RADIO FREQUENCY INTERFERENCE ANALYSIS REPORT

WA-1010 - Lake Forest Intermod Study for Dish, AT&T, and T-Mobile

October 14, 2022

Dish, AT&T, and T-Mobile antenna usage will not interfere with other existing adjacent or neighboring transmission reception signals in accordance with the proposed deployment plan

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1.0 Executive Summary

This report presents a radio frequency interference (RFI) analysis which was performed on the WA-1010 - Lake Forest site. The RFI analysis consists of transmitter noise, receiver desensitization, intermodulation, harmonic and transmitter spurious output interference. The report consists of Sections that provide details of the communications site, antenna systems, operational frequencies and each interference analysis mode.

A summary of the interference analysis results is depicted in the following Table.

Interference Analysis Mode	Type Mix	Status	Summary	Worst-Case Margin (dB)
Transmitter Noise	N/A	Passed	No Interference was predicted	16
Receiver Desensitization	N/A	Passed	No Interference was predicted	46.8
Transmitter Intermodulation	1 Tx	Passed	No Interference was predicted	N/A
Transmitter Intermodulation	2 Tx	Passed	No Interference was predicted	N/A
Transmitter Intermodulation	3 Tx	Passed	No Interference was predicted	N/A
Receiver Intermodulation	1 Tx	Passed	No Interference was predicted	N/A
Receiver Intermodulation	2 Tx	Passed	No Interference was predicted	N/A
Receiver Intermodulation	3 Tx	Passed	No Interference was predicted	N/A
Transmitter Harmonics	N/A	Passed	No Interference was predicted	N/A
Transmitter Spurious Output	N/A	Passed	No Interference was predicted	N/A
Interference Level Summing - C/(I+N)	N/A	Passed	No Interference was predicted	N/A

The analysis was performed with the setup options depicted in the Table below.

Analysis	Description
Receiver Performance	Receiver Sensitivity Threshold
Receiver Bandwidth	Receiver Dependent
Antenna Patterns Considered	Yes
Measured Antenna Isolation Data	No
Filters/Multicouplers Considered	Yes
Number of Simultaneous Transmitters Mixed	3
Highest Intermodulation Order Tested	7
Condense Intermodulation Hit Quantity	Yes - 1000/Order
TX IM Bandwidth Multiplication	Yes
Tx/Rx Systems Excluded	None
Site File Name	WA-1010 Intermod Study for Dish_ATT_TMobile.dta
Report File Name	test.docx
WirelessSiteRFI Software Version	10.0.12A

2.0 Site Description

The communication systems located at this site are described in this section as well as the configuration of the antenna systems.

The site parameters are:

Site Name: WA-1010 - Lake Forest
Site Description: Tower
Address: 19701 47th Avenue NE
Lake Forest Park, WA 98155
Latitude: 47:46:19.50 N
Longitude: 122:16:51.40 W

Notes: Intermod study to evaluate co-locators Dish, AT&T and T-Mobile

2.1 Communications Systems

System	Provider	Technology	Frequency Band
1	Dish	LTE/5G	600 - 2200 MHz
2	AT&T	LTE/5G	698 - 2300 MHz
3	T-Mobile	LTE/5G	600 - 2200 MHz

2.2 Antenna Systems

Ant #	Mfg	Antenna Model	Hgt (ft)	Orient (deg)	Sec-tor	Ant Use	Transmission Line Type	Line Loss (/100')	Line Length (ft)
1	JMA Wireless	MX08FRO665-21	77	0	A	Dplx	Fiber	0.001	5
2	JMA Wireless	MX08FRO665-21	77	120	B	Dplx	Fiber	0.001	5
3	JMA Wireless	MX08FRO665-21	77	240	C	Dplx	Fiber	0.001	5
4	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	0	A	Dplx	Fiber	0.001	5
5	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	0	A	Dplx	Fiber	0.001	5
6	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	120	B	Dplx	Fiber	0.001	5
7	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	120	B	Dplx	Fiber	0.001	5
8	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	240	C	Dplx	Fiber	0.001	5
9	Cellmax	CMA UBTULBULBHH-6517-17-21-21	67	240	C	Dplx	Fiber	0.001	5
10	Commscope	FFVV-65C-R3-V1-2100	57	0	A	Dplx	Other	0.001	5
11	Commscope	FFVV-65C-R3-V1-2100	57	120	B	Dplx	Other	0.001	5
12	Commscope	FFVV-65C-R3-V1-2100	57	240	C	Dplx	Other	0.001	5

