JAPANESE PROPAGATION EXPERIMENTS WITH ETS-V

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Abstract--Propagation experiments for maritime, aeronautical and land mobile satellite communications have been carried out using Engineering Test Satellite-five (ETS-V). The propagation experiments are one of major missions of Experimental Mobile Satellite System (EMSS) which is aimed for establishing basic technology for future general mobile satellite communication systems. This paper presents a brief introduction for the experimental results on propagation problems of ETS-V/EMSS.

1. Introduction

Ministry of Posts and Telecommunications (MPT) of Japan has promoted experiments on mobile satellite communications using an Engineering Test Satellite-five (ETS-V). The experimental system is called Experimental Mobile Satellite System (EMSS) (Hase et al, 1986). The EMSS consists of the ETS-V, a feeder link earth station at Kashima and several kinds of mobile earth stations including a small ship, an aircraft, land mobiles and a hand carried terminal. The ETS-V is maintained in a geostationary orbit over the Pacific Ocean (150deg. E).

Communications Research Laboratory (CRL) is leading the EMSS experiments, and both Nippon Telegraph and Telephone Co. (NTT) (Mishima et al, 1988) and Kokusai Denshin Denwa Co. (KDD) (Yasuda et al, 1989) are participating in the experiments to establish basic technology of future mobile satellite communication systems. This paper describes a brief introduction of the experimental results on propagation problems.

2. Maritime satellite channel

2.1 Outline of experiments

On board experiments have been carried out using a fish training ship of Hokkaido University (1700 tons). The cruising courses for the experiments are shown in Fig.1. A ship earth station for small ship consists of an improved short backfire antenna (40 cm in diameter and 15dBi in gain) with a mechanical stabilizer and of communication terminals with several kinds of MODEMs and CODECs. The antenna system has a fading reduction circuit for compensating the fading effect due to sea surface reflection, because this effect can not be neglected in low elevation areas to the satellite (Ohmori et al, 1983). Fig.2 is a block diagram of the fading reduction circuit. The circuit cancels out the co-polarized and cross-polarized signal components caused by the sea reflection by adjusting an attenuator and a phase shifter to make both components same in amplitude and out of phase each other.

2.2 Sea reflection fading

Fig.3(a)(b) show the received signal levels at elevation angle of

5.9deg. without/with a fading reduction circuit, Fig.3(c) shows the received signal level of the cross-polarized component and Fig.3(d) shows wave height measured by an onboard microwave height detector, respectively. Apparently the amount of fading is reduced by the fading reduction circuit. This fact is confirmed by considering cumulative distribution as in Fig.4 in which the received signal levels are found to fit to the Rician distribution and a fading depth of 10.9dB is reduced to 1.4dB. The observed fading depths at various elevation angles are plotted in Fig.5. It should be noted that the larger the wave height is coming up to 0.5m in standard deviation and the lower the elevation angle is going down, the fading is becoming deeper (Ikegami et al, 1989).

2.3 Blocking effect of above deck structures

The antenna system is installed on the upper deck near a radar mast in order to evaluate the blocking effect to the transmitting and receiving signal to/from the satellite. Fig.6 shows an overlook of the antenna and the mast, on which some radar antennas are installed as indicated by a dotted circle. When a beam of the antenna is shadowed by the mast, the received signals are suffered from blocking effect. Even if the beam is partly shadowed, by the scattering effects due to the mast, the received signal consists not only of a co-polarized component but of a cross-polarized component. Fig.7 shows the co- and cross-polarized components of received signals under the slight shadowing condition. The cumulative distributions of the co- and cross-components are shown in Fig.8. The co- and cross-components are found to fit to the Rician and Gaussian distribution, respectively.

3. Aeronautical mobile satellite channel

3.1 Outline of experiments

In-flight experiments were carried out using a Japan Air Line (JAL) Boeing-747 cargo plane between Tokyo and Anchorage. Three additional flights from Tokyo to Singapore, from Anchorage to Los Angles and from Bangkok to Tokyo were conducted to collect data under various kinds of antenna pointing conditions.

