5 Marblestone Lane ● So. Setauket, NY 11720
tel: 631-698-6765 ● fax: 631-732-2919
e-mail: RStrick@RFSafetySolutions.com
www.RFSafetySolutions.com

RF Safety Report

An Analysis of RF Field Levels at the Arecibo Observatory

Prepared for
Cornell University
Department of Environmental Health and Safety
Ithaca, New York
and
Arecibo Observatory
National Astronomy & Ionosphere Center
Arecibo, Puerto Rico

Revised
August 25, 2005

Formatted: Centered
Deleted: June 8, 2004

Executive Summary

Purpose

This is the 305-meter-diameter reflector antenna that is the principal feature of the Arecibo Observatory. The Visitor Center is located near the end of the catwalk.

The Environmental Health and Safety Department of Cornell University commissioned this RF Safety Report. The primary objective of the analysis and the report is to determine whether the RF field levels in the vicinity of the large antenna system at the Arecibo Observatory in Arecibo, Puerto Rico are in compliance with Federal Communications Commission (FCC) and Occupational Safety and Health Administration (OSHA) Regulations regarding RF radiation safety. The other objectives are to determine whether operating procedures represent industry-best practice regarding RF safety and whether any safety risks exist. The goals of Cornell and the NAIC are to:

- Minimize the risk to all personnel: employees, contractors, and visitors.
- Comply with all FCC Regulations.
- Comply with all OSHA Regulations.
- Comply with all state and local regulations.
- Minimize liability risk.

Description of the Arecibo Observatory Facilities

The Arecibo Observatory is located in the mountains several miles south of the city of Arecibo, which is on the north coast of Puerto Rico. The Arecibo Observatory is also referred to as the National Astronomy and Ionosphere Center (NAIC). Cornell University manages the NAIC under cooperative agreement with the National Science Foundation.

The principal feature of the observatory is the 1,000-foot-diameter antenna—the largest reflector antenna in the world—that is set in the mountains. The antenna design is unique because the reflector is stationary and the feeds move independent of the reflector. The feed systems are mounted on a large platform that is suspended over the reflector from cables connected to three towers.

The antenna system is used in the receive mode about 85 percent of the time. Two high-power systems are used to transmit energy into space. One system is a pulsed radar system that operates at 430 MHz and the other is an S-Band CW

Deleted: 8/24/2005

(continuous wave) system. The S-band transmitter is located inside a geodesic dome on the platform with the Gregorian feed. The 430-MHz transmitter is located in a building several hundred feet from the antenna. The energy from this transmitter is conducted to the feeds on the suspended platform via a large waveguide. This waveguide, which is comprised of both rigid and flexible sections, is mounted about seven feet over the catwalk that leads to the platform.

Standards and Regulations

NAIC must comply with FCC Regulations regarding to exposure to RF radiation. By complying with the FCC Regulations, it would also satisfy OSHA requirements. Currently, NAIC must meet the more restrictive FCC's Maximum Permissible Exposure (MPE) limits for General Population/Uncontrolled exposure. NAIC will qualify to use the FCC's higher MPE limits for Occupational/Controlled exposure in areas not open to the public once it develops and implements an RF safety program. See *Section 1: The Arecibo Observatory and RF Regulations* for details.

RF Field Levels at the Arecibo Observatory

RF Field levels vary by area and are also very dependent on which of the two high power transmitter systems is in operation and how the system is configured. The RF field levels at the facility and nearby are as follows:

RF Field Levels above the Reflector

This area includes all areas within the 1000-foot diameter cylindrical space directly above the reflector. It includes the platform, the catwalk, the cable car, and the surface of the reflector.

Field Levels with the 430-MHz Radar

RF field levels on the catwalk and in accessible areas of the platform, other than inside the Gregorian dome and the area adjacent to the open waveguide below the catwalk, are below the FCC's MPE limits for General Population/Uncontrolled exposure. However, the potential for waveguide leaks is significant, especially in the flexible sections above the catwalk.