3.0 Transmitter Frequencies

Freq #	Ant #	Provider	Model	Technology	Channel Label	ID	Frequency	Power (Watts)	BW (KHz)
1	1	Dish	Generic	LTE/5G	Dish 600 MHz	A	680.50000	60	5000
2	1	Dish	Generic	LTE/5G	Dish 700 MHz	B	725.00000	60	5000
3	1	Dish	Generic	LTE/5G	Dish 850 MHz	C	876.500000	60	5000
4	1	Dish	Generic	LTE/5G	Dish 1900 MHz	D	1997.50000	60	5000
5	1	Dish	Generic	LTE/5G	Dish 2100 MHz	E	2185.50000	60	5000
6	1	Dish	Generic	LTE/5G	Dish 2100 MHz	F	2102.50000	60	5000
7	2	Dish	Generic	LTE/5G	Dish 600 MHz	G	680.500000	60	5000
8	2	Dish	Generic	LTE/5G	Dish 700 MHz	H	725.000000	60	5000
9	2	Dish	Generic	LTE/5G	Dish 850 MHz	I	876.500000	60	5000
10	2	Dish	Generic	LTE/5G	Dish 1900 MHz	J	1997.50000	60	5000
11	2	Dish	Generic	LTE/5G	Dish 2100 MHz	K	2185.50000	60	5000
12	2	Dish	Generic	LTE/5G	Dish 2100 MHz	L	2102.50000	60	5000
13	3	Dish	Generic	LTE/5G	Dish 600 MHz	M	680.500000	60	5000
14	3	Dish	Generic	LTE/5G	Dish 700 MHz	N	725.000000	60	5000
15	3	Dish	Generic	LTE/5G	Dish 850 MHz	O	876.500000	60	5000
16	3	Dish	Generic	LTE/5G	Dish 1900 MHz	P	1997.50000	60	5000
17	3	Dish	Generic	LTE/5G	Dish 2100 MHz	Q	2185.50000	60	5000
18	3	Dish	Generic	LTE/5G	Dish 2100 MHz	R	2102.50000	60	5000
19	4	AT&T	Generic	LTE/5G	AT&T 700 MHz	S	737.000000	60	5000
20	4	AT&T	Generic	LTE/5G	AT&T 850 MHz	T	874.500000	60	5000
21	4	AT&T	Generic	LTE/5G	AT&T 1900 MHz	U	1937.50000	60	5000
22	4	AT&T	Generic	LTE/5G	AT&T 2100 MHz	V	2125.00000	60	5000
23	4	AT&T	Generic	LTE/5G	AT&T 2100 MHz	W	2162.50000	60	5000
24	4	AT&T	Generic	LTE/5G	AT&T 2300 MHz	X	2352.50000	60	5000
25	6	AT&T	Generic	LTE/5G	AT&T 700 MHz	Y	737.000000	60	5000
26	6	AT&T	Generic	LTE/5G	AT&T 850 MHz	Z	874.500000	60	5000
27	6	AT&T	Generic	LTE/5G	AT&T 1900 MHz	AA	1937.50000	60	5000
28	6	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AB	2125.00000	60	5000
29	6	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AC	2162.50000	60	5000
30	6	AT&T	Generic	LTE/5G	AT&T 2300 MHz	AD	2352.50000	60	5000
31	8	AT&T	Generic	LTE/5G	AT&T 700 MHz	AE	737.000000	60	5000
32	8	AT&T	Generic	LTE/5G	AT&T 850 MHz	AF	874.500000	60	5000
33	8	AT&T	Generic	LTE/5G	AT&T 1900 MHz	AG	1937.50000	60	5000
34	8	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AH	2125.00000	60	5000
35	8	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AI	2162.50000	60	5000
36	8	AT&T	Generic	LTE/5G	AT&T 2300 MHz	AJ	2352.50000	60	5000
37	10	T-Mobile	Generic	LTE/5G	T-Mobile 600 MH	AK	685.500000	60	5000
38	10	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AL	731.000000	60	5000
39	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AM	1957.50000	60	5000
40	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AN	1972.50000	60	5000
41	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AO	1982.50000	60	5000
42	10	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	AP	2142.50000	60	5000
43	10	T-Mobile	Generic	LTE/5G	T-Mobile 2100 M	AQ	2137.50000	60	5000
44	11	T-Mobile	Generic	LTE/5G	T-Mobile 600 MH	AR	685.500000	60	5000
45	11	T-Mobile	Generic	LTE/5G	T-Mobile 600 MH	AS	731.000000	60	5000
46	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	AT	1957.50000	60	5000
47	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	AU	1972.50000	60	5000
48	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	AV	1982.50000	60	5000
49	11	T-Mobile	Generic	LTE/5G	T-Mobile 2100 M	AW	2142.50000	60	5000
50	11	T-Mobile	Generic	LTE/5G	T-Mobile 2100 M	AX	2137.50000	60	5000
51	12	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AY	685.500000	60	5000
52	12	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AZ	731.000000	60	5000
53	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	BA	1957.50000	60	5000
54	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	BB	1972.50000	60	5000
55	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 M	BC	1982.50000	60	5000
56	12	T-Mobile	Generic	LTE/5G	T-Mobile 2100 M	BD	2142.50000	60	5000
57	12	T-Mobile	Generic	LTE/5G	T-Mobile 2100 M	BE	2137.50000	60	5000