The onboard antenna subsystem is composed of two 16-element phased array antennas, which is installed on the top of fuselage and its gain varies from 12 to 15 dBi within scanning angles of 30 to 150 degrees in azimuth. The coverage of the antenna is shown in Fig.9. Communication terminals with several kinds of MODEMs and CODECs are installed in the upper deck of a cabin.

3.2 Experimental results

As shown in Fig.10(a), the fading effects by the sea reflection was so small as to be neglected and a stable communication channel is kept even in low elevation of 5deg. near Anchorage. The reason is that the antenna is installed on the top of the aircraft body, so the reflected signals by the sea surface were blocked by main wings and a fuselage. However, in a certain condition, slow fluctuations of about 3dB were observed as shown in Fig.10(b). Fig.11(a) illustrates the cumulative distribution of the received signal revel. This effect is considered to be the scattering from a main wing and its edge, because the beam direction corresponds to the direction of a right side main wing (Hase

et al, 1989). These experimental results are summarized in Fig.12 .

An interesting point to note is that even in the case where the elevation angles to the satellite were bellow 0 degree, the signals from the satellite could be received as shown in Fig.10(c) and Fig.11(b). This is because that at altitude of 30000ft., the satellite can be seen with the elevation angles of -3 degrees.

4. Land mobile satellite channel

The effect of fading and shadowing due to terrains, trees and such structures as buildings or traffic signs must be considered in land mobile satellite communications. In order to evaluate these effects, measurements were carried out on freeways (Tokyo-Kyoto, Tokyo-Yuzawa) and on roads in urban Tokyo. In these experiments, the elevation angles to the satellite are 46 to 48 degrees. The cumulative distributions of the received signal level with an omnidirectional antenna are shown in Fig.13. On the freeways, the fading depths for a line-of-sight path are only a few decibels, and a large amount of fade due to shadowing effects appeared only 1-2% of the time. This result indicates that the land mobile satellite communication is feasible on freeways. However, from an example of urban experiments, about 30% of places are affected by the shadowing effects. This result suggests that there would be some difficulties in offering stable communication channels in the urban areas.

Propagation experiments on a superexpress train "Shinkansen" are now in progress, and the early result indicates that the effect of electrical noise from pantographs of the train is a significant factor in satellite channels for railways.

5. Conclusion

The results of ETS-V propagation experiments are briefly reported. The most of experiments have now been in progress and a large amount of data are now analyzed. Especially experiments on land mobile satellite channels have just started. The results of the experiments on aeronautical satellite channels are expected to contribute to the early introduction of commercial aeronautical satellite services.

