Radiation Hazard Analysis Northrop Grumman Mission Systems FCC File Number 0756-EX-CN-2026

1. Introduction

This document serves as the Radiation Hazard Analysis for the Northrop Grumman experimental system hardware identified by the part number NP307K401G01, operating at the requested frequencies, power and waveforms detailed in FCC application file numbers 0756-EX-CN-2026, and 0757-EX-CN-2026.

This analysis predicts the radiation power density levels in and around the antenna for the referenced developmental radar system, and the human safety mitigation steps required. This report is developed in accordance with the predication methods contained in OET Bulletin No. 65, Sections 1.1307 and 1.1310 of the FCC rules, and IEEE standard C95.1-2019.

The maximum level of time averaged non-ionizing RF radiation to which the unrestricted general public may be exposed are those values defined in Table 7 of IEEE C95.1-2019 for the frequency bands requested under these license applications. The immediate power density limit for pulsed emitters is defined by IEEE C95.1-2019, annex D.1.2.2.1. This is given by the requirement that the peak power density (the ERL from Table 7) multiplied by 10% of the duty cycle must be less than the ERL multiplied by 20% of the time allowance (six minutes or 360 seconds):

$$(S_{peak} \text{ x Duty Cycle})/10 <= (\text{ERL x } 360)/5$$

For this pulsed radar system, the allowable power density (peak and time average) is shown in Table 1.

Table 1. Allowable power density limits for requested frequencies.

Freq (MHz)	ERL Time Averaged safe Power Density value (mW/cm2)	Instantaneous Power Density Limit (mW/cm^2) = Peak Power Density*360/5
450	0.2	14.4
928	0.464	33.408

Northrop Grumman Mission Systems follows an established procedure to ensure the safety of both the hardware and personnel for their radiating systems. Procedure K200-312-MSM requires a transmit readiness review (TxRR) for all labs, with involvement from systems engineering to ensure proper hardware safeguards are in place (interlocked power and cooling as an example). Industrial Health and Safety leads the team review to ensure proper RF safety procedures are followed and that the proper license is in place for use. Figure 1 provides the pertinent information regarding this procedure and its relation to safe operations.

Due to the nature of the test environment, the Northrop Grumman policy is to limit occupied areas impacted by radiating systems to not exceed the defined general public levels. Any area that exceeds this limit is physically blocked off with a barrier (chain or locked access) and with signage warning people of the potential for RF hazard and to stay out of the restricted area.

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Purpose

This document defines the elements needed to complete a Transmit Readiness Review (TxRR) before radiating Radio Frequency (RF) energy.

This document does not pertain to Class B Federal Communications Commission (FCC) approved devices, commercial devices used as intended by the manufacturer with no modifications or other devices having documentation that shows they meet Institute of Electrical and Electronics Engineers (IEEE) C95.1, IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz- to 300 GHz, standards for the general public. Devices having FCC approval but have attached warning statements identifying specific operating conditions to prevent RF exposure must adhere to this procedure. Programs/projects that are doing receive only testing using test equipment (signal generators) are not required to conduct a TxRR.

Requirements and Procedure

TxRR

This document provides the minimum requirements that a TxRR must address to ensure the safety of both personnel and Northrop Grumman assets.

If outdoor transmission testing is going to be performed, refer to E260-MSM, Requirements for Radio Frequency Spectrum Management and Licensing, and K200-306-MSM, Radiation Protection Program.

To avoid situations where there is a chance of exceeding the power rating of the RF absorber, exposing personnel to harmful RF levels, or damaging Northrop Grumman assets; a systematic review of the operating procedures and safeguards is essential. The method developed to accomplish this review is with the use of a TxRR.

The following identifies the topics that shall be addressed at a minimum in the TxRR Template or equivalent:

- Overview of testing objectives.
- Review of test procedures that will be performed for safety hazards and applicable site documents.
- Review of potential hazards expected during testing.
- Review of system safeguards, i.e.:
  - Emergency shutdowns (locations, speed of shutdown, etc.).
  - Software (if applicable)

Figure 1. Excerpt from Northrop Grumman TxRR Safety Procedure.

