A STUDY ON MOBILE PROPAGATION LOSS CHARACTERISTICS IN UHF-TV BAND

[*]Masahiro NISHI, [*]Teruaki YOSHIDA, [**]Masaharu HATA, and [***]Shigeaki OGOSE

[*] Hiroshima City University, 3-4-1, Ozuka-higashi, Asa-minami-ku, Hiroshima, 731-3194, Japan
[**] Okayama University, 3-1-1, Tsushima-naka, Okayama, 700-8530, Japan
[***] Kagawa University, 2217-20, Hayashi-cho, Takamatsu, 761-0396, Japan
E-mail: nishi@ieee.org

1. Introduction

Recently, the demand of broadband and high mobility has increased in the mobile communication fields. To achieve the broadband capacity, higher frequency bands such as micro or millimeter bands have been mainly investigated. However, the radio propagation performance deteriorates as the radio frequency becomes higher[1][2]. In order to easily realize the high mobility, the lower frequency band should be applied to mobile communication systems. On the other hand, the terrestrial TV broadcasting will be digitalized all over Japan after the year 2006[3]. The terrestrial digital TV systems will utilize the UHF band from 470 to 770 MHz. This frequency band has better performances in radio propagation compared with higher frequency bands.

Considering above situations, authors have proposed the new type of UHF band mobile platforms constructed with both digital communication and broadcasting systems in order to effectively provide IS (Information Services) that is integrated with communication and broadcasting services[4]. Since the UHF-TV band has been mainly utilized for the fixed reception of TV broadcasting waves, it is necessary to newly investigate and clarify the mobile propagation characteristics of UHF-TV band radio wave for constructing the proposed mobile platforms.

In this investigation, to study the mobile propagation loss characteristics in UHF-TV band, we have measured the UHF-TV band radio wave with the mobile radio propagation measurement system, using existent TV broadcasting wave and GPS systems, in the various environments such as urban, suburban, and hilly areas. And to increase generality of measurement results, the measurement was performed in Hiroshima, Okayama, and Takamatsu regions. This paper discusses the mobile propagation loss in UHF-TV band based on our measurement results.

2. Measurement Method

Figure 1 shows the mobile radio propagation measurement system. In this measurement system, UHF band monopole antenna is fixed on the rooftop of the vehicle, and the receiving signal of TV broadcasting is detected in the UHF band receiver. The RSSI (Received Signal Strength Indicator) associated with the received level is transferred through an A/D converter to be recorded in a personal computer as digital data. This measurement system can also record the positioning data using GPS system. By use of this mobile measurement system, we can measure the propagation loss in various outdoor environments such as urban, suburban, and hilly areas[5]. In this system, the existent UHF band TV station is utilized as a transmitter. And it is confirmed that the accurate measurement can be achieved by use of the voice carrier frequency in the existent NTSC TV signal as a measurement frequency[5]. Table 1 shows the parameters of the measurement system. The 3 dB bandwidth of the receiver is about 230 kHz, and the measurement limitation is about –105 dBm in the received level. The receiving antenna height is about 1.5 m and the length of antenna is 1/4

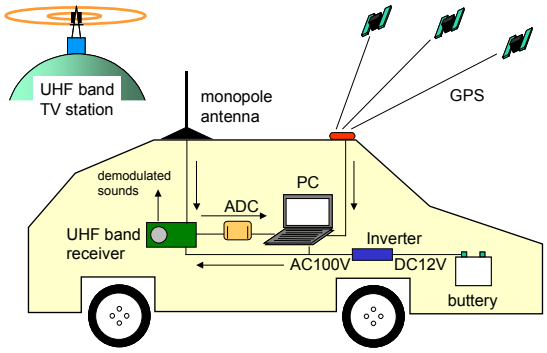

Figure 1: Mobile propagation measurement system

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wavelength of measuring frequency. In this measurement, both received level data and GPS positioning data are recorded every one second with the maximum vehicle speed of 40 km/h.

