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Interference Potential of FSS and BWA on the Extended C-Band

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Abstrak

Pihak Regulator Indonesia telah menetapkan pemakaian pita frekuensi 3.3-3.4 GHz untuk layanan Broadband Wireless Access (BWA) yang bersisian dengan pita extended C 3.4-3.7 GHz. Pita extended C telah digunakan oleh layanan Fixed Satellite Service (FSS) dan telah menjadi tulang punggung telekomunikasi Indonesia. Penelitian ini menunjukkan adanya potensi interferensi antara kedua sistem tersebut jika untuk keduanya dialokasikan pada pita frekuensi yang bersisian. Dengan pemanfaatan cluster loss sebesar 10 dB dan site shielding sebesar 40 dB, jaringan BWA dengan 57 base-station berpotensi menginterferensi FSS dengan probabilitas 56.16% bila digunakan jarak proteksi 1.55 km. Potensi interferensi dapat diturunkan menjadi 0% pada kasus yang sama bila jarak proteksi ditingkatkan hingga 3 km. Bila jaringan BWA memiliki 20 base-station maka probabilitas interferensi pada FSS adalah 10.72% untuk jarak proteksi 1.55 km, dan menurun menjadi 0% pada jarak 2 km. Dengan adanya potensi interferensi tersebut, Regulator Indonesia perlu menekankan penggunaan teknik mitigasi interferensi agar operasi BWA tidak mengganggu operasi FSS.

Kata kunci *: FSS, BWA, interferensi, extended C-band*

Abstract

The Indonesian government has allocated the 3.3-3.4 GHz band, which is adjacent to the extended C-band 3.4-3.7 GHz, for Broadband Wireless Access (BWA) services. The country has been using the extended C-band for Fixed Satellite Service (FSS). This research shows the interference potential between the two systems if an adjacent band is allocated for them. Using a clutter loss of 10 dB and site shielding of 40 dB, a BWA network consisting of 57 base-stations will potentially intefere an FSS with probability 56.16% if the protection distance used is 1.55 km. The interference potential will decrease to 0% if the protection distance is increased to 3 km. With a BWA network consisting of 20 base-stations, the interference probability is 10.72% and 0% for a protection distance of 1.55 km and 2 km, respectively. With this interference potential it is urgent that Indonesia enforces interference mitigation techniques to protect FSS from disruptive interference.

Keywords *: FSS, BWA, interference, extended C-band*

1. Introduction

The geographical condition of Indonesia, the largest archipelago in the world with a total of 17,000 islands, necessitates the use of satellite systems as one the most relied-upon telecommunication backbones. Today, the country uses fixed satellite services (FSS) as well as mobile satellite services (MSS) and broadcast satellite services (BSS) to provide internet, television, surveillance, tracking and telephony services.

Palapa-D is the latest addition to the satellites owned and operated by Indonesia, which was launched in 2009 and has a lifetime of 15 years. It is equipped by 24 standard C-band and 11 extended C-Band transponders which are used extensively in the South-East Asia region as they are relatively resistant to rain attenuation compared to the 5 Ku-band transponders also borne by the satellite.

On the other hand, the growing need for telecommunication services propels the development of terrestrial Broadband Wireless Access (BWA) networks, predominantly in the large cities of Indonesia. The Indonesia government is committed to accommodate various telecommunication technologies within the limited spectrum frequency to serve the need of telecommunication services. In the Indonesian Information and Communication Ministry

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Stipulation published in 2009, it is stated that for upcoming broadband wireless access (BWA) services, Indonesia has allocated the 3.3 – 3.4 GHz spectrum. This spectrum is adjacent to the 3.4-3.7 GHz already used for downlink communication by FSS operating in extended-C band.

Two systems operating in adjacent bands will potentially undergo unwanted interferences which will disrupt the systems' performances. Interference analysis for FSS and BWA systems operating in extended-C band is therefore important before any decision is made on the national level on whether or not BWA operators can be allowed to use the band previously allocated for FSS.

