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Interference Analysis Between 5G System and Fixed Satellite Service in the 28 GHz Band

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Abstract - **Fixed Satellite System (FSS) service in the uplink direction has used the 27.5–28.5 GHz band as one of the most favourable frequency bands for 5G technology. This band could cause interference between the two systems. The study reported in this paper analyses the interference that occurs between satellite earth stations and 5G access points (AP) and between 5G AP and satellite sky stations. The simulation-based analysis employed the Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) software with two scenarios. The first scenario analyzed the interference between the 5G AP and the FSS sky station. With the *C/I* interference criterion of 40.2 dB, the simulation results show that the 5G AP will not interfere with the FSS sky station. The second scenario analyzed the interference simulation between the FSS earth station and 5G AP. The simulation used various distances between the earth station and the 5G AP, the height of the earth station, and the height of the 5G AP. The simulation results showed that the FSS earth station can interfere with 5G AP with a probability of up to 60%, so it is necessary to adjust the distance between systems and the height of the antenna to minimize interference. The shortest distance needed to minimize interference is 36 km with an earth station height of 5 m. The study can be one solution or reference to overcome interference in sending and receiving communication signals.**

Keywords: Interference, 5G mobile communication, satellite communication, spread spectrum communication

I. INTRODUCTION

The increasing need for mobile telecommunication system services with high data rates has driven the high demand for the frequency spectrum. Various telecommunications technologies that are continuously being developed and telecommunications services that already exist now require additional frequencies, eventually leading to frequency scarcity [1]. One of the telecommunications technologies being developed to enable high data rates with low latency, comprehensive service coverage, low power, and high reliability is 5G technology [2], [3]. 5G technology can provide services including Enhanced Mobile Broadband (eMBB) communications, Massive Machine - Type. Communication (mMTC), and Ultra - reliable and Low-Latency Communication (URLLC), which all require large bandwidths [1] [4]. Due to the many provided services and the high number of interconnected devices with 5G technology, high-frequency bands, especially in the millimetre wave spectrum, namely 30–300 GHz, will be very suitable for this technology. The millimetre wave spectrum will enable 5G services to provide maximum data rates exceeding 10 Gb/s and cell edge rates of up to 1 Gb/s [1]. The 28 GHz band is a strong candidate for use by 5G services. However, band 27.5–28.5 has been allocated for earth-to-space segment fixed satellite services [5] [6].

The radio frequency spectrum is a limited resource. The increased variety of technologies or wireless communication systems and the high number of users for each of these technologies has caused each operator of the said system to use frequencies that are close together. Systems operating at adjacent frequencies need to be mutually compatible because they do not interfere with each other. An essential criterion for compatibility between radio systems is the difference between the desired signal level and the interfering signal at the input of the victim receiver (the system affected by the interference). This parameter calculates the required protection distance between the victim and interfering systems in the geographic and frequency domains [7]. Carlo-based simulation and a theoretical method called the Minimum Coupling Loss (MCL) method are techniques that can perform interference analysis.

In research [2] and [8], the coexistence of the 5G system and FSS has been analyzed for C-band, namely the 3.4–4.2 GHz band. Research [5] discusses the potential for interference between 5G systems and satellite systems for the 28 GHz band using a mathematical model. Research [9] has addressed the potential for interference between International Mobile Telecommunications (IMT) systems and Fixed Satellite Systems (FSS). However, the interference studied was limited to interference caused by the IMT base station to the space station FSS.

This study aims to analyze the potential interference between 5G systems and fixed satellite services on the 28 GHz band. The analysis was conducted on a simulation basis with the Spectrum Engineering Advanced Monte Carlo Analysis Tool (SEAMCAT) software. There are two scenarios in the simulations. In the first scenario, the interference caused by the transmission of 5G Access

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Points (AP) in the uplink direction to the space station of FSS is simulated and analyzed. In the second scenario, the interference simulated and analyzed is from the earth station of FSS to 5G AP.

