

Evaluation of Co-Frequency Interference with IMT System Caused by Mobile-Satellite Service System

Jong-Min Park¹ · Dong-Chul Park²

Abstract

Interference scenarios involving and a methodology for a terrestrial international mobile telecommunication(IMT) system and mobile-satellite service(MSS) system in a co-channel environment are established. Taking into account a practical deployment situation for both systems, a computational simulation of interference in terms of the ratio of interference power to thermal noise(I/N) is performed in order to evaluate the co-frequency interference with the IMT system caused by the MSS system. The methodology and results could be used for planning an IMT deployment without an unacceptable interference impact caused by the MSS system.

Key words : IMT, Mobile-Satellite Service, Interference, I/N.

I. Introduction

Considering that international mobile telecommunication (IMT) systems can provide various telecommunication services over a wide range of user densities and geographic coverage areas^[1], the World Radiocommunication Conference(WRC), organized by International Telecommunication Union(ITU), has already identified several frequency bands for IMT use. In addition, in response to increasing demand for additional spectrums for IMT, the WRC held in 2007 has further identified some frequency bands based on technical studies such as those in [2].

We also need to note that interest in mobile-satellite service(MSS) is increasing worldwide, and developments toward multimedia, broadband, and integrated systems have been made to provide various communication services for land mobile, maritime, and aeronautical users^[3]. An MSS may operate as a co-primary service in some of the frequency bands used by IMT systems. Under these circumstances, when planning to deploy a terrestrial IMT system, it is very important to conduct a timely investigation of any possibility of another service, such as an MSS in the same frequency band, causing unallowable interference.

In this paper, we present interference scenarios and a methodology to evaluate co-frequency interference with a terrestrial IMT system caused by an MSS system using a geostationary satellite. We conducted a computational simulation of interference using the methodology, also taking into account practical deployment environments

for both systems. We also provide some simulation results that can be used as a guide for a deployment plan of an IMT system.

II. Interference Scenarios and Methodology

For the interference scenarios involving an MSS system and an IMT system, the selected approach is based on the wanted or interfering system. Therefore, we can consider an interference path from an MSS downlink (space-to-earth direction), where the transmitting space station of the MSS would be a source of interference into the user equipment(UE) and base station(BS) of the IMT. We can also consider the other interference path from the MSS uplink(earth-to-space direction), where the transmitting mobile earth station(MES) for the MSS would also be a source of interference for the UE and BS for the IMT.

In this paper, we take into account the practical deployment environments for both interfering and interfered systems. We assume an MSS system employing frequency reuse similar to a cellular system in different spot beams, and an IMT system using a code division multiple access(CDMA) scheme.

Fig. 1 shows the interference methodology from the MSS downlink into the IMT system. For the interference evaluation in this situation, we first modeled the MSS operation environments using some operational parameters such as the number of spot beams and frequency reuse factor. If we select one reference cell for the MSS downlink, some other cells using the same frequency as in the refe-

Manuscript received July 17, 2009 ; revised August 24, 2009. (ID No. 20090717-029J)

¹Broadcasting & Telecommunications Convergence Research Laboratory, Electronics and Telecommunications Research Institution(ETRI) Daejeon, Korea.

²Department of Radio Science & Engineering, Chungnam National University, Daejeon, Korea.

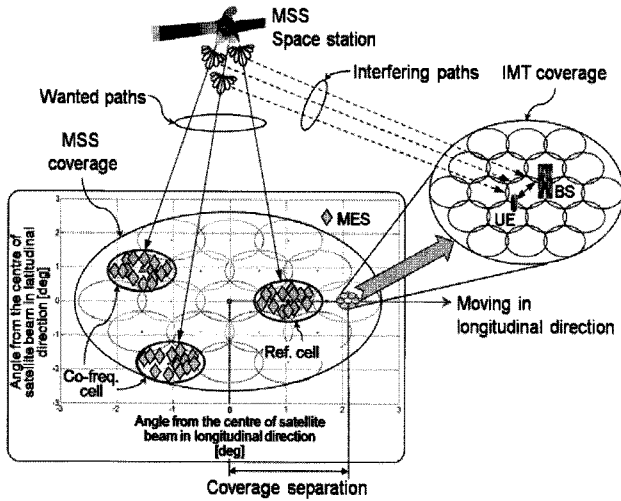


Fig. 1. Interference methodology from an MSS downlink into an IMT.

rence cell can be identified according to the frequency reuse factor selected. Then, we calculate the aggregate interference from all co-frequency transmitting beams of the space station into a UE and BS for the IMT. Further, we calculate the aggregate interference by moving the IMT coverage from the centre of the MSS coverage linearly in longitude in order to obtain the range of geographic separation.

We can use (1) to calculate the interference with a UE or BS for the IMT caused by a single beam of space station for the MSS.

$$i = \frac{P_{Tx,MSS} \cdot g_{Tx,MSS} \cdot g_{Rx,IMT}}{l_p \cdot l_f} a_{bw} \quad (1)$$

where, i is the interference power on an in-band UE or BS due to the transmitting beam from a space station for an MSS; $P_{Tx,MSS}$ is the transmit beam power at the antenna input of a space station; $g_{Tx,MSS}$ is the gain of a beam from a space station in the direction of the interfered receiver of a UE or BS; $g_{Rx,IMT}$ is the gain of a UE or BS in the direction of the transmitting beam of a space station; l_p is the propagation loss between the interfering transmitter of a space station and interfered receiver of a UE or BS; l_f is the feeder loss at the receivers of a UE or BS; and a_{bw} is the adjustment factor for different bandwidths between a space station and UE or BS. For the case of an in-band narrow band carrier into a wide carrier, a_{bw} is the number of carriers that each transmit station is transmitting simultaneously.

Since we consider multi-beam operation for the MSS space station, we need to sum up the interference over all co-frequency transmitting beams of the interfering space station.

Using (1) and the multi-beam consideration above, we evaluate the interference in terms of the ratio of interference power to thermal noise (I/N) given in (2).

$$I/N = \sum_{\text{for all co-frequency beams}} i / N \quad (2)$$

where N is the thermal noise of the interfered receiver of the UE or BS in the relevant bandwidth.

We also evaluated the interference with the IMT system caused by the MSS uplink system, in a similar way as the case of the MSS downlink described above. The major difference is that we calculated the aggregate interference from all co-frequency transmitting MESSs, instead of multi-spot beams from the space station, into a UE and BS for the IMT. For the calculation of I/N , we need to replace some terms for the multi-beam space station in (1) and (2) with those for multi-MES users.

III. Simulation Results

Tables 1 and 2 present the operational system parameters for the MSS and IMT systems for simulation, respectively.

For the antenna pattern of the space station, we assume a symmetrical circular pattern given in (3)^[4].

$$G(\phi) = G_{\max} \left| 2^{n+1} (n+1)! \frac{J_{n+1}(\phi)}{(\phi)^{n+1}} \right|^2 \quad (3)$$

where ϕ is the off-axis angle, G_{\max} is the maximum antenna gain, n is the circular aperture taper, which determines characteristics of beamwidth, sidelobe level and directivity and $J_{n+1}(x)$ is a Bessel function of the first kind of order $n+1$.

Fig. 2 shows the assumed distribution of the MSS

Table 1. MSS system parameters for simulation^[5].

Altitude of satellite		35,786 km
Number of spot beams		37
Frequency reuse		9
Space station	Antenna pattern	Eq.(3)
	Max. antenna gain	40 dBi
	Transmission power	-0.1 dBW
MES	Antenna pattern	Rec. ITU-R M.1091
	Max. antenna gain	12 dBi
	Transmission power	1 dBW
Frequency(Down-/up-link)		2.185 / 1.995 GHz
Bandwidth		200 kHz

Table 2. IMT system parameters for simulation^[6].

Number of cells		37
BS	Antenna pattern	Rec. ITU-R F.1336
	Max. antenna gain	18 dBi
	Transmission power	10 dBW
	Height	30 m
	Thermal noise power of receiver	-139 dB(W/MHz)
UE	Max. antenna gain	0 dBi
	Transmission power	-13 dBW
	Height	1.5 m
	Thermal noise power of receiver	-135 dB(W/MHz)
Bandwidth		5 MHz

system for simulation. We select a downlink reference cell at the centre of the MSS coverage and then some other co-frequency cells are identified according to the frequency reuse factor.

Fig. 3 shows the assumed distribution of MS system for simulation. As shown in the figure, we assume that the interfered UE and BS are located at the center of the IMT service coverage.

Fig. 4 shows the calculated results of the I/N at a UE

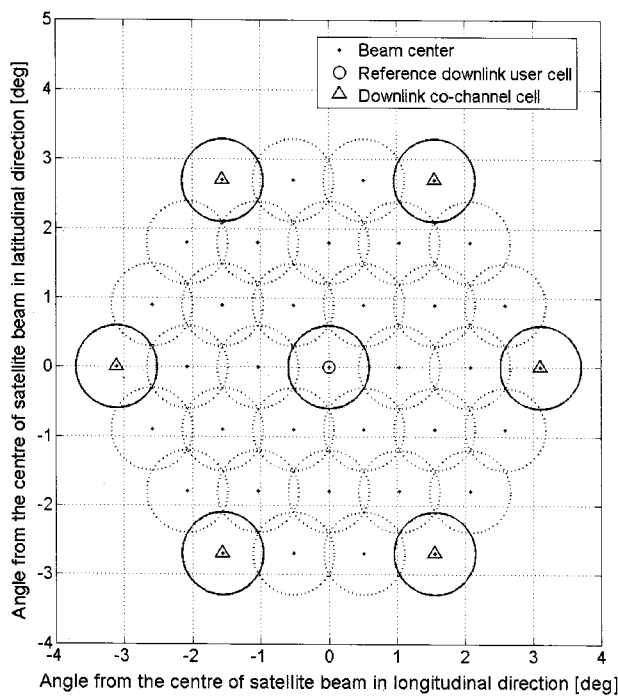


Fig. 2. Distribution of the interfering MSS system for downlink.

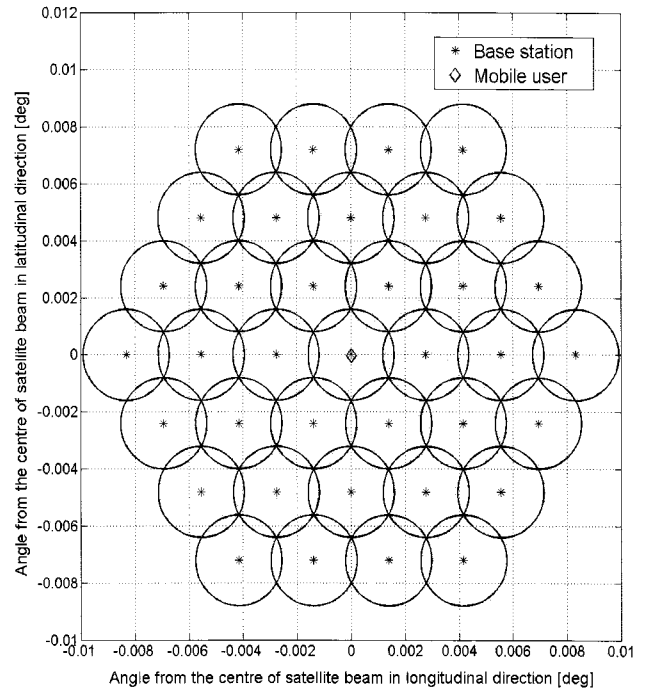


Fig. 3. Distribution of the interfered IMT system.

and BS for the IMT due to interference from the MSS downlink, which is obtained by moving the IMT coverage from the centre of the MSS coverage linearly in longitude. For the propagation loss, we assumed free space loss between the space station for the MSS and UE or BS for the IMT.

As shown in Fig. 4, the interference effect on a BS is larger than that into a UE due to the larger antenna gain of the BS. The simulation results also indicate that when we deploy an IMT system around MSS coverage,

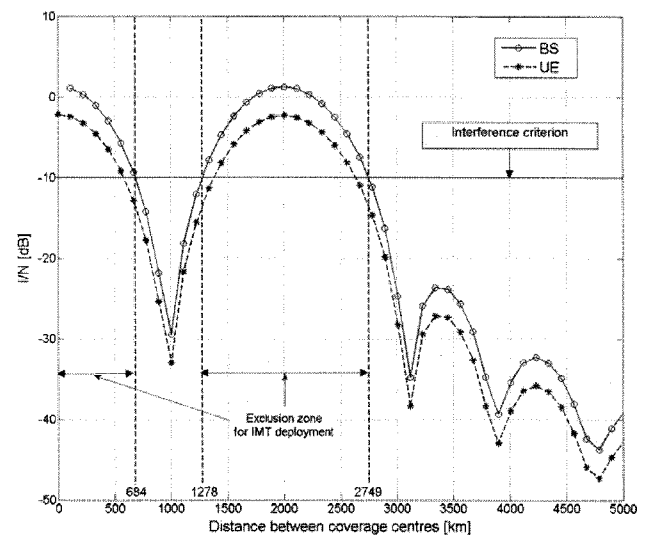


Fig. 4. Evaluation of interference with an IMT caused by an MSS downlink.

we need to avoid the centre of the IMT coverage from 0 to 684 km and also from 1,278 to 2,749 km from the centre of the MSS coverage in order to not be affected by unacceptable interference from the MSS downlink, taking into account an interference criterion of $I/N = -10$ dB^[6].

From the frequency allocation of the MSS and the reuse factor, the average capacity per beam can be calculated as 2.22 MHz. With the carrier bandwidth of 200 kHz, this can be rounded to 11 MESs in each cell. Therefore, for the evaluation of interference with a UE or BS for the IMT caused by the MSS uplink, we assumed a random distribution of 11 MES users in each co-frequency cell of the MSS uplink as shown in Fig. 5 and the same location of the UE or BS for the IMT, as shown in Fig. 2. The propagation loss between an MES and a UE or BS for the IMT was assumed as in [7].

Fig. 6 shows the results of the evaluation of interference with a UE or BS for the IMT caused by the MSS uplink in terms of I/N , which is obtained by moving the IMT coverage from the centre of the MSS coverage linearly in longitude.

The simulation results indicate that when we deploy an IMT system around MSS coverage, we need to consider the range from 306 to 1,700 km for the IMT deployment from the centre of the MSS coverage in order to not be affected by unacceptable interference from the MSS uplink, taking into account the same interference criterion as previously described.

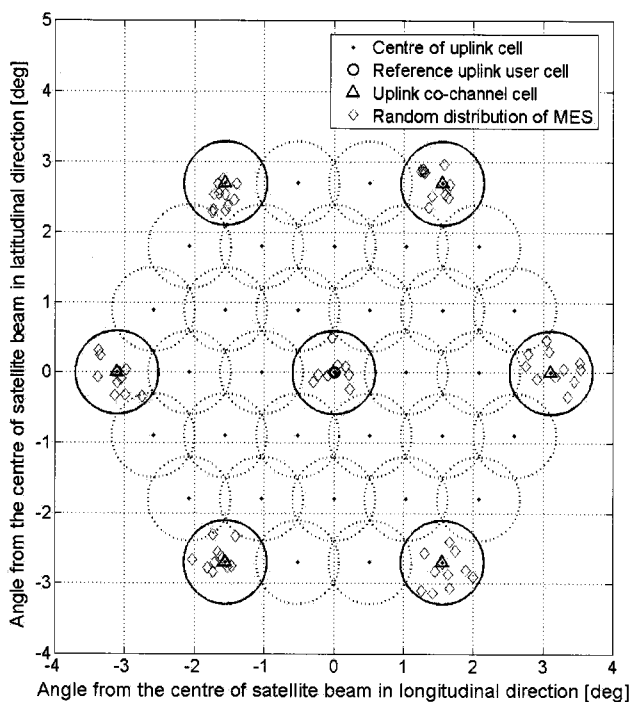


Fig. 5. Distribution of the interfering MSS system for uplink.

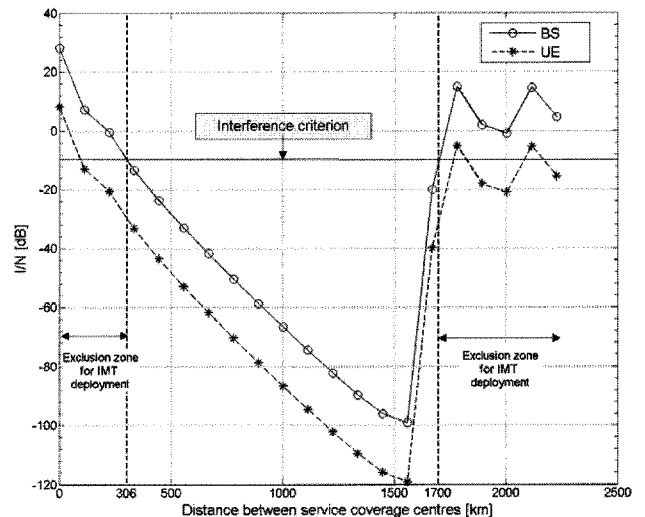


Fig. 6. Evaluation of interference with an IMT caused by an MSS uplink.

IV. Conclusion

This paper presented interference scenarios and a methodology to evaluate co-frequency interference with an IMT system caused by an MSS system. As a result of computational simulation based on practical deployment environments, we need to consider the exclusion zone for IMT deployment in a wide area in order to not be affected by unacceptable interference from MSS system. With these results, we can conclude that compatibility between an MSS and IMT is hardly feasible in a co-frequency, co-located situation.

We can use the methodology proposed in this paper when planning the deployment of an IMT system without the impact of unacceptable interference from an MSS system.

The proposed methodology can also be extended to evaluate the interference with MSS system caused by the MS system including IMT for planning MSS system deployment without an unacceptable interference impact from the MS system^[8].

This work was supported in part by the IT R&D program of KCC/IITA. [2009-F-013-02, Development of spectrum engineering and millimeter-wave utilizing technology]

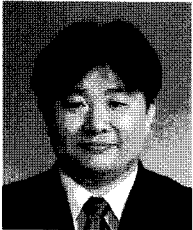
References

- [1] Recommendation ITU-R M.687, "International mobile telecommunications-2000", 1997.
- [2] Woo-Ghee Chung, Euntaek Lim, Jong-Gwan Yook,

et al., "Calculation of spectral efficiency for estimating spectrum requirements of IMT-Advanced in Korean mobile communication environments", *ETRI Journal*, vol. 29, no. 2, pp. 153-161, Apr. 2007.

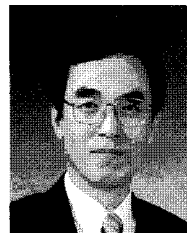
- [3] B. G. Evans, "Role of satellites in mobile wireless systems", *Proc. PIMRC'04*, Sep. 2004.
- [4] Warren L. Stutzman, Gary A. Thiele, *Antenna Theory and Design*, 2nd Ed., John Wiley & Sons, New York, p. 320, 1998.
- [5] *Recommendation ITU-R M.1184*, "Technical characteristics of mobile satellite systems in the frequency bands below 3 GHz for use in developing criteria for sharing between the mobile-satellite service (MSS) and other services", 2003.
- [6] *Recommendation ITU-R M.1646*, "Parameters to be used in co-frequency sharing and pfd threshold studies between terrestrial IMT-2000 and broadcasting-satellite service(sound) in the 2630-2655 MHz band", 2003.
- [7] *Recommendation ITU-R P.452*, "Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz", 2007.
- [8] Jong-Min Park, Dae-Sub Oh, and Dong-Chul Park, "Coexistence of mobile-satellite service system with mobile service system in shared frequency bands", Submitted for Publication in *IEEE Transactions on Consumer Electronics*.

Jong-Min Park



received the B.S. and M.S. degrees in electronic engineering from Chungnam National University, Daejeon, Korea, in 1991 and 1993, respectively. From 1993 through 2000, he was a senior researcher at the Agency for Defense Development, Chungnam, Korea in the area of radar and optical instrumentation. In 2000, he joined Electronics and Telecommunications Research Institute, Daejeon, Korea, where he is currently a Special Fellow and Senior Member of Engineering Staff in the Broadcasting and Telecommunications Convergence Research Laboratory. His research interests include satellite communication system, IMT system and High Altitude Platform Stations.

Dong-Chul Park



received the B.S. degree in electronics from Seoul National University, Seoul, Korea, in 1974, M.S. degree from Korea Advanced Institute of Science and Technology, Seoul, Korea, in 1976, and the Ph.D. degree from the University of California, Santa Barbara, in 1984. Since 1976, he has been with Chungnam National University, Daejeon, Korea, where he is a Professor in the Department of Radio Science and Engineering. From 1977 to 1978, he was a Visiting Scholar at Ruhr University, Bochum, Germany, where he worked on integrated optics. He was the Chairman of IEEE MTT-S Korea Chapter from January 1995 to December 1998, the Chairman of IEC CISPR Korea Committee from March 1995 to October 1998, the Chairman of IEEE EMC-S Korea Chapter from November 1998 to December 2001, the President of Korea Electromagnetic Engineering Society KEES from January 2000 to December 2001. His present research interests are in microwave and millimeter-wave passive devices, EMI/EMC topics, and antennas.