References

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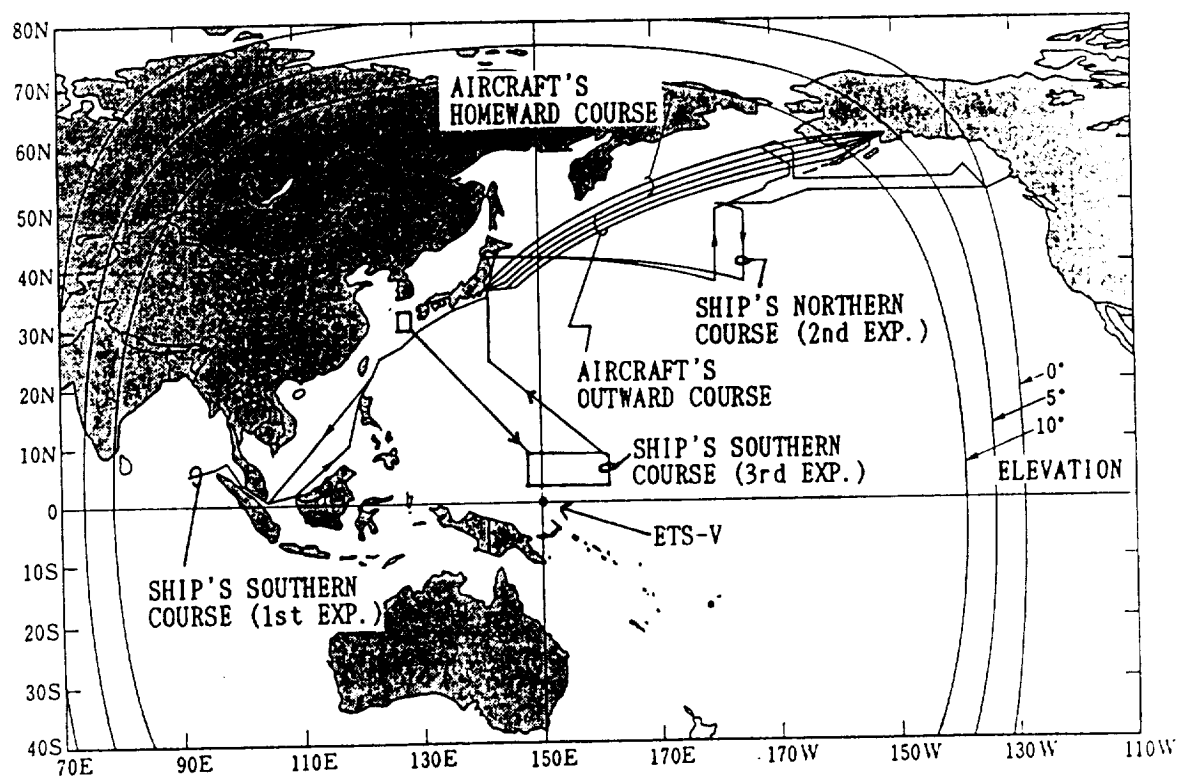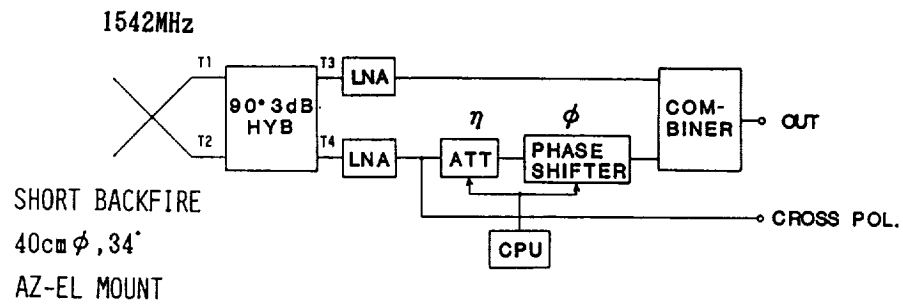
Fig.1 Cruising course of the ship and aircraft