RF field levels inside the Gregorian dome ***exceed*** the FCC's MPE limits for Occupational/Controlled exposure ***even when only 20 percent of the potential power is being distributed to this feed.***

Field Levels with the S-Band CW System

RF field levels above the reflector exceed the FCC limits for General Population/ Uncontrolled exposure and may exceed the MPE limits for Occupational/ Controlled exposure in some areas. ***RF field levels near the Gregorian dome are estimated to be extremely dangerous and present an immediate, extreme risk to human health should anyone go into this area while the S-band system is transmitting.***

Deleted: 8/24/2005

RF Field Levels under the Reflector

This area includes the entire area underneath the 1000-foot diameter reflector.

The levels under the reflector are far below the MPE limits for General Population/Uncontrolled exposure except where there are openings in the reflector surface. These openings are in the center of the reflector and at three points where adjustable tie-down points are located.

RF field levels on the platforms of the three tie-down points and under the center hole of the reflector exceed the MPE limits for General Population/Uncontrolled exposure under several different test conditions. The RF field levels directly underneath these four openings in the reflector can exceed the MPE limits for Occupational/Controlled exposure under worse case conditions with the S-Band system in operation. The high RF field levels extend outward beyond the areas directly beneath the four openings by as much as 3 feet when the feed is tilted significantly off center, which is a fairly common operational condition.

Deleted: at

RF Field Levels around the Perimeter of the Reflector

This area includes all areas within 300 feet of the edge of the 1000-foot reflector. It includes the rim road, the three towers, the guard shack at Tower 4, and the Visitor Center.

The RF field levels on the ground outside the perimeter of the reflector, which includes the rim road, are below the FCC's Maximum Permissible Exposure (MPE) limits for General Population/Uncontrolled exposure and in many areas are below the minimum measurement threshold of the survey instrument. *This is true when either the 430-MHz radar or the S-Band system is operating at full power.*

RF field levels on the observation deck of the Visitor Center were less than 20 percent of the MPE limits for General Population/Uncontrolled exposure under all normal operating conditions with either transmitter operating at full power. Normal operating conditions limit the tilt of the line feed to a maximum of 15º. When the 430 MHz radar is in operation with the line feed tilted to the maximum angle of 19.6º with the operating power at maximum, the RF field levels on the observation deck exceed the MPE limits for General Population/Uncontrolled exposure when the reflected energy from the reflector is directed towards the Visitor Center (line feed pointed 180º away).

The RF field levels at the Guard Shack at Tower 4 are below the MPE limits for General Population/Uncontrolled exposure under all conditions with either transmitter operating at full power.

RF field levels at the upper elevations of the three towers can exceed the MPE limits for Occupational/Controlled exposure under some conditions. The high RF fields occur when either of the feeds is tilted to a fairly high elevation angle and the beam of energy is aimed in the direction of the tower. ***Under these conditions, the upper elevations of the tower are within the main beam of energy from the antenna.***

Deleted: ¶

Deleted: 8/24/2005

RF Field Levels outside the area around the Reflector

This area includes all areas more than 300 feet from the edge of the 1000-foot reflector. It includes all building areas within the observatory and the main road through the facility. It also includes all areas outside the facility.

The RF field levels near the buildings, the main road inside the facility, and outside the grounds of the observatory were less than 0.01 percent of the MPE limits for General Population/Uncontrolled exposure when the S-Band system is operating at half power. This field level is below the typical field levels found in many urban environments.

The actual field levels are not known because they were below the minimum measurement threshold of the most sensitive broadband RF field probes available on the market. Although no measurements were made in this area with the 430 MHz radar in operation, it is quite certain the RF field levels would be even lower.

Statement of Richard R. Strickland, RF Safety Consultant

Richard R. Strickland of RF Safety Solutions LLC certifies that the statements in this report accurately describe, to the best of his knowledge, the conditions on the grounds of Arecibo Observatory in Puerto Rico as they were when surveyed on November 15–16, 2003, and on February 17, 2004. The findings within this report are based on observations from those surveys and sound engineering practice. Changes in operating practices and/or hardware or property reconfigurations should be followed by another survey and report modification as appropriate.

