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June 21, 2018

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

Re: Astronics AeroSat Corporation – Section 1.65 Submission
Update Information in Pending Blanket License Modification Application
File No. SES-MOD-20180223-00157 (Call Sign E140087)

Dear Ms. Dortch:

Pursuant to Section 1.65 of the Commission's rules, 47 C.F.R. § 1.65, Astronics AeroSat Corporation ("Astronics") hereby updates certain information in connection with the above-referenced application to modify its earth stations aboard aircraft ("ESAA") blanket license by adding earth station onboard vessel ("ESV") and vehicle-mounted earth station ("VMES") operating authority for its previously licensed HR129 and HR6400 mobile terminals.

First, in response to a Commission request, Astronics provides updated radiation hazard studies for the HR129 and HR6400 antennas that address ESV and VMES-specific issues. As demonstrated in the attached reports, the anticipated locations of the terminals (*i.e.*, on marine vessel superstructures or atop special-use ground vehicles) and terminal characteristics (*i.e.*, automatic transmission muting when blockage detected) will ensure compliance with the FCC limits for maximum permissible exposure ("MPE") to RF fields.

Second, Astronics requests that the terminal model number (Schedule B, E31) be updated to reflect the multiple model names associated with each terminal. The model names proposed below are used interchangeably by Astronics (and its customers) to refer to each terminal, and adding them to the license will ensure that Astronics' commercial authorization accurately captures all hardware designations.

Existing Terminal Model (E31)	**Proposed Terminal Model (E31)**
HR129	HR129/T-210/T-310
HR6400	HR6400/F-210/F-310

Finally, Astronics recently relocated its Network Operations Center ("NOC") facility and seeks to update the terminal remote control point accordingly. Control and monitoring of the ESAA/VMES/ESV network will be provided on a 24/7 basis from the following location, where personnel will have the authority to cease ESAA, ESV or VMES terminal transmissions remotely:

Network Operations Center
220 Hackett Hill Road
Manchester, NH 03102
Office: +1 603 879-0205
Email: AeroSat.support@astronics.com

No other information in support of this modification application has changed. Please do not hesitate to contact me with any questions regarding this matter.

Respectfully submitted,

Jason Davila
LMI Advisors

Enclosure(s)

Radiation Hazard Analysis for HR129 Antenna (ESV/VMES)

In support of the license modification application by Astronics AeroSat Corporation ("Astronics") to operate its previously licensed 0.29m Ku-band remote antenna as an earth station onboard vessel ("ESV") and vehicle-mounted earth station ("VMES"),[1] the following assessment is provided demonstrating compliance with the FCC limits for maximum permissible exposure ("MPE") to RF fields.

Bulletin No. 65 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 General Population/Uncontrolled Environment and the Controlled Environment (where the general population does not have access).

Generally, the power densities at or around the antenna radiating surface is expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high-exposure area. Procedures are established to ensure that all transmitters are turned off before this area may be accessed by operators, maintenance or other authorized personnel.

Based on the mathematical analyses described herein, the potential RF exposure levels in the areas of possible occupancy during antenna operations can be considered in compliance with the applicable FCC limits for controlled or occupational exposure (access to the earth station antenna is restricted to trained personnel) and for protection of the general population. The proposed operations are therefore in compliance with the FCC regulations and exposure limits.

The sections that follow provide the analysis and conclusions regarding compliance.

1. Operational Data

The relevant data for the subject operations are summarized as follows:

Transmitting Frequency Band:	14.0 – 14.5 GHz
Antenna Manufacturer / Model:	Astronics AeroSat / HR 129 (aka T-310)
Antenna Type:	Fresnel Lens
Antenna Dimension:	0.29 m (11.4 in.) diameter
Antenna Efficiency:	80 %
Net Power Input to Antenna (at flange):	10.0 Watts

2. Applicable MPE Limits

This report analyzes the non-ionizing radiation levels for the HR129 antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

[1] *See* Astronics AeroSat Corporation, File No. SES-MOD-20180223-00157, Call Sign E140087.