1542MHz

SHORT BACKFIRE
40cm φ ,34°
AZ-EL MOUNT

Fig.2 Block diagram of fading reduction circuit

(a) Without fading reduction technique

(b) With fading reduction technique

(c) Cross-polarized component

(d) Wave height
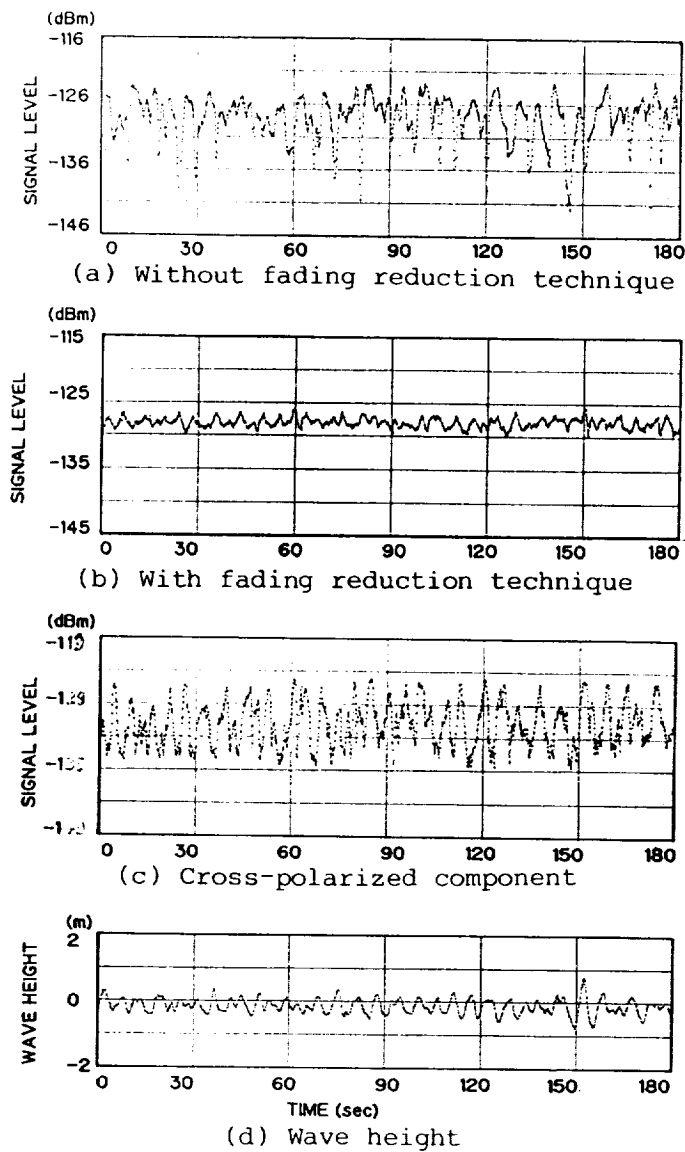
Fig.3 An example of maritime experiments

El=5.9deg.
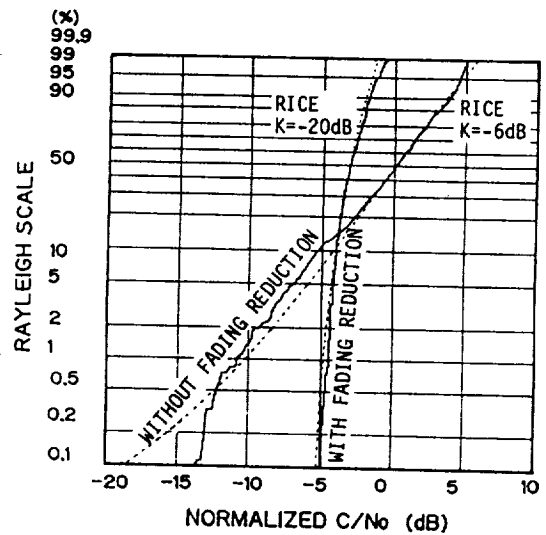
Fig.4 Cumulative distributions of received signal with and without fading reduction technique

52
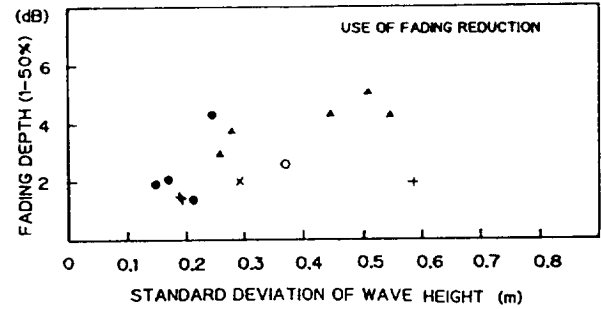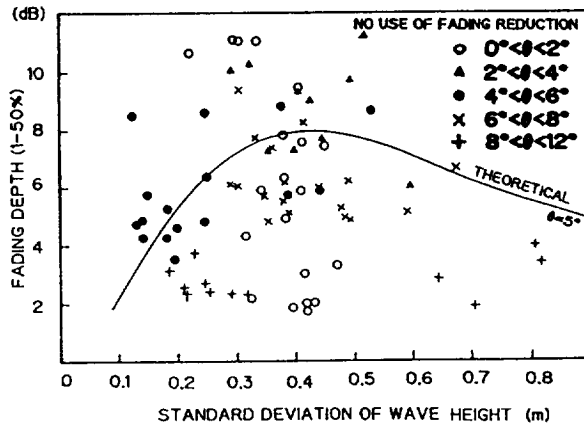
(a) No use of fading reduction technique (b) Use of fading reduction technique