Simulation with SEAMCAT is based on the Monte Carlo method. This statistical simulation technique allows for direct simulations of physical processes without requiring differential equations that describe the system's behaviours. This technique contrasts with conventional analytical methods, where the differential equations that describe some underlying physical or mathematical system must be known first before the analysis can be conducted. The Monte Carlo simulation method is based on taking samples of random variables from a given distribution [7]. In this paper, the simulations are carried out for dynamic traffic conditions. This dynamic is represented by varying the position of 5G AP relative to the FSS space station (SS) for each of the 100 simulations done while maintaining the distance at 35,786 km. In [10], simulations based on the Monte Carlo method have been done to consider the randomness of interference power. The systems under consideration in [10] are 5G AP and FSS SS in the same band and Earth Exploration Satellite Service (EESS) operating in an adjacent channel. However, the simulations in [10] do not consider the interference from the earth station of FSS to 5G AP. The new contribution provided in this paper is that we consider the interference from the earth station of FSS to 5G AP.

We organize this paper into four sections. The first section is the introduction. In the second section, this paper discusses the methodology covering the simulation parameters needed and the simulation steps. The third section gives the simulation results, and the last section provides the conclusions.

II. Methodology

A. *Calculations for Interference Received by FSS Space Station from 5G AP*

The path loss for transmission from the 5G AP to the SS uses the free space loss formula as follows [11]

$$P_{LO} = 32.45 + 20\log(f) + 20\log(d) \quad (1)$$

where f is the frequency band (MHz), and d is the distance between 5G AP and SS in km. Table 1 shows the other parameters needed to calculate the interference.

The link budget analysis can determine the interference between the two communication systems. If there is one 5G AP that interferes with the SS, then the power of the interference signal received by the SS can be calculated using [9]

$$I = P_T + G_T(\theta) + G_R - PL_0 - CL - L_{rain} - L_P \quad (2)$$

where I is the interference power received by the satellite receiver, P_T is 5G AP transmit power, P_{L0} is free space loss, G_T (θ) is the gain of 5G AP transmitter antenna with a maximum value of 5 dBi, G_R is the receiver antenna gain, C_L is the clutter loss, L_P is polarization loss which value is 3 dB, L_{rain} is rain attenuation.

Table 1. Parameters for 5G AP to SS Interference Calculation

Parameters	Value
Elevation angle of AP transmitter	30°
Bandwidth (MHz) of AP transmitter	500
AP transmitter power (dBm)	24
AP antenna height (m)	6
Maximum AP antenna gain (dBi)	5
AP activity factor	50%
I/N for SS (dB)	-12.2
SS Band width (MHz)	500
SS transmitter and receiver gain (dBi)	34
SS Noise Temperature (K)	550
SS Noise Level N (dBm)	-111.2
SS Polarization loss (dB)	3
SS Rain attenuation (dB)	20
SS Clutter loss (dB)	20
Earth station transmitter power (dBm)	48

Satellite systems can cover large service areas with more than one 5G AP. If all APs have the same power, then the total interference from M APs in the satellite service area is [9]

$$I_{total} = I + 10\log(M) \quad (3)$$

The value of M is affected by the coverage area of the satellite K_{area}, the ratio of the urban area of K_{urban}, and the AP density factor $K_{density}$, so that M can be expressed by

$$M = K_{area} \cdot K_{urban} \cdot K_{density} \quad (4)$$

The coverage area of the satellite is K_{area} = 3,000,0000 km^2. The urban area ratio of K_{urban} is 0.4%, and the number of APs in the urban area is 19 per km^2 [9]. The maximum acceptable value of I_{max} interference in a satellite receiver is

$$I_{max} = I/N(dB) + N(dB) \quad (5)$$

where N is the thermal noise. A calculation based on (1) – (5) shows that the interference received by the satellite space station is -139,89 dBm, while I_{max} is -126,41 dBm. Therefore, it can be stated that 5G APs do not cause an interference on SS.