In [1]-[2], it is stated that Fixed Wireless Access (FWA) operating in extended-C band will cause unacceptable interference to FSS stations, unless some interference mitigation means such as the use of minimal protection distance and bandpass filters are implemented. In [3] the interference between International Mobile Telecommunication (IMT) and FWA is studied, using spectral emission mask model with different channel bandwidths, frequency separation and different receive antenna heights to estimate the impact of interference between the two services. In our study the mathematical analysis and simulations are done to calculate the interference between BWA base-station and FSS earth station, and explore the possibilities of interference mitigation means. The BWA base-station use OFDMA and serves mobile users, which are not modelled in the above-mentioned previous studies. Section 2 of this paper explains the research method used, the parameters of the analyzed systems and the mathematical review of pathloss and interference calculations. Section 3 describes the results of simulations using Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT). Conclusion is given in the last section.

2. Research Method

The systems analyzed are the FSS earth station receiver of Palapa-D satellite operating in 3.4- 3.7 GHz and WiMAX base station operating in 3.4-3.8 GHz. WiMAX systems operating in this particular frequency band has not been deployed yet in Indonesia. The FSS satellite is located at 113^{0}E at a geostationary orbit and serves the Asia region.

The research method is divided into two parts. The first part is a mathematical approach to calculate the maximum interference level from BWA transmitter that can be tolerated by the FSS earth station receiver, and the protection distance between the two systems. The second part is a simulation using SEAMCAT to calculate the probability of interference received by FSS earth station, with BWA transmitter located at a protection distance. The steps required to analyze the interference potential between the two systems are illustrated in Figure 1. The parameters of FSS earth station used are given in Table 2.

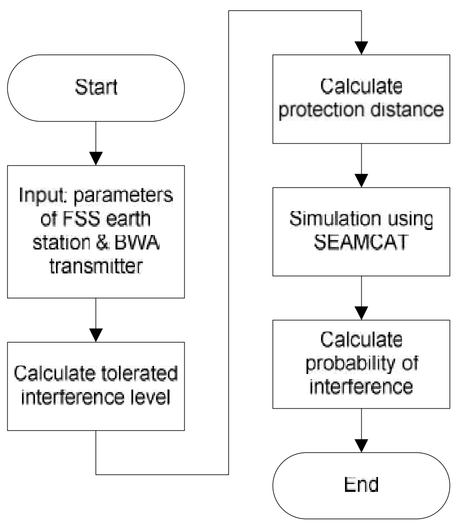

Figure 1. Steps required to analyze the probability of interference between FSS earth station and BWA transmitter

Table 1. Parameters of FSS Earth Station

Parameter	FSS Earth Station
Antenna height	25 m
Antenna azimuth	83.91^0
Elevation angle	30^0

The spectrum mask for WiMAX base station is given in Figure 2 and taken from [5], which also allows for OFDMA access method used in WiMAX.

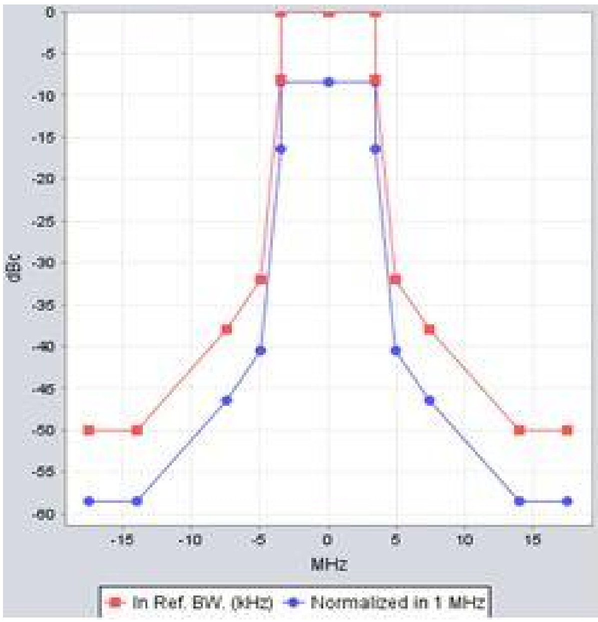

Figure 2. Spectrum emission mask for WiMAX base station, channel bandwidth = 7 MHz

