ETS-V PROPAGATION EXPERIMENTS IN JAPAN

Shingo Ohmori
Kashima Space Research Center
Communications Research Laboratory
Ministry of Posts and Telecommunications
Kashima, 314 Japan

Abstract-- Propagation experiments on ship, aircraft, and land mobile earth stations have been carried out using Engineering Test Satellite V (ETS-V), which was launched in August, 1987. The propagation experiments are one of missions of an Experimental Mobile Satellite System (EMSS). The project of EMSS is aimed for establishing basic technologies for future mobile satellite communications systems. This paper shows initial experimental results of ETS-V/EMSS on propagations using ship, aircraft and land mobiles with the ETS-V.

1. Introduction

Ministry of Posts and Telecommunications (MPT) of Japan has promoted Experiments on Mobile Satellite Communications using an Engineering Test Satellite V (ETS-V), which experimental system is called an Experimental Mobile Satellite System (EMSS) (Hase et al, 1987). The EMSS consists of the ETS-V, a feeder link earth station (Kashima Space Research Center) and several kinds of mobile earth stations including a ship, an aircraft, land mobiles and a hand carrying terminal. The ETS-V was launched on August 27 in 1987 by an H-1 rocket to a geostationary orbit over the Pacific Ocean (150 E).

Communications Research Laboratory (CRL) is leading the EMSS experiments, and Nippon Telegraph and Telephone Co. (NTT) (Shindo et al, 1987) and Kokusai Denshin Denwa Co. (KDD) are participating in the experiments to establish basic technologies of future mobile satellite communication systems. This paper describes initial experimental results on propagation problems.

2. Ship earth station

2.1 Outline of experiments

On board experiments were carried out in the South Pacific Ocean from Oct. 20 to Dec. 24 in 1987 by using a fish training ship of Hokkaido University (about 1400 tons). A ship earth station (SES) consists of an antenna system (15 dBi in gain) with a mechanical stabilizer and experimental terminals with several kinds of MODEMs and CODECs. The antenna system has a function to reduce effects of sea reflection fading, which can not be neglected in low elevation areas to the satellite (Ohmori et al, 1983)

2.2 Sea reflection fading

Before the launch of ETS-V, several experimental and theoretical analyses of sea reflection fading were carried out by CRL (Ohmori et al, 1985) and KDD (Karasawa et al, 1984), especially in the case of low elevation angles. Figure 1 shows the data of wave height and received signal level, which were measured during 180 seconds. The wave height was measured by a wave height detector mounted on the head of a ship, which measures wave motion by using microwave doppler effects. Sea wave condition shown in Fig. 1 was very rough, however, a

range of fading was as small as about 2 dB, because elevation angles to the satellite were so high as to vary from 20 to 55 degrees. As shown in Fig.2, spectra of wave height, ship motion and antenna motion were analyzed to evaluate sea conditions and a satellite tracking capability of the antenna system. Fig.2 shows clearly that ship moves according to wave motions and the antenna moves according to ship motions; it means that the antenna system has enough capability to track the satellite.

2.3 Blocking effect of above deck structures

The antenna system is installed on the deck near a mast in order to evaluate blocking effect to received signal level from the satellite. Figure 3 shows overlook of the antenna and the mast, on which sets of radars are installed as shown by a dotted circle. By scattering effects due to the mast, received signals consists not only of co-polarized component but of cross-polarized component. Figure 4 shows co- and x-polarized components of received signals under the blocking conditions. Accumulative distributions of co- and x-components are shown in Fig. 5. Co-component and X-component are found to fit to Ricean and Gaussian distribution, respectively.

3. Aircraft earth station

3.1 Outline of experiments

In flight experiments were carried out using a Boeing 747 jet cargo (JAL) between Tokyo and Anchorage. At Anchorage, an elevation angle to the ETS-V is 5 degrees, in such low elevation areas multipath fading cased by sea reflection is expected to be observed. Newly developed phased array antenna is adopted as an airborne antenna and its gain varies from about 12 to 15 dBi within beam coverage area. The antenna is mounted on the top of fuselage. Flight routes are shown in Fig. 6 with those of a ship.