The desired received signal strength (dRSS) calculation of the FSS space station is as follows

$$dRss_{SS} = P_{T,ES} + G_{T,ES}(\theta) + G_{R,SS} - PL_o \quad (6)$$

where $P_{T,ES}$ is the transmit power of the earth station in the FSS, $G_{T,ES}$ is the transmitter gain of the earth station, $G_{R,SS}$ is the receiver gain of the space station, and P_{Lo} is the path loss.

B. *Calculations for Interference Received by 5G AP from Earth Station FSS*

The interference received by the 5G AP due to transmission from the FSS earth station is calculated ITU-R.P 452-17 propagation model on prediction procedure for the evaluation of interference between stations on the surface of the Earth at frequencies above about 0.1 GHz [12]

$$I = P_{T,ES} + G_{T,ES} + G_{R,5G} - L_{bfsg} \quad (7)$$

where $G_{R,5G}$ is the gain of 5G AP, and L_{bfsg} is path loss due to free-space propagation and attenuation due to atmospheric gases (dB) [13]. The dRSS of the 5G AP is similar to (6), namely:

$$dRss_{5G} = P_{T,UE} + G_{T,UE}(\theta) + G_{R,AP} - PL_o \quad (8)$$

where $P_{T,UE}$ is the transmit power of the user equipment in the 5G cellular system, $G_{T,UE}$ is the transmitter gain of the user equipment, $G_{R,AP}$ is the receiver gain of 5G AP and P_{Lo} is the path loss.

C. Interference Criteria

Interference Criteria indicate the level of protection required for the system to suppress interference. In the SEAMCAT simulation, the interference criteria needed to run the simulation are Carrier to Interference (*C/I*), Carrier to Noise plus Interference (*C/N+I*), Noise to Noise plus Interference (*N/N+I*), and Interference to Noise (*I/N*). The interference criteria can be calculated by using the following equations [7]

$$\left[\frac{C}{N+I}\right]_{dB} = \left[\frac{C}{I}\right]_{dB} + \left[\frac{N+I}{I}\right]_{dB} \quad (9)$$

$$\left[\frac{N+I}{I}\right]_{dB} = \left[\frac{N+I}{N}\right]_{dB} - \left[\frac{I}{N}\right]_{dB} \quad (10)$$

$$\left[\frac{N+I}{N}\right]_{dB} = 10.\log\left\{1 + 10^{\frac{(I/N)}{10}dB}\right\} \quad (11)$$

D. Interference Simulation from 5G AP to FSS System (Scenario 1) Using SEAMCAT

In SEAMCAT, we must define parameters for transmitter, receiver, position, and propagation with the default frequency of 28 GHz. All parameters in Table 1 are entered in the systems tab in SEAMCAT, as illustrated in Figure 1. The next step in the interference simulation is to determine the scenario parameters, where interference system data is needed, which includes the interference frequency, the distance between interfering and interfered systems, the propagation model, and the number of interfering transmitters. The simulations are run on two computers, whose specifications are listed in Table 2. The results obtained from the two computers are identical, as detailed in section III.

Table 2. Specifications of Computers Used for Simulations

	Computer 1	Computer 2
Operating System	Windows 11	Windows 11
Processor	AMD Ryzen 5 5600H	Intel i7-1165G7
Base clock-speed	3.30 GHz	2.80 GHz
RAM	16 GB	8 GB

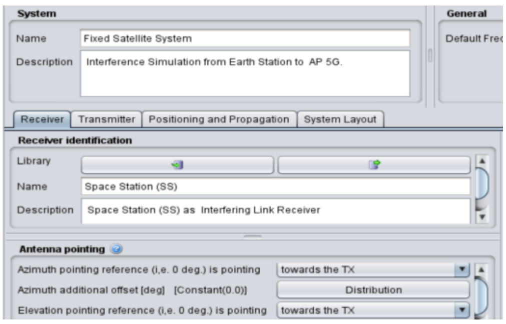

Figure 1. Setting the system parameters in SEAMCAT

It is also necessary to include the running number of simulations in this simulation tab. In the Scenario tab, the parameters used are:

- 1 km simulation radius of 1 km,
- the number of active transmitters is 1,
- the distance between the SS receiver (Victim Receiver) and the AP transmitter (Interfering link Transmitter) is 35,786 km and
- the use of ITU-R P.525 propagation model for free space [11].