For the frequency range of interest here, the applicable limit for acceptable, continuous exposure of the general population is 1.0 milliwatt per square centimeter (mW/cm^2) averaged over any 30-minute period, and for "controlled" occupational exposure, it is 5.0 mW/cm^2 averaged over any 6-minute period. Access to the antenna is generally restricted to trained personnel, and thus the latter limit is generally applicable.

Although Astronics has also examined the MPE limit for the general population in this report, in no circumstances will untrained members of the general population be within certain distances from the mounting location on the marine vessel or land vehicle.

3. FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the areas of interest here. Using the formulas from Bulletin OET 65, Astronics reports the exposure levels (1) directly in front of the antenna, (2) in the main beam at the transition from near to far field, and (3) farther away but still in the main beam where the MPE limit is met for both controlled and general population exposure; and (4) to the side of the antenna. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Potential Exposure Directly in Front of the Antenna

The worst-case possible exposure occurs right at the surface (aperture) of the antenna. According to Bulletin OET 65, the applicable formula for power density, **S**, at the antenna surface is as follows:

Ssurface = 4 * P / A

Where: **P** represents the antenna input power; and
A is the surface area of the antenna.

In this case, with 10 Watts antenna of input power at the flange, an antenna diameter of 0.29 m (11.4 inches), the power density at the antenna surface is 60.56 mW/cm^2, which exceeds the 5.0 mW/cm^2 MPE limit for controlled access.

However, for normal ESV and VMES installations, there will be no convenient or easily accessible way to approach this close to the antenna when it is in operation.

In **VMES applications**, the antenna will be mounted high on a special-purpose vehicle, above the plane were people normally would be present. The main beam points toward the sky at a typical elevation angle of 25 degrees such that human exposure is not possible.

In **ESV applications**, the antenna will be mounted high on the vessel's superstructure, well above the area where the general population are present or able to access.

In both the ESV and VMES context, the antenna will be switched off completely (i.e. unpowered) when a technician needs to perform work in this area. Standard RF safety procedures will be applied and the power to the antenna will be removed during the period of the work. Regardless, any blockage (human or otherwise) will cause the transmitter to be disabled within 100 milliseconds as the system does not transmit unless it can receive the downlink carrier from the satellite. Finally, normal TDMA operation uses a duty cycle of 10% or less, reducing maximum near field exposure by an order of magnitude. Therefore, prolonged exposure is not possible in normal operation.

3.2 *Potential Exposure in the Near-Field, Far-Field & Transition Region*

The formula for near-field, on-axis power density, directly in front of the antenna is as follows:

$$\mathbf{Snf = 16 * I * P / (\pi * D^2)}$$

Where: **P** represents the antenna input power;
I represents the antenna illumination efficiency; and
D is the antenna diameter.

In this case, when Astronics applies an illumination efficiency of 80 %, the result of the calculation is 48.53 mW/cm^2, which exceeds the occupational MPE limit. This is the exposure level directly in front of the antenna at a distance of 1m. For the reasons stated above, there is no way for a technician or the general public to approach this close to the antenna while it is transmitting.

The formula for far-field, on-axis power density, directly in front of the antenna is as follows:

$$\mathbf{Sff = P * G / (4 * \pi * R^2)}$$

Where: **P** represents the antenna input power;
G represents the power gain of the antenna in the direction of interest relative to an isotropic radiator; and
R is the distance to the point of interest.

The HR129 antenna potentially exceeds MPE limits at the far-field boundary of 2.44m with a power density value 20.8 mW/cm^2.

The transition region distance is the distance between the near and far fields. However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

3.3 Controlled and General Population Distance Limits

Astronics can calculate the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population using the following formula:

$$R_{MPE} = SQRT\ \{ (G * P) / (4 * \pi * MPE) \}$$

Where: **G** represents the Gain of the antenna; [31.9 dBi @ 14.500 GHz]
P represents the antenna aperture input power: and
MPE represents the maximum permissible exposure limit.