3.2 Fading effects by a main wing

As shown in Fig. 7(a), fading effects by sea reflection was so small as to be neglected even in low elevation areas near Anchorage. The reasons may be that the antenna is installed on the top of the aircraft body, so reflected signals by sea surface were blocked by main wings and fuselage. However, slow speed fading effects were observed as shown in Fig. 7(b). The deviation of received signals was about 3 dB. The reason of this phenomenon is consider to be the scattering of signals due to a main wing and its edge, because in these experimental conditions the beam direction was correspond to the direction of a right side main wing.

4. Land Mobile Earth Station

CRL has already developed several kind of land mobile earth stations using such modulation techniques as ACSSB, MSK and SS (spread spectrum). However, propagation experiments on land mobiles with ETS-V have just started and there are only basic data. Figure 8(a) and (b) show propagation data measured in city area (down town Tokyo) and in open area (Kashima Space center), respectively. An antenna for measurements is an one-element microstrip patch and its gain is about 7 dBi.

5. Conclusion

The ETS-V propagation experiments on an initial stage were reported. The experiments have now been on progress and a large amount of data are now analyzed. Main topics of experiments in the initial stage on aircraft and on a ship are scattering by main wings and blocking effects by above deck structures such as masts and radars, respectively. In 1988, CRL has a plan to perform 2-on board experiments in North and South Pacific Ocean, 14-in flight experiments between Tokyo and Anchorage and Land mobile experiments in many kinds of terrains. NTT and KDD have also many schedules to carry out propagation experiments using ships, aircraft and land vehicles.

References

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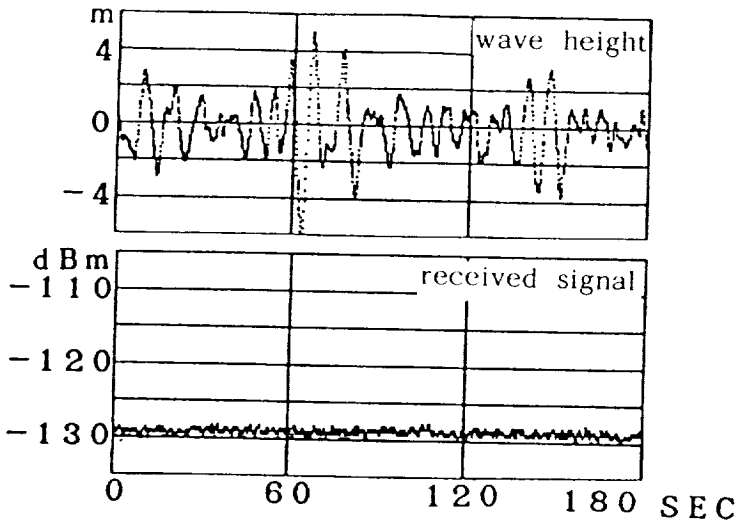


Fig.1 Wave height and received signal level.