The setting for the Scenario parameters is illustrated in Figure 2. Following the parameters given in Table 1, *I/N* for SS is -12.2 dB, while *C/N* is 28 dB [14]. Calculation of the *C/I* interference criterion uses equations (9) – (11) to give *C/I* = 40.2 dB. Following the same equations, the (*N+I*)/*N* criterion is found to be 0.25 dB. The Interference Criteria are then entered into SEAMCAT, as illustrated in Figure 3.

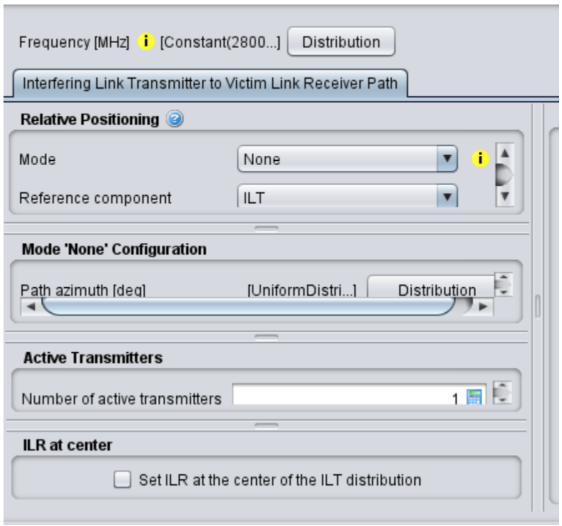

Figure 2. Setting the interference scenario in SEAMCAT

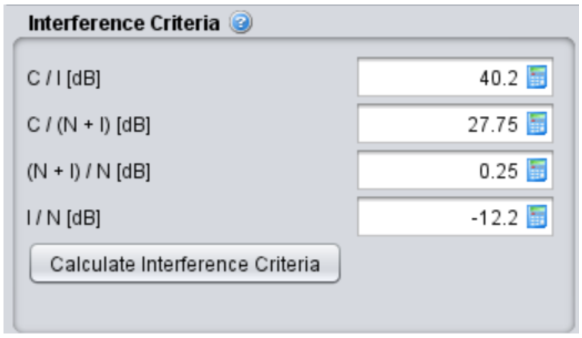

Figure 3. Interference criteria for simulations of interference between 5G AP to FSS

E. Interference Simulation from Earth Station FSS to 5G AP System (Scenario 2) Using SEAMCAT

Table 3 gives the parameters needed for this simulation. Using the parameters given in Table 3 and Equations (9)-(11), it is known that *C/I* for 5G AP is 32 dB and (*N+I*)/*N* is 0.97 dB. The Interference Criteria are then entered into SEAMCAT, as depicted in Figure 4.

Table 3. Parameters for Simulations of Interference Between Earth Station FSS and 5G AP

Parameter	Value
Earth station transmit power $P_{T,ES}$ (dBm)	12.2
Gain of 5G AP (dBi)	29
Distance between Earth Station and 5G AP (km)	1-42
User equipment transmit power $P_{T,UE}$ (dBm)	14
I/N (dB) in 5G AP	-6

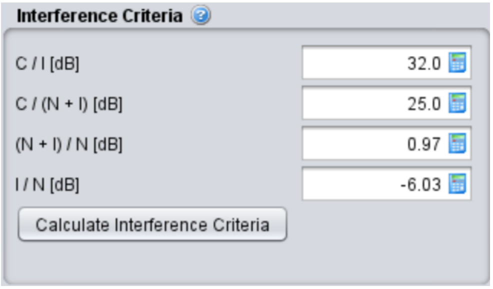

Figure 4. Interference criteria for simulations of interference between earth station FSS and 5G AP

All parameters are entered into SEAMCAT, as illustrated in Figures 1 and 2. The propagation model for this simulation is ITU-R P. 452-17 [12].