2. Referenced Transmitting System Parameters

Transmitter Type: Solid State Transmit Module
Antenna: Active Electronically Scanned Antenna (AESA)
Antenna area: 1.32 sq meters (3.25 x 0.4 meters)
Scanning: Mechanically fixed, electronically scanned, 70 degree cone about boresight
Frequency and Power Parameters: See Table 2.

Table 2. System waveform power parameters for requested frequencies.

Freq MHz	Tx max watts	Gain (dBi)	EIRP MW
450	18900	18.05	1.206
928	15500	22.5	2.756

3. Safe Distance Calculations

IEEE C95.1-2019 establishes the immediate and time average Radio Frequency Power Specific Density (RF PSD) for unwarned personnel / general public as noted above in Table 7 and in annex D.1.2.2.1.

There are three areas of concern for the predications of energy density (S); the Reactive Zone at the immediate antenna face, the Transition Zone between the face of the antenna and the Fraunhofer (near field/far field boundary) distance, and the Far Field.

The Reactive Zone power density is given by S=4P/A, or four times the time average transmit power of the antenna divided by the antenna area.

The Transition Zone power density is approximated by S=16P/Pi*D^2, or sixteen times the time average transmit power of the antenna divided by Pi and the square of the antenna major dimension. The power density in this zone varies but in general decreases with distance from the antenna out to the Fraunhofer or far field distance. These power levels are shown in Table 3.

Table 3. Maximum time average power density in near-field zones of interest.

Freq (MHz)	Reactive Zone Power Density S=4P/A mWatts/cm^2	Transition Zone Power Density S=16P/Pi*D^2 mW/cm^2
450	1144.3	182.1
928	938.5	149.4

For this radar system with a waveform maximum duty cycle of 20%, the maximum allowed general public (unrestricted) far field time average exposure is as shown in Table 1.

The Fraunhofer distance for this antenna is defined by 2D^2/lambda, or twice the major dimension squared divided by the transmitted wavelength. Beyond the Fraunhofer distance the power density is given by S = EIRP*Duty/(4pi*range^2), or the EIRP times the duty cycle percentage divided by the product of the square of the range of interest times four Pi.

The time-averaged far-field minimum safe distance (from the antenna face) for the main beam of the subject system for the general public (ERL) is given by the range equation:

R= SQRT[EIRP (W)*Duty/(4*pi* ERL W/m^2)]

This can also be used as an approximation in the Transition Zone for distances nearing the Fraunhofer range.

Using the range equation, the range at which the estimated Instantaneous power does not exceed the limit can be estimated. For the power density limit for each frequency, the approximate distance at which the power density falls below the limit is shown in Table 4.

Table 4. Instantaneous power safe distance limits (meters).

Freq (MHz)	Instantaneous Power Density Limit (mW/cm^2) = Peak Power Density*360/5	Range at which 100% Duty Far Field Power Density in 100 msec <= Limit
450	14.4	25.9
928	33.408	25.7

Similarly, the range at which the estimated time average power density does not exceed the ERL limit is estimated by the range equation for each system frequency.

Table 5. Far Field Time Average Safe Distance (meters).

Freq (MHz)	ERL Time Averaged safe Power Density value (mW/cm2)	Range of Interest = Range at which Time Average ERL Power Limit is not exceeded using far field equation.	Fraunhofer Far Field Distance R=2D^2/lambda
450	0.2	98.0	31.8
928	0.464	97.2	65.6

In all instances, the calculated time average safe distance exceeds the instantaneous safe distance. Based on the IEEE C95.1-2019 standard based ERL and system transmit power and antenna gain, the overall safe distance minimum from the face of the antenna for this system is 136.2 meters. This is associated with a frequency of 1380 MHz, where the antenna system is most efficient in transmit power production and antenna gain.

4. Physical Safety Precautions

The transmitting system used in this application operates across multiple frequencies. Licenses have been requested for all frequencies. This hazard analysis and its worse-case result will be applied to all situations. Program personnel will restrict all personnel access to the area in front of the transmitting antenna within its field of regard, out to a distance of 150 meters or 490 feet, providing a margin of safety over the calculated minimum safe distance of 136.2 meters.