PROPAGATION CHARACTERISTICS FOR LAND MOBILE SATELLITE SYSTEMS IN 1.5-GHz BAND

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1. INTRODUCTION

The research and development of land mobile satellite communications systems are conducted in Japan. In 1987, the Engineering Test Satellite V (EST-V) was launched. The ETS-V carries a 1.5-GHz band transponder for experiments of maritime, aeronautical and land mobile satellite communications systems. For realization of land mobile satellite communications systems, it is necessary to investigate the radio wave propagation characteristics between a satellite and vehicles running on roads, because the propagation characteristics depend on the environment around the vehicles.

Some experimental results on propagation characteristics were reported in U.S.A. and Canada.[(1),(2),(3)] Conditions of roads and elevation angle in Japan are different from roads in those countries. The expressways in Japan run through mountainous areas and have many two-level crossings, and the older roads are not very wide and run in part through urban areas.

The measurements of the propagation characteristics are conducted on two main expressways and one on an older road using the ETS-V. This paper describes the experimental results obtained through these measurements.

2. OUTLINE OF EXPERIMENTAL SYSTEM

The configuration of the experimental system and the typical system parameters are shown in Fig. 1 and Table 1, respectively. The ETS-V is placed in the orbit of 150°E.[(4)] The elevation angle and the azimuth angle to the satellite are 46-47 degrees and 155-162 degrees in the areas measured, respectively. The transponder transmits the continuous wave (CW) at 1.543 GHz and the satellite EIRP is 52 dBm.

The measuring equipment is installed in a measuring van. The quadrifilar helix antenna is used and has an omnidirectional azimuthal antenna pattern. It is mounted in the middle of the van's roof. The antenna height is 2.7 m above ground. The band-pass filter and the low noise amplifier are used for rejection of strong unwanted signals from the antenna and for amplification of the weak signal to be measured. Receiving bandwidth is selected at 1 kHz avoiding the Doppler effect frequency shift and the variation of the local oscillator in the satellite transponder. The received power measured by the spectrum analyzer and sampling pulses generated every 10 cm of vehicle running are recorded on analog magnetic tape.

The routes where the measuring vehicles run are shown in Fig. 2. They are in both directions of Tomei Expressway (total length : 900 km) which is an important road between Tokyo and Kyoto, Kan-etsu Expressway (total length : 150 km) from Tokyo to Yuzawa and the old road (total length : 150 km) alongside Kan-etu Expressway from Yuzawa to Tokyo. The arrival direction of radio waves from the satellite is also shown by arrows in Fig. 2. Both Tomei Expressway and Kan-etsu Expressway run through flat areas and mountainous areas, and both have many two-level crossings with local roads. The old road runs through local urban areas, suburbs and farms with many bridge crossings for pedestrians.

3. EXPERIMENTAL RESULTS

The typical example of received power recorded on the expressway is shown in Fig. 3. The many sudden drops of received power with short duration result from shadowing effects by two-level crossings. The long-term drops of the received power indicate system noise of the measuring equipment and result from shadowing by tunnels.

The received power recorded on the analog magnetic tapes are sampled by the recorded sampling pulses every 10 cm. One value of received power is the medium value obtained from 100 samples of data during the interval of 10 m. Data obtained in tunnels is omitted in data processing, because the received power in the tunnel is less than the system noise power as shown in Fig. 3. The total tunnel lengths in Tomei Expressway and Kan-etu Expressway are 2.9 % and 8.2 % of the total test route length, respectively.

The cumulative distribution of the received power relative to the line-of-sight received power of 0dB measured on Tomei Expressway and Kan-etsu Expressway is shown in Fig. 4 (a) and (b). The line-of-sight propagation is shown on the greater part of the expressway. The degradation of the received power on the expressway mainly results from the shadowing effects by many two-level crossings. The rapid degradation occurs at the points of around 99.1 % and 98.7 % in cumulative distribution characteristics for Tomei Expressway and Kan-etsu Expressway, respectively. The difference of cumulative distribution characteristics corresponds on the number of two-level crossings. The densities of the two-level crossings are 1.01/km for Tomei Expressway and 1.24/km for Kan-etu Expressway.