Fig.5 Relation between wave height and fading depth
:elevation angle
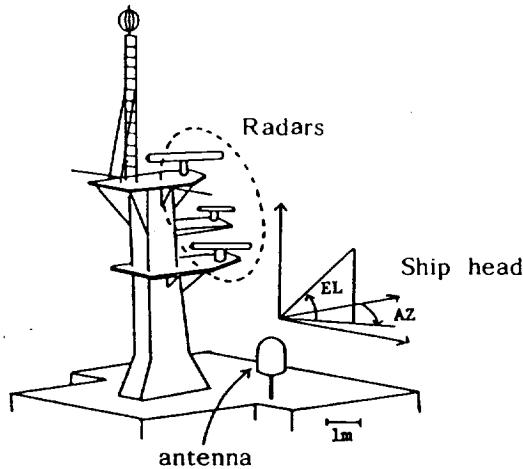
Fig.6 Overlook of the antenna
and above deck structures
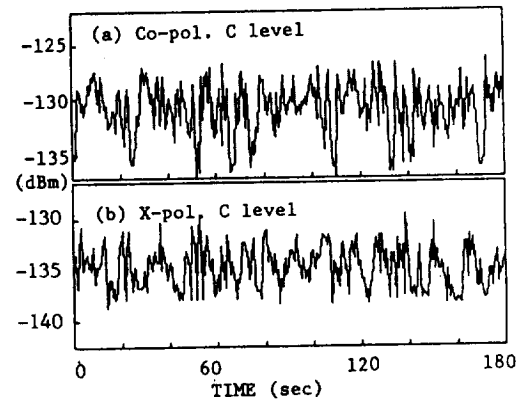
Fig.7 Co- and cross-polarized received
signals under blocking conditions
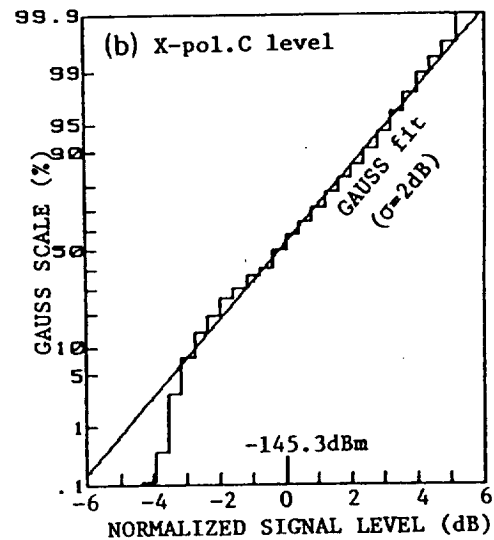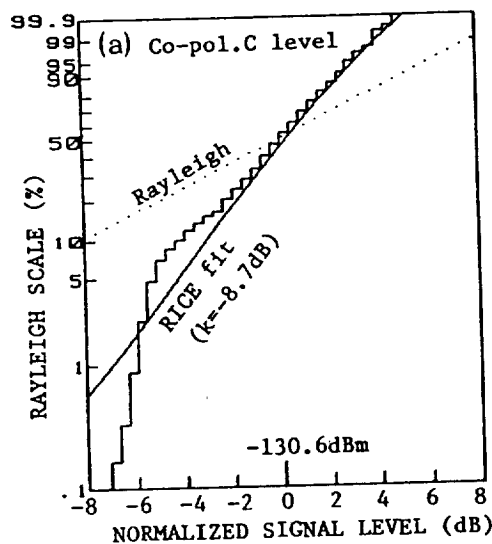
Fig.8 Cumulative distributions of co- and cross-polarized signals