Deleted: 8/24/2005

Table of Contents

Deleted: 8/24/2005

Section 3. Risks and Recommendations

The Gregorian Dome and Waveguide Leaks are Concerns

Appendices

Section
1

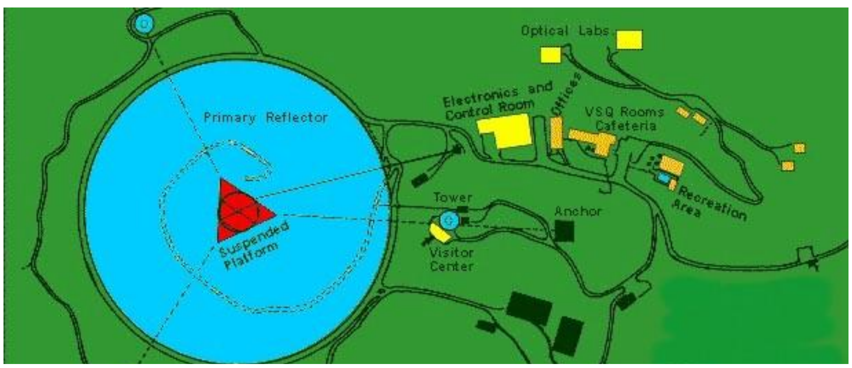
The Arecibo Observatory and RF Regulations

The Arecibo Observatory Must Conform to FCC Regulations

Description of Observatory and Transmission Systems

Description of the Antenna System

The Arecibo Observatory, or NAIC, is located in the mountains several miles south of the city of Arecibo, which is on the north coast of Puerto Rico. This facility is managed by Cornell University in cooperation with the National Science Foundation.

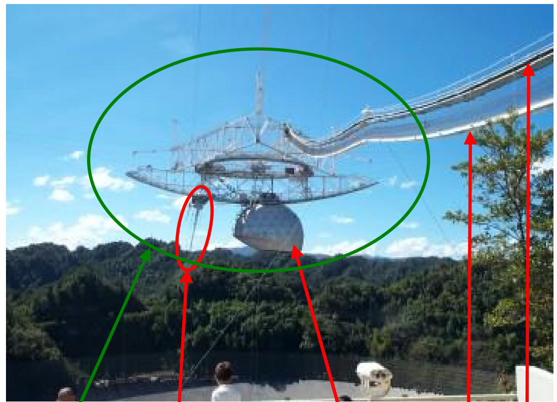


This diagram shows the layout of the NAIC. The important features are the 1,000-foot-diameter reflector, the suspended platform, the three support towers, and the Visitor Center, which is near one of the towers.

The principal feature of the observatory is the very large fixed-reflector antenna that is set into a former sinkhole in the mountains. This is the largest reflector in the world with a diameter of 305 meters (1,000 feet). Normal reflector antennas have a feed at a fixed point centered on the reflector and the entire antenna is moved to point the system. The Arecibo antenna is unique in that it has a large platform suspended over the reflector by cables attached to tall towers near the edges of the reflector. Two feeds—the line feed and the Gregorian feed—are connected to the platform. Both feeds can be tilted from the vertical position and rotated in azimuth. The system is aimed by moving one or both of the feeds. This arrangement requires that the actual illumination pattern be smaller than the reflector since it is often not centered. One concern and reason for the RF survey was to determine whether a significant amount of energy is present outside the perimeter of the reflector. The illumination pattern from the line feed has a very

Deleted: 8/24/2005

steep null in the center where the energy may be as much as 30 dB (1,000:1) below the maximum that extends out about 10º from the center line. The illumination pattern from the Gregorian feed is elliptical. The pattern is 700 feet by 776 feet at the reflector. The energy is concentrated towards the center. It is 7 dB lower at the edge of the pattern.



