Interference Impact of LTE on Mobile WiMAX in TV White Spaces

Yanming Cheng, Ye Wang, Hyeju Yun, and Ilkyoo Lee

***Abstract*—This paper assumes that LTE and mobile WiMAX will operate in TV White Spaces (TVWS) bands in near future. However, compatibility between LTE and mobile WiMAX has to be taken into account in advance. Only the case of adjacent channel interference impact of LTE on Mobile WiMAX is analyzed by using Spectrum Engineering Advanced Monte-Carlo Analysis Tool (SEAMCAT). As a result, if interference probability of 5% is accepted, under condition of the assumed emission mask and specified transmitting power of LTE, the protection distance between the reference LTE BS and the reference Mobile WiMAX BS is should be more than 0.8km when the guard band between LTE Down link (DL) and mobile WiMAX is 1MHz and the guard band between LTE Up link (UL) and mobile WiMAX is 4 MHz.**

***Index Terms*—LTE, mobile WiMAX, interference, guard band.**

I. Introduction

Because TV White Spaces (TVWS) bands located in the VHF and UHF bands, TVWS bands have several important properties, such as excellent propagation, ability to penetrate buildings and foliage, Non-line of sight connectivity and broadband payload capacity， which make them highly desirable for wireless communications systems [1]. Mobile Worldwide Interoperability for Microwave Access (WiMAX) and Long Term Evolution (LTE) are being developed and will be put into service soon. Therefore, LTE and Mobile WiMAX are assumed to be deployed in TVWS in DTV bands. However, the compatibility between LTE and Mobile WiMAX must be taken into account. This paper analyzes only the case of adjacent channel interference impact of LTE on mobile WiMax in TVWS through Spectrum Engineering Advanced Monte-Carlo Analysis Tool (SEAMCAT).

II. System Descriptions

3GPP Long Term Evolution (LTE) is the latest standard in the mobile network technology tree that produced the GSM/EDGE and UMTS/HSPA network technologies [2]. It is a project of the 3rd Generation Partnership Project (3GPP), operating under a name trademarked by one of the associations within the partnership, the European Telecommunications Standards Institute (ETSI). The key parameters of the 3G LTE specification are summarized in Table I [3].

TABLE I: Some Necessary Parameters of LTE for Simulation

Parameters	Value
Duplex	FDD
Carrier Frequency	579 MHz
Band Width	10 MHz
Thermal Noise	-174 dBm/Hz
I/N	-10 dB
LTE Link Coverage requirement	95% at the coverage edge Log-normal shadowing=10 dB
Building Penetration Loss	8 dB
Propagation Model	Macro cell propagation model Urban
Coverage Radius	2.8668km
Network Topology	Hexagonal Grid, 19 sites (57cells) with wrap around.
Inter-Side Distance	4.9654km
Sectorization	Tri- sector antennas
Minimum Coupling Loss	70 dB
Number of Available Resource Blocks (M)	24
Number of Resource Block per UE (N)	1
Number of Active UEs per Cell (K)	24 (K=M/N)
Minimum subcarrier usage per Base Station	assumed full loaded system100%
Hand Over (HO) Margin	3 dB

The specified LTE BS spectrum emission limit [4] and the assumed LTE BS Spectrum emission limit are illustrated in Fig. 1.

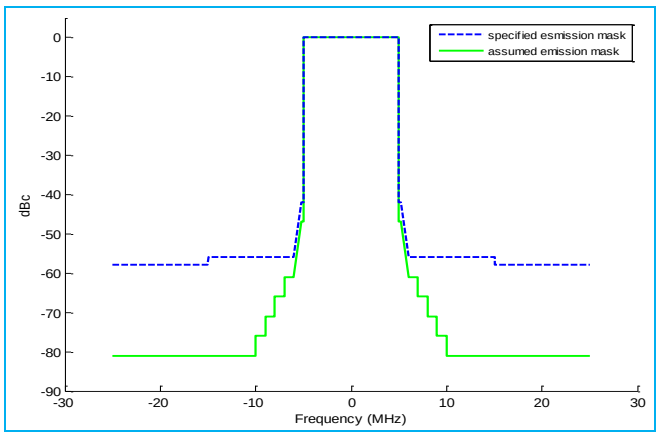

Fig. 1. Spectrum emission mask of LTE BS.

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The specified LTE MS Spectrum emission limit [4] and the assumed LTE MS Spectrum emission limit are illustrated in Fig. 2.