4.0 Receiver Frequencies

Freq #	Ant #	Provider	Model	Technology	Channel Label	ID	Frequency	Sen (dBm)	BW (KHz)
1	1	Dish	Generic	LTE/5G	Dish 600 MHz	A	634.500000	-110	5000
2	1	Dish	Generic	LTE/5G	Dish 700 MHz	B	705.000000	-110	5000
3	1	Dish	Generic	LTE/5G	Dish 850 MHz	C	831.500000	-110	5000
4	1	Dish	Generic	LTE/5G	Dish 1900 MHz	D	1907.50000	-110	5000
5	1	Dish	Generic	LTE/5G	Dish 2100 MHz	E	1785.50000	-110	5000
6	1	Dish	Generic	LTE/5G	Dish 2100 MHz	F	1702.50000	-110	5000
7	2	Dish	Generic	LTE/5G	Dish 600 MHz	G	634.500000	-110	5000
8	2	Dish	Generic	LTE/5G	Dish 700 MHz	H	705.000000	-110	5000
9	2	Dish	Generic	LTE/5G	Dish 850 MHz	I	831.500000	-110	5000
10	2	Dish	Generic	LTE/5G	Dish 1900 MHz	J	1907.50000	-110	5000
11	2	Dish	Generic	LTE/5G	Dish 2100 MHz	K	1785.50000	-110	5000
12	2	Dish	Generic	LTE/5G	Dish 2100 MHz	L	1702.50000	-110	5000
13	3	Dish	Generic	LTE/5G	Dish 600 MHz	M	634.500000	-110	5000
14	3	Dish	Generic	LTE/5G	Dish 700 MHz	N	705.000000	-110	5000
15	3	Dish	Generic	LTE/5G	Dish 850 MHz	O	831.500000	-110	5000
16	3	Dish	Generic	LTE/5G	Dish 1900 MHz	P	1907.50000	-110	5000
17	3	Dish	Generic	LTE/5G	Dish 2100 MHz	Q	1785.50000	-110	5000
18	3	Dish	Generic	LTE/5G	Dish 2100 MHz	R	1702.50000	-110	5000
19	4	AT&T	Generic	LTE/5G	AT&T 700 MHz	S	701.000000	-110	5000
20	4	AT&T	Generic	LTE/5G	AT&T 850 MHz	T	829.500000	-110	5000
21	4	AT&T	Generic	LTE/5G	AT&T 1900 MHz	U	1857.50000	-110	5000
22	4	AT&T	Generic	LTE/5G	AT&T 2100 MHz	V	1725.00000	-110	5000
23	4	AT&T	Generic	LTE/5G	AT&T 2100 MHz	W	1762.50000	-110	5000
24	4	AT&T	Generic	LTE/5G	AT&T 2300 MHz	X	2307.50000	-110	5000
25	6	AT&T	Generic	LTE/5G	AT&T 700 MHz	Y	701.00000	-110	5000
26	6	AT&T	Generic	LTE/5G	AT&T 850 MHz	Z	829.500000	-110	5000
27	6	AT&T	Generic	LTE/5G	AT&T 1900 MHz	AA	1857.50000	-110	5000
28	6	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AB	1725.00000	-110	5000
29	6	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AC	1762.50000	-110	5000
30	6	AT&T	Generic	LTE/5G	AT&T 2300 MHz	AD	2307.50000	-110	5000
31	8	AT&T	Generic	LTE/5G	AT&T 700 MHz	AE	707.000000	-110	5000
32	8	AT&T	Generic	LTE/5G	AT&T 850 MHz	AF	829.500000	-110	5000
33	8	AT&T	Generic	LTE/5G	AT&T 1900 MHz	AG	1857.50000	-110	5000
34	8	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AH	1725.00000	-110	5000
35	8	AT&T	Generic	LTE/5G	AT&T 2100 MHz	AI	1762.50000	-110	5000
36	8	AT&T	Generic	LTE/5G	AT&T 2300 MHz	AJ	2307.50000	-110	5000
37	10	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AK	639.500000	-110	5000
38	10	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AL	701.000000	-110	5000
39	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AM	1877.50000	-110	5000
40	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AN	1892.50000	-110	5000
41	10	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AO	1902.50000	-110	5000
42	10	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	AP	1742.50000	-110	5000
43	10	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	AQ	1737.50000	-110	5000
44	11	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AR	639.500000	-110	5000
45	11	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AS	701.000000	-110	5000
46	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AT	1877.50000	-110	5000
47	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AU	1892.50000	-110	5000
48	11	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	AV	1902.50000	-110	5000
49	11	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	AW	1742.50000	-110	5000
50	11	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	AX	1737.50000	-110	5000
51	12	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AY	639.500000	-110	5000
52	12	T-Mobile	Generic	LTE/5G	T-Mobile 600 MHz	AZ	701.000000	-110	5000
53	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	BA	1877.50000	-110	5000
54	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	BB	1892.50000	-110	5000
55	12	T-Mobile	Generic	LTE/5G	T-Mobile 1900 MHz	BC	1902.50000	-110	5000
56	12	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	BD	1742.50000	-110	5000
57	12	T-Mobile	Generic	LTE/5G	T-Mobile 2100 MHz	BE	1737.50000	-110	5000