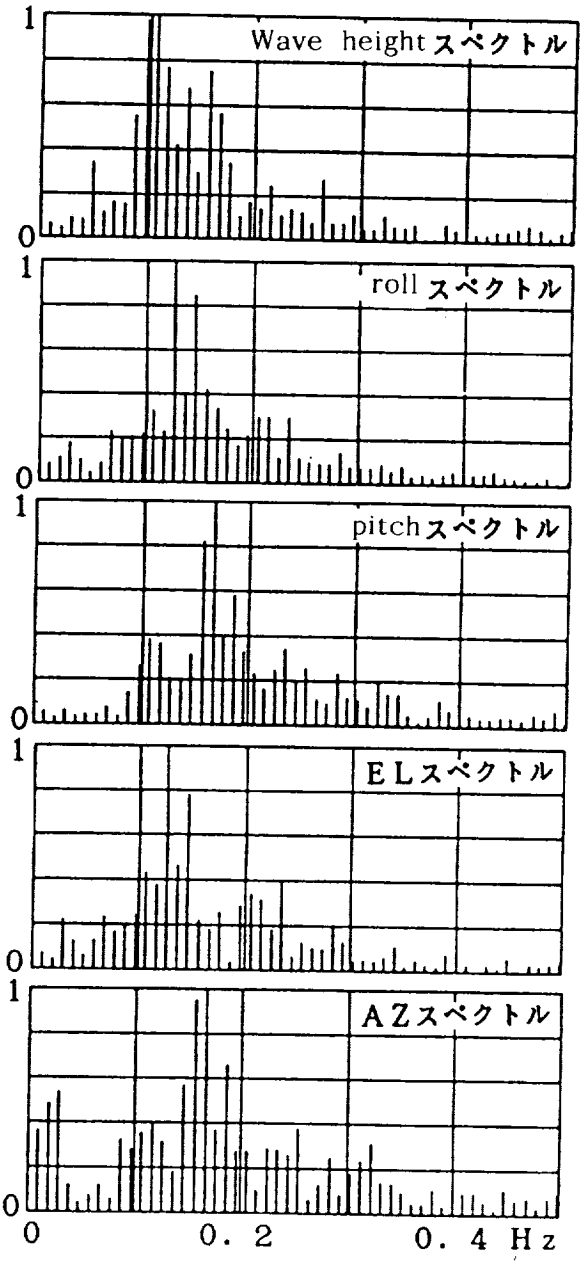


Fig.2 Spectra of wave height, ship motion (roll & pitch) and antenna motion (Az & El).

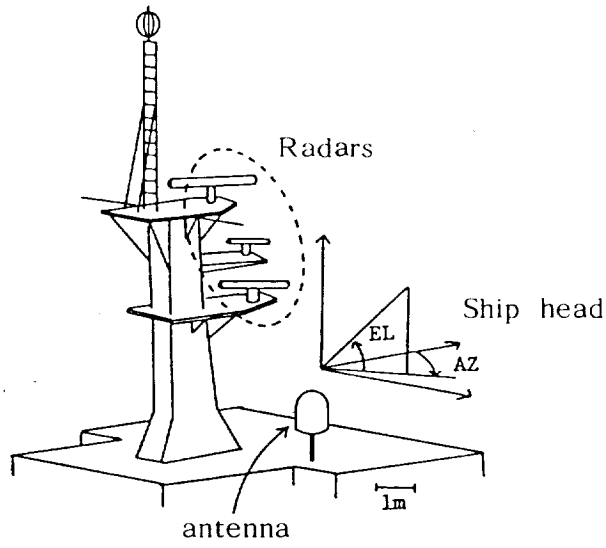


Fig.3 Overlook of the antenna and above deck structures.

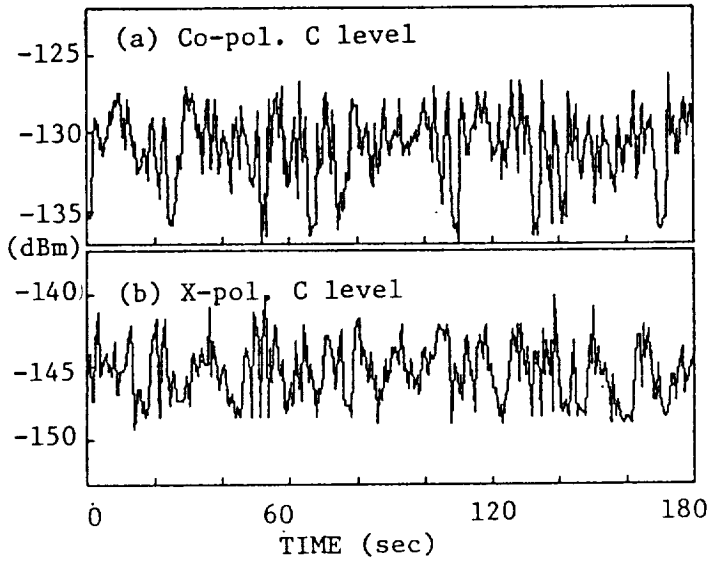


Fig.4 Co- and X-polarized received signals under the blocking conditions.

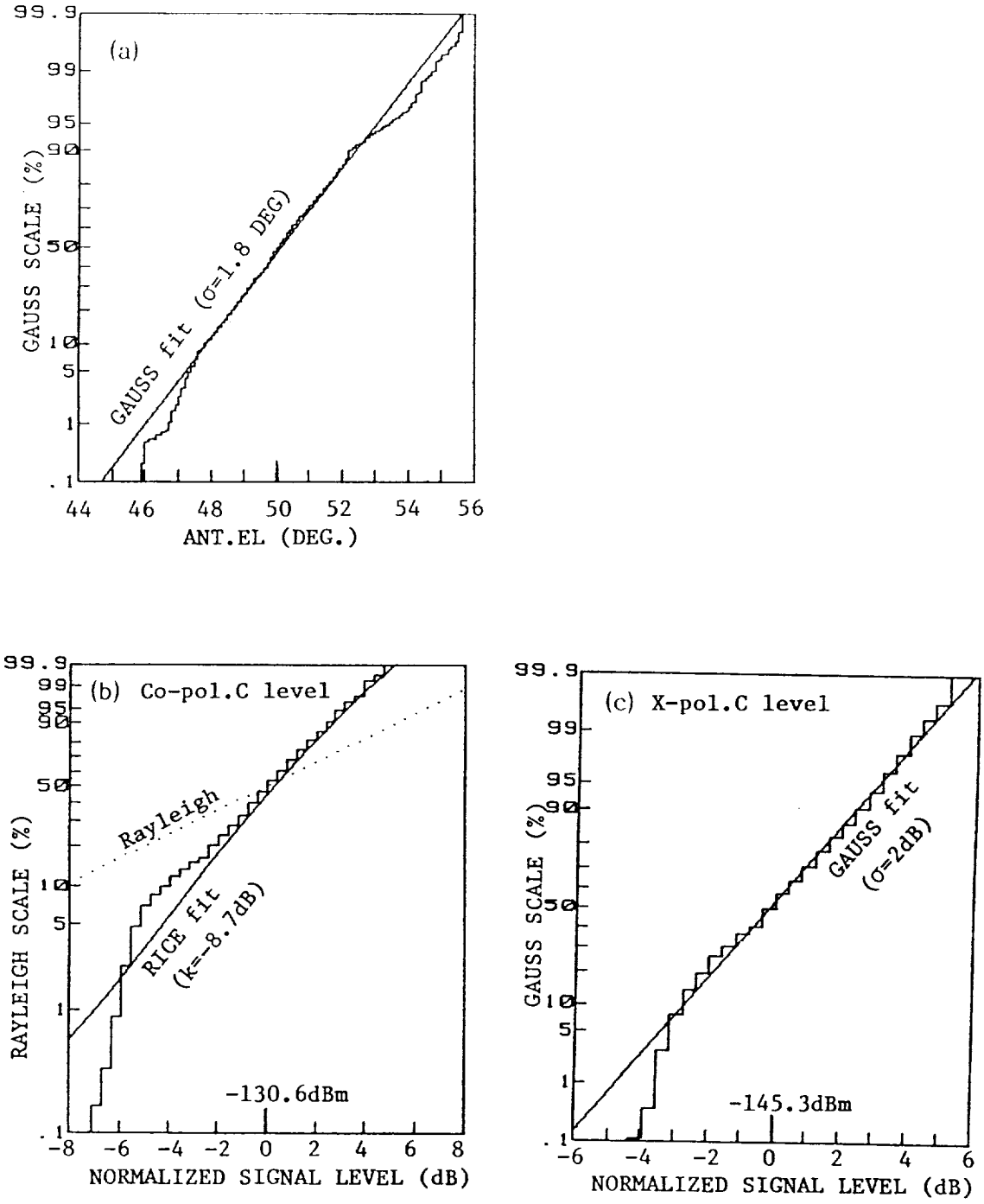


Fig.5 Accumulative distributions of antenna motion (a), co- (b) and X-polarized signal levels (c).

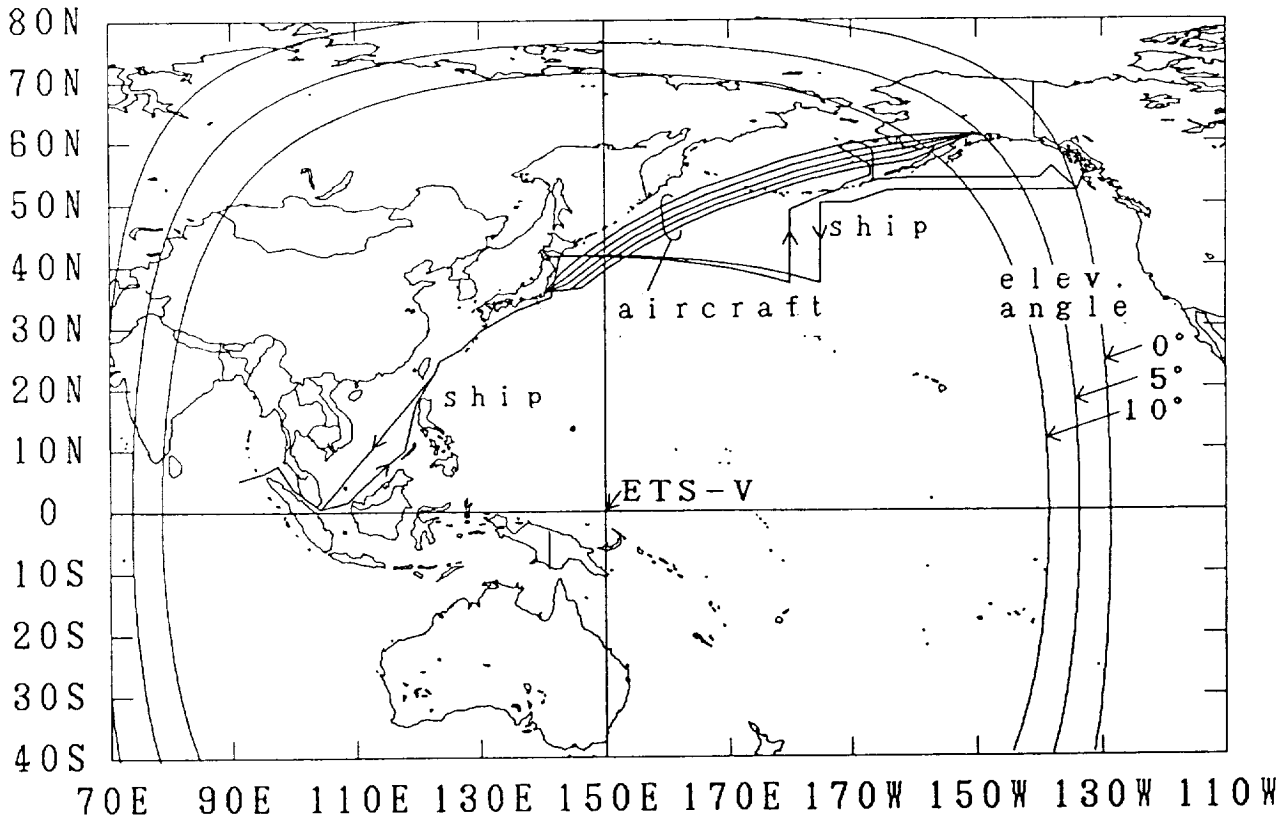
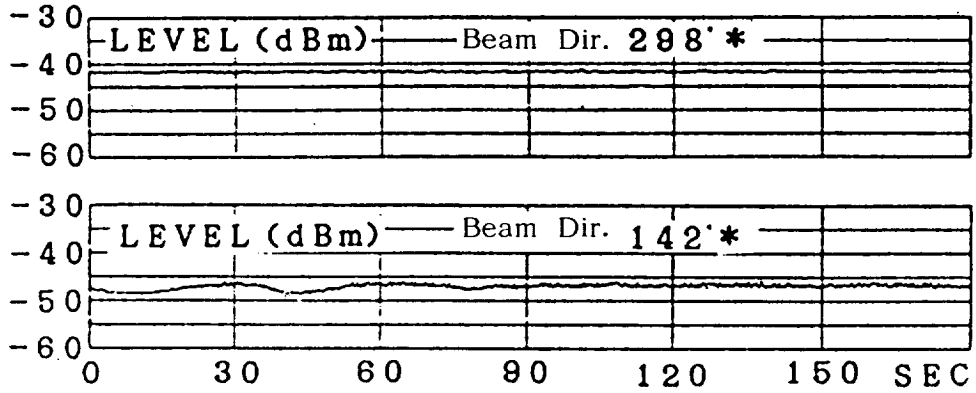
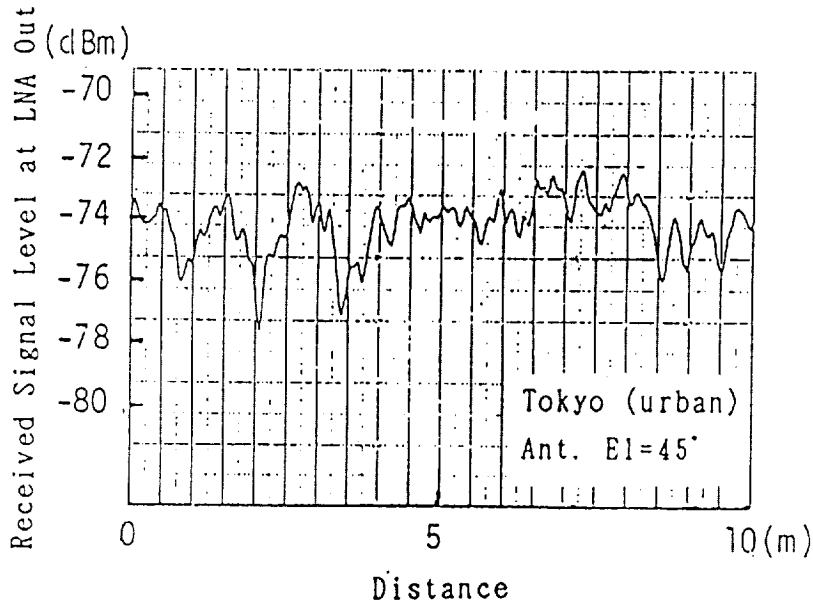


Fig.6 Flight and cruising routes of the aircraft and the ship.

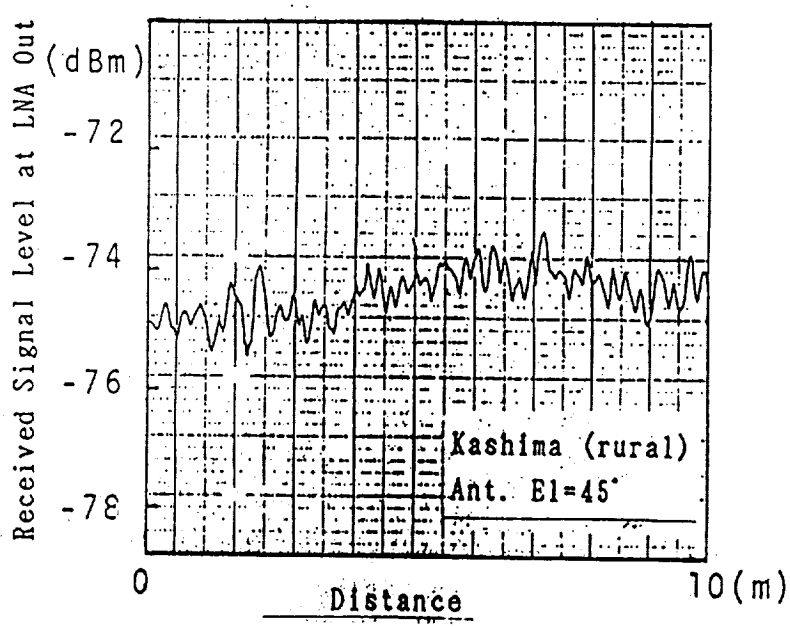


* CW from the aircraft head.

Fig.7 Received signal levels measured on the aircraft.



Received Signal at Moving Trolley



Received Signal at Moving Trolley

Fig.8 Received signal levels measured on the land mobile.
(a) Urban area (b) Rural area.