Using the clear-air propagation model given in [6], the path loss between an FSS earth station and BWA base station can be stated as

$$L(d) = 92.5 + 20\log d + 20\log f + A_h \tag{1}$$

where d is the distance between the interferer and the victim receiver in kilometers, interferer being the BWA base station and victim receiver is the FSS earth station. The carrier frequency in GHz is denoted as f while A_h denotes the clutter losses.

Table 2. Parameters of WiMAX Base station [4]

Parameter	WiMAX Base Station
EIRP	46 dBm
Antenna gain (transmit and receive)	17 dBi
Receiver feeder loss	1 dB
Receiver noise figure	5 dB
Receiver thermal noise	-109 dBm/MHz
Protection criteria (I/N)	-6 dB
Antenna height above ground level (rural-urban)	15-30 metres
Antenna elevation	-2^0

Clutter losses are contributed by local ground clutter such as buildings and vegetations, and can be stated as [6]

$$A_h = 10.25 F_{fc} \cdot e^{-d_k}\left(1 - \tanh\left[6\left(\frac{h}{h_a} - 0.625\right)\right]\right) - 0.33\,\text{dB} \quad (2)$$

where:

$$F_{fc} = 0.25 + 0.375\{1 + \tanh[7.5(f - 0.5)]\} \quad (3)$$

and d_k is the distance from nominal clutter point to the antenna in kilometers, h is the antenna height above local ground level in meter, and h_a is nominal clutter height above local ground level in meter. Clutter losses for several environment categories are given in Table 3.

Table 3. Nominal clutter heights and distances [5]

Clutter category	Nominal height, h_a (m)	Nominal distance, d_k (km)
Suburban	9	0.025
Dense suburban	12	0.02
Urban	20	0.02
Dense urban	25	0.02
High-rise urban	35	0.02

The clutter losses as a function of antenna heights based on Table 3 is plotted in Figure 3. It is shown that to compensate for clutter losses in urban areas, the antenna heights required are up to 30 meters.

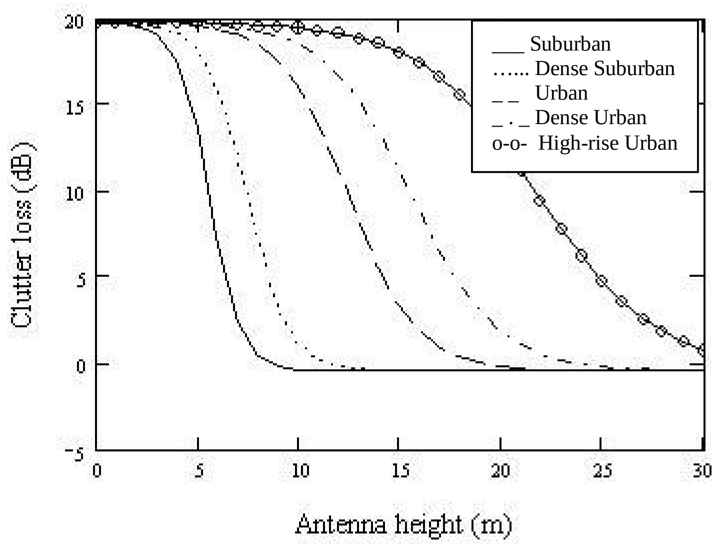

Figure 3. Clutter losses at varied antenna heights

The required protection distance between FSS earth station and a BWA transmitter can be calculated using [6]

$$20 \log(d) = -I + EIRP_{BWA} - 92.5 - 20 \log(f) - A_h + G_{vs}(\sim) \quad (4)$$

where $EIRP_{BWA}$ is taken to be 46 dBm [4], and I is the system interference. The parameter $G_{vs}(\sim)$ is the FSS earth station off-axis antenna receiving gain, which for a typical receiving antenna of 2.4 m diameter is given by [2].