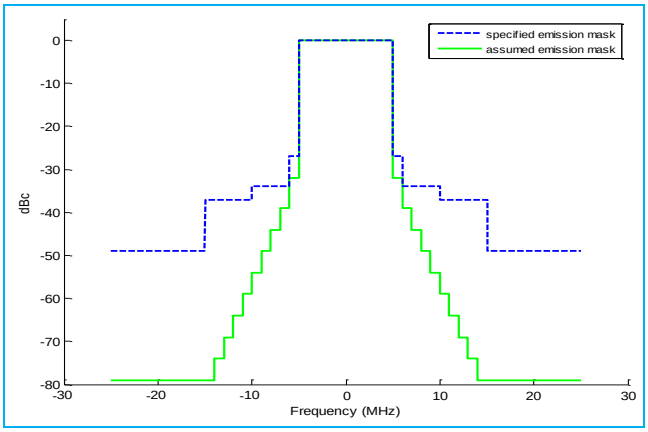

Fig. 2. Spectrum emission mask of LTE MS.

TABLE II: SOME PARAMETERS OF MOBILE WIMAX FOR SIMULATION

Parameter	Value
Duplex	TDD
Carrier Frequency	589 MHz
Band Width	10 MHz
Thermal Noise	-174 dBm/Hz
I/N	-10 dB
Mobile WiMAX Link Coverage requirement	95% at the coverage edge Log-normal shadowing= 10 dB
Building Penetration Loss	8 dB
Propagation Model	Macro cell propagation model Urban
Coverage Radius	Macro cell propagation model Urban : 1.9939 km
Inter-Side Distance	3.4535 km

Mobile WiMAX is a rapidly growing broadband wireless access technology based on IEEE 802.16-2004 and IEEE 802.16e-2005 air-interface standards. The WiMAX Forum is developing mobile WiMAX system profiles that define the mandatory and optional features of the IEEE standard that are necessary to build a mobile WiMAX compliant air interface which can be certified by the WiMAX Forum. For simulation, some necessary parameters of Mobile WiMAX are assumed and summarized in Table II [5].

Blocking response of Mobile WiMAX BS and Mobile WiMAX MS [4] is summarized in Table III and Table IV, respectively.

TABLE III: BLOCKING RESPONSE OF MOBILE WIMAX BS

Frequency offset from centre (MHz)	Attenuation [dB]
±10	46
±20	56
±25	56

TABLE IV: BLOCKING RESPONSE OF MOBILE WIMAX MS

Frequency offset from centre (MHz)	Attenuation [dB]
±10	33
±20	47
±25	47

III. METHODOLOGY AND SCENARIO

A. Methodology

A new statistical simulation model has been developed based on the Monte-Carlo method is developed by the European Conference of Postal and Telecommunications Administrations (CEPT), named SEAMCAT (Spectrum Engineering Advanced Monte-Carlo Analysis Tool). Fig. 3 illustrates the principle of calculating the interference probability in victim receiver in SEAMCAT. When interference is introduced, the interference adds to the noise floor. The difference between desired received signal strength (dRSS) and the interfering received signal strength (iRSS) is measured in dB, which is defined as the Signal to Interference ratio(C/I_{trial}). This ratio must be more than the required C/I threshold (C/I_{target}) if interference is to be avoided. The Monte Carlo simulation methodology is used to check for this condition and records whether or not interference is occurring [6]-[8].

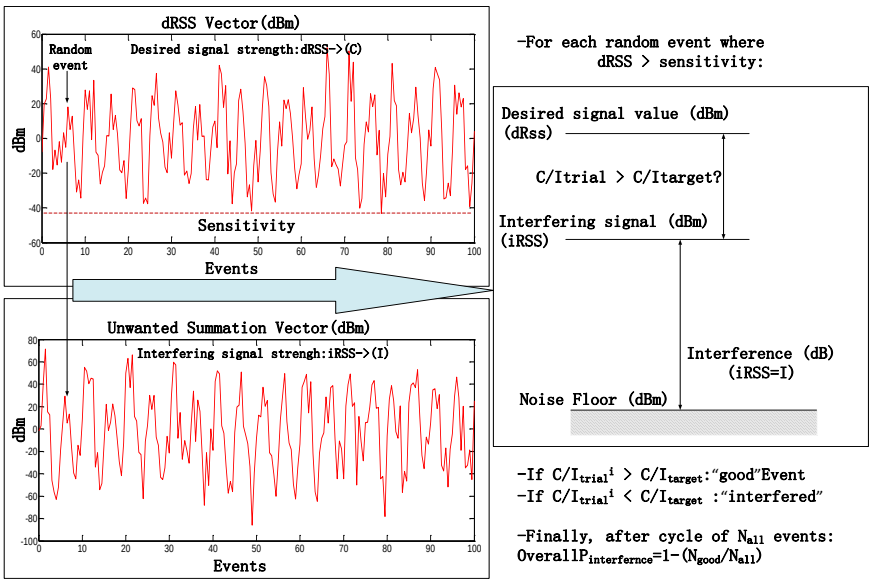

Fig. 3. Illustrative summary of the interference criteria computation.

SEAMCAT calculates the probability of interference (P_I) of the victim receiver as follows:

$$P_I = 1 - P_{NI} \tag{1}$$

where P_I is the probability of interference in the victim receiver. P_{NI} is the probability of non interference (NI) of in victim receiver. When a *C/I* criterion is considered, P_{NI} is defined as:

$$P_{NI} = P\left(\frac{dRSS}{iRSS_{comp}} > \frac{C}{I} \middle| dRSS > Sensitivity\right) \tag{2}$$

Since by definition of $P(A|B)=P(A\cap B)/P(B)$, P_{NI} becomes:

$$P_{NI} = \frac{P\left(\frac{dRSS}{iRSS_{comp}} > \frac{C}{I}, dRSS > Sensitivity\right)}{P(dRSS > Sensitivity)} \tag{3}$$

with $iRSS_{comp} = \sum_{j=1}^{P} iRSS_j$ where P is the number of interferers (i.e. active interferer transmitters).

B. Scenario

Fig. 4 illustrates assumption of frequency allocation for FDD LTE and Mobile WiMAX in TVWS.

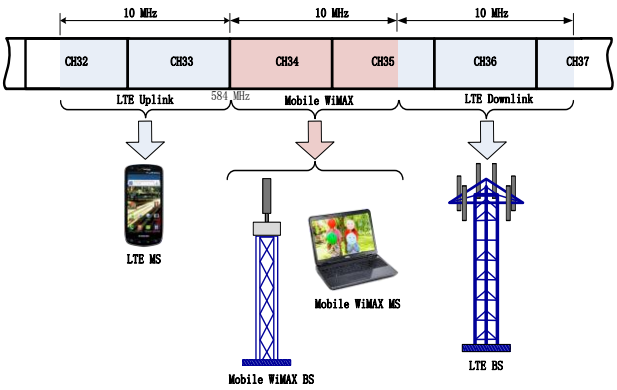

Fig. 4. Assumption of adjacent channel frequency allocation for LTE and Mobile WiMAX in TVWS.

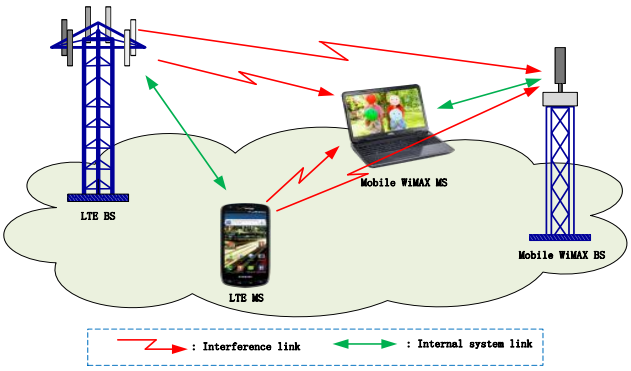

Fig. 5. Scenario of LTE interfering with Mobile WiMAX.

Fig. 5 shows the scenario of LTE potentially interfering with Mobile WiMAX. Moreover, in the case of LTE potentially interfering with Mobile WiMAX, there are four scenarios to be taken into account as following:

1) LTE BS is interferer and Mobile WiMAX BS is victim
2) LTE BS is interferer and Mobile WiMAX MS is victim
3) LTE MS is interferer and Mobile WiMAX BS is victim
4) LTE MS is interferer and Mobile WiMAX MS is victim

IV. Simulation and Results

A. The Case of LTE BS Interfering with Mobile WiMAX BS

Main parameters are set up in SEAMCAT as following:

General:
- Snapshot: 100

Victim: Mobile WiMAX BS
- F_{victim}=589 MHz;
- Desired received signal strength (dRss) of -89.58 dBm is the mean desired recicved signal strength in Mobile WiMAX BS recever;
- I/N= -10 dB;
- Propagation model: Macro cell propagation model, Urban.

