Analysis of Interference Between LTE System and TETRA System in The 800 MHz Band

Fadhilah Natasha [1*)], Uke Kurniawan Usman [2)], Rizky Satria [3)]

[1,2)] Department of Telecommunication Engineering,
Faculty of Electrical Engineering, Telkom University
[3)] Department of Electrical Engineering,
Faculty of Electrical Engineering, Telkom University
[*] email: fadhilahnatasha05@gmail.com

Abstract

Wireless communication is used in many sectors to support the need of communication, the example of wireless communication is applied in mission critical network. Wireless communication system that used in mission critical are Terrestrial Trunked Radio (TETRA) and Long Term Evolution (LTE). TETRA systems supports voice services while LTE supports voice and data services. Co-exsitence between LTE and TETRA in same frequency band is one of the optimilazition quality for mission critical network. For this research analyses interference in co-exsitence between LTE and TETRA in frequency band 800 MHz. There are four scenarios using extended-hata model propagation in urban area. There are several parameters that reviewed, desired Received Signal Strength (dRSS), interfering Received Signal Strength (iRSS), Carrier to Interference ratio (C/I) and probability of interference. In all scenarios occur Co-Channel Interference (CCI) between LTE and TETRA in frequency band 800 MHz so the performance not optimal. The performance increased when add guard band variation. The variation that applied are 0,5 MHz, 0,75 MHz, 1 MHz. Based on the result of the simulation that have been done, proposed the used of guard band variation for elevate the performance.

Keywords — C/I, Interference, LTE, mission critical, probability of interference, TETRA

1. Introduction

Nowadays application and choice of suitable wireless communication that can support optimization to elevate the quality that user need because of every time there is increasing in traffic but also frequency allocation is limited. Wireless communication offers many variant of technology for some sectors, one of the example is services for mission critical network.

One of the technology that used in mission critical communication is Teresstrial Trunked Radio (TETRA). TETRA has primacy that usual techonology don't have. TETRA designed to offer wide coverage and high rate availbality network that can operate pretty well in disaster area. [1]. Along with the primacy TETRA also has lack and that is low data rate and smaller capacity if compare with usual cellular network. The lack that TETRA has make operator in mission network do coexesistence between TETRA with one of cellular technology, Long Term Evolution (LTE). LTE is a broadband technology. LTE network offer better quality if compare with previous generation of cellular technology.

Coexistence two different technology with same operate frequency could occur interference. In this research LTE and TETRA operate in 800 MHz band. LTE used 814-849 for uplink and 859-894 for downlink and TETRA used 806-824 MHz for uplink and 851-869 for downlink. The probability of interference that standardized by ETSI is 10%.

Manuscript submitted December 28, 2019; revised 16 January 2020; accepted 20 January 2020.
Published 23 January 2020; http://dx.doi.org/10.28989/avitec.v2i1.592

2. Basic Theory

2.1 Basic Theory of Interference

Coexsistence more thans one base station in same coverage could occur intereference between transmitter and receiver. In general interference divided into two category co-channel interference dan adjacent channel interference [3].

Co-channel interference is interference signal have same carrier frequency with information signal or interference signal entering receiver get close with the center of bandwidth so the filter could not muffle [3]. In other word co-channel interference is an interference between cell that use same channel or same frequency. The Co-channel interference is illustrated in figure 1.

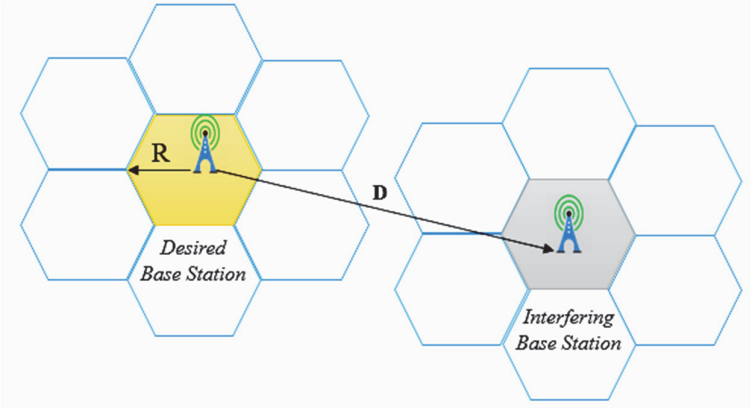

Figure 1. Co-channel Interference [4]

Interference that produce by assigned frequency with original signal defined as Adjacent Channel Intereference (ACI) [5]. In other word ACI is an interference of assigned channel. The ACI is illustrated in figure 2.

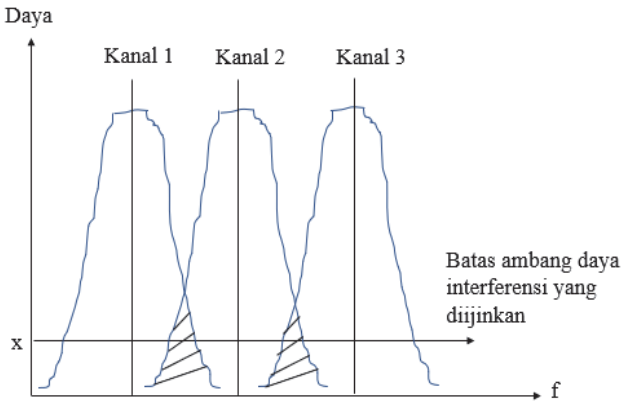

Figure 2. Adjacent Channel Interference [4]

2.2 The Parameters Used

Parameters that being used in analysis of interference between LTE and TETRA are *desired Received Signal Strength* (dRSS), *interfering Received Signal Strength* (iRSS), and *Probability of interference*/*Carrier to Interference* (C/I).

dRSS is strength of victim wanted signal, a calculation of link budget between *Victim Link Receiver* (VLR) and Victim Link Transmitter (VLT) [6].

$$dRSS = PowerTx + Gain\,Tx + Gain\,Rx - Pathloss \quad (1)$$

where:

$dRSS$ = desired Received Signal Sterngth [dBm]
$Power$ = transmit power from transmitter [dBm]
$GainTx$ = gain total of transmitter [dBi]
$GainRx$ = gain total of transmitter [dBi]
$Pathloss$ = loss of link budget [dB]

iRSS is calculation that consider as a link budget between VLR and Interfering Link Transmitter (ILT) [6].

$$iRSS = PowerTx + Gain\,Tx + Gain\,Rx - Pathloss \quad (2)$$

where:

$iRSS$ = interfering Received Signal Sterngth [dBm]
$Power$ = transmit powerfrom transmitter [dBm]
$GainTx$ = total gain from transmitter [dBi]
$GainRx$ = total gain of transmitter [dBi]
$Pathloss$ = loss of link budget [dB]

Carrier to Interference (C/I*)* is measure that used to rate between signal quality and interference stated with C/I (dB). C/I should higher than C/I minimum that standardized by standardization [4].

2.3 The Guard Band

Guard band is frequency range that separate two bigger frequencies. Guard band used by communication channel to prevent interference that could decreased performance of transmission system. Guard band located between frequency LTE and TETRA. LTE used 814-849 MHz for uplink and 859-894 MHz for downlink and TETRA used 806-824 MHz for uplink and 851-869 MHz for downlink. The guard band frequency is illustrated in figure 3.

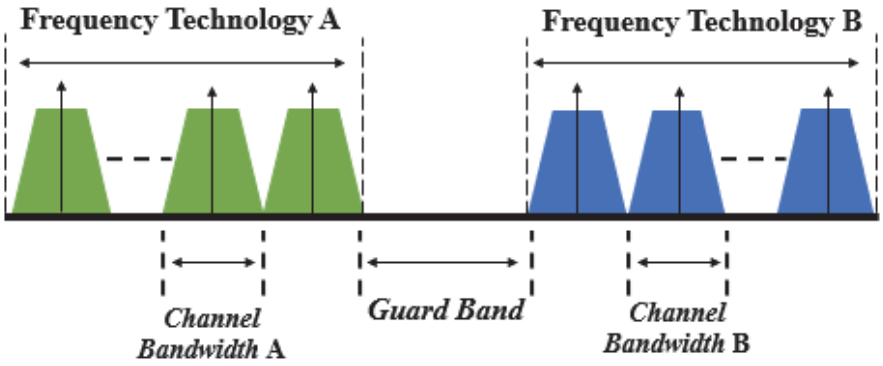

Figure 3. Guard Band

3. Design of Simulation System

3.1 Scenario Design for Simulation on SEAMCAT

Each simulation on software SEAMCAT iterated with 21.000 samples. There are four scenarios simulated with each scenario with four schemes, *co-channel* (*no guard band*) and with guard band addition (0,5 MHz, 0,75 MHz, and 1 MHz). There are one interfering link and one victim link in each scenario. In Interfering link there are Interfering Link Transmitter (ILT) and Interfering Link Receiver (ILR). In Victim Link there are Victim Link Transmitter (VLT) and Victim Link Receiver (VLR). Every scenario produces dRSS, iRSS, C/I and probability of interference. The scenario of simulation on SEAMCAT is illustrated in figure 4.

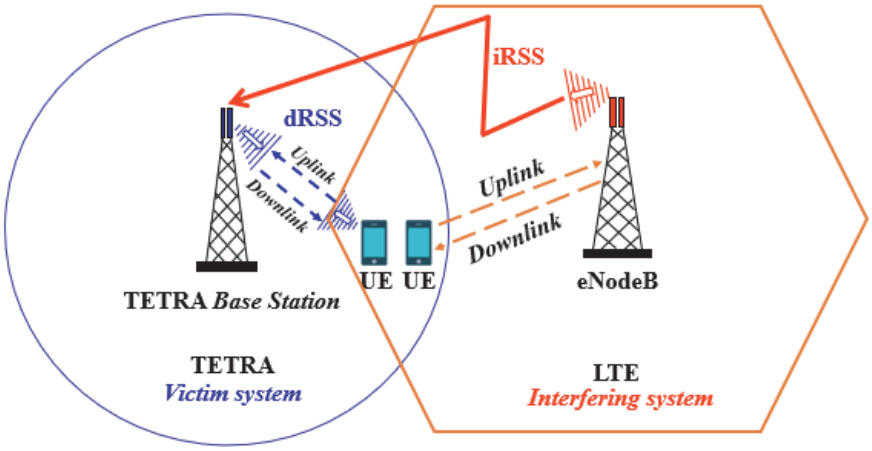

Figure 4. Scenario Simulation on SEAMCAT

3.1.1 Scenario 1 (Downlink LTE vs Downlink TETRA)

There are four variations in scenario 1, no guard band, 0,5 MHz guard band, 0,75 MHz guard band, and 1 MHz guard band. Guard band variation located on TETRA. Guard band located between LTE frequency and TETRA frequency that caused shifted in LTE operating frequency LTE (interfering link). LTE used channel bandwidth 10 MHz and TETRA used channel bandwidth 25 KHz. The scenario 1 is illustrated in figure 5.

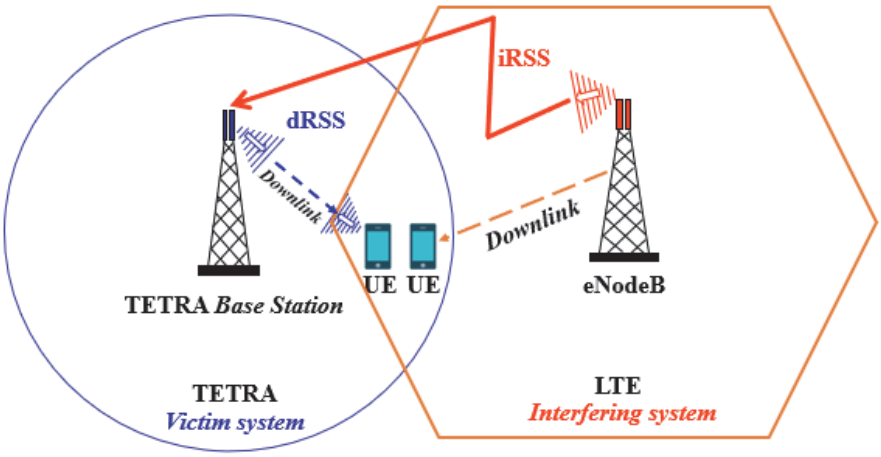

Figure 5. Scenario 1

Table 1. The Scenario 1

Scenario	*Inter-fering Link*	*Frequency Interfering Link*	*Rsimu Interfering Link*	*Victim Link*	*Frequency Victim Link*	*Rsimu Victim Link*
No guard band	*Downlink LTE*	859-894 MHz	1,67 km	*Downlink* TETRA	859-859,025 MHz	0,86 km
Guard band 0,5 MHz	*Downlink* LTE	859,525-869,518 MHz	1,67 km	*Downlink* TETRA	859-859,025 MHz	0,86 km
Guard band 0,75 MHz	*Downlink* LTE	859,775-869,775 MHz	1,67 km	*Downlink* TETRA	859-859,025 MHz	0,86 km
Guard band 1 MHz	*Downlink* LTE	869,025-879,025 MHz	1,67 km	*Downlink* TETRA	859-859,025 MHz	0,86 km

3.1.2 Scenario 2 (Uplink LTE vs Downlink TETRA)

There are four variations in scenario 2, no guard band, 0,5 MHz guard band, 0,75 MHz guard band, and 1 MHz guard band. Guard band variation located on TETRA. Guard band located between LTE frequency and TETRA frequency that caused shifted in LTE operating frequency LTE (interfering link). LTE used channel bandwidth 10 MHz and TETRA used channel bandwidth 25 KHz. The scenario 2 is illustrated in figure 6.

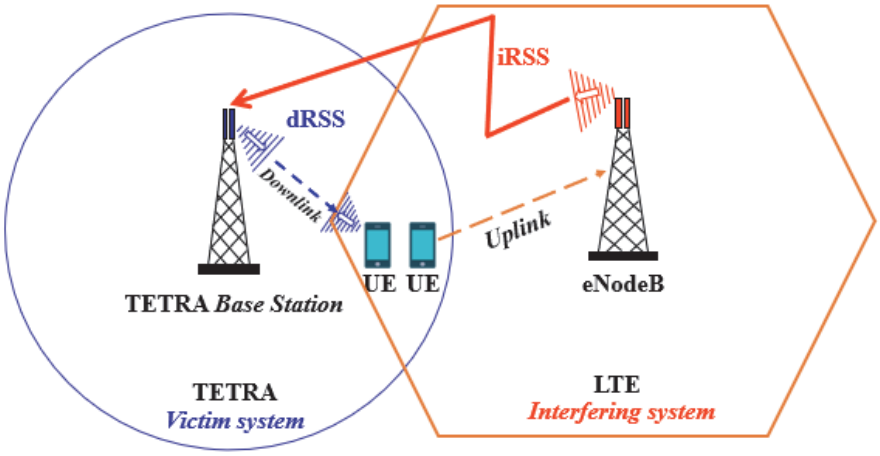

Figure 6. Scenario 2

Table 2. The Scenario 2

Scenario	*Interfering Link*	*Frequency Interfering Link*	*Rsimu Interfering Link*	*Victim Link*	*Frequency Victim Link*	*Rsimu Victim Link*
No guard band	*Uplink* LTE	849-859 MHz	1,67 km	*Downlink* TETRA	859-859,025 MHz	0,86 km
Guard band 0,5 MHz	*Uplink* LTE	849-859 MHz	1,67 km	*Downlink* TETRA	859,50-859,525 MHz	0,86 km
Guard band 0,75 MHz	*Uplink* LTE	849-859 MHz	1,67 km	*Downlink* TETRA	859,75-859,775 MHz	0,86 km
Guard band 1 MHz	*Uplink* LTE	849-859 MHz	1,67 km	*Downlink* TETRA	860-860,025 MHz	0,86 km

3.1.3 Scenario 3 (Downlink LTE vs Uplink TETRA)

There are four variations in scenario 3, no guard band, 0,5 MHz guard band, 0,75 MHz guard band, and 1 MHz guard band. Guard band variation located on TETRA. Guard band located between LTE frequency and TETRA frequency that caused shifted in LTE operating frequency LTE (interfering link). LTE used channel bandwidth 10 MHz and TETRA used channel bandwidth 25 KHz. The scenario 3 is illustrated in figure 7.

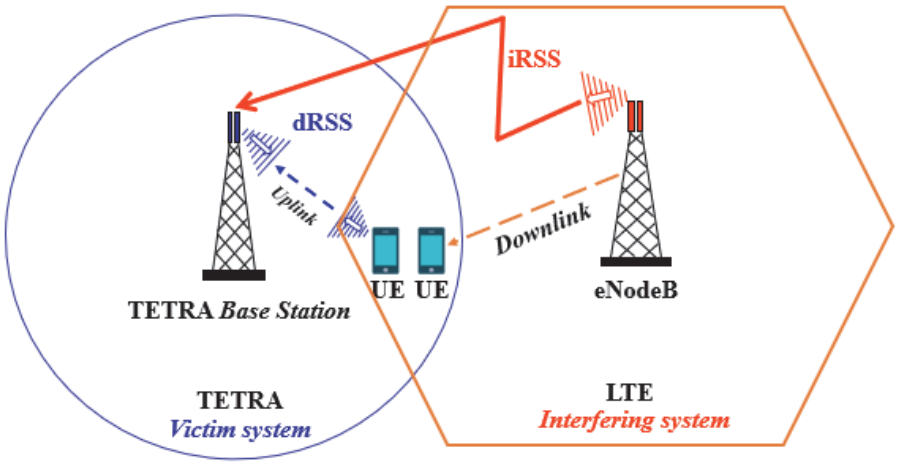

Figure 7. Scenario 3

Table 3. The Scenario 3

Scenario	*Interfering Link*	*Frequency Interfering Link*	*Rsimu Interfering Link*	*Victim Link*	*Frequency Victim Link*	*Rsimu Victim Link*
No guard band	*Downlink* LTE	824-834 MHz	1,67 km	*Uplink* TETRA	823,975-824 MHz	0,86 km
Guard band 0,5 MHz	*Downlink* LTE	824,5-834,5 MHz	1,67 km	*Uplink* TETRA	823,975-824 MHz	0,86 km
Guard band 0,75 MHz	*Downlink* LTE	824,75-834,75 MHz	1,67 km	*Uplink* TETRA	823,975-824 MHz	0,86 km
Guard band 1 MHz	*Downlink* LTE	825-835 MHz	1,67 km	*Uplink* TETRA	823,975-824 MHz	0,86 km

3.1.4 Scenario 4 (Uplink LTE vs Uplink TETRA)

There are four variations in scenario 4, no guard band, 0,5 MHz guard band, 0,75 MHz guard band, dan 1 MHz guard band. Guard band variation located on TETRA. Guard band located between LTE frequency and TETRA frequency that caused shifted in LTE operating frequency LTE (interfering link). LTE used channel bandwidth 10 MHz and TETRA used channel bandwidth 25 KHz). The scenario 4 is illustrated in figure 8.

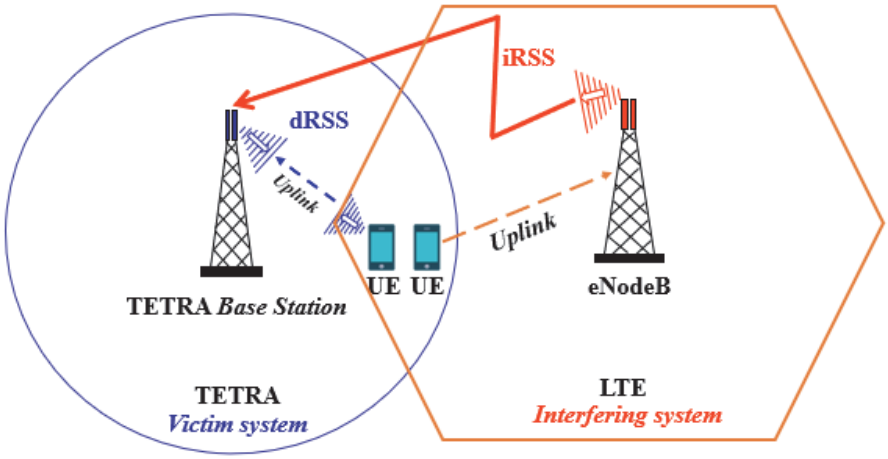

Figure 8. Scenario 4

Table 4. The Scenario 4

Scenario	*Interfering Link*	*Frequency Interfering Link*	*Rsimu Interfering Link*	*Victim Link*	*Frequency Victim Link*	*Rsimu Victim Link*
No guard band	*Uplink* LTE	814-824 MHz	1,67 km	*Uplink* TETRA	813,975-814 MHz	0,86 km
Guard band 0,5 MHz	*Uplink* LTE	814,5-824,5 MHz	1,67 km	*Uplink* TETRA	813,975-814 MHz	0,86 km
Guard band 0,75 MHz	*Uplink* LTE	814,75-824,75 MHz	1,67 km	*Uplink* TETRA	813,975-814 MHz	0,86 km
Guard band 1 MHz	*Uplink* LTE	815-825 MHz	1,67 km	*Uplink* TETRA	813,975-814 MHz	0,86 km

Then, the flowchart of analysis of interference between LTE and TETRA can be shown in Figure 9.

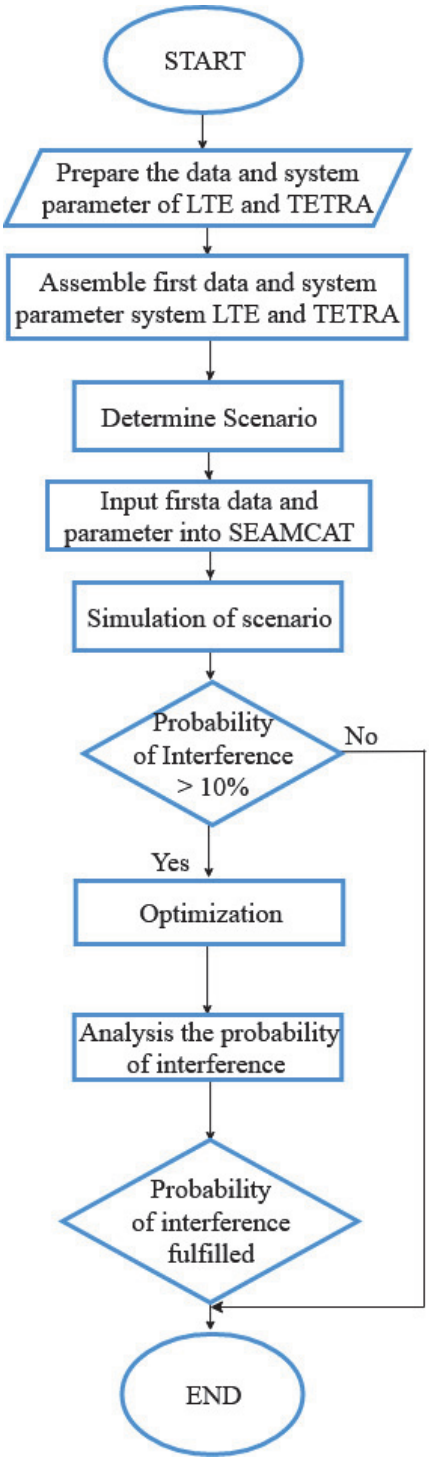

Figure 9. Flow chart of analysis of interference between LTE and TETRA

4. Simulation and Analysis

4.1 Analysis of Scenario 1

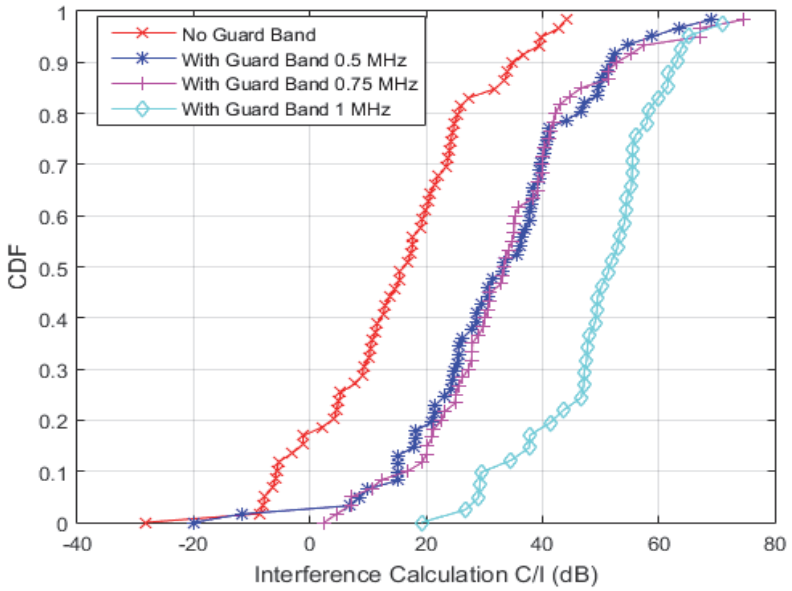

Figure 10. Interference Calculation C/I Scenario 1

Table 5. The Results of Scenario 1

Scenario		*Mean of dRSS*	*Mean of iRSS*	*Mean of C/I*	*Probability of Interference*	*Fullfil ETSI Standart*
Dowmlink LTE vs *Downlink* TETRA	*Co-channel (no guard band)*	-89,39 dBm	-117,12 dBm	26,81 dB	35%	No
	Guard Band 0,5 MHz	-89,19 dBm	-149,49 dBm	64,71 dB	1%	Yes
	Guard Band 0,75 MHz	-89,16 dBm	-153,33 dBm	66,33 dB	0%	Yes
	Guard Band 1 MHz	-89,99 dBm	-152,32 dBm	71,52 dB	0%	Yes

With guard band variation produced different result of each parameter in scenario no guard band occur Co-Channel Interference it showed with probability of interference is above the threshold, with guard band variation guard band 0,5 MHz, 0,75 MHz, and 1 MHz the value of probability of interference below threshold. Guard band addition increase system performance if it compared to probability of interference no guard band is higher than used guard band. When $\frac{dRSS}{iRSS} > \frac{C}{I}$ interference will occur and that will decrease the optimization of the system and that is in harmony with the result in table above, when $\frac{dRSS}{iRSS} > \frac{C}{I}$ probability of interference will be above the threshold and when $\frac{dRSS}{iRSS} < \frac{C}{I}$ the probability of interference will be below the threshold.

4.2 Analysis of Scenario 2

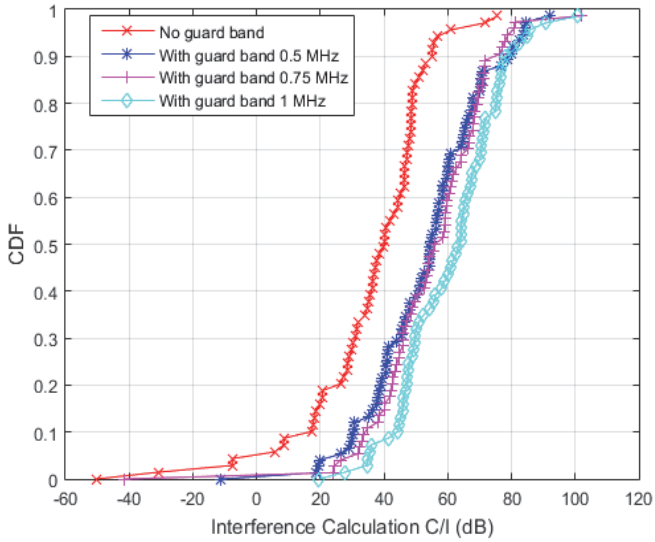

Figure 11. Interference Calculation C/I Skenario 2

Table 6. The Results of Scenario 2

Scenario		*Mean of dRSS*	*Mean of iRSS*	*Mean of C/I*	*Probability of Interference*	*Fullfil ETSI Standart*
Uplink LTE vs *Downlink* TETRA	*Co-channel (no guard band)*	-96,94 dBm	-127,93 dBm	35,47 dB	16%	No
	Guard Band 0,5 MHz	-95,16 dBm	-145,38 dBm	53,05 dB	2 %	Yes
	Guard Band 0,75 MHz	-96,19 dBm	-146,36 dBm	54,4 dB	1 %	Yes
	Guard Band 1 MHz	-97,27 dBm	-152,8 dBm	60,53 dB	0 %	Yes

With guard band variation produced different result of each parameter in scenario no guard band occur Co-Channel Interference it showed with probability of interference is above the threshold, with guard band variation guard band 0,5 MHz, 0,75 MHz, and 1 MHz the value of probability of interference below threshold. Guard band addition increase system performance if it compares to probability of interference no guard band is higher than used guard band. When $\frac{dRSS}{iRSS} > \frac{C}{I}$ interference will occur and that will decrease the optimization of the system and that is in harmony with the result in table above, when $\frac{dRSS}{iRSS} > \frac{C}{I}$ probability of interference will be above the threshold and when $\frac{dRSS}{iRSS} < \frac{C}{I}$ the probability of interference will be below the threshold.

4.3 Analysis of Scenario 3

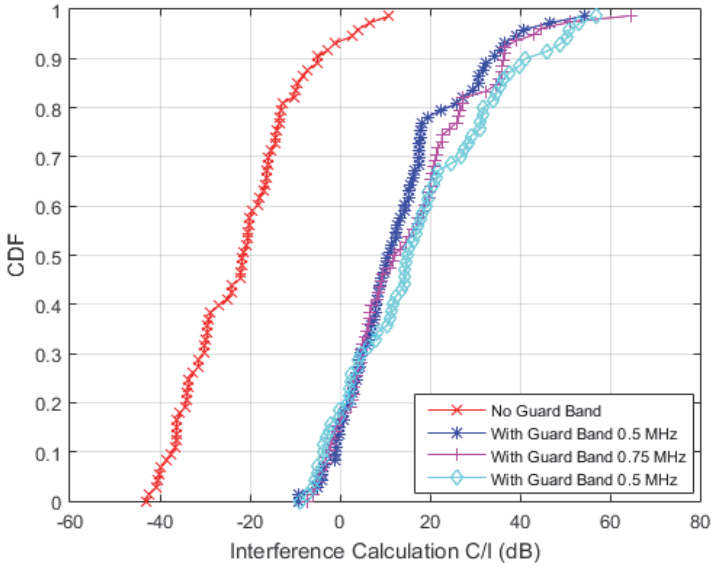

Figure 12. Interference Calculation C/I Scenario 3

Table 7. The Results of Scenario 3

Scenario		*Mean of dRSS*	*Mean of iRSS*	*Mean of C/I*	*Probability of Interference*	*Fullfil ETSI Standart*
Downlink LTE vs *Uplink* TETRA	*Co-channel (no guard band)*	-95,98 dBm	-70,03 dBm	-22,24 dB	100%	No
	Guard Band 0,5 MHz	-96,47 dBm	-105,67 dBm	13,02 dB	78 %	No
	Guard Band 0,75 MHz	-94,82 dBm	-105,35 dBm	14,84 dB	61 %	No
	Guard Band 1 MHz	-96,79 dBm	-108,64 dBm	16,92 dB	60%	No

With guard band variation produced different result of each parameter in scenario no guard band occur Co-Channel Interference it showed with probability of interference is above the threshold, with guard band variation guard band 0,5 MHz, 0,75 MHz, and 1 MHz the value of probability of interference below threshold. Guard band addition increase system performance if it compares to probability of interference no guard band is higher than used guard band. When $\frac{dRSS}{iRSS} > \frac{C}{I}$ interference will occur and that will decreases the optimization of the system and that is in harmony with the result in table above, when $\frac{dRSS}{iRSS} > \frac{C}{I}$ probability of interference will be above the threshold and when $\frac{dRSS}{iRSS} < \frac{C}{I}$ the probability of interference will be below the threshold.

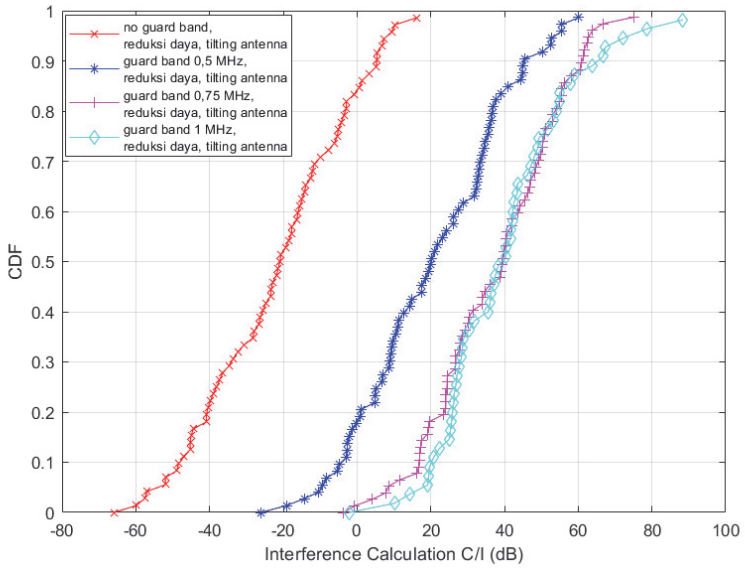

Figure 13. Interference Calculation scenario 3 after optimazition

Table 8. The Results with Guard Band Addition, Power Reduction, and Tilting Antenna

Scenario		*Mean of dRSS*	*Mean of iRSS*	*Mean of C/I*	*Probability of Interference*	*Fullfil ETSI Standard*
Downlink LTE vs *Uplink* TETRA	*Co-channel (no guard band), Power reduction BS TETRA, and tilting antenna*	-103,65 dBm	-121,91 dBm	26.54 dB	80%	No
	Guard Band 0,5 MHz, *Power reduction BS TETRA, and tilting antenna*	-115,21 dBm	-74,31 dBm	38.47 dB	47%	No
	Guard Band 0,75 MHz, *Power reduction BS TETRA, and tilting antenna*	-99,07 dBm	-133,23 dBm	42.99 dB	12%	Yes
	Guard Band 1 MHz, Power reduction BS TETRA, and tilting antenna	-93,15 dBm	-153,05 dBm	47.84 dB	5%	Yes

With guard band addition, power reduction, and tilting antenna produced result of parameter. In scenario no guard band occur co-channel interference it showed with probability of interference above the threshold, with guard band 0,5 MHz, 0,75 MHz, and 1 MHz performance system increased with the probability of interference decreased. System will be in optimum state when added 1 MHz guard band, power reduction of BS TETRA, and tilting antenna. When $\frac{dRSS}{iRSS} > \frac{C}{I}$ will occur inreference that will decreased performance of the system and that is in harmony with the result in table above, when $\frac{dRSS}{iRSS} > \frac{C}{I}$ probability of interference

will be above the threshold and when $\frac{dRSS}{iRSS} < \frac{C}{I}$ the probability of interference will be below the threshold.

4.4 Analysis of Scenario 4

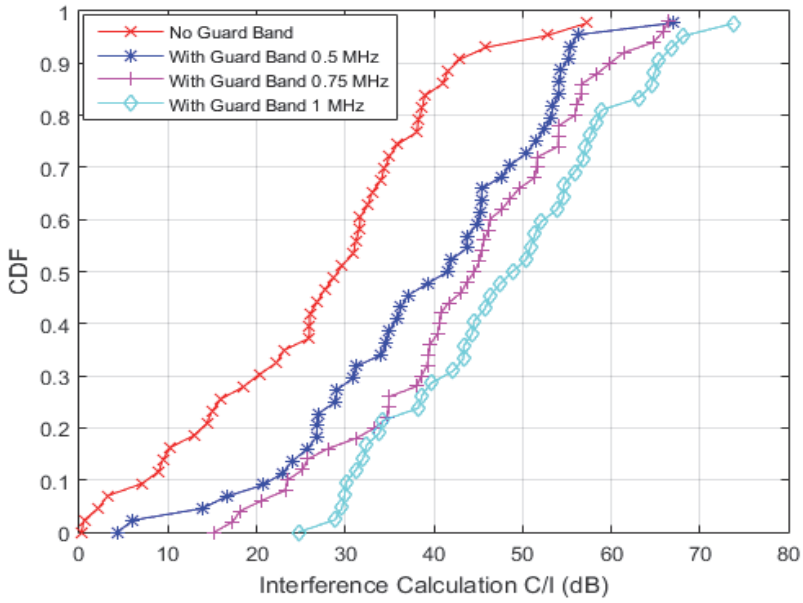

Figure 14. Interference Calculation scenario C/I Scenario 4

Table 9. The Results of Scenario 4

Scenario		*Mean of dRSS*	*Mean of iRSS*	*Mean of C/I*	*Probability of Interference*	*Fullfil ETSI Standart*
Uplink LTE vs *Uplink* TETRA	*Co-channel (no guard band)*	-103,65 dBm	-121,91 dBm	26.54 dB	31%	No
	Guard Band 0,5 MHz	-104,63 dBm	-134,80 dBm	38.47 dB	11%	No
	Guard Band 0,75 MHz	-102,98 dBm	-136,81 dBm	42.99 dB	6%	Yes
	Guard Band 1 MHz	-104,09 dBm	-140,60 dBm	47.84 dB	0%	Yes

With guard band variation produced different result of each parameter in scenario no guard band occur Co-Channel Interference it showed with probability of interference is above the threshold, with guard band variation guard band 0,5 MHz, 0,75 MHz, dan 1 MHz the value of probability of interference below threshold. Guard band addition increase system performance if it compares to probability of interference no guard band is higher than used guard band. When $\frac{dRSS}{iRSS} > \frac{C}{I}$ interference will occur and that will decrease the optimization of the system and that is in harmony with the result in table above, when $\frac{dRSS}{iRSS} > \frac{C}{I}$ probability of interference will be above the threshold and when $\frac{dRSS}{iRSS} < \frac{C}{I}$ the probability of interference will be below the threshold.

Table 10. The Probability of Interference

Scenario		*Probabilty of Interference (%)*	*Category*
Scenario 1 Downlink LTE vs Downlink TETRA	Co-channel (no guard band)	35%	Co-channel interference
	Guard Band 0,5 MHz	1%	Interference minimum
	Guard Band 0,75 MHz	0%	Interference minimum
	Guard Band 1 MHz	0%	Interference minimum
Scenario 2 Uplink LTE vs Downlink TETRA	Co-channel (no guard band)	16%	Co-channel interference
	Guard Band 0,5 MHz	2 %	Interference minimum
	Guard Band 0,75 MHz	1 %	Interference minimum
	Guard Band 1 MHz	0 %	Interference minimum
Scenario 3 Downlink LTE vs Uplink TETRA	Co-channel (no guard band)	100%	Co-channel interference
	Guard Band 0,5 MHz	78 %	Adjacent channel interference
	Guard Band 0,75 MHz	61%	Adjacent channel interference
	Guard Band 1 MHz	60%	Adjacent channel interference
Scenario 3 Optimization Downlink LTE vs Uplink TETRA	Co-channel (no guard band) Power reduction BS TETRA, and *tilting antenna*	80%	Co-channel interference
	Guard Band 0,5 MHz, Power reduction BS TETRA, and *tilting antenna*	47%	Adjacent channel interference
	Guard Band 0,75 MHz, Power reduction BS TETRA, and *tilting antenna*	12%	Adjacent channel interference
	Guard Band 1 MHz, Power reduction BS TETRA, and *tilting antenna*	5%	Interference minimum
Scenario 4 Uplink LTE vs Uplink TETRA	Co-channel (no guard band)	16%	Co-channel interference
	Guard Band 0,5 MHz	2%	Interference minimum
	Guard Band 0,75 MHz	1%	Interference minimum
	Guard Band 1 MHz	0%	Interference minimum

There are three categories, first category co-channel interference occurs if probability of interference above 10%, and in the same operating frequency. Second category, adjacent channel interference will occur if after added guard band the probability of interference still above 10%. Third category, interference minimum will occur if probability of interference below 10%. Simulation with guard band addition will increase system performance. Beside guard band addition, power reduction and tilting antenna also could increase system performance.

5. Conclusion

1. Based on the results of simulation there are three categories. Co-Channel Interference (CCI), Adjacent Channel Interference (ACI) and Interference minimum.
2. CCI occur if the probability of interference value is above 10%, and when LTE and TETRA operate in the same frequency.
3. ACI occur if the probability of interference is above 10 % after added guard band.
4. Interference minimum occur if probability of interference is below 10%.
5. Based on final result of simulation that have been analyzed, suggested to use minimum guard band 1 MHz for scenario 1,2,3 and 4 to avoid degradation performance between LTE and TETRA that caused by interference. And for optimization for scenario 3 suggested to do power reduction of TETRA base station and tilting antenna eNodeB and TETRA base station.

References

[1] W. H. Y. Commercial, N. Are, and N. O. T. Enough. (2012) "*Mission Critical Communications Designed To a Tougher Standard*," pp. 1–6.
[2] TCC, (2014) "*Tetra and lte working together*," no. 4155039.
[3] Oudah, A., Rahman, T. A. B. D., & Seman, N. (2012). Coexistence and Sharing Studies of Collocated and Non-Collocated Fourth Generation Networks in The 2.6 Ghz Band. *Journal of Theoretical & Applied Information Technology*, *43*(1).
[4] Commtech Indonesia, "*Seamcat Training-Setyono*." Commtech. Indonesia.
[5] T. I. B. M. Sesia Stefania, (2011) *LTE The UMTS Long Term Evolution*.
[6] European Conference of Postal and Telecommunications Administrations (CEPT), (2016) "Seamcat," *Spectr. Eng. Adv. Monte Carlo Anal. Tool*, vol. Ecc Report.