Exhibit C
Radiation Hazard Analysis

Introduction

This exhibit constitutes the Radiation Hazard Analysis for Row 44's transmitter considering the FCC procedure outlined in FCC Bulletin #65. The limit for exposure to RF energy, (frequencies greater than 1.5 GHz), is 5 mW/cm^2 up to a 6 minute duration (categorized as Occupational / 'Controlled Exposure'), and 1 mW/cm^2 up to a 30 minute duration (categorized as General Population / 'Uncontrolled Exposure').[1]

Analysis regarding radiation exposure is presented considering behavior in the Near Field, Far Field and Transition 'regions'. Appropriate separation-distances are provided for the 'Controlled' and 'Uncontrolled Exposure' scenarios, considering individuals located in the direction of either the antenna's main beam or its side-lobes.

Analysis

The extent of the Near Field region in the main beam is defined as distances out to a radius R_{nf} according to the relation

$$R_{nf} = D^2/4\lambda$$

where D is the antenna panel width and λ is the transmit wavelength.

The Near Field maximum Power Density, S_{nf}, is determined from

$$S_{nf} = 0.1\eta\, P_{PA}/A \text{ (in mW/cm}^2\text{)}$$

where P_{PA} is the transmit power (after cable losses), A is the surface area of the antenna aperture, and η the efficiency of the antenna aperture. (With an antenna height h, the surface area A = Dh.)

The Far Field region for the main beam is defined as beginning and continuing out-from a radius R_{ff}, given by

$$R_{ff} = 0.60\, D^2/\lambda$$

[1] "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields," Federal Communications Commission, Office of Engineering and Technology, Bulletin 65, Fourth Edition, August, 1999, p.15. http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf

The Far Field Power Density S_{ff} at the Far Field radius and farther is determined (in terms of the EIRP, denoted by P_{EIRP}) from

$$S_{ff} = P_{EIRP}/4\pi R_{ff}^2 \text{ (in mW/cm}^2\text{)}$$

(The value of P_{EIRP} should already consider coax losses and aperture efficiency.)

Note that when the radius is expressed in meters, the Power Density is in units of W/m^2. The results are converted to units consistent with the FCC limits (mW/cm^2) by multiplying values in W/m^2 by 0.1.

Exposure from the Main Antenna Beam

Row 44's antenna has dimensions D = 0.625 m (24.6"), h = 0.157 m (6.2"), and a surface area A = $0.098m^2$. At the highest transmit frequency of 14.5 GHz, the wavelength is 0.0207 m. The Near Field radius is then

R_{nf} = 4.72 m

The antenna aperture efficiency factor is 0.93 and the feeder coax loss is 4.58 dB.

Based on the wavelength and panel-width given farther above, the Far Field radius is then

R_{ff} = 11.33 m

In the operation of Row 44's system, the antenna may be fed with ten different signal levels, as provided in Tables 1 and 2. The associated Near Field radius Power Density values are:

Table 1 Transmit Power and Near Field Power Density at Distance Rnf

Transmit power (dBm)	EIRP (dBW)	S_{nf} (mW/cm^2)
45.0	43.8	10.4
44.5	43.3	9.30
43.2	42.0	6.90
43.0	41.8	6.59
42.5	41.3	5.87
42.0	40.8	5.23
41.5	40.3	4.66
40.5	39.3	3.70
40.2	39.0	3.46
40.0	38.8	3.30
39.0	37.8	2.62
37.5	36.3	1.86
37.2	36.0	1.73
34.5	33.3	.930

(Note that the equation for the maximum Power Density in the Near Field considers a given radiated signal/ power confined-to and passing-through a physical area corresponding to that of the antenna aperture. Along these lines, the Snf values cannot be assumed to vary with distance from the antenna, for locations within the Near Field.)

The associated Far Field radius Power Density values are as well:

Table 2 Transmit Power, EIRP and Far Field Power Density at Distance Rff

Transmit power (dBm)	EIRP (dBW)	S_{ff} (mW/cm^2)
45.0	43.8	1.49
44.5	43.3	1.33
43.2	42.0	.983
43.0	41.8	.939
42.5	41.3	.837
42.0	40.8	.746
41.5	40.3	.664
40.5	39.3	.528
40.2	39.0	.493
40.0	38.8	.470
39.0	37.8	.374
37.5	36.3	.265
37.2	36.0	.247
34.5	33.3	.133

We are considering exposure to two values of Power Density: 5 mW/cm^2 and 1 mW/cm^2.

<u>5 mW/cm^2 Analysis</u>

Some of the Snf values in Table 1 are greater than 5 mW/cm^2, and some are less than 5 mW/cm^2. As the Near Field analysis assumes that the Power Density in the Near Field does not vary with distance, for cases where Snf exceeds 5 mW/cm^2, there is no location in the Near Field where the Power Density is less. An individual therefore cannot be located in the Near Field anywhere whatsoever at all to avoid such an exposure level. We'll defer this analysis to the 'Transition Region' between the Near and Far Fields:

Assuming that the Power Density decreases linearly between the Near Field radius and the Far Field radius, the distance at which the Power Density will equal 5 mW/cm^2 (for the selected TX powers) is given in Table 3.

Table 3 Separation for 'Controlled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Controlled' Limit (5 mW/cm^2)	
	meters	feet
45.0	8.74	28.7
44.5	8.29	27.2

43.2	6.84	22.4
43.0	6.58	21.6
42.5	5.86	19.2
42.0	5.06	16.6

Somewhat similar to the above, applicable to cases where Snf is less than 5 mW/cm^2, in attempting to determine the location at which the Power Density may equal 5 mW/cm^2, we cannot project a location closer than Rnf.

For such cases in the Near Field, we shall adopt a precautionary stance, and will assign (Table 4) the Near Field radius of 4.72 meters (15.5 feet) as the minimum physical separation to facilitate an exposure no greater than 5 mW/cm^2.

Table 4 Separation for 'Controlled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Controlled' Limit (5 mW/cm^2)	
	meters	feet
41.5	4.72	15.5
40.5	4.72	15.5
40.2	4.72	15.5
40.0	4.72	15.5
39.0	4.72	15.5
37.5	4.72	15.5
37.2	4.72	15.5
34.5	4.72	15.5

1 mW/cm^2 Analysis

As the Snf values are each greater than 1 mW/cm^2, we need consider distances greater than Rnf where the 1 mW/cm^2 will be encountered:

The EIRP and the resulting Far Field Power Density at distance Rff are once again provided in Table 5 for each transmit power value:

Table 5 Transmit Power, EIRP and Far Field Power Density at Distance Rff

Transmit power (dBm)	EIRP (dBW)	S_{ff} (mW/cm^2)
45.0	43.8	1.49
44.5	43.3	1.33
43.2	42.0	.983
43.0	41.8	.939
42.5	41.3	.837
42.0	40.8	.746
41.5	40.3	.664
40.5	39.3	.528

40.2	39.0	.493
40.0	38.8	.470
39.0	37.8	.374
37.5	36.3	.265
37.2	36.0	.247
34.5	33.3	.133

Some Sff values exceed 1 mW/cm^2, and some do not.

For the TX levels where Sff is greater than 1 mW/cm^2, we'll use standard 'inverse-squared' analysis to identify the necessary separations listed in Table 6:

Table 6 Separation for 'Uncontrolled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Uncontrolled' Limit of 1 mW/cm^2 (m)	Separation for 'Uncontrolled' Limit of 1 mW/cm^2 (feet)
45.0	13.8	45.3
44.5	13.0	42.7

For the remaining TX levels, we need interpolate the Power Density values between Rnf and Rff to project the location at which 1 mW/cm^2 exists.

Assuming that the Power Density decreases linearly between the Near Field radius and the Far Field radius, the distances at which the Power Density equals 1 mW/cm^2 are projected according to Table 7.

Table 7 Separation for 'Uncontrolled Exposure' Limit (Main Beam)

Transmit power (dBm)	Separation for 'Uncontrolled' Limit (1 mW/cm^2)	
	meters	feet
43.2	11.3	37.1
43.0	11.3	37.1
42.5	11.1	36.5
42.0	11.0	35.9
41.5	10.8	35.4
40.5	10.3	33.9
40.2	10.2	33.5
40	10.1	33.1
39	9.49	31.1
37.5	8.28	27.2
37.2	7.98	26.2
34.5	4.14	13.6

Exposure from Antenna Beam Side-Lobes

The previous calculations assumed the individual was located in the 'sight' of the main antenna beam. (The main antenna beam is less than 10 degrees-wide in azimuth.) The following analysis provides insight into the exposure when an individual is located to-the-side or behind the antenna.

Table 8 provides Power Density values at distances R_{nf} and R_{ff} when an individual is located in the direction of the highest antenna side-lobe (which corresponds to a 12 dB gain reduction from the main beam).

Table 8 TX Power, Sidelobe Attenuation, and Power Density at Rnf and Rff

Tx power (dBm)	Sidelobe (dB)	S_{nf} (mW/cm^2)	S_{ff} (mW/cm^2)
45.0	-12	0.659	0.0939
44.5	-12	0.587	0.0837
43.2	-12	0.435	0.0620
43.0	-12	0.416	0.0592
42.5	-12	0.370	0.0528
42.0	-12	0.330	0.0470
41.5	-12	0.294	0.0419
40.5	-12	0.234	0.0333
40.2	-12	0.218	0.0311
40.0	-12	0.208	0.0297
39.0	-12	0.165	0.0236
37.5	-12	0.117	0.0167
37.2	-12	0.109	0.0156
34.5	-12	0.0587	0.00837

As is obvious, neither the Snf or Sff values (at distances Rnf and Rff) exceed even the 'Uncontrolled' Limit of 1 mW/cm^2. Therefore, no minimum distance of separation will apply for individuals located in directions outside the antenna's main beam.

Summary

This document presents the radiation hazard analysis for Row 44's transmitter transmitting at EIRP values of 43.8, 43.3, 42.0, 41.8, 41.3, 40.8, 40.3, 39.3, 39.0, 38.8, 37.8, 36.3, 36.0, or 33.3 dBW. Considering the worst-case, individuals positioned in the direction of the main beam of the antenna, and in a 'Controlled Exposure' environment should be at least 8.74 meters (28.7 feet) away from the antenna aperture (for a 6 minute duration). Under the same circumstances, individuals in a 'Uncontrolled Exposure' environment should be at least 13.8 meters (45.3 feet) away from the antenna aperture (for a 30 minute duration).

For individuals located in directions which are outside the antenna's main beam, no minimum distance of separation is applicable.