The cumulative distribution characteristics measured on the old road is shown in Fig. 5. The cumulative distribution on the old road shows a gentler degradation than on the expressway. The decrease of received power is caused by various kinds of shadowing such as bridge crossings for pedestrians high buildings near the road in the urban areas, and trees, utility poles and road signs along the road. This route runs in the same direction as the radio wave path and it is expected that the shadowing effects are less than on typical roads.

4.CONCLUSION

From the experimental results, the main degradation factor of received power on the expressway is due to shadowing effects by many two-level crossings with older roads. At the elevation of 46-47 degrees, natural obstacles such as mountains, hills and trees have little effect on the propagation characteristics. The shadowed area is 1.0 % on Tomei Expressway and 1.3 % on Kan-etsu Expressway. Therefore, the shadowed area should be expected from the construction of each expressway.

On the old road, the decrease of received power depends upon various kinds of shadowing and it is expected that every road has different characteristics of cumulative distribution according to the road environment.

REFERENCES

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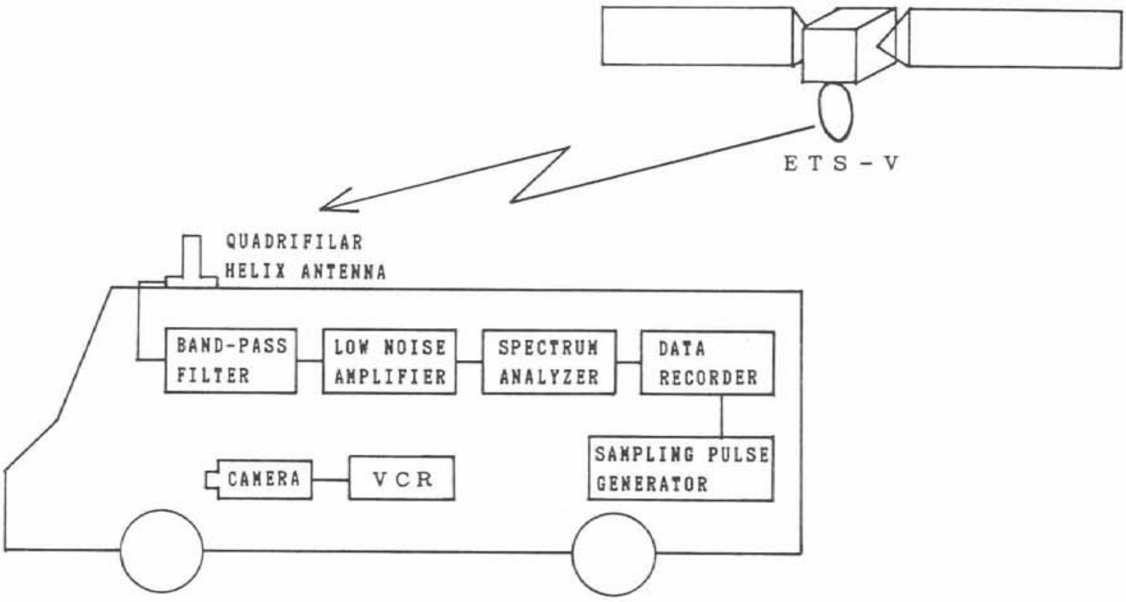


Fig.1 Configuration of Experimental System

TABLE 1 Parameters of Experimental System

Satellite	Engineering Test Satellite V
Orbit	150° E
EIRP	52 dBm
Frequency	1.543 GHz
Measuring System	Mounted on van
Antenna	Quadrifilar helix type Gain : 3 dBi
Noise Figure	3 dB
Receiver Bandwidth	1 kHz

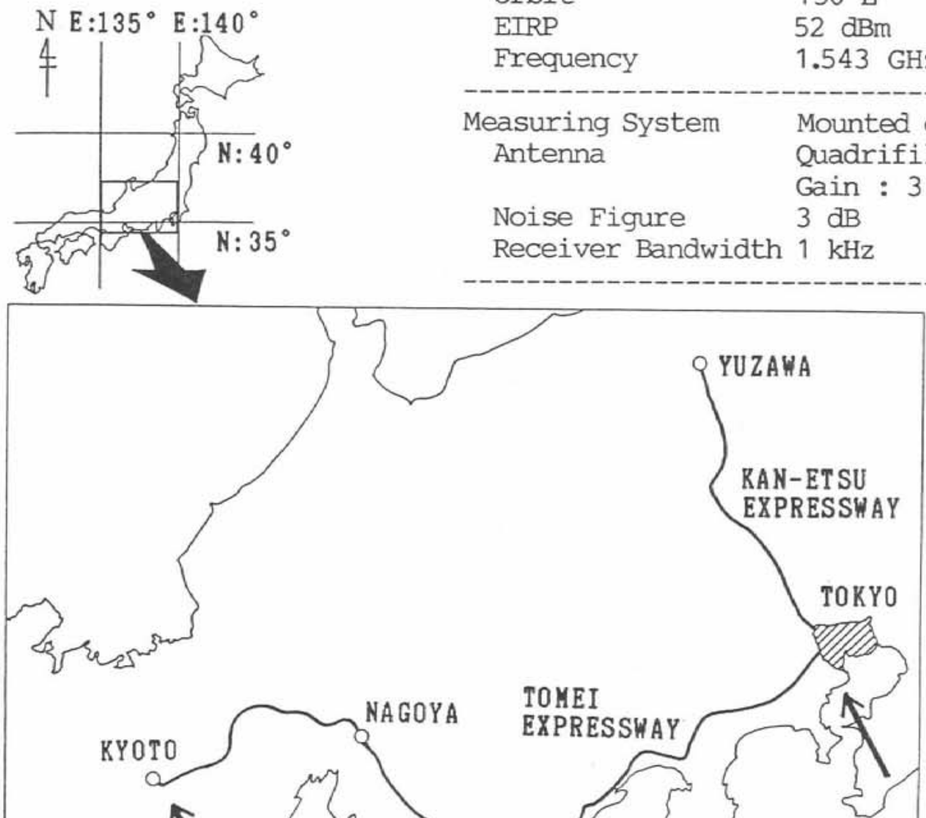


Fig.2 Experimental Routes

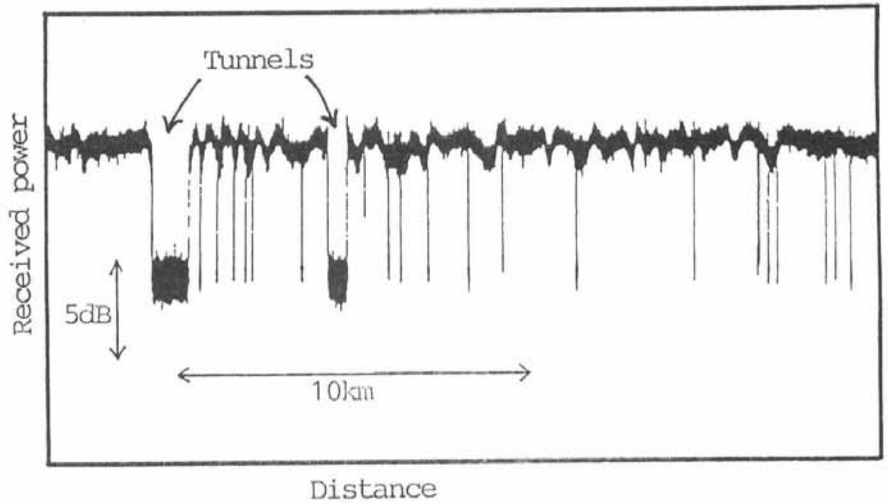
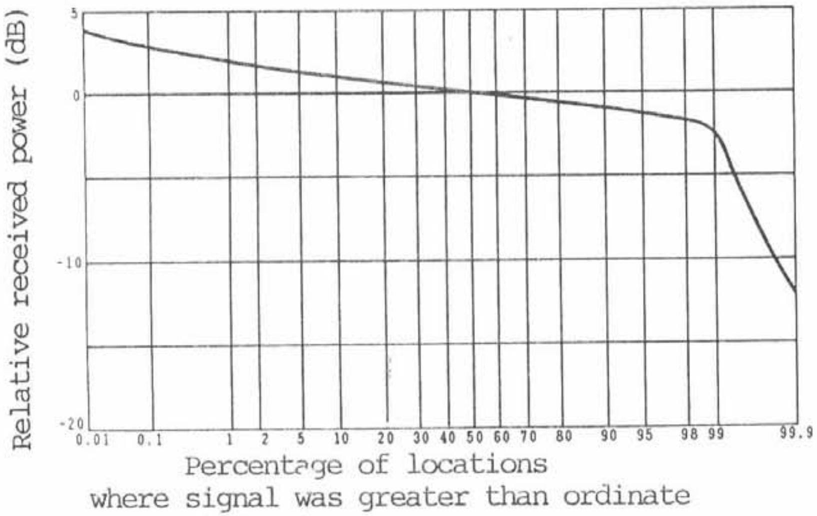
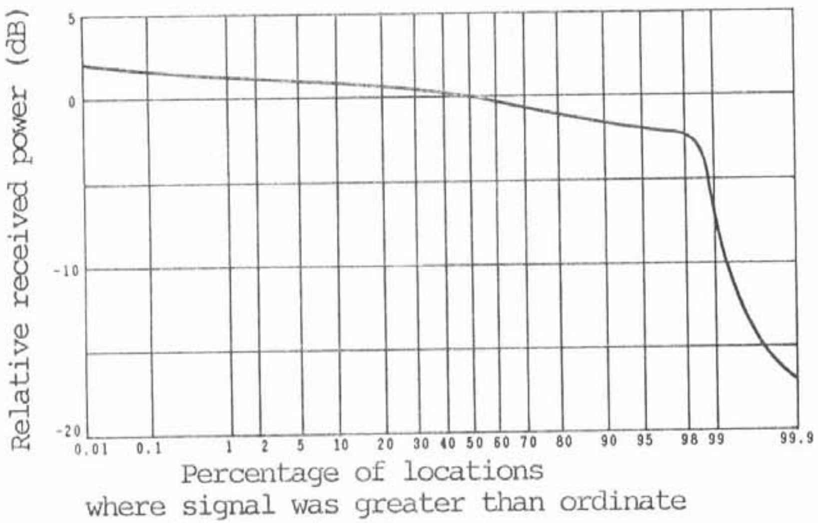


Fig.3 Example of received power



(a) Tomei Expressway



(b) Kan-etsu Expressway

Fig.4 Comulative Distribution of received power

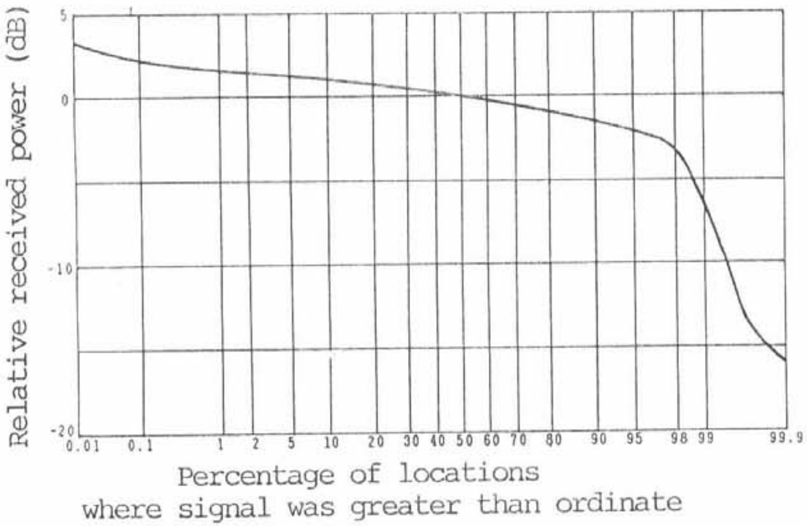


Fig.5 Comulative distribution of received power : Old Road