View of the platform from the Observation Deck of the Visitor Center.

View of the 1,000-foot reflector showing the center hole and the 50-foot-high ground screen along the outer edge of the reflector.

The Visitor Center is located more than 200 feet above the rim of the reflector and more than 200 feet outside the edge of the reflector. It is adjacent to Tower 12.

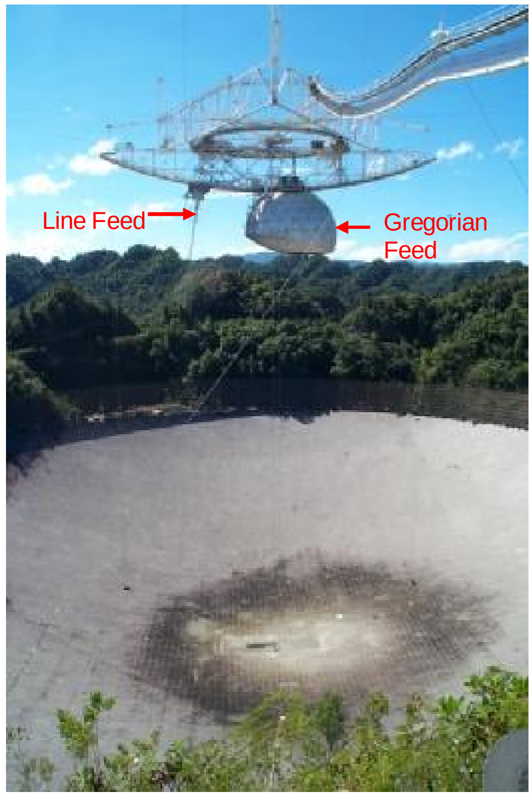
This is a view of the suspended platform from the helicopter pad near Tower 4 and the guard shack.

Deleted: 8/24/2005

Description of the Transmitter Systems

The antenna system is used in receive mode about 85 percent of the time. Two different high-power systems can be used to transmit energy into space. One system is a pulsed radar that operates at 430 MHz. This system has a peak output power of 2,500 kW with a 6 percent duty cycle, or 150 kW average power. The other system is an S-Band CW (continuous wave) system that operates at 2,380 MHz. with a maximum output power of 2,000 kW.

430-MHz Radar System



This pulsed radar operates at 430 MHz. This system has a peak output power of 2,500 kW with a 6 percent maximum duty cycle, or an average power of 150 kW. The transmitter is located in the control building several hundred feet from the reflector. The energy from the transmitter is sent to either the line feed or the Gregorian feed on the platform via a large waveguide. In some test modes, the energy is sent to both the line feed and the Gregorian feed.

The waveguide is mounted about 7 feet above the catwalk that runs between an area near the Visitor Center and the platform. The waveguide is comprised of long sections of rigid, rectangular waveguide with short (2-3 feet long) sections of flexible waveguide in between. This waveguide is subject to considerable mechanical stress when the area experiences high wind conditions which can lead to breaks, especially in the flexible sections. This has occurred in the past and can be expected to happen in the future.

S-Band System

The S-Band CW system operates at 2,380 MHz. with a maximum output power of 2,000 kW. Power is generated by two large Klystrons that are located inside the Gregorian dome. Only the Gregorian feed is used with the S-band transmitter.

Deleted: 8/24/2005

Standards and Regulations

Federal Communications Commission (FCC) Regulations

The FCC updated its RF safety regulations in 1997. Initially, certain sites were "grandfathered" in—not immediately constrained by these new regulations. However, the regulations require that all transmitting sites in the United States must meet all aspects of these regulations as of September 1, 2000.

The FCC Regulations are based on setting limits for human exposure. The FCC limits are similar to, but not identical to, the limits of several other major standards. There are two sets of exposure limits:

- Occupational/Controlled
- General Population/Uncontrolled

These are Maximum Permissible Exposure (MPE) limits averaged over the body and averaged over time. The Occupational/Controlled limits are five times higher than the General Population/Uncontