Spire Global, Inc.
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March 5, 2020

VIA IBFS AND EMAIL

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Spire Global Inc. - Earth Station License Modification Application Supplement
IBFS File Nos:
SES-MFS-20191111-01421 (Call Sign E160032); SES-MFS-20191111-01429 (Call Sign E160033); SES-MFS-20191111-01422 (Call Sign E160037); SES-MFS-20191111-01423 (Call Sign E160038); SES-MFS-20191111-01424 (Call Sign E160039); SES-MFS-20191111-01425 (Call Sign E160041); SES-MFS-20191111-01431 (Call Sign E160043); SES-MFS-20191127-01545 (Call Sign E160044); SES-MFS-20191111-01426 (Call Sign E170148); SES-MFS-20191111-01427 (Call Sign E170149); SES-MFS-20191111-01428 (Call Sign E170150); SES-MFS-20191111-01430 (Call Sign E170171)

Dear Ms. Dortch:

Spire Global, Inc. ("Spire") clarifies in the attached appendices the number and type of antennas at each earth station, total input power, EIRP values, and associated Exhibit B - Radiation Hazard Report(s).

Spire appreciates the Commission expeditiously processing these applications. Please contact the undersigned if you have any questions regarding this letter.

Respectfully submitted,

/s/ Francisca Adeuyi
Francisca Adeuyi
Spectrum Manager
francisca.adeuyi@spire.com

cc: (via email)
Trang Nguyen

Appendix 1

File Number	Call Sign	Site ID	Response to Question in Form 312 Schedule B										Radiation Hazard Report Reference in This Document
			E28. Antenna ID	E30. Manufacturer	E32. Antenna Size	E38. Total Input Power at antenna flange (Watts)	E40. Total EIRP for all carriers (dBW)	E41/42. Antenna Gain Transmit and/or Recieve(_dBi at _GHz)	E45. T/R Mode	E48. Maximum EIRP per Carrier (dBW)	E49. Maximum ERIP Density per Carrier (dBW/4kHz)	E60. Maximum EIRP Density toward the Horizon (dBW/4kHz)	
SES-MFS-20191111-01421	E160032	BDLGS	UHF-1	Kathrein	0.74	70	26.95	8.5 at 0.4025	T	26.95	21.21	21.21	Appendix 4
SES-MFS-20191111-01429	E160033	WBUGS	UHF-1	Innov	1.85	70	31.45	13 at 0.402.5	T	31.45	25.71	25.71	Appendix 2
			UHF-2	Innov	1.85	70	31.45	13 at 0.402.5	T	31.45	25.71	25.71	Appendix 2
SES-MFS-20191111-01422	E160037	ITOGS	UHF-1	Taco	2.46	70	31.85	13.4 at 0.450	T	31.85	26.11	26.11	Appendix 3
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01423	E160038	GUMGS	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01424	E160039	SEAGS	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01425	E160041	DALGS	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01431	E160043	SFOGS	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191127-01545	E160044	STXGS	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01426	E170148	JNUGS2	UHF-1	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
			UHF-2	Innov	1.85	70	31.45	13 at 0.402.5	T	31.45	25.71	25.71	Appendix 2
SES-MFS-20191111-01427	E170149	TUSGS	UHF-1	Innov	1.85	70	31.45	13 at 0.402.5	T	31.45	25.71	25.71	Appendix 2
			UHF-2	Innov	1.85	70	31.45	13 at 0.402.5	T	31.45	25.71	25.71	Appendix 2
SES-MFS-20191111-01428	E170150	DLHGS	UHF-1	Taco	2.46	70	31.85	13.4 at 0.450	T	31.85	26.11	26.11	Appendix 3
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5
SES-MFS-20191111-01430	E170171	CLTGS	UHF-1	Taco	2.46	70	31.85	13.4 at 0.450	T	31.85	26.11	26.11	Appendix 3
			UHF-2	M2	1.85	70	29.95	11.5 at 0.4025	T	29.95	24.21	24.21	Appendix 5

Appendix 2

Analysis of Non-Ionizing Radiation for a 1.85-Meter (Innov) Earth Station System

This report analyzes the non-ionizing radiation levels for a 1.85-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the Federal Communications Commission ("FCC") Office of Engineering and Technology Bulletin No. 65 ("Bulletin No. 65"), which was first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC Report and Order ("R&O") 96-326. Bulletin No. 65 and the FCC R&O (collectively "FCC RF Guidelines") specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure.

The Maximum Permissible Exposure ("MPE") limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	1.85	m
Ant Equiv Surface Area	$A_{surface}$	7 elements	1.4#	m^2
Frequency	F	Input	402.5	MHz
Wavelength	λ	300 / F	0.7453	m
Transmit Power	P	Input	70	w
Antenna Gain (dBi)	G_{es}	Input	13	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	19.95	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G*\lambda^2/(4*\pi)/A_{surface}$	0.63	N/A

For a Yagi Antenna with 7 elements the surface area of each element is estimated to be 0.2 m^2. Total surface area is 1.4 m^2.

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region	$R_{ff} = 0.60\ D^2 / \lambda$ $= 2.76$ m	(1)

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field	$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ $= 14.64$ W/m^2 $= 1.464$ mW/cm^2	(2)

2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field	$R_{nf} = D^2 / (4\ \lambda)$ $= 1.148$	(3)

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density	$S_{nf} = 4^*\ \eta^*\ P / A_{surface}$ $= 126.01$ W/m^2 $= 12.601$ mW/cm^2	(4)

3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 2 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_{tz} can be determined from the following equation:

Transition Region Power Density	$R_{tz} = S_{nf} * R_{nf} / R$ $= 74.12\ W/m^2$ $= 7.412\ mW/cm^2$	(5)

R above is given at a halfway point (1.952m) between the edge of the near field, and the beginning of the far field, but can be any value between R_{nf} and R_{ff}.

4. Region between the Antenna and the Ground

Assuming uniform illumination of the antenna surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Antenna and Ground	$S_g = P / A_{surface}$ $= 50.00\ W/m^2$ $= 5.00\ mW/cm^2$	(6)

5. Summary of Calculations

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 2.76m)	S_{ff}	1.464	Potential Hazard
Near Field (R_{nf}=1.148m)	S_{nf}	12.601	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	7.412	Potential Hazard
Between Antenna and Ground	S_g	5.00	Potential Hazard

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 2.76m)	S_{ff}	1.464	Potential Hazard
Near Field (R_{nf} tra=1.148m)	S_{nf}	12.601	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	7.412	Potential Hazard
Between Antenna and Ground	S_g	5.00	Potential Hazard

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in all fields of the Uncontrolled (Table 4) environments. In the Controlled (Table 5) environments, all regions exceed the FCC RF Guidelines. The applicant proposes to comply with the MPE limits of 0.27 mW/cm^2 for the Uncontrolled Areas and the MPE limits of 1.34 mW/cm^2 for the Controlled Areas.

The earth station **Yagi** antenna will be mounted on a platform, so the applicant agrees that the antenna is in an area secured from the public and worker personnel not familiar with the earth station system. Non-assigned worker personnel and the general public must be accompanied by knowledgeable earth station personnel when they enter the earth station secured area.

The earth station's secured area will be marked with the required radiation hazard signs as described in the recent FCC R&O 13-39. The area in the vicinity of the earth station secured area will also have signs to inform those in the general population and those who may be working in the area or otherwise present that they are close to a RF System capable of producing hazardous levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

Appendix 3

Analysis of Non-Ionizing Radiation for a 2.46-Meter (Taco) Earth Station System

This report analyzes the non-ionizing radiation levels for a 2.46-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the Federal Communications Commission ("FCC") Office of Engineering and Technology Bulletin No. 65 ("Bulletin No. 65"), which was first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC Report and Order ("R&O") 96-326. Bulletin No. 65 and the FCC R&O (collectively "FCC RF Guidelines") specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure.

The Maximum Permissible Exposure ("MPE") limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	2.46	m
Ant Equiv Surface Area	$A_{surface}$	Input	1.06	m^2
Frequency	F	Input	450	MHz
Wavelength	λ	300 / F	0.667	m
Transmit Power	P	Input	70	W
Antenna Gain (dBi)	G_{es}	Input	13.4	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	21.88	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G*\lambda^2/(4*\pi)/A_{surface}$	0.73	N/A

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region	$R_{ff} = 0.60\ D^2 / \lambda$ = 5.45 m	(1)

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field	$S_{ff} = G\ P\ /\ (4\ \pi\ R_{ff}^2)$ = 4.11 W/m^2 = 0.411 mW/cm^2	(2)

2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field	$R_{nf} = D^2\ /\ (4\ \lambda)$ = 2.269	(3)

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density	$S_{nf} = 4^*\ \eta^*\ P\ /\ A_{surface}$ = 192.82 W/m^2 = 19.282 mW/cm^2	(4)

3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 2 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_{tz} can be determined from the following equation:

Transition Region Power Density	$R_{tz} = S_{nf} * R_{nf} / R$ $= 113.42\ W/m^2$ $= 11.342\ mW/cm^2$	(5)

R above is given at a halfway point (3.858m) between the edge of the near field, and the beginning of the far field, but can be any value between R_{nf} and R_{ff}.

4. Region between the Antenna and the Ground

Assuming uniform illumination of the antenna surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Antenna and Ground	$S_g = P / A_{surface}$ $= 66.04\ W/m^2$ $= 6.604\ mW/cm^2$	(6)

5. Summary of Calculations

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 5.45m)	S_{ff}	0.411	Potential Hazard
Near Field (R_{nf}=2.269m)	S_{nf}	19.282	Potential Hazard
Transition Region (R_{nf}<R_t<R_{ff})	S_t	11.342	Potential Hazard
Between Antenna and Ground	S_g	6.60	Potential Hazard

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 5.45m)	S_{ff}	0.411	Satisfies FCC MPE
Near Field (R_{nf}=2.269m)	S_{nf}	19.282	Potential Hazard
Transition Region (R_{nf}<R_t<R_{ff})	S_t	11.342	Potential Hazard
Between Antenna and Ground	S_g	6.60	Potential Hazard

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in all fields of the Uncontrolled (Table 4) environment. In the Controlled (Table 5) environments, all regions besides the Far Field exceed the FCC RF Guidelines. The applicant proposes to comply with the MPE limits of 0.3 mW/ cm^2 for the Uncontrolled Areas and the MPE limits of 1.5 mW/cm^2 for the Controlled Areas.

The earth station **Helical** antenna will be mounted on a platform, so the applicant agrees that the antenna is in an area secured from the public and worker personnel not familiar with the earth station system. Non-assigned worker personnel and the general public must be accompanied by knowledgeable earth station personnel when they enter the earth station secured area.

The earth station's secured area will be marked with the required radiation hazard signs as described in the recent FCC R&O 13-39. The area in the vicinity of the earth station secured area will also have signs to inform those in the general population and those who may be working in the area or otherwise present that they are close to a RF System capable of producing hazardous levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

Appendix 4

Analysis of Non-Ionizing Radiation for a 0.74-Meter (Kathrein) Earth Station System

This report analyzes the non-ionizing radiation levels for a 0.74-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the Federal Communications Commission ("FCC") Office of Engineering and Technology Bulletin No. 65 ("Bulletin No. 65"), which was first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC Report and Order ("R&O") 96-326. Bulletin No. 65 and the FCC R&O (collectively "FCC RF Guidelines") specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure.

The Maximum Permissible Exposure ("MPE") limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	0.74	m
Ant Equiv Surface Area	$A_{surface}$	10 elements	2.0#	m^2
Frequency	F	Input	402.5	MHz
Wavelength	λ	300 / F	0.7453	m
Transmit Power	P	Input	70.00	w
Antenna Gain (dBi)	G_{es}	Input	8.5	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	7.08	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G*\lambda^2/(4*\pi)/A_{surface}$	0.1565	N/A

For a Log Periodic Antenna with 10 elements the surface area of each element is estimated to be 0.2 m^2. Total surface area is 2.0 m^2.

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region	$R_{ff} = 0.60\ D^2 / \lambda$ = 0.44 m	(1)

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field	$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ = 202.94 W/m^2 = 20.294 mW/cm^2	(2)

2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field	$R_{nf} = D^2 / (4\ \lambda)$ = 0.184	(3)

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density	$S_{nf} = 4 * \eta * P / A_{surface}$ = 21.91 W/m^2 = 2.191 mW/cm^2	(4)

3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 2 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance S_t can be determined from the following equation:

Transition Region Power Density	$S_t = S_{nf} * R_{nf} / R$ = 12.89 W/m^2 = 1.289 mW/cm^2	(5)

R above is given at a halfway point (0.312m) between the edge of the near field, and the beginning of the far field, but can be any value between R_{nf} and R_{ff}.

4. Region between the Antenna and the Ground

Assuming uniform illumination of the antenna surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Antenna and Ground	$S_g = P / A_{surface}$ = 35 W/m^2 = 3.5 mW/cm^2	(6)

5. Summary of Calculations

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 0.44m)	S_{ff}	20.294	Potential Hazard
Near Field (R_{nf}=0.184m)	S_{nf}	2.191	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	1.289	Potential Hazard
Between Antenna and Ground	S_g	3.5	Potential Hazard

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Region	Calculated Maximum Radiation Power Density Level (mW/cm^2)		Hazard Assessment
Far Field (R_{ff} = 0.44m)	S_{ff}	20.294	Potential Hazard
Near Field (R_{nf}=0.184m)	S_{nf}	2.191	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	1.289	Satisfies FCC MPE
Between Antenna and Ground	S_g	3.5	Potential Hazard

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in all fields of the Uncontrolled (Table 4) environments and in all fields except the Transition Region of the Controlled (Table 5) environments. The applicant proposes to comply with the MPE limits of 0.27 mW/cm^2 for the Uncontrolled Areas and the MPE limits of 1.34 mW/cm^2 for the Controlled Areas.

The earth station **Log Periodic** antenna will be mounted on a dedicated pedestal, so the applicant agrees that the antenna is in an area secured from the public and worker personnel not familiar with the earth station system. Non-assigned worker personnel and the general public must be accompanied by knowledgeable earth station personnel when they enter the earth station secured area.

The earth station's secured area will be marked with the required radiation hazard signs as described in the recent FCC R&O 13-39. The area in the vicinity of the earth station secured area will also have signs to inform those in the general population and those who may be working in the area or otherwise present that they are close to a RF system capable of producing hazardous levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

Appendix 5

Analysis of Non-Ionizing Radiation for a 1.85-Meter (M2) Earth Station System

This report analyzes the non-ionizing radiation levels for a 1.85-meter earth station system. The analysis and calculations performed in this report comply with the methods described in the Federal Communications Commission ("FCC") Office of Engineering and Technology Bulletin No. 65 ("Bulletin No. 65"), which was first published in 1985 and revised in 1997 in Edition 97-01. The radiation safety limits used in the analysis are in conformance with the FCC Report and Order ("R&O") 96-326. Bulletin No. 65 and the FCC R&O (collectively "FCC RF Guidelines") specifies that there are two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to the exposure.

The Maximum Permissible Exposure ("MPE") limits for persons in a General Population/Uncontrolled environment are shown in Table 1. The General Population/Uncontrolled MPE is a function of transmit frequency and is for an exposure period of thirty minutes or less. The MPE limits for persons in an Occupational/Controlled environment are shown in Table 2. The Occupational MPE is a function of transmit frequency and is for an exposure period of six minutes or less. The purpose of the analysis described in this report is to determine the power flux density levels of the earth station in the far-field, near-field, transition region, and between the antenna edge and the ground and to compare these levels to the specified MPEs.

Table 1. Limits for General Population/Uncontrolled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	0.2
300-1500	Frequency (MHz)*(0.8/1200)
1500-100,000	1.0

Table 2. Limits for Occupational/Controlled Exposure (MPE)

Frequency Range (MHz)	Power Density (mW/cm^2)
30-300	1.0
300-1500	Frequency (MHz)*(4.0/1200)
1500-100,000	5.0

Table 3. Formulas and Parameters Used for Determining Power Flux Densities

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	1.85	m
Ant Equiv Surface Area	$A_{surface}$	7 elements	1.4#	m^2
Frequency	F	Input	402.5	MHz
Wavelength	λ	300 / F	0.7453	m
Transmit Power	P	Input	70.00	w
Antenna Gain (dBi)	G_{es}	Input	11.5	dBi
Antenna Gain (factor)	G	$10^{Ges/10}$	14.13	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G*\lambda^2/(4*\pi)/A_{surface}$	0.4460	N/A

For a Yagi Antenna with 7 elements the surface area of each element is estimated to be 0.2 m^2. Total surface area is 1.4 m^2.

1. Far Field Distance Calculation

The distance to the beginning of the far field can be determined from the following equation:

Distance to the Far Field Region	$R_{ff} = 0.60\ D^2 / \lambda$ $= 2.76$ m	(1)

The maximum main beam power density in the far field can be determined from the following equation:

On-Axis Power Density in the Far Field	$S_{ff} = G\ P / (4\ \pi\ R_{ff}^2)$ $= 10.37\ W/m^2$ $= 1.037\ mW/cm^2$	(2)

2. Near Field Calculation

Power flux density is considered to be at a maximum value throughout the entire length of the defined Near Field region. The region is contained within a cylindrical volume having the same diameter as the antenna. Past the boundary of the Near Field region, the power density from the antenna decreases linearly with respect to increasing distance.

The distance to the end of the Near Field can be determined from the following equation:

Extent of the Near Field	$R_{nf} = D^2 / (4\ \lambda)$ $= 1.148$	(3)

The maximum power density in the Near Field can be determined from the following equation:

Near Field Power Density	$S_{nf} = 4 * \eta * P / A_{surface}$ $= 89.21\ W/m^2$ $= 8.921\ mW/cm^2$	(4)

3. Transition Region Calculation

The Transition region is located between the Near and Far Field regions. The power density begins to decrease linearly with increasing distance in the Transition region. While the power density decreases inversely with distance in the Transition region, the power density decreases inversely with the square of the distance in the Far Field region. The maximum power density in the Transition region will not exceed that calculated for the Near Field region. The power density calculated in Section 2 is the highest power density the antenna can produce in any of the regions away from the antenna. The power density at a distance R_{tz} can be determined from the following equation:

Transition Region Power Density	$R_{tz} = S_{nf} * R_{nf} / R$ $= 52.48\ W/m^2$ $= 5.248\ mW/cm^2$	(5)

R above is given at a halfway point (1.952m) between the edge of the near field, and the beginning of the far field, but can be any value between R_{nf} and R_{ff}.

4. Region between the Antenna and the Ground

Assuming uniform illumination of the antenna surface, the power density between the antenna and the ground can be determined from the following equation:

Power Density between Antenna and Ground	$S_g = P / A_{surface}$ $= 50.00\ W/m^2$ $= 5.00\ mW/cm^2$	(6)

5. Summary of Calculations

Table 4. Summary of Expected Radiation Levels for Uncontrolled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 2.76m)	S_{ff}	1.037	Potential Hazard
Near Field (R_{nf}=1.148m)	S_{nf}	8.921	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	5.248	Potential Hazard
Between Antenna and Ground	S_g	5.00	Potential Hazard

Table 5. Summary of Expected Radiation Levels for Controlled Environment

Region	**Calculated Maximum Radiation Power Density Level (mW/cm^2)**		**Hazard Assessment**
Far Field (R_{ff} = 2.76m)	S_{ff}	1.037	Satisfies FCC MPE
Near Field (R_{nf} tra=1.148m)	S_{nf}	8.921	Potential Hazard
Transition Region ($R_{nf}<R_t<R_{ff}$)	S_t	5.248	Potential Hazard
Between Antenna and Ground	S_g	5.00	Potential Hazard

It is the applicant's responsibility to ensure that the public and operational personnel are not exposed to harmful levels of radiation.

6. Conclusions

Based upon the above analysis, it is concluded that FCC RF Guidelines have been exceeded in all fields of the Uncontrolled (Table 4) environments. In the Controlled (Table 5) environments, all regions besides the Far Field exceed the FCC RF Guidelines. The applicant proposes to comply with the MPE limits of 0.27 mW/cm^2 for the Uncontrolled Areas and the MPE limits of 1.34 mW/cm^2 for the Controlled Areas.

The earth station **Yagi** antenna will be mounted on a platform, so the applicant agrees that the antenna is in an area secured from the public and worker personnel not familiar with the earth station system. Non-assigned worker personnel and the general public must be accompanied by knowledgeable earth station personnel when they enter the earth station secured area.

The earth station's secured area will be marked with the required radiation hazard signs as described in the recent FCC R&O 13-39. The area in the vicinity of the earth station secured area will also have signs to inform those in the general population and those who may be working in the area or otherwise present that they are close to a RF System capable of producing hazardous levels.

The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*