Appendix E
Electromagnetic Radiation

APPENDIX E
ELECTROMAGNETIC RADIATION

General Discussion of the X-Band Radar

The X-Band Radar (XBR) of the National Missile Defense (NMD) program is a ground-based, tasked, multi-function radar. In the NMD role, it performs acquisition, tracking, discrimination, and kill assessment of incoming warheads. An XBR uses X-band (8–12 gigahertz) emissions and advanced radar signal processing technology to improve target resolution, which permits the radar to perform more effectively against closely-spaced warheads, debris, and penetration aids.

The XBR is a phased array radar that utilizes solid state transmit/receive module technology and performs search, track, and discrimination functions on incoming intercontinental ballistic missiles. The technical characteristics of the XBR are classified and are not available for this environmental impact statement.

Electromagnetic Radiation Calculations for the XBR

General. The following sections provide the equations used in calculating the field strength levels, the distance separations, and the interference pulse counts presented in this environmental impact statement. Actual calculations are classified due to the XBR's classified parameters.

Field Strength Calculations. The following equation was used in calculating the field strength levels:

$$P_d = P_t + G_t - L_p + 20\log F - 38.5 \quad \textbf{R-1}$$

where

P_d = power density, in decibels relative to a milliwatt per square meter

P_t = transmitter power, in decibels relative to a milliwatt

G_t = antenna gain, in decibels relative to an isotropic radiator

L_p = free-space path loss = $20\log F + 20\log D + 32.4$, in decibels

F = frequency, in megahertz

D = distance, in meters

Equation R-1 can be solved for the distance D,

$$D = 10^{-1} ((P_d - P_t - G_t + 70.9)/(-20)) \quad \textbf{R-2}$$

Calculations of Pulsed Interference to Plan Position Indicator (PPI) Displays. The PPI display is similar to a television screen that displays storm cells for weather radar or incoming aircraft for precision approach radar. In order to determine the number of interference pulses present on a PPI display, two things must be considered: (1) interference pulses cannot be presented when radar is transmitting a pulse, and (2) the interfering pulse must fall within the time interval when the radar is expecting target returns. In the latter case, the receive time interval is based upon the maximum display range of the radar. Once a pulse is transmitted, the radar receiver will be expecting returns from a target that can only be as far away as the maximum range permits. However, the radar also has an unambiguous range that is determined by the rate at which pulses are transmitted, or PRF (see figure E-1). The maximum display range and unambiguous range are important factors in calculating the fractional on-time of the radar receiver. The fractional on-time can simply be defined as the percent of time that the radar's receiver is turned on; i.e., expecting radar returns from a target. The fractional on-time of the receiver can be calculated using equation R-3.

$$O = M / U \quad \textbf{R-3}$$

where,

O = fractional on-time of receiver

M = maximum display range of the PPI radar, in meters

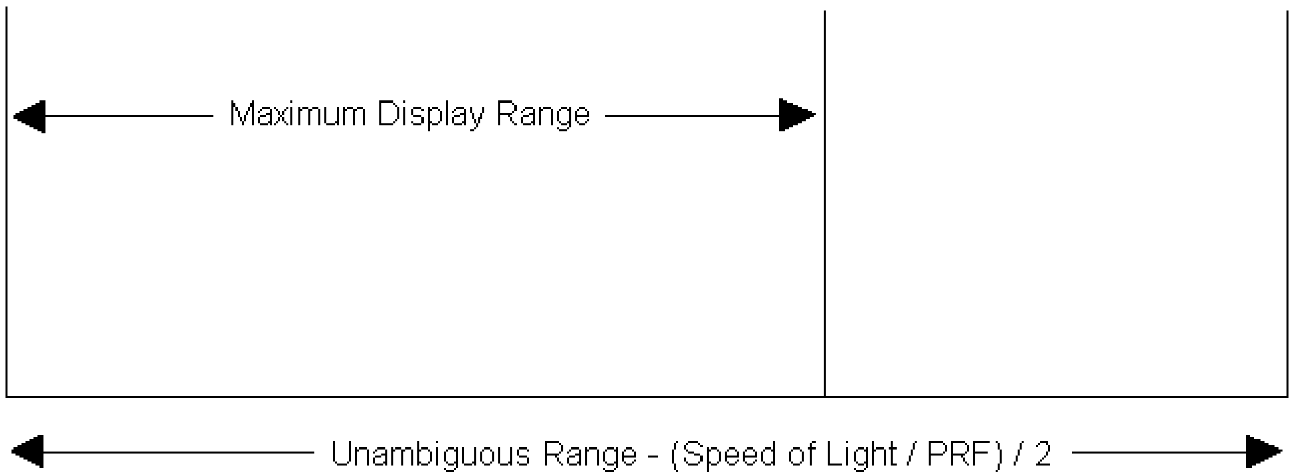
U = unambiguous range of the PPI radar = (C / PRF) / 2, in meters

C = speed of light, in meters/second

PRF = pulse repetition frequency, in pulses per second

Next, the receive time intervals of the PPI radar were calculated based upon the maximum range, unambiguous range, and PRF of the radar. Also, the arrival time intervals of the interfering radar were calculated based upon the pulsewidth and PRF of that radar. For every pulse transmitted by the interfering radar, a comparison was made to determine whether that pulse arrived at the PPI radar during a time at which the PPI radar was looking to receive returns. Of those pulses meeting that criteria, another comparison was made to determine if the interfering pulses exceeded the threshold of the PPI radar for pulses to be displayed. That total number of pulses meeting both criteria was then multiplied by the fractional on-time of the receiver to determine the exact number of pulses that would appear on the PPI display.

Figure E-1: Maximum Display Range and Unambiguous Range of a PPI-type Radar



Formula Application Table. Table E-1 identifies the equations used to calculate the values found in chapters 3.0 and 4.0 by paragraph or table number.

Table E-1: Equation Calculation Cross-Reference

Type of Calculation	EIS Paragraph or Table	Calculated Value	Equation Used
Weather Radar Interference Pulses	4.3.4.7	< 200 pulses	R-3
Precision Approach Radar Interference Pulses	4.3.4.7	< 5 pulses	R-3
In-band Airborne System Separation Distance	4.3.4.7	1 kilometer (0.6 mile)	R-2
High Power Effects	4.3.4.7	Field Strength and Distance Separation	R-1, R-2
Aircraft/Avionics Fly-by-Wire Systems	4.3.4.7	6.7 kilometers (4 miles)	R-2
Radiation Control Zone—Personnel	4.3.4.7	150 meters (492 feet)	R-2
Radiation Control Zone—Personnel	4.3.4.7	Field Strength and Distance Separation	R-1, R-2

THIS PAGE INTENTIONALLY LEFT BLANK