$$G_{vs}(\sim) = 32 - 25\log(\sim) \quad dBi \quad ;3.6^0 < \sim < 48^0$$
$$G_{vs}(\sim) = 10 \quad dBi \quad ;48^0 < \sim < 180^0 \qquad (5)$$

The protection criterion *I/N* used is 10 dB according to ITU regulation, and the *C/N* value is 5.5 dB for Palapa-D satellite. The system interference *I* can be calculated using

$$I = (C/N + 10\log(k \cdot B \cdot T)) - C/I \quad \text{dB} \qquad (6)$$

where *k* is the Boltzmann constant, *T* is the noise temperature valued at 70^0K [4], and *B* is system bandwidth which can be varied according to the service provided by the FSS.

The carrier to interference ratio can be calculated using

$$C/I = I/N + C/N \quad dB \qquad (7)$$

The maximum interference level that can be accepted by FSS earth station without disrupting its performance is calculated using (6)-(7) and yields -152.4 dB. In our previous study [7] it has been shown that *I* = -152.4 dB can be reached with A_h = 10 dB, site shielding *R* = 40 dB and protection distance *d* = 1.55 km. Greater distance is needed for lower values of A_h and *R*. Simulations using Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) are done in this study to further analyze the interference between the two systems operating in adjacent channel.

3. Results and Analysis

The parameters given in Section 2 are used to define the Victim Link (the link between the victim receiver and the wanted transmitter) and Interfering Link (the link between the interfering transmitter and the wanted receiver) required by SEAMCAT. In this study, the victim receiver is the FSS earth station, the wanted transmitter is the Palapa D satellite transmitter, the interfering transmitter is the BWA base station while the wanted receiver is the BWA users. SEAMCAT also requires 4 interference criteria to be defined, namely carrier to interference ratio (*C/I*), carrier to noise and interference ratio (*C/N+I)*, noise and interference to noise ratio (*N+I/N*) and interference to noise ratio (*I/N*). For this simulation, the *C/I* is 15.5 dB; *C/N+I* is 14.4 dB; *N+I/N* is 6.5 and *I/N* is 5.4 dB.

For the first simulations, the BWA is assumed to have 2-tier network, consisting of 57 base stations. The base station antenna height is set at 30 meter, the system uses OFDMA and the bandwidth is 7 MHz. The spectrum mask shown in Figure 2 is loaded into the BWA simulation parameters. The relative position between the interfering transmitter and the FSS earth station is 1.55 km according to [7]. The simulation generated 20,000 iterations and the yielded mean of interfering signal strength received by the victim receiver is -18.35 dBm. The interference signal strength vector received by the earth station is depicted in Figure 4. Contrary to the finding in Section 2, which states that with a separation distance of 1.55 km the interference can be mitigated, the simulation shows that there is a probability as high as 56.16% that interference can still occur. This is because the calculation in section 2, also known as minimum coupling loss method, does not include cell layout and cell radius factors in BWA. A number of other BWA parameters such as the handover margin and minimum SNR are also disregarded in the mathematical calculations. With interfering signal strength of -18.35 dBm, it is apparent that the earth station will be disrupted, albeit not 100% of the time.

Increasing the protection distance *d* to 2 km decreases the probability of interference to 25.42%. The mean interfering signal strength received by the victim receiver is down to -21.53 dBm. The interference signal strength vector received by the earth station for *d* = 2 km is given in Figure 5. The probability of interference drops significantly to 2.15% when *d* is increased to 2.5 km, whereas for *d* = 3 km, the probability of interference is 0%. The interference signal strength vectors received by the earth station for *d* = 2.5 and 3 km are given in Figure 6 and 7, respectively.

In the second simulations, the BWA is assumed to have 1-tier network with 20 base stations. Using *d* = 1.55 km, the resulting interfering signal strength is -24.83 dBm, giving an interference probability of 10.72%. Increasing *d* to 2 km will yield interfering signal strength of -

27.73 dBm. The interference signal strength vectors received by the earth station for *d* = 1.55 and 2 km for a BWA having 1-tier networks are given in Figure 8 and 9, respectively.

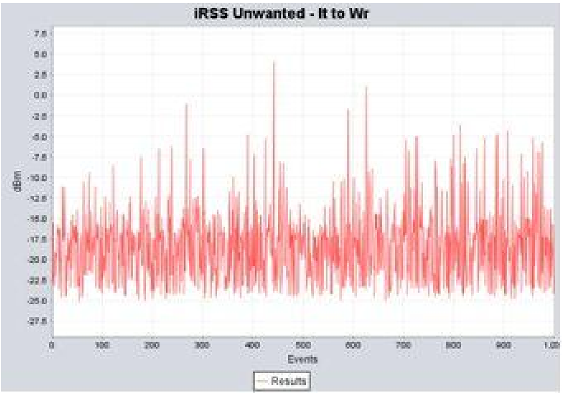

Figure 4. Interference signal strength vector received by the earth station from a 2-tiered BWA, *d* = 1.55 km

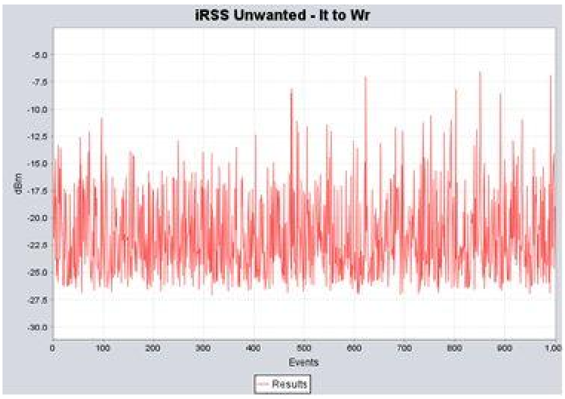

Figure 5. Interference signal strength vector received by the earth station from a 2-tiered BWA, *d* = 2 km

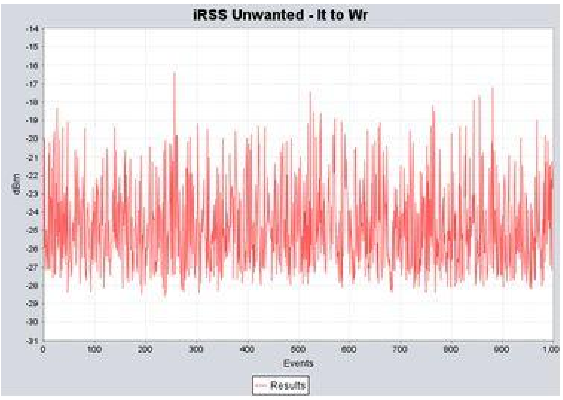

Figure 6. Interference signal strength vector received by the earth station from a 2-tiered BWA, *d* = 2.5 km

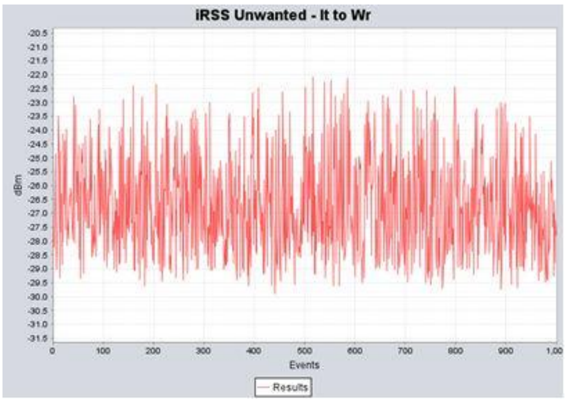

Figure 7. Interference signal strength vector received by the earth station from a 2-tiered BWA, *d* = 3 km

