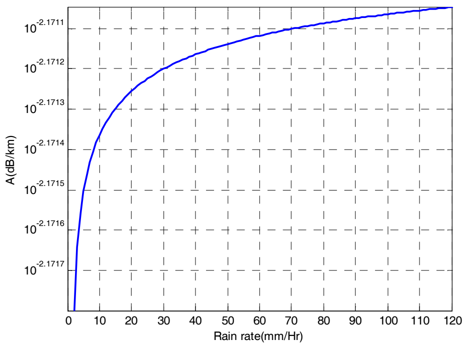

Figure 7.Attenuation at Broadband satellite (20 GHz) due to DSD

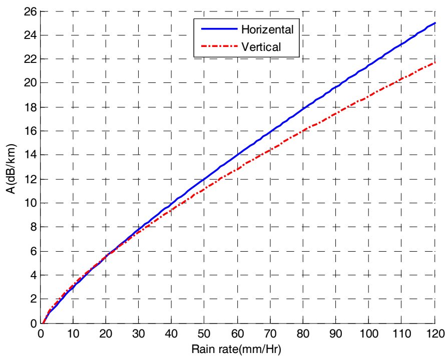

Figure 8.Rain attenuation at Broadband Satellite (20 GHz) in Linear polarization

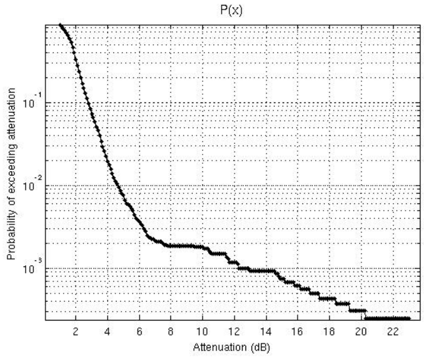

Figure 9 .Illustrated Cumulative rain attenuation

IV. Numerical Analysis

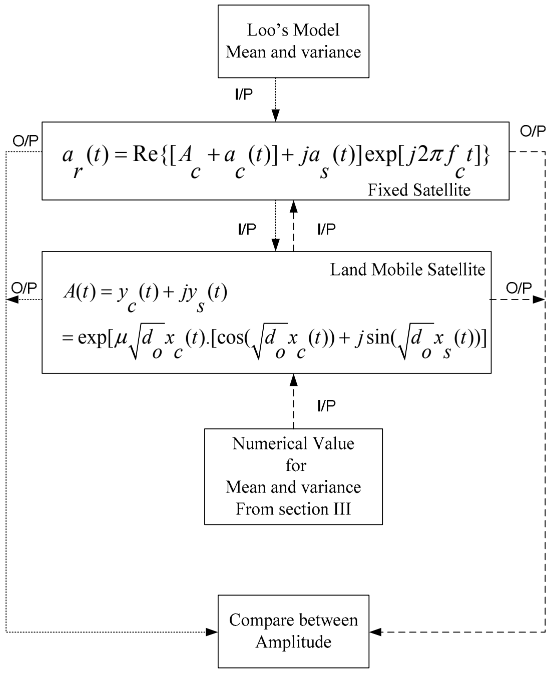

Figure10. Diagram for consideration

From (13) and(22) for find the amplitude for the fixed satellite and LMS respectively. The Amplitude received signal from Loo's model and new model from the weather-affected(new mean and variance) in section III was compare. In figure 11 and 12 we show amplitude compare between Loo's Model and new model

V. Result

From Figure 11 and 12 illstraucted the amplitude received signal in Fixed satellite and LMS. In Fix satellite new model have amplitude more than Loo's model. Cause to do signal in receive is higher more and high effective. In LMS new model have less than Loo's model

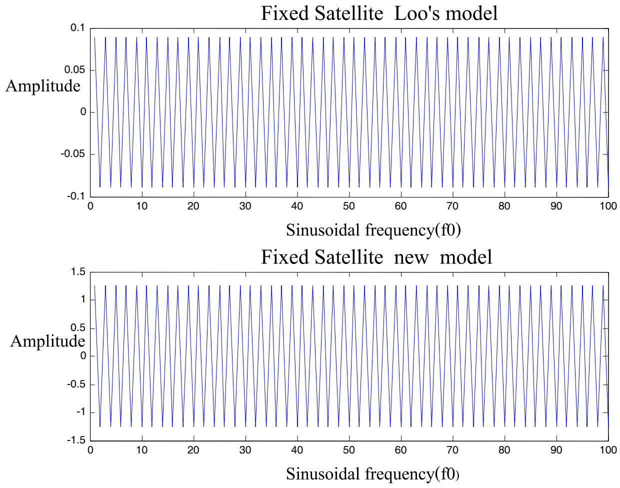

Figure 11.Compare amplitude received signal From Loo’s model and new mode (Fixed Satellite)

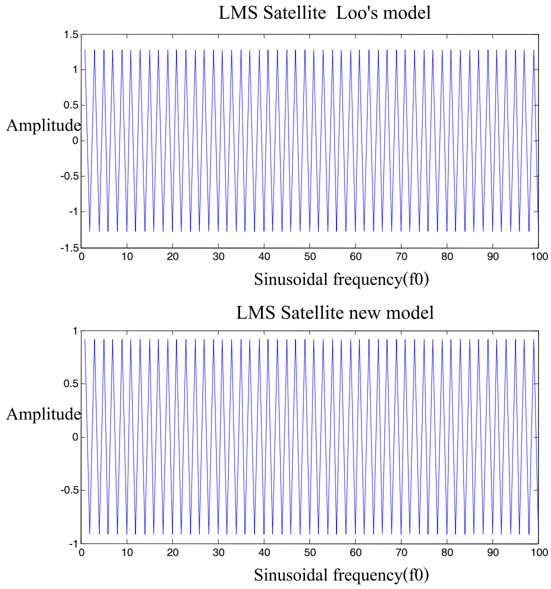

Figure 12.Compare amplitude received signal From Loo’s model and new mode (LMS)

VI. Conclusion

From this paper has introduced the changes and update the parameter values from the weather, the mean and variance In the sec III and be updated in the Loo’s model that makes the value amplitude more than of the signal receiving side is more Fixed satellite but for LMS charge amplitude tune has also have a value lower than the value of the model which Loo’s for LMS is the factor of over from factors that come from external factor because user move on to receive a signal which different from Fixed satellite which the receive signal is fix the most important factor in the receiver

VII. Acknowledge

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VIII. References

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