III. RESULTS AND DISCUSSION

A. Calculations Results for Interference Received by FSS Space Station from 5G AP

The calculations are done using Equations (1)-(6), the parameters given in Table 1, and the 5G AP transmit power values of 24 dBm, 25 dBm, and 26 dBm. Table 4 summarizes the results, where *dRss* is the desired received signal strength of the FSS space station and iRss is the interference received by the FSS space station.

From Equations (9)-(11) and the parameters given in Table 1, it is known that the lowest *C/I* value to avoid interference is 40.2 dB. However, from the calculations shown in Table 4, the *C/I* value far exceeds 40.2 dB. Therefore, the calculations show that the 5G AP will not interfere with the FSS space station.

Table 4. Interference From 5G AP to Satellite Space Station

5G AP Power (dBm)	dRss (dBm)	iRss (dBm)	C/I (dB)	Interference Probability (%)
24	-96.67	-192.467	95.8	0
25	-96.67	-191.467	94.8	0
26	-96.67	-190.467	93.8	0

B. Results of Interference Simulation from 5G AP to SS

The distance between 5G AP and SS was 35,786 km, but the position of 5G AP varied relative to the SS position. The simulations were done 100 times, each with different numbers of active AP transmitters. The simulation results are given in Tables 4, 5, and 6 for AP transmitter power = 24, 25, and 26 dBm, respectively.

Based on the simulation results summarized in Tables 5, 6, and 7, the 5G system will not interfere with the FSS system in the 28 GHz band if the 5G transmit power is varied by 24, 25, or 26 dBm.

Table 5. 5G AP Interference Probability to Satellite Space Station, with AP Power = 24 dBm

Number of Active 5G AP	dRss (dBm)	iRss (dBm)	C/I (dB)	Interference Probability (%)
1	-97.07	-189.67	92.6	0
100	-97.07	-169.76	72.69	0
1000	-97.07	-159.75	62.68	0
2000	-97.07	-156.74	59.67	0
3000	-97.07	-154.98	57.91	0
4000	-97.07	-153.73	56.66	0
5000	-97.07	-152.76	55.69	0
6000	-97.07	-151.97	54.9	0
7000	-97.07	-151.3	54.23	0
8000	-97.07	-150.72	53.65	0
9000	-97.07	-150.21	53.14	0
10000	-97.07	-149.75	52.68	0

Table 6. 5G AP Interference Probability to Satellite Space Station, with AP Power = 25 dBm

Number of Active 5G AP	dRss (dBm)	iRss (dBm)	C/I (dB)	Interference Probability (%)
1	-97.07	-188.67	91.6	0
100	-97.07	-168.76	71.69	0
1000	-97.07	-158.75	61.68	0
2000	-97.07	-155.74	58.67	0
3000	-97.07	-153.98	56.91	0
4000	-97.07	-152.73	55.66	0
5000	-97.07	-151.76	54.69	0
6000	-97.07	-150.97	53.9	0
7000	-97.07	-150.3	53,23	0
8000	-97.07	-149.72	52.65	0
9000	-97.07	-149.21	52.14	0
10000	-97.07	-148.75	51.68	0

Table 7. 5G AP Interference Probability to Satellite Space Station, with AP Power = 26 dBm

Number of Active 5G AP	dRss (dBm)	iRss (dBm)	C/I (dB)	Interference Probability (%)
1	-97.07	-187.67	90.6	0
100	-97.07	-167.76	70.69	0
1000	-97.07	-157.75	60.68	0
2000	-97.07	-154.74	57.67	0
3000	-97.07	-152.98	55.91	0
4000	-97.07	-151.73	54.66	0
5000	-97.07	-150.76	53.69	0
6000	-97.07	-149.97	52.9	0
7000	-97.07	-149,3	52,23	0
8000	-97.07	-148,72	51,65	0
9000	-97.07	-148,21	51,14	0
10000	-97.07	-147,75	50,68	0

Table 8 compares the calculation and simulation results for the dRss and iRss values. For the simulations, we can easily increase the number of 5G AP and varied positions while keeping the distance between the interfering and the interfered systems constant. Those cannot be precisely done using mathematical equations. Therefore, the number of 5G AP is kept at 1 for the calculations. The result depicted in Table 8 is taken when the number of 5G AP is 1.

