PROPAGATION MEASUREMENTS FOR LAND MOBILE SATELLITE SYSTEM AT 1.5 GHz: RURAL ENVIRONMENT IN EUROPE.

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ABSTRACT

A LMSS propagation experiment has been carried out in Europe using a van and the MARECS satellite. Its objective was to analyse the propagation factors required to design the LMSS planned for Europe. The results obtained from measurements made in rural environments in Spain, France and Sweden are described in this paper.

INTRODUCTION

These measurements have been performed in the framework of ESA's PROSAT phase II program /1/. The measuring campaigns took place in 1987 using the MARECS satellite as the signal source and a van with a receiver and data acquisition equipment. This van travelled through selected areas of Spain , France and Sweden collecting data from various types of environments /2,3/. Following a brief description of the rural measurements, we will discuss the results obtained from them.

MEASUREMENTS AND EQUIPMENT

The van routes were planned in agreement with ESA through selected rural areas of Spain, France and Sweden. The environment in each area can be described as follows:

Spain - The van traversed a mountaineous area with pine-trees near Gredos, west of Madrid, where the elevation angle is 39º. It is an area with rather soft mountains and not very dense woods. The pine-trees, growing in small groups or isolated, are high and have large round tops.

France - The selected route started near Colmar an traversed part of the Vosges Mountains. It went first through a rural area with low buildings and trees, and later through mountains covered with very dense woods. There was also a stretch of mountain road where vegetation was sparser. Since these measurements took place in May, decidious trees were in full foliage. The elevation angle is 26º for that part of France.

Sweden - The van moved along a stretch of road through low hills North of Stockholm, where the elevation angle is 13º. Groups of fir-trees were frequent on the roadsides and on nearby hills. The road went also through a small village with low buildings.

The van was fitted with an omnidirectional antenna mounted on its roof, a receiver (with a 13.5 dB S/N ratio), and data acquisition and recording equipment including and IBM PC computer. The received signal was digitised at 511 Hz and stored on floppy disks. At the same time it was recorded on PCM tape at a 12.5 kHz sampling rate. The van speed was registered once per second by means of an odometer connected to the PC.

RESULTS

A plot like the one shown in fig.1 was obtained from each floppy disk which usually contained a file where a nine minutes run was stored. The graph includes signal level, frequency and van speed variations (a point is depicted each five seconds). Signal levels are plotted relative to line of sight signal level. This one corresponds to a stretch of the road going fron Colmar to the Vosges Mountains (France). During the first minutes the van was moving through a rural area with hills, some low buildings and trees near the road which caused frequent fades. Later the signal was sometimes blocked due to dense woods. Several clearings allowed signal reception.

In order to observe with more detail the signal behaviour, the signal level was averaged approximately each 0.1 seconds, also relative to line of sight level. Fig.2 shows the fragment between mins. 3 and 3.5 of fig.1. Strong attenuation (10 dB) due to tree shadowing can be appreciated. When some event deserved a deeper analysis, the envelope time series was obtained for any given second. In fig.3 is depicted the envelope time series of a second registered in the woods, just before a clearing.

The three cumulative distributions shown in fig.4 were obtained from the data registered in rural environments in Spain, France (leaving out the mountains), and Sweden. The differences among them are due to the elevation angles and also to the peculiarities of each rural area. The amount of vegetation and the types of trees, the hills or mountains, affect the received signal in different ways.

In Spain, the signal is above -3 dB (relative to line of sight level) 90% of the time, and attenuated 6 dB or more 5% of the time.

In France, the signal level is above -5 dB with a 90% probability. This can be attributed to the combination of the elevation angles and the density of vegetation. As higher attenuations occur when the van is poorly oriented and closer to the trees, that part of the distribution is not very different from the first one (Spain).

In Sweden, we observe that signal levels above -6 dB correspond to a 90% probability, while attenuations of 8 dB are exceeded 5% of the time. This is due to the low elevation angle. The van was probably close to the trees less often than in the former cases, and therefore higher attenuations correspond to lower probabilities.

In fig.5 are depicted three cumulative distributions corresponding to France. They have been obtained from data registered in a rural area, in a mountaineous area with some vegetation and in a wooded area. Two of them are very similar, with fades of at least 7 dB ocurring 5% of the time, but in the woods case the signal is attenuated 11 dB or more for that same probability level. It can also be observed that in the wooded area the signal level is above -9 dB only 80% of the time.

The cumulative distributions shown in fig. 6. were obtained from the measurements made in Sweden. They correspond to fragments of few minutes during which the van orientation was more or less constant. For the first two ones the van was moving along the same stretch of road perpendicular to the satellite direction, in both directions (-90º, satellite on the right, and 90º on the left), through an area with trees and low buildings. As the roadside trees were closer in the first case, and orientation was very poor, fades are stronger, longer and more frequent. Therefore the signal is attenuated 8 dB or more 10% of the time. In the second case, attenuations of 5 dB or more occur 5% of the time. This improvement is due to a larger distance between the van and the trees, since the road was rather broad. The third distribution plotted corresponds to a stretch of road with nearby trees. The satellite was located at 30º on the right. The van was then better oriented than in the previous case but, as it was moving nearer the trees, the third distribution obtained is rather similar to the second one.

The analysis performed included plotting signal and envelope spectra for short fragments of data (about 20 sec.) so that van speed and orientation could be kept constant. The effects of multipath propagation were investigated through these spectra. Fig.7 shows a signal spectrum obtained from data registered in the Vosges mountains (France). The spread that appears in this plot is probably due to a combination of both multipath propagation effect and tree shadowing.

CONCLUSIONS

The main factor to be considered in european rural enviroments is tree shadowing. Its effect on the received signal depends on the elevation angle combined with the density of vegetation, presence of mountains or hills (with vegetation), The height of trees and their distance to the road, and van orientation. In the worst situations the signal can be sometimes blocked (Vosges Mountains and Sweden), but usually attenuations higher than 8 dB are exceeded only 5% of the time or even less.

Multipath propagation effects have been found only in a few spectra. The spreads observed in some of them are due most of times to frequent fades and only in a few cases they might appear as the combined effect of multipath propagation and tree shadowing.

REFERENCES

/1/. Jongejans et al, PROSAT phase I Report. ESA STR-216, ESTEC, Nordwijk, The Netherlands, 1986.

/2/. A. Benarroch, L. Mercader, G. Sastre, Results from the Propagation Experiment for the Land Mobile Satellite Service at 1.5 GHz, Proceedings of the U.R.S.I. B Group VII Meeting, Cuenca, 1988, (in spanish).

/3/. Study of Propagation Factors Applicable to Land-Mobile Satellite Missions (Summary). ESA Contract NO. 6757/86/NL/PB and CCN No. 1, July 1988.

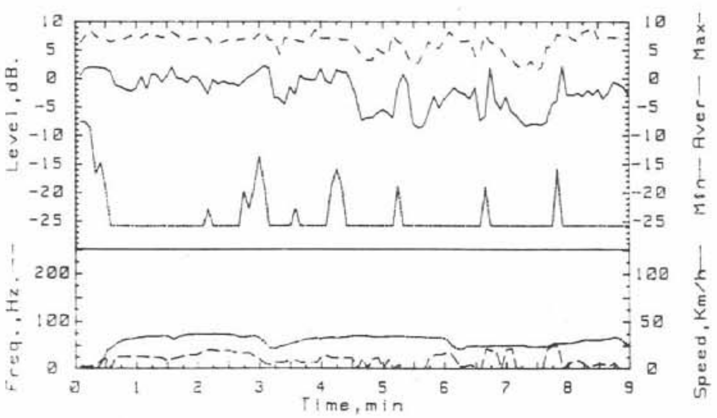

Fig. 1. Data file presentation. Rural area and woods (France).

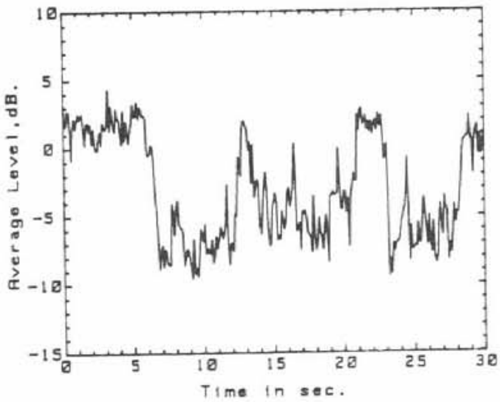

Fig. 2. Average signal level variations. Tree shadowing (France)

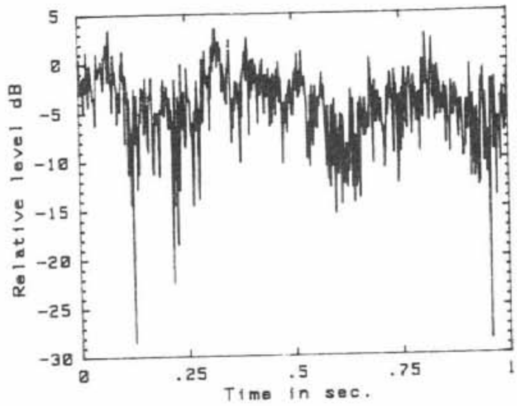

Fig. 3. Envelope time series. Woods (France).

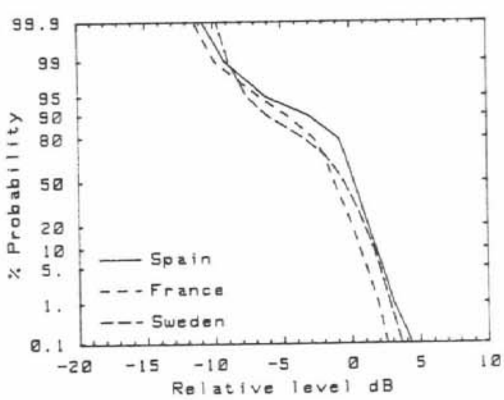

Fig. 4. Cumulative distributions. Spain, France and Sweden.

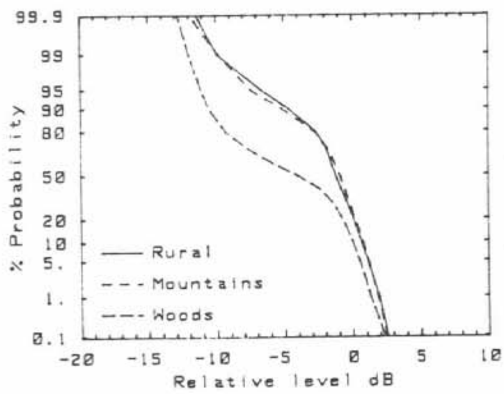

Fig. 5. Cumulative distributions. Rural, Mountaineous and wooded areas (France).

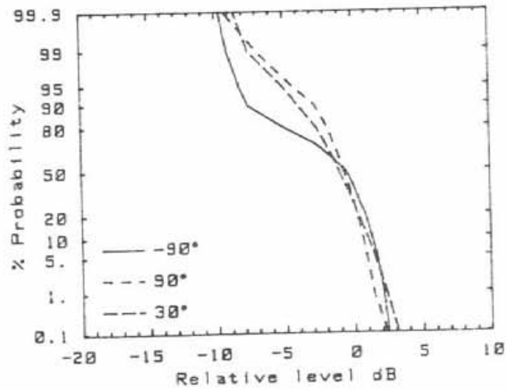

Fig. 6. Cumulative distributions. Effects of van orientation and road lane (Sweden).

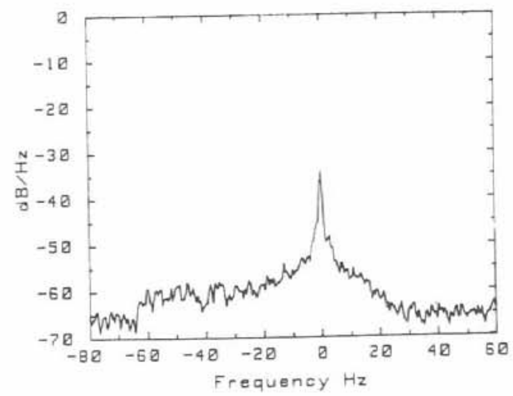

Fig. 7. Signal Spectrum. Wooded area (France).