5.0 Transmitter Noise Analysis

Transmitter noise interference occurs because a transmitter radiates energy on its operating frequency as well as frequencies above and below the assigned frequency. The energy that is radiated above and below the assigned frequency is known as sideband noise energy and extends for several megahertz on either side of the operating frequency. This undesired noise energy can fall within the passband of a nearby receiver even if the receiver's operating frequency is several megahertz away. The transmitter noise appears as "on-channel" noise interference and cannot be filtered out at the receiver. It is on the receiver's operating frequency and competes with the desired signal, which in effect, degrades the operational performance.

The analysis predicts each transmitter's noise signal level present at the input of each receiver. It takes into account the transmitter's noise characteristics, frequency separation, power output, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in both systems. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required, if any, to prevent receiver performance degradation caused by transmitter noise interference. The Table below depicts the results of this analysis. For each receiver, the transmitter that has the worst-case impact is displayed. The Signal Margin represents the margin in dB, before the receiver's performance is degraded. A negative number indicates that the performance is degraded and the value indicates how much additional isolation is required to prevent receiver performance degradation.

Receiver Provider	Receive Channel	Receive Frequency (MHz)	Transmitter Provider	Transmit Channel	Transmit Frequency (MHz)	Attn Required (dB)	Attn Provided (dB)	Signal Margin (dB)
None								

No transmitter noise interference problems were predicted.

6.0 Receiver Desensitization Analysis

Receiver desensitization interference occurs when an undesired signal from a nearby "off-frequency" transmitter is sufficiently close to a receiver's operating frequency. The signal may get through the RF selectivity of the receiver. If this undesired signal is of sufficient amplitude, the receiver's critical voltage and current levels are altered and the performance of the receiver is degraded at its operating frequency. The gain of the receiver is reduced, thereby reducing the performance of the receiver.

A transmitter can be operating several megahertz away from the receiver frequency and/or its antenna can be located several thousand feet from the receiver's antenna and still cause interference.

The analysis predicts each transmitter's signal level present at the input of each receiver. It takes into account the transmitter's power output, frequency separation, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in both systems. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required, if any, to prevent receiver performance degradation caused by receiver desensitization interference. The Table below depicts the results of this analysis. For each receiver, the transmitter that has the worst-case impact is displayed. The Signal Margin represents the margin in dB, before the receiver's performance is degraded. A negative number indicates that the performance is degraded and the value indicates how much additional isolation is required to prevent receiver performance degradation.