Table 8. Comparison of dRss and iRss Values from Calculation and Simulation for 5G AP to FSS Sky Station Interference

AP Power	dRss (dBm)		iRss (dBm)	
	Calculation	Simulation	Calculation	Simulation
24	-96.67	-97.07	-192.467	-189.67
25	-96.67	-97.07	-191.467	-188.67
26	-96.67	-97.07	-190.467	-187.67

Table 8 shows that the dRss values differ by 0.414% between the calculations and simulations, whereas the difference for the iRss values is 1.45%. The difference is due to the varied positions of 5G AP during the simulations. During the 100 simulations, the position of 5G AP is randomized while keeping the distance with the FSS sky station constant at 35,786 km. This varied positions, in turn, will affect the power received by the FSS sky station and cause the difference between calculated and simulated dRss and iRss.

The *C/I* values in Tables 5, 6, and 7 are contrasted with the number of active 5G AP and summarized in Figure 5. Figure 5 shows that the *C/I* lessens as the number of active 5G AP increases, and the worst *C/I* values are obtained when the AP power is highest or equal to 26 dBm in this case.

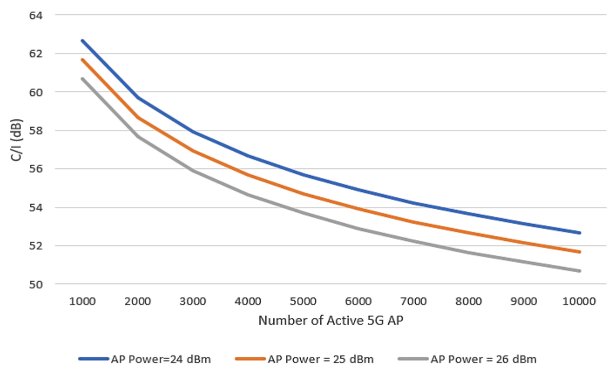

Figure 5. Comparison of C/I values for different AP power values and number of active 5G AP

C. *Results of Interference Simulation from Earth Station FSS to 5G AP*

The probability of interference received by 5G APs from Earth Station FSS with varied distances between the two systems is given in Tables 9 and 10. The first experiment for scenario 2 was carried out with an earth station height of 20 m, a 5G AP height of 6 meters, and an AP gain of 29 dBi. The distance between the earth station and the AP varies from 5 km to 42 km.

Table 9. Probability of Interference received by 5G AP From Earth Station FSS With AP Gain = 29 dBi, AP Height = 6 m and Earth Station Height = 20 m

Distance Between Earth Station to AP 5G (km)	dRss (dBm)	iRss (dBm)	C/I (dB)	Inter-ference Proba-bility (%)
5	-59.45	-79.82	20.37	56
10	-59.45	-86.35	26.9	52
15	-59.45	-90.39	30.94	52
20	-59.45	-93.4	33.95	52
25	-59.45	-95.85	36.4	52
30	-59.45	-97.94	38.49	52
35	-59.45	-107.92	48.47	35
40	-59.45	-122.41	62.96	6
42	-59.45	-128.42	68.97	0

Based on the simulation results in Table 9, the *C/I* values for the AP range from 20.37 dB to 68.97 dB. When the distance between the earth station and 5G AP is 5 km, the *C/I* value is 20.37 dB, or below the interference criterion of 32 dB. It can be seen from the simulation results that the probability of interference is 56% if the distance between the systems is 5 km. If the distance between systems is increased to 20 km, the C/I value is 33.95 dB, which meets the interference criteria. If the distance between systems continues to increase until it reaches 40 km, the probability of interference decreases to 6%. The interference probability value will reach 0% after the distance between systems is increased to 42 km.

In the following simulation, the heights of the 5G AP and Earth Station are adjusted to reduce the probability of interference, and the result is given in Table 10.

Table 10. Probability of Interference Received by 5G AP from FSS Earth Station with AP Gain = 29 dBi, AP Height = 10 m and Earth Station Height = 15 m

Distance Between Earth Station to AP 5G (km)	dRss (dBm)	iRss (dBm)	C/I (dB)	Inter-ference Proba-bility (%)
5	-57.76	-79.85	22.09	56
10	-57.76	-86.4	28.64	52
15	-57.76	-90.44	32.68	52
20	-57.76	-93.46	35.7	52
25	-57.76	-95.91	38.15	52
30	-57.76	-98	40.24	52
35	-57.76	-107.93	50.17	20
40	-57.76	-122.42	64.66	3
41	-57.76	-125.42	67.66	0

Based on the simulation results shown in Table 10, the C/I values for the AP range from 22.09 dB to 67.66 dB. When the distance between the earth station and 5G AP is 10 km, the C/I value is 28.64 dB, or below the interference criterion of 32 dB. It can be seen from the simulation results that the probability of interference is 52% if the distance between the systems is 10 km. If the distance between systems is increased to 15 km, the C/I value is

32.68 dB, which meets the interference criteria. Further increasing the distance to 40 km will decrease the probability of interference to 3%. The interference probability value will reach 0% with *C/I* = 67.66 dB after the distance between systems is increased to 41 km. The distance between systems needed to reach a 0% probability of interference has decreased by 1 km compared to the previous simulation depicted in Table 9.

In the following simulation, the earth station height is reduced to 10 m, 5G AP height is 10 m and AP gain is 29 dBi. The distance between the earth station and the AP varies from 5 km to 37 km. The results are given in Table 11.

Based on the simulation results shown in Table 11, the *C/I* values for the AP range from 34.85 dB to 68.46 dB. Results show that the probability of interference is 52% if the distance between the systems is 5 km. If the distance between systems continues to be increased until it reaches 35 km, the probability of interference decreases to 4%.

Table 11. Probability of Interference Received by 5G AP From FSS Earth Station with AP Gain = 29 dBi, AP Height = 10 m and Earth Station Height = 10 m

Distance Between Earth Station to AP 5G (km)	dRss (dBm)	iRss (dBm)	C/I (dB)	Interference Probability (%)
5	-57.76	-92.61	34.85	52
10	-57.76	-99.17	41.41	52
15	-57.76	-103.21	45.45	39
20	-57.76	-106.22	48.46	21
25	-57.76	-108.57	50.81	18
30	-57.76	-110.76	53	16
35	-57.76	-120.69	62.93	4
37	-57.76	-126.22	68.46	0

The interference probability value will reach 0% after the distance between systems is increased to 37 km. The distance between systems has decreased by 4 km to achieve a probability of 0% compared to the results given in Table 10, which requires a distance between systems of 41 km to achieve a 0% probability of interference.

In the following simulation, the earth station height is reduced to 5 m, 5G AP height is 10 m, and AP gain is 29 dBi. The distance between the earth station and the AP varies from 5 km to 36 km. The results are given in Table 12.

Table 12. Probability of Interference Received by 5G AP from FSS Earth Station with AP Gain = 29 dBi, AP Height = 10 m and Earth Station Height = 5 m

Distance Between Earth Station to AP 5G (km)	dRss (dBm)	iRss (dBm)	C/I (dB)	Inter-ference Probability (%)
5	-57.76	-96.06	38.3	43
10	-57.76	-102.61	44.85	18
15	-57.76	-106.65	48.89	21
20	-57.76	-109.66	51.9	17
25	-57.76	-112.11	54.35	12
30	-57.76	-114.21	56.45	10
35	-57.76	-121.24	63.48	3
36	-57.76	-126.91	69.15	0

Based on the simulation results shown in Table 12, the *C/I* values for the AP range from 38.3 dB to 69.15 dB. It can be seen from the simulation results that the probability of interference is 43% if the distance between the systems is 5 km. If the distance between the systems is further increased to 35 km, the probability of interference decreases to 3%. The interference probability will reach 0% with *C/I* = 69.15 dB after the distance between systems is increased to 36 km. The distance between systems has decreased by 1 km compared to the previous simulation; which results are depicted in Table 11.

The results given in Tables 7–10 are summarized in Figure 6. The comparison between dRss and iRss values from calculations and simulations for the interference between the earth station and 5G AP when the distance between two systems is 5 km is given in Table 13. The dRss values based on calculation and simulation differ by 1.5% when the Earth Station (ES) height is 20 m. When the ES heights are 15, 10, and 5 m, the difference between the calculated and simulated dRss values is 4%. Similar to the comparison given in Table 8, during the 100 simulations done for each ES height, the position of 5G AP is randomized while keeping the distance with ES constant at 5 km. This varied position of 5G causes the difference between calculated and simulated dRss and iRss. In real life cases, the 5G AP is situated randomly around the ES. This phenomenon can be simulated using SEAMCAT but cannot be reflected in the mathematical calculation.

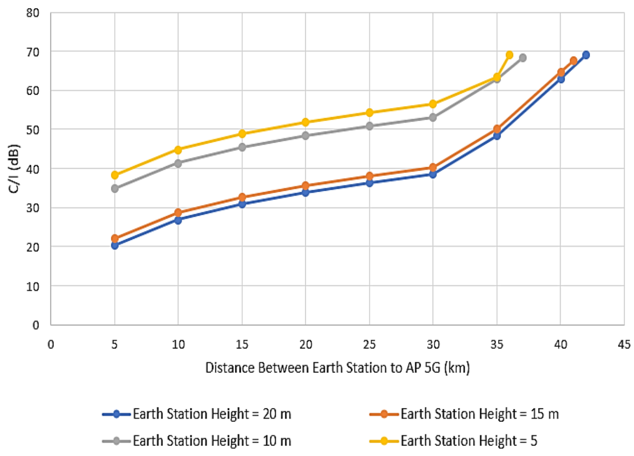

Figure 6. Comparison of C/I values for different earth station heights and distance between earth station and AP 5G

Table 13. Comparison of dRss and iRss Values from Calculation and Simulation for Earth Station (ES) to 5G AP Interference

ES Height(m)	dRss (dBm)		iRss (dBm)	
	Calculation	Simulation	Calculation	Simulation
20	-60.37	-59.45	-79.57	-79.82
15	-60.37	-57.76	-79.57	-79.85
10	-60.37	-57.76	-92.57	-92.61
5	-60.37	-57.76	-95.77	-96.06

IV. CONCLUSION

Based on the calculation and simulation results of the interference between access point system 5G scenarios, the 5G AP will not interfere with the FSS system. This is because the *C/I* value on the FSS sky station when there is a 5G AP operating in the 28 GHz band ranges from 50.58 dB to 92.6 dB depending on the number of active AP transmitters and AP transmitter power, which is still greater than interference criterion value of 40.2 dB. However, based on the calculation and simulation results, the 5G AP will potentially experience interference from FSS earth stations. Although the *C/I* values at the 5G AP exceed the interference criterion value, which is 32 dB, the probability of interference does not reach 0% unless the ES height and the distance between systems are modified. The *C/I* value of a 5G AP when there is an earth station in the 28 GHz band ranges from 20.37 dB to 60.15 dB, depending on the distance between systems, AP height, and earth station height. The shortest distance between systems to prevent interference is 36 km, with an earth station height of 5 m and an AP height of 10 m. With an earth station height of 10 m and the same AP height, a minimum distance of 37 km between systems is required to prevent interference. If the earth station is 15 m high, a minimum distance of 41 km between systems is required to prevent interference, while for an earth station height of 20 m a minimum distance of 42 km between systems is required to prevent interference. Therefore, it is advisable to keep the ES height at a low height (no higher than 20 m) and the 5G AP and the distance between the two systems is ideally at least 36 km.

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