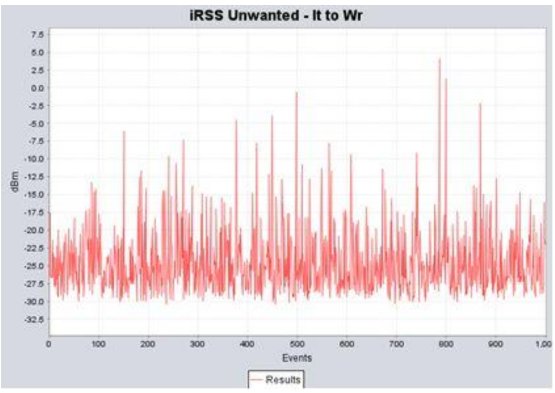

Figure 8. Interference signal strength vector received by the earth station from a 1-tiered BWA, *d* = 1.55 km

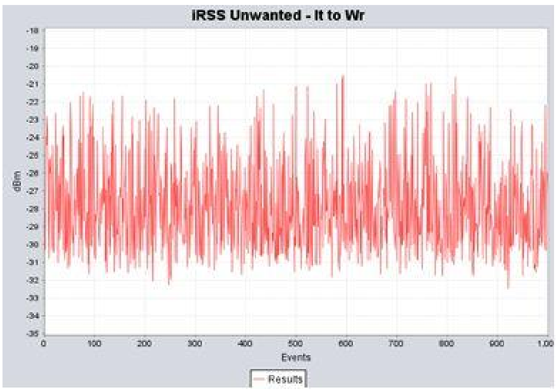

Figure 9. Interference signal strength vector received by the earth station from a 1-tiered BWA, *d* = 2 km

The simulation results show that the two systems can coexist in the same frequency band provided that the protection distance is at least 3 km for a 2-tiered BWA network, and 2 km for a 1-tiered BWA network. It is also shown that an interference level of -152.4 dB cannot be achieved with 57 base-stations and 20 base-stations in 2-tiered and 1-tiered BWA networks respectively. The simulation results are summarized in Table 4.

Table 4. Simulation Results from 2-tiered and 1-tiered BWA Network

Protection distance (km)	Interference Signal Strength (dBm)	Probability of Interference (%)
2 tiered BWA Network		
1.55	-18.35	56.16
2	-21.53	25.42
2.5	-24.68	2.15
3	-26.71	0
1 tiered BWA Network		
1.55	-24.83	10.72
2	-27.73	0

4. Conclusion

An interference scenario between FSS earth station operating in extended C-band and BWA network has been simulated and analyzed. It is shown that the current frequency allocation stipulated by the Indonesian government, which places the two systems in an adjacent band, will potentially disrupt the FSS operation. The simulations were done assuming a clutter loss of 10 dB as normally found in high-rise urban areas, and a site shielding of 40 dB. Even with these protective measures, it is found that the operation of an FSS earth station will be interfered by BWA network. The probability that a 2-tiered and 1-tiered BWA network will interfere the operation of FSS earth station given a protection distance of 1.55 km is 56.16% and 10.72%, respectively. The probability of interference will drop to 0% only if the separation distance between the FSS earth station and BWA network is increased to 3 km for a 2-tiered BWA network and 2 km for a 1-tiered BWA network. As both the FSS and BWA systems are important for Indonesia, careful interference mitigations techniques must be adapted to ensure the coexistence of the two systems in adjacent frequency band will not lead to destructive interference.

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