Receiver Provider	Receive Channel	Receive Frequency (MHz)	Transmitter Provider	Transmit Channel	Transmit Frequency (MHz)	Attn Required (dB)	Attn Provided (dB)	Signal Margin (dB)
None								

No receiver desensitization interference problems were predicted.

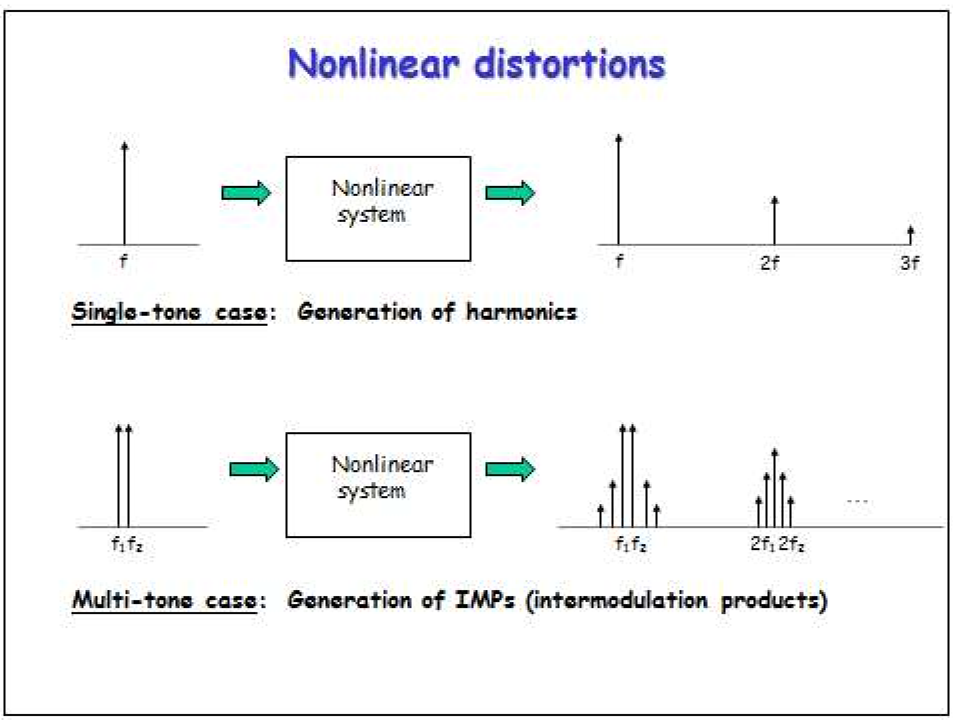
7.0 Intermodulation Interference Analysis

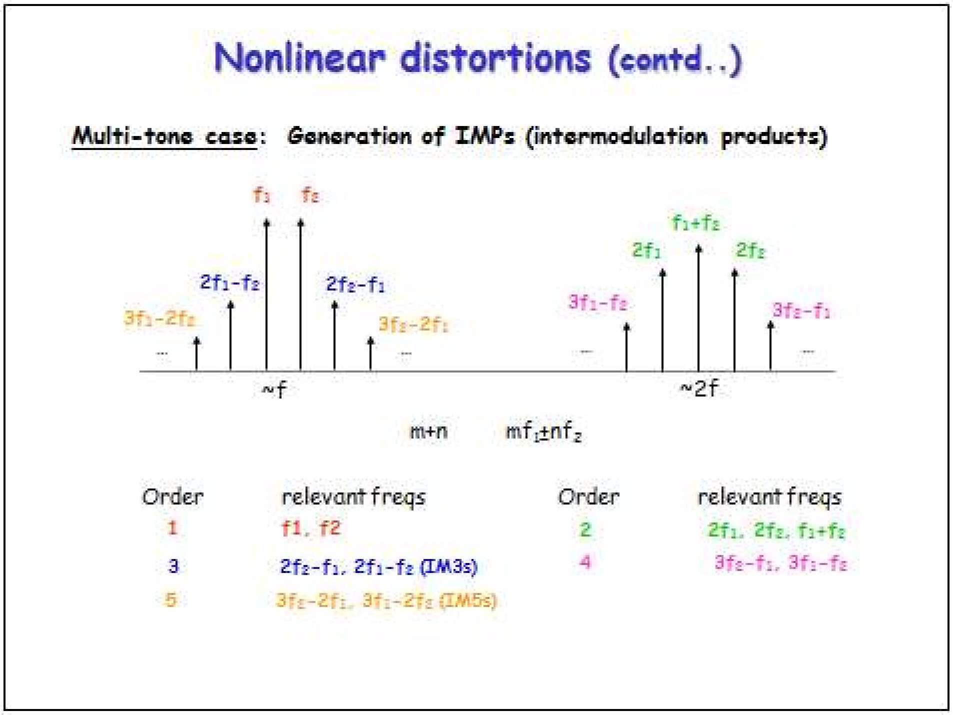
There are three basic categories of Intermodulation (IM) interference. They are receiver produced, transmitter produced, and "other" radiated IM. Transmitter produced IM is the result of one or more transmitters impressing a signal in the non-linear final output stage circuitry of another transmitter, usually via antenna coupling. The IM product frequency is then re-radiated from the transmitter's antenna. Receiver produced IM is the result of two or more transmitter signals mixing in a receiver RF amplifier or mixer stage when operating in a non-linear range.

"Other" radiated IM is the result of transmitter signals mixing in other non-linear junctions. These junctions are usually metallic, such as rusty bolts on a tower, dissimilar metallic junctions, or other non-linear metallic junctions in the area. IM products can also be caused by non-linearity in the transmission system such as antenna, transmission line, or connectors.

Communication sites with co-located transmitters, usually have RF coupling between each transmitter and antenna system. This results in the signals of each transmitter entering the nonlinear final output (PA) circuitry of the other transmitters. When intermodulation (IM) products are created in the output circuitry and they fall within the passband of the final amplifier, the IM products are re-radiated and may interfere with receivers at the same site or at other nearby sites. Additionally, these strong transmitter signals may directly enter a receiver and drive the RF amplifier into a nonlinear operation, or if not filtered effectively by the receiver input circuitry, these signals could mix in the nonlinear circuitry of the receiver front-end or mixer, creating IM products directly in the receiver.

The frequencies of IM mixing are known as nonlinear distortions. The images below depict how these IM products are derived when passing through a nonlinear junction/system.





Not all of the mixing possibilities are significant in creating interference signals. Some fall "out-of-band" of the receiver and the higher order IM products are usually weaker in signal strength.

7.1 Transmitter Generated Intermodulation Analysis

Intermodulation in transmitters occurs when a signal from another transmitter is impressed on the nonlinear final output stage circuitry, usually via antenna coupling. The power level of the IM product is determined by the power level of the incoming extraneous signal from another transmitter and by a conversion loss factor. The conversion loss factor takes into account the mixing efficiency of the transmitter's final output stage. Conversion loss differs with transmitter design, adjustment, frequency separation of the source signals, and with the order of the IM product.

The analysis calculates all possible IM product frequencies that could potentially interfere with receivers at the communications site based on each receiver's individual bandwidth. It then predicts each IM signal level present at the input of each affected receiver. For each IM frequency, the analysis considers all possible sources of IM generation in the transmitters. For example, if there are four transmitters involve, the analysis will calculate the IM signal level that would be generated in each transmitter. For this example, that would be four possible mixing conditions.

The analysis takes into account the transmitter's power output, modulation bandwidth, conversion losses, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in each system. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required to prevent receiver performance degradation for each IM interference signal that occurs. Receivers experiencing transmitter generated intermodulation interference are depicted in the following Table.

Tx 1 Source Mix Tx		Tx 2 Source		TX 3 Source		Tx 4 Source		Tx 5 Source		Intermod Hit		Affected Receiver		Attn Need
ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	Freq (MHz)	Ord	ID	Freq (MHz)	
None														

No transmitter generated intermodulation interference problems were predicted.

7.2 Receiver Generated Intermodulation Analysis

Within a receiver, when two or more strong off-channel signals enter and mix in the receiver and one of the IM product frequencies created coincides with the receiver operating frequency, potential interference results. This internal IM mixing process takes place in the receiver's RF amplifier when it operates in a nonlinear range and/or in the first mixer, which, of course, has been designed to operate as a nonlinear device.

Receivers have a similar conversion loss type factor and receiver performance is commonly described in terms of conversion loss with respect to the 2A - B type products. Here, conversion loss is the ratio of a specified level of A and B to the level of the resulting IM product, when the product is viewed as an equivalent on-channel signal. Receiver conversion loss varies with input levels, AGC action, and product order.

The analysis calculates all possible IM product frequencies that could potentially interfere with receivers at the communications site based on each receiver’s individual bandwidth. It then predicts each IM signal level present at the input of each affected receiver. For each IM frequency, the analysis considers that the IM signal is generated directly in the receiver.

The analysis takes into account the transmitter’s power output, modulation bandwidth, conversion losses, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in each system. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required to prevent receiver performance degradation for each IM interference signal that occurs. Receivers experiencing receiver generated intermodulation interference are depicted in the following Table.

Tx 1 Source		Tx 2 Source		TX 3 Source		Tx 4 Source		Tx 5 Source		Intermod Hit		Affected Receiver		Attn Need
ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	ID	Freq (MHz)	Freq (MHz)	Ord	ID	Freq (MHz)	
None														

No receiver generated intermodulation interference problems were predicted.

8.0 Transmitter Harmonic Output Interference Analysis

Transmitter harmonic interference is due to non-linear characteristics in a transmitter. The harmonics are typically created due to frequency multiplers and the non-linear design of the final output stage of the transmitter. If the harmonic signal falls within the passband of a nearby receiver and the signal level is of sufficient amplitude, it can degrade the performance of the receiver.

The analysis takes into account the transmitter's harmonic characteristics, output level, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in each system. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required to prevent receiver performance degradation for any harmonics that fall within a receiver's passband. Receivers experiencing transmitter harmonic interference are depicted in the following Table.

Transmitter		Harmonic		Affected Receiver		Attn Needed
ID	Frequency (MHz)	Frequency (MHz)	Order	ID	Frequency (MHz)	
None						

No transmitter generated harmonic interference problems were predicted.

9.0 Transmitter Spurious Output Interference Analysis

Transmitter spurious output interference can be attributed to many different factors in a transmitter. The generation of spurious frequencies could be due to non-linear characteristics in a transmitter or possibly the physical placement of components and unwanted coupling. If a spurious signal falls within the passband of a nearby receiver and the signal level is of sufficient amplitude, it can degrade the performance of the receiver.

The analysis takes into account a transmitter's spurious output specification, output levels, transmission line losses, filters, duplexers, combiners, isolators, multi-couplers and other RF devices that are present in each system. Additionally, the analysis considers the antenna separation space loss, horizontal and vertical gain components of the antennas as well as how they are mounted on the structure. The gain components are derived from antenna pattern data published by each manufacturer.

The analysis determines how much isolation is required to prevent receiver performance degradation for any transmitter spurious signals that fall within a receiver's passband. Receivers experiencing transmitter spurious output interference are depicted in the following Table.

Transmitter		Affected Receiver		Attn Needed
ID	Frequency (MHz)	ID	Frequency (MHz)	
None				

No transmitter generated spurious interference problems were predicted.

10.0 Interference Power Level Summing Analysis

This section of the report provides a simulation of Intermodulation (IM) interference, transmitter wideband noise and receiver desensitization interference occurring on each individual receiver when all transmitters at the site are active at the same instance in time. Even though individual interference modes may not be reported in other report sections, this summing analysis represents a worst-case interference scenario.

However, the probability of this interference occurrence for an individual receiver could be low since it depends on the utilization of the transmitters involved in the interference generation.

The carrier-to-noise C/(I + N) ratio for each receiver is based on the aggregate of interference power levels. A negative C/(I + N) ratio indicates that the performance of the receiver could possibly be degraded by the value shown.

The following Table presents this data:

Receiver		Interference Power Level (dBw)				
Channel Label	Freq (MHz)	Tx Noise	Rx Desense	IM Power	Aggregate	C / (I+N)
None						

11.0 Interference Determination Analysis Discussion

Interference **is not predicted** as a result of the proposed system deployment(s). The information used to model the systems contain in this report were provided by the requestor. Best practice engineering assumptions were used for operators considered in this analysis in instances whereas exact operational parameters were not available.

12.0 Preparer Certification

I, Tim Harris, preparer of this report, certify that I am fully trained and aware of the rules and regulations of the Federal Communications Commission (FCC) and of telecommunications engineering principles regarding intermodulation and interference. In addition, I have been trained in the use of the WS-RFI modeling software used to perform the interference analysis for the proposed deployment at this site.

I certify that the information contained in this report is true and correct to the best of my knowledge.

Timothy A. Harris *11/7/2022*

Signature Date