Interferer: LTE BS (DL)
- Finterferer=599MHz;
- Interferer Transmit power=43 dBm;
- Emission mask of LTE BS is respectively set up according to Fig. 1 and Fig. 2;
- Interfering system link: Macro cell propagation model, Urban;
- Interference link (LTE DL to Mobile WiMAX BS): Macro cell propagation model, Urban.

When the protection distance between reference LTE BS and the reference Mobile WiMAX BS is 1km, the scenario of LTE BS interfering with Mobile WiMAX BS is established in SEAMCAT, which is illustrated in Fig. 6.

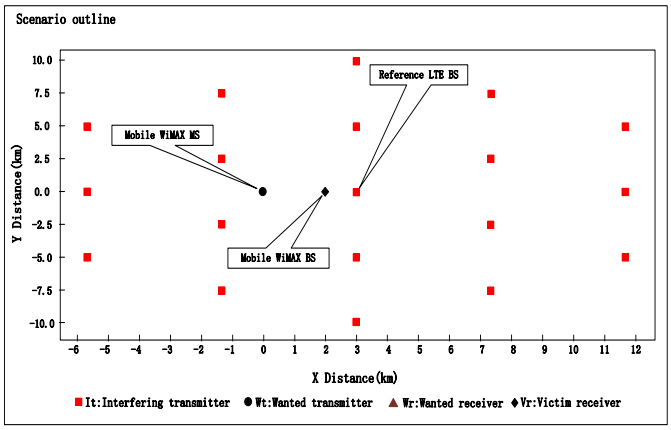

Fig. 6. Scenario of LTE BS interfering with Mobile WiMAX BS in SEAMCAT.

Simulation results are obtained in Fig. 7.

Results in Fig. 7 show that for meeting the interference probability of 5% and the maximum allowable transmit power of LTE BS of 43 dBm, if the specified emission mask of LTE BS is used, the protection distance between the reference LTE BS and the reference Mobile WiMAX BS should be at least 1.4 km to meet the interference probability of 5% when the guard band is 1 MHz. When the assumed emission mask of LTE BS is used, and then the protection distance between the reference LTE BS and the reference Mobile WiMAX BS should be at least 0.8 km when the guard band is 1 MHz.

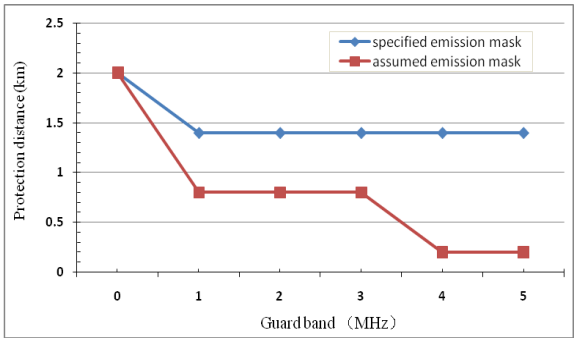

Fig. 7. The relationship between the guard band and the protection distance in the case of LTE BS interfering with Mobile WiMAX BS.

B. The Case of LTE BS Interfering with Mobile WiMAX MS

Main parameters are set up in SEAMCAT as following:

General:
- Snapshot: 100

Victim: Mobile WiMAX MS
- Fvictim=589 MHz;
- I/N= -10 dB;
- Propagation model: Macro cell propagation model, Urban.

Interferer: LTE BS (DL)

Setup is same as the case of LTE BS interfering with Mobile WiMAX BS

When the protection distance between reference LTE BS and the reference Mobile WiMAX BS is 0.5 km, the scenario of LTE BS interfering with Mobile WiMAX MS is established in SEAMCAT, which is illustrated in Fig. 8.

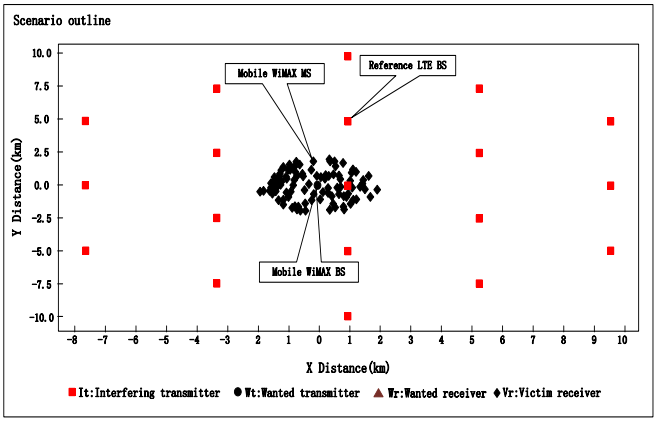

Fig. 8. Scenario of LTE BS interfering with Mobile WiMAX MS in SEAMCAT.

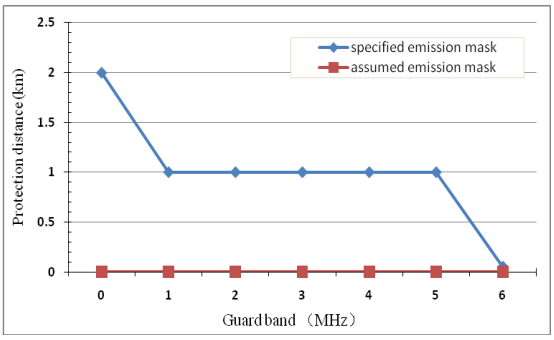

Fig. 9. The relationship between the guard band and the protection distance in the case of LTE BS interfering with Mobile WiMAX MS.

Simulation results are obtained in Fig. 9.

Results in Fig. 9 indicate that when the specified emission mask of LTE BS is used, when the guard band of 1 MHz is required, the protection distance is 1 km. When the assumed emission mask of LTE BS is used and there is not guard, LTE BS does not interfere with Mobile WiMAX MS.

C. The Case of LTE MS Interfering with Mobile WiMAX BS

Main parameters are set up in SEAMCAT as following:

General:
- Snapshot: 100

Victim: Mobile WiMAX BS
- Setup is same as the case of LTE BS interfering with Mobile WiMAX BS

Interferer: LTE MS (UL)
- Finterferer=579 MHz;
- Interferer Transmit power=-30 dBm~ 24 dBm
- Emission mask of LTE MS is set up according to Fig. 1and Fig. 2;
- Interfering system link: Macro cell propagation model, Urban;
- Interference link (LTE UL to Mobile WiMAX BS): Macro cell propagation model, Urban.

When the protection distance between the reference LTE BS and the Mobile WiMAX BS is 4 km, the scenario of LTE MS interfering with Mobile WiMAX BS in SEAMCAT is shown in Fig. 10 when snapshot is 100.

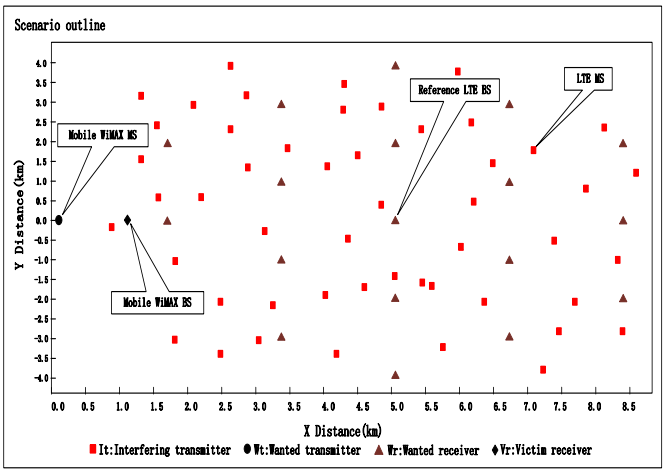

Fig. 10. Scenario of LTE MS interfering with Mobile WiMAX BS in SEAMCAT.

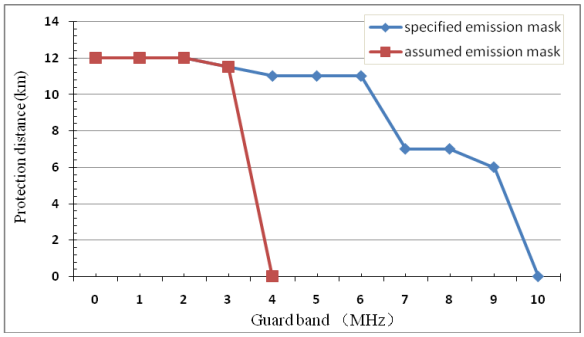

Fig. 11. The relationship between the guard band and the protection distance in the case of LTE MS interfering with Mobile WiMAX BS.

Simulation results obtained in Fig. 11 show that for meeting the interference probability of 5% and the maximum allowable transmit power of LTE MS of 24 dBm, if the sepcified emission mask of LTE BS is used, and then the

protection distance between the reference LTE BS and the reference Mobile WiMAX BS is 0 when the guard band is 8 MHz. If the assumed emission mask of LTE BS is used, and then the protection distance between the reference LTE BS and the reference Mobile WiMAX BS is 0 when the guard band is 4 MHz.

D. The Case of LTE MS Interfering with Mobile WiMAX MS

Main parameters are set up in SEAMCAT as following:

General:

Snapshot: 100

Victim: Mobile WiMAX MS

Setup is same as the case of LTE BS interfering with Mobile WiMAX BS.

Interferer: LTE MS (UL)

Setup is same as the case of LTE MS interfering with Mobile WiMAX BS.

Scenario of LTE MS interfering with Mobile WiMAX BS in SEAMCAT is shown in Fig. 12 when snapshot is 100.

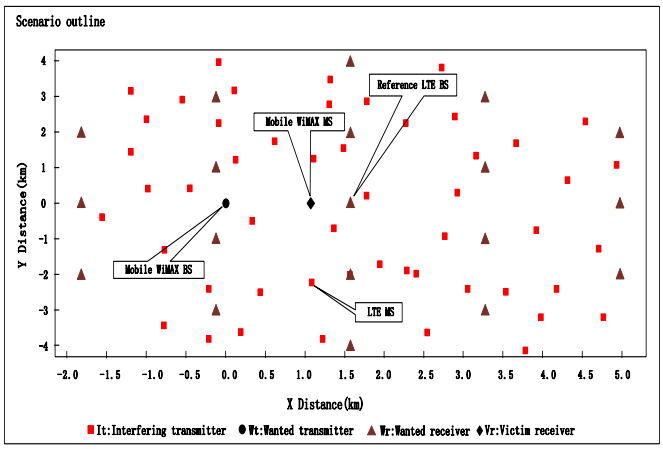

Fig. 12. Scenario of LTE MS interfering with Mobile WiMAX MS in SEAMCAT.

Simulation results are obtained in Fig. 13.

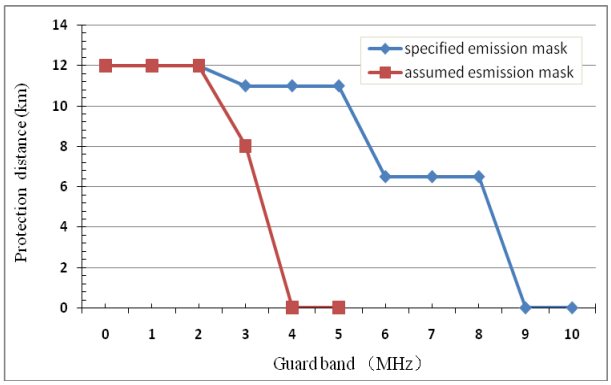

Fig. 13. The relationship between the guard band and the protection distance in the case of LTE MS interfering with Mobile WiMAX MS.

Fig. 13 shows that for meeting the interference probability of 5% and the maximum allowable transmit power of LTE MS of 24 dBm, if the specified emission mask of LTE BS is used, and then the protection distance between the reference LTE BS and the reference Mobile WiMAX BS is not needed when the guard band is 9 MHz. If the assumed emission mask of LTE BS is used, and then the protection distance between the reference LTE BS and the reference Mobile WiMAX BS is not needed when the guard band is 4 MHz.

V. Conclusions

LTE and Mobile WiMAX are assumed to be deployed in TVWSs because TVWSs are able to provide significantly better coverage and wall penetration inside buildings and other structures. And then the interference impact of LTE on Mobile WiMAX was analyzed by using SEAMCAT. As results of study, if interference probability of 5% is accepted for Mobile WiMAX, under condition of the assumed emission mask and specified transmitting power of LTE, the protection distance between the reference LTE BS and the reference Mobile WiMAX BS is should be more than 0.8 km when the guard band between LTE DL and mobile WiMAX is 1MHz and the guard band between LTE UL and mobile WiMAX is 4 MHz. The results can be as a reference and guideline for government and related organizations to make frequency plan for deploying LTE and mobile WiMAX in TVWSs.

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