The results of the analysis show that the MPE for controlled access are met at 5.0 m (16.3 feet) directly in front of the antenna. The MPE for the general population is met at 11.1 m (36.5 feet) directly in front of the antenna.

3.4 Potential Exposure to the Side of the Antenna

The near-field power density drops off dramatically outside the imaginary cylinder extending from the surface along the axis of the main beam of an aperture antenna. As stated in Bulletin OET 65:

> "For off-axis calculations in the near-field and in the transition region it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20 dB) less than the value calculated for the equivalent distance in the main beam."

In **VMES applications**, the antenna will be mounted on top of a vessel superstructure well above the main deck, at least 1m above a point of interest on the closest deck. This minimum 1m distance is equal to more than 3 antenna aperture diameters below the main beam, thus will result in at least a 20 dB decrease in power density compared to that in the main beam.

In **ESV applications**, Astronics does not generally contemplate use of this antenna in real-world commercial applications (*i.e.*, on an ordinary passenger sedan on public roads), but rather the terminal will be mounted on special-purpose ground vehicle such as an SUV, van, or troop carrier in a fully-controlled environment. Typical mounting arrangements will result in the antenna aperture being located a minimum of 12 inches above the highest point of interest (*i.e.*, a person standing next to the vehicle). Furthermore, due to the fact that the antenna operates at an elevation angle that is typically 25° or more above the horizon, and the fact that the antenna will typically be mounted on the center roof, the vertical separation from the main beam to the highest point of a person standing next to the vehicle will be increased by at least another 15 inches. Thus, there will be a minimum 27-inch separation from the main beam to the highest point of a person standing next to the vehicle, which equates to approximately 2.36 aperture diameters, which is significantly below 20 dB power density in the main beam.

The previous calculation of the power density immediately in the near field in front of the antenna resulted in a value of 48.53 mW/cm^2. The anticipated distance from the main beam of 2.36 aperture diameters or greater would decrease the exposure level by at least a factor of 100, to less than 0.49 mW/cm^2.

4. Compliance Conclusion

Astronics will observe standard safety precautions with respect to operations and maintenance of the HR129/T-310 antenna, including powering the antenna off in advance of maintenance activities. In addition, given the anticipated locations of the antenna (i.e., marine vessel superstructures or atop a special-use ground vehicle) and automatic muting of transmissions with a blockage, there is no possibility that members of the general public will be located in regions where MPE values may be exceeded.

Based on the result of the analysis with regard to the potential exposure levels in all respects – directly in front of the antenna, to the side of the antenna, and at ground level – and taking into account the access restrictions for both trained and untrained persons and standard safety procedures, the operation of the 0.29m Ku-band antenna as an ESV or VMES satisfies the MPE compliance requirements in the FCC regulations.

Radiation Hazard Analysis for HR6400 Antenna (ESV/VMES)

In support of the license modification application by Astronics AeroSat Corporation ("Astronics") to operate its previously licensed HR6400 Ku-band remote antenna as an earth station onboard vessel ("ESV") and vehicle-mounted earth station ("VMES"),[1] the following assessment is provided demonstrating compliance with the FCC limits for maximum permissible exposure ("MPE") to RF fields.

Bulletin No. 65 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 General Population/ Uncontrolled Environment and the Controlled Environment, where the general population does not have access.

Generally, the power densities at or around the antenna radiating surface is expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians will receive training specifying this area as a high exposure area. Procedures are established to ensure that all transmitters are turned off before this area may be accessed by operators, maintenance or other authorized personnel.

Based on the mathematical analyses described herein, the potential RF exposure levels in the areas of possible interest for antenna operations can be considered in compliance with the applicable FCC limits for controlled or occupational exposure (access to the earth station antenna is restricted to trained personnel) and for protection of the general population. The proposed operations are therefore in compliance with the FCC regulations and exposure limits.

The sections that follow provide the analysis and conclusions regarding compliance.

1. Operational Data

The relevant data for the subject operations are summarized as follows:

Transmitting Frequency Band:	14.0 – 14.5 GHz
Antenna Manufacturer / Model:	Astronics Aerosat / HR6400, aka F-310
Antenna Type:	Horn with Lens Array
Antenna Dimension:	W: 0.864 m (34 in.) / H: 0.165(6.5 in.)
Antenna Efficiency:	70 %
Net Power Input to Antenna (at flange):	16.8 Watts

2. Applicable MPE Limits

This report analyzes the non-ionizing radiation levels for the HR6400 Antenna System. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01.

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[1] *See* Astronics AeroSat Corporation, File No. SES-MOD-20180223-00157, Call Sign E140087.

For the frequency range of interest here, the applicable limit for acceptable, continuous exposure of the general population is 1.0 milliwatt per square centimeter (mW/cm^2) averaged over any 30-minute period, and for "controlled" occupational exposure, it is 5.0 mW/cm^2 averaged over any 6-minute period. Access to the antenna is generally restricted to trained personnel, and thus the latter limit is generally applicable.

In no circumstances will untrained members of the general population be within certain distances from the mounting location on the marine vessel or land vehicle, however, Astronics has also examined the MPE limit for the general population in this report.

3. FCC Formulas and Calculations

FCC Bulletin OET 65 provides standardized formulas for calculating the power density in the areas of interest here. Using the formulas from Bulletin OET 65, Astronics reports the exposure levels (1) directly in front of the antenna, (2) in the main beam at the transition from near to far field, and (3) farther away but still in the main beam where the MPE limit is met for both controlled and general population exposure; and (4) to the side of the antenna. Each area of interest will be addressed below and the results of the calculations are given.

3.1 Potential Exposure Directly in Front of the Antenna

The worst-case possible exposure occurs right at the surface (aperture) of the antenna. According to Bulletin OET 65, the applicable formula for power density, **S**, at the antenna surface is as follows:

Ssurface = 4 * P / A

Where: **P** represents the antenna input power; and
A is the surface area of the antenna.

In this case, assuming that all 16.8 Watts of input power at the flange are uniformly distributed across the surface area of the panel, the power density at the antenna surface is 11.75 mW/cm^2, which exceeds the 5.0 mW/cm^2 MPE limit for controlled access.

However, for normal ESV and VMES installations, there will be no convenient or easily accessible way to approach this close to the antenna when it is in operation.

In **VMES applications**, the antenna will be mounted high on a special-purpose vehicle, above the plane were people normally would be present. The main beam points toward the sky at a typical elevation angle of 25 degrees such that human exposure is not possible.

In **ESV applications**, the antenna will be mounted high on the vessel's superstructure, well above the area where the general population are present or able to access.

In both the ESV and VMES context, the antenna will be switched off completely (i.e. unpowered) when a technician needs to perform work in this area. Standard RF safety procedures will be applied and the power to the antenna will be removed during the period of the work. Regardless, any blockage (human or otherwise) will cause the transmitter to be disabled within 100 milliseconds as the system does not transmit unless it can receive the downlink carrier from the satellite. Finally, normal TDMA operation uses a duty cycle of 10% or less, reducing maximum near field and transition region exposures by an order of magnitude to, respectively, 1.2, 4.5 and 1.9 mW/cm^2 at the surface, near-field boundary, and far-field boundary. Therefore, prolonged exposure is not possible in normal operation.

3.2 *Potential Exposure in the Near-Field, Far-Field & Transition Region*

The formula for near-field, on-axis power density, directly in front of the antenna is as follows:

$$\mathbf{Snf = 16 * I * P / (\pi * D^2)}$$

Where: **P** represents the antenna input power;
I represents the antenna illumination efficiency; and
D is the antenna diameter.

In this case, when Astronics applies an illumination efficiency of 70%, the result of the calculation is 44.6 mW/cm^2, which exceeds the occupational MPE limit. This is the exposure level directly in front of the antenna at a distance of 1.6m. For the reasons stated above, there is no way for a technician or the general public to approach this close to the antenna while it is transmitting.

The formula for far-field, on-axis power density, directly in front of the antenna is as follows:

$$\mathbf{Sff = P * G / (4 * \pi * R^2)}$$

Where: **P** represents the antenna input power;
G represents the power gain of the antenna in the direction of interest relative to an isotropic radiator; and
R is the distance to the point of interest.

The HR6400 antenna potentially exceeds MPE limits at the far-field boundary of 3.9m with a power density value 19.1 mW/cm^2.

The transition region distance is the distance between the near and far fields. However, the power density in the transition region will not exceed the power density in the near-field. Therefore, for purposes of the present analysis, the distance of the transition region can equate the distance to the near-field.

3.3 Controlled and General Population Distance Limits

Astronics can calculate the distance at which the antenna emissions would meet the MPE limits for controlled access and for the general population using the following formula:

R_{MPE} = SQRT { (G * P) / (4 * π * MPE) }

Where: **G** represents the Gain of the antenna; [33.2 dBi @ 14.250 GHz]
P represents the antenna aperture input power: and
MPE represents the maximum permissible exposure limit.

The results of the analysis show that the MPE for controlled access are met at 7.5 m (24.7 feet) directly in front of the antenna. The MPE for the general population is met at 16.8 m (55.1 feet) directly in front of the antenna.

3.4 Potential Exposure to the Side of the Antenna

The near-field power density drops off dramatically outside the imaginary cylinder extending from the surface along the axis of the main beam of an aperture antenna. As stated in Bulletin OET 65:

> "For off-axis calculations in the near-field and in the transition region it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20 dB) less than the value calculated for the equivalent distance in the main beam."

In **VMES applications**, the antenna will be mounted on top of a vessel superstructure well above the main deck, at least 1m above a point of interest on the closest deck. This minimum 1m distance is equal to more than 2.5 antenna aperture diameters below the main beam, thus will result in at least a 20 dB decrease in power density compared to that in the main beam.

In **ESV applications**, Astronics does not generally contemplate use of this antenna in real-world commercial applications (*i.e.*, on an ordinary passenger sedan on public roads), but rather the terminal will be mounted on special-purpose ground vehicle such as an SUV, van, or troop carrier in a fully-controlled environment. Typical mounting arrangements will result in the antenna aperture being located a minimum of 12 inches above the highest point of interest (*i.e.*, a person standing next to the vehicle). Furthermore, due to the fact that the antenna operates at an elevation angle that is typically 25° or more above the horizon, and the fact that the antenna will typically be mounted on the center roof, the vertical separation from the main beam to the highest point of a person standing next to the vehicle will be increased by at least another 15 inches. Thus, there will be a minimum 27-inch separation from the main beam to the highest point of a person standing next to the vehicle, which equates to approximately 1.87 aperture diameters, which is significantly below 20 dB power density in the main beam.

The previous calculation of the power density immediately in the near field in front of the antenna resulted in a value of 44.6 mW/cm^2. The anticipated distance from the main beam of 1.87 aperture diameters or greater would decrease the exposure level by at least a factor of 100, to less than 0.45 mW/cm^2.

4. Compliance Conclusion

Astronics will observe standard safety precautions with respect to operations and maintenance of the HR6400/F-310 antenna, including powering the antenna off in advance of maintenance activities. In addition, given the anticipated locations of the antenna (i.e., marine vessel superstructures or atop a special-use ground vehicle) and automatic muting of transmissions with a blockage, there is no possibility that members of the general public will be located in regions where MPE values may be exceeded.

Based on the result of the analysis with regard to the potential exposure levels in all respects – directly in front of the antenna, to the side of the antenna, and at ground level – and taking into account the access restrictions for both trained and untrained persons and standard safety procedures, the operation of the HR6400 Ku-band antenna as an ESV or VMES satisfies the MPE compliance requirements in the FCC regulations.