Table 1: Parameters of measurement system

Receiving antenna height	1.5 m
Length of antenna	1/4 wavelength
Receiving bandwidth	230 kHz (3 dB)
Measurement limitation	-105 dBm
Sampling rate	1 sec

3. Measurement Environments

Using above propagation measurement system, we measured the received level of UHF -TV band radio wave in different three regions, Hiroshima, Okayama, and Takamatsu regions. Table 2 shows the parameters of transmitter (TV station) used in the measurement. The altitudes of the transmitters in Hiroshima, Okayama, and Takamatsu regions are about 440 m, 427 m, and 334 m, respectively. And measurement frequencies in Hiroshima, Okayama, and Takamatsu are voice carrier frequencies of Ch. 40, Ch. 23, and Ch. 19, respectively. Considering the city characteristic of each region, we decided that the measurement environments were urban and hilly areas in Hiroshima, urban, suburban, and hilly areas in Okayama, suburban and hilly areas in Takamatsu, respectively.

Table 2: Parameters of UHF-TV transmitter

	Hiroshima	Okayama	Takamatsu
Tx. Site	E.132.24.54 N.34.25.27	E.133.57.53 N.34.33.33	E.134.07.39 N.34.18.55
Altitude	440.2 m	427.2 m	334 m
Frequency	637.75 MHz	535.75 MHz	511.75 MHz
Tx. Power	2.5 W	5 kW	1.25 kW
ERP	7.3 W	69 kW	22.75 kW
Polarization	Vertical	Horizontal	Horizontal

4. Measurement Results

In this study, the propagation distance between the transmitter and the receiver is obtained through the measured GPS positioning data, and the mobile loss propagation characteristics are analyzed considering the directivity of both transmitting and receiving antennas. In this analysis, the average value of propagation loss over 100 m is evaluated.

In the following measurement results, the propagation loss performances of the free space loss[6] and the Okumura-Hata formula[2] are shown for comparisons. The original Okumura -Hata formula for urban area is used in the results of urban propagation loss, and the correcting Okumura-Hata formula for suburban area is used in the results of the propagation loss in suburban and hilly areas. It should be noted that the height of transmission antenna is used for calculation being out of the applicable range (30 - 200 m) of the Okumura-Hata formula. And the log approximation curves of measurement data are also shown in the results in order to discuss the propagation loss related to the distance.

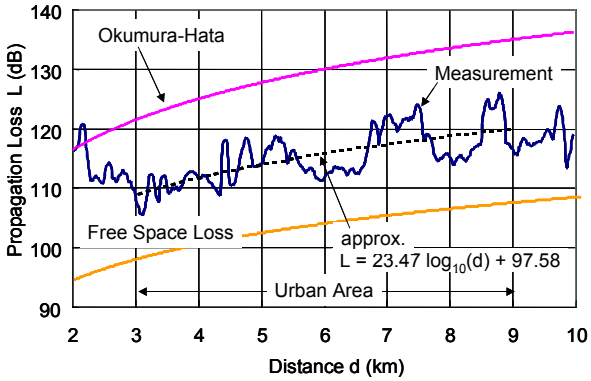

Figure 2: Propagation loss in Hiroshima urban area

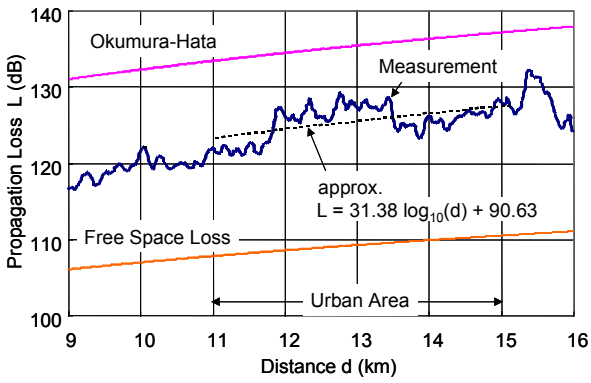

Figure 3: Propagation loss in Okayama urban area

4.1 Urban Area

Figure 2 and 3 show the mobile propagation loss characteristics of urban areas in Hiroshima and Okayama regions, respectively. The measured urban areas are located from 3 to 9 km in the southwest direction, and from 11 to 15 km in the north direction from the transmission site in Hiroshima and Okayama regions, respectively.

From these figures, it is found that both propagation loss characteristics in Hiroshima and Okayama regions are about 10 dB lower than that of the Okumura-Hata formula. It can be considered as the main reason that there are many LOS (Line Of Sight) paths in these environments because of the high altitude of the transmitter (440 m in Hiroshima, 427 m in Okayama) and the received level becomes high. The propagation loss of Hiroshima or Okayama increases in proportion to 2.3 or 3.1 powers of propagation distance, respectively, as shown in the approximation results in these figures. Moreover, it can be seen that propagation loss characteristic in Hiroshima fluctuates in the range of about 10 dB. This fluctuation range is 5 dB larger than that of Okayama. This fluctuation is caused by variation of radio propagation environment due to the urban structure in Hiroshima, where there are many big rivers and large parks.

4.2 Suburban Area

Figure 4 and 5 show the propagation loss characteristics of suburban area in Okayama and Takamatsu regions, respectively. The measured suburban areas are located from 7 to 11 km in the north direction, and from 4 to 14 km in the west direction from the transmission site in Okayama and Takamatsu regions, respectively.

From these figures, it can be seen that the propagation loss in Takamatsu suburban area fluctuates contrastively to the propagation loss in Okayama suburban area. As shown in the approximation results in these figures, the propagation loss of Okayama or Takamatsu increases in proportion to 6.5 or 3.9 powers of propagation distance, respectively. The reason of large propagation constant in Okayama suburban area is that surrounding environment rapidly changes from open area (< 7 km) to urban area (> 11 km) in only 4 km range, and the propagation loss also rapidly increases as the distance becomes long. From the results, we can see that the both propagation loss in these two suburban areas come close to the free space loss as the distance decreases. This reason is that the LOS effect largely affects the propagation loss in the UHF-TV system that generally utilizes high-altitude transmitter.

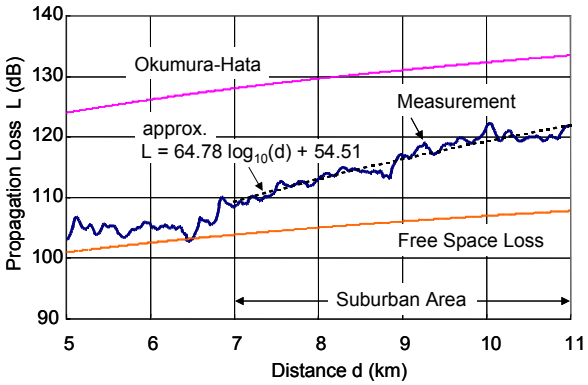

Figure 4: Propagation loss in Okayama suburban area

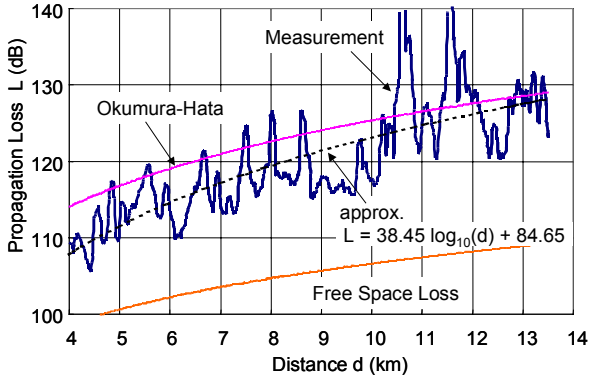

Figure 5: Propagation loss in Takamatsu suburban area

4.3 Hilly Area

Figure 6, 7, and 8 show the propagation loss characteristics of hilly areas in Hiroshima, Okayama, and Takamatsu regions, respectively. The measured hilly areas are located from 1 to 7 km in the northwest direction, from 15 to 25 km in the north direction, and from 13 to 25 km in the west direction from the transmission site in Hiroshima, Okayama, and Takamatsu regions, respectively.

From these figures, it can be found that the propagation loss in hilly area fluctuates from 20 to 30 dB in all cities. This reason is that there

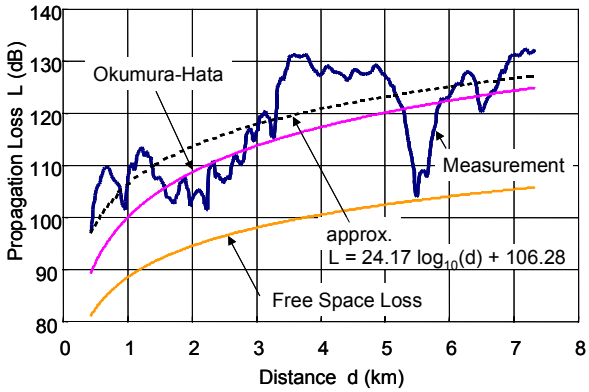

Figure 6: Propagation loss in Hiroshima hilly area

are two different propagation cases because of the complex propagation environments in hilly area, in one case, there are LOS paths between receiver and transmitter, and in the other case, there are not LOS paths. From the approximation results of measurements, the propagation loss in hilly area in all cities is larger than that of the Okumura-Hata formula, and the propagation loss of Hiroshima, Okayama or Takamatsu increases in proportion to 2.4, 7.3 or 7.0 powers of propagation distance, respectively. The reason that the propagation constant of Hiroshima is lower than those of other regions is considered as that the propagation distance is 10 km or less in Hiroshima hilly area, and the propagation loss is not affected by the plane earth loss[6] only in Hiroshima hilly area.

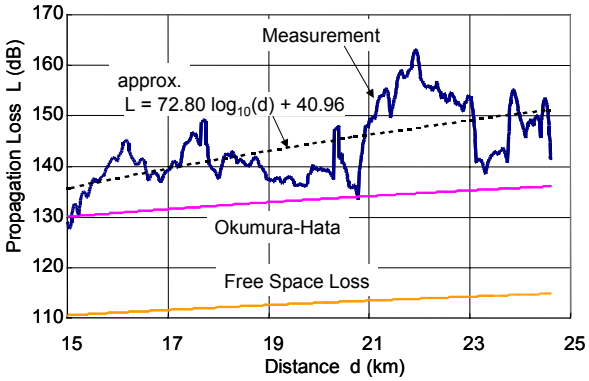

Figure 7: Propagation loss in Okayama hilly area

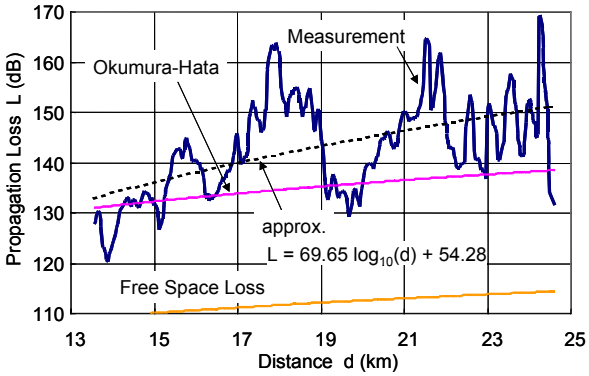

Figure 8: Propagation loss in Takamatsu hilly area

5. Conclusions

In this paper, the UHF-TV band mobile propagation loss characteristics were studied on the basis of the measurement results. The measurement of mobile radio propagation was performed in Hiroshima, Okayama, and Takamatsu regions by use of existent UHF-TV broadcasting radio wave and GPS systems. From the measurements in the various areas such as urban, suburban, and hilly areas in these regions, following results were obtained.

(1) Since, in general, the TV transmitter is located on the top of mountain and height of transmitter is high in provincial cities, the propagation loss of UHF band in urban area is about 10 dB lower than the metropolitan propagation loss modeled by the Okumura-Hata formula.
(2) The propagation loss in suburban area comes close to the free space loss performance as the distance decreases, since the LOS paths between transmitter and receiver can be established in short range propagation in suburban area.
(3) The propagation loss in hilly area fluctuates from 20 to 30 dB because of the complex propagation environments of hilly area, depending on whether there are LOS paths between receiver and transmitter or not.

In the future, the system design of the new UHF band mobile platforms will be investigated based on the measurement results of the mobile propagation loss characteristics.

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