Radiation Hazard Analysis
Northrop Grumman Mission Systems
Experimental License WJ2XDZ, FCC File No. 0327-EX-CM-2023

1. Introduction

This analysis predicts the radiation levels in and around the developmental lab for the referenced radar system at the Linthicum, MD Northrop Grumman facility. This report is developed in accordance with the predication methods contained in OET Bulletin No. 65, and Sections 1.1307 and 1.1310 of the FCC rules. For the frequency band used under this license, per section 1.1310 and the IEEE C95.1 standard the maximum level of non-ionizing radiation to which people may be exposed is limited to 5 milliwatts per square centimeter(5mW/cm^2) over any 6 minute period in a controlled environment and 1 mW/cm^2 for the general public.

Northrop Grumman Mission Systems follows an established procedure to ensure the safety of both the hardware and personnel for our radiating labs. 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 of the labs to not exceed the general public levels, or 1 mW/cm^2 exposure. Any area that exceeds this limit is physically blocked off with a barrier (chain) and with signage warning people of the potential for RF hazard and to stay out of the restricted area.

NORTHROP GRUMMAN

Mission Systems (MS) Manual

K200-312-MSM

Subject
Radio Frequency Transmit Readiness Review

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Defined Terms None

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 Radar System Parameters

Transmitter Type: Solid State Transmit Module
Antenna: Active Electronically Scanned Antenna (AESA)
Major axis: 0.5 meters x 0.3 meters
Scanning: Mechanically fixed, electronically scanned
Total EIRP: 7.3 MW
Total ERP: 4.4 MW
Max Duty Cycle: 25%

3. Safe Distance Calculations

IEEE C95.1-2019 and FCC Bulletin 65 establish the Power Specific Density (PSD) for unwarned personnel / general public at 1 mW/cm^2 (10 W/m^2) for the frequencies used by the subject radar (16.2 – 17.3 GHz). The RF field strength at the face of the antenna and in its near field region exceeds the allowed limit.

$$S=4P/A = 4*2300W/.15m^2 = 61KW/m^2$$

Similarly, the near-field region exceeds human safe values:

$$S=16P/Pi*D^2 = 16*2300/(3.14*.5^2) = 46.8\ KW/m^2$$

The Fraunhofer distance for this antenna is 2D^2/lambda, or approximately 16 meters or about 50 feet. The far-field minimum safe distance for the main beam of the subject radar for the general public (1mw/cm^2) is given by:

$$R= SQRT[(EIRP\ (W)*duty\ cycle)/(4*pi*\ 10\ W/m^2)]$$

$$= SQRT[(7273238 * 0.25)/(4*3.14*10)] = 120\ meters \sim 380\ feet$$

Without any mitigating power reductions, personnel will not be allowed in the areas noted above; at the face of the antenna, in the near field region, or in the far field region to the hazard limit distance (380 feet).

4. Physical Safety Precautions

Northrop Grumman Mission Systems implements numerous safety controls in all of its radiating labs in accordance with Procedure K200-312-MSM. The TxRR reviews all the calculations of the predicted hazard areas. Physical barriers (chains/ropes/curtains) with signs are installed to keep people out of the hazard areas. The radar antenna electronically scans over the field of regard to the front of the antenna and the outside roof area of the lab. Due to the scanning nature of the antenna, the area to the front of the radar is physically cordoned off for human safety assuming main-beam power levels are present throughout the field of regard.

This includes in the lab itself, where personnel are not allowed to the immediate front or sides of the installed radar when it is capable of transmitting. In accordance with K200-312, the NGMS Industrial Health and Safety office conducts an RF safety survey in the lab using a calibrated RF field density meter to ensure there are no hazardous reflections or emissions in the lab, or that they are properly marked off. Outside of the lab, an RF horizon surrounds the immediate area of the radome. This horizon consists of a fine copper wire mesh (100x0.0045) with a 30 dB attenuation at 10 GHz supported on a frame that extends about 3 feet above the antenna center and about 7 feet above the surrounding roof deck. The horizons are the horse-shoe shaped objects shown in figure 2. The horizons are grounded to limit re-radiation and effectively reduce the hazard area to that contained within the horizon structure. Access to the roof area is restricted to trained / authorized personnel by badge swipe control interlocks. Chains block off the hazard area on the roof; the area is further enhanced by signage and flashing lights that are activated when a lab is actively transmitting.

Figure 2. RF Horizons surround the radiating labs on the roof.

The above precautions are valid for stationary operations in the development lab. The mobile operations requested are to support flight test operations. In this configuration, the radar system is not activated until the aircraft is airborne, where flight safety rules ensure safe separation distances for main beam exposure. Safety surveys are conducted pre-flight to ensure there are no hazardous reflections in the cabin of the flight aircraft, to include the pilot area on the flight deck.

5. Summary

The safety systems put in place for all Northrop Grumman radiating labs, to include subject radar lab, protect unwarned and untrained personnel from accessing the hazard zones around the radiating system.