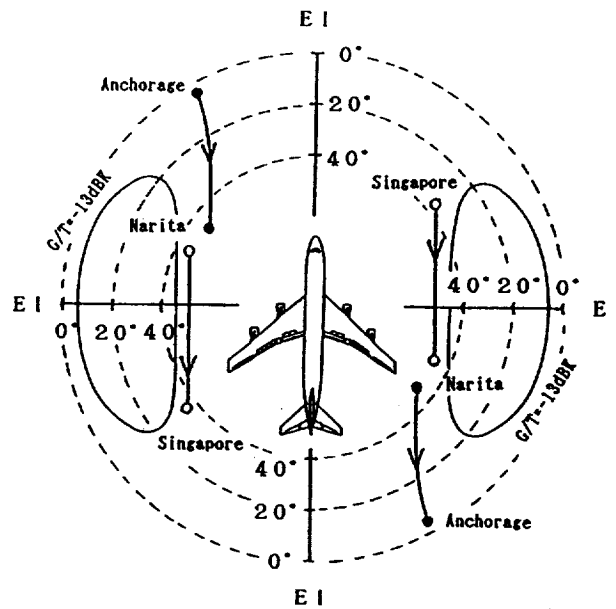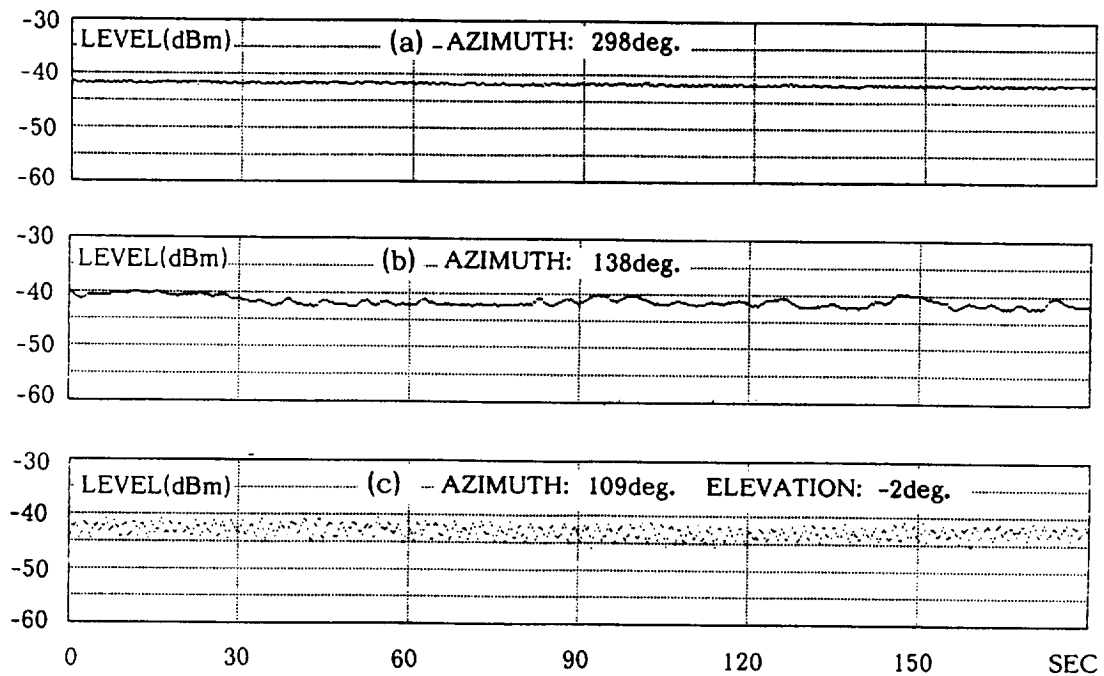Fig.9   Coverage of airborne antenna

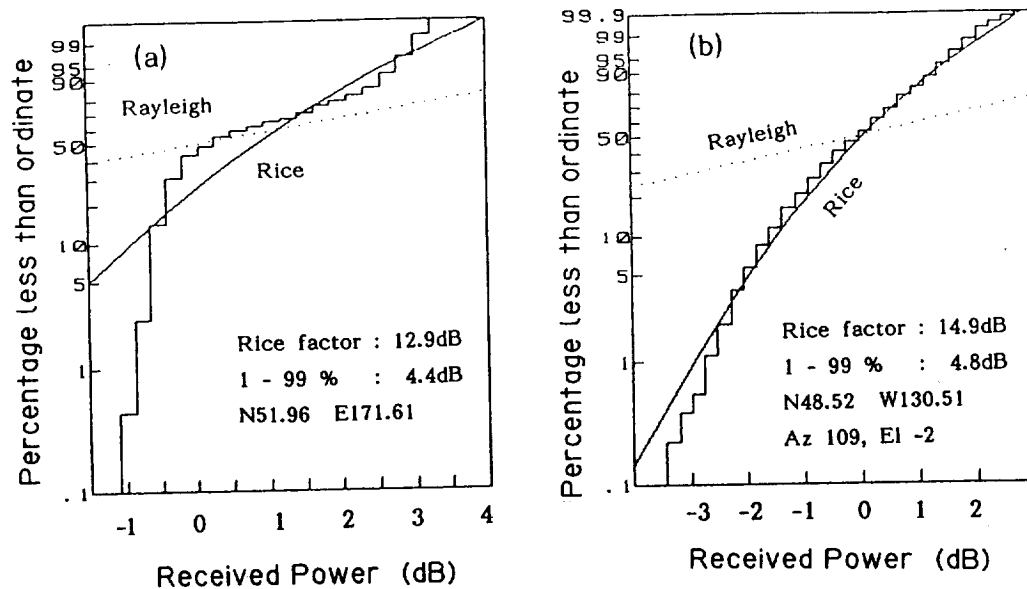Fig.10   Received signal levels measured on the aircraft

Fig.11 Cumulative distributions of received signals measured on the aircraft
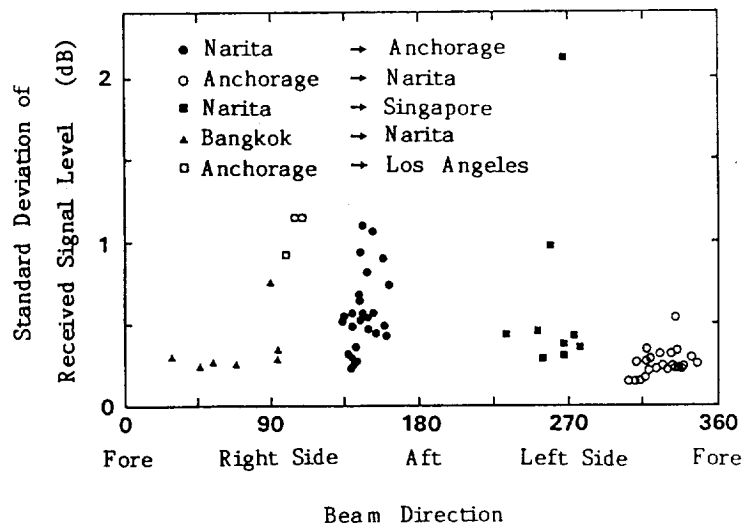

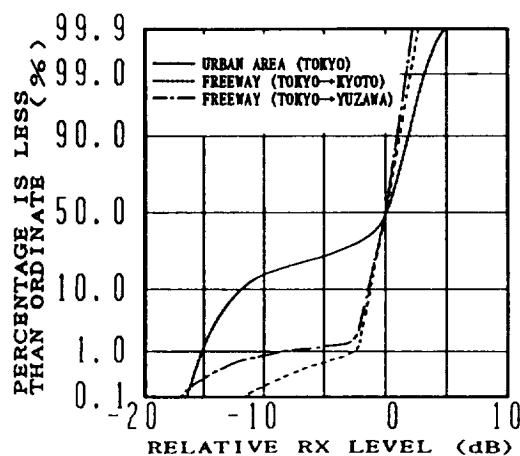Fig.12 Standard deviation of received signals measured on the aircraft

Fig.13 Cumulative distributions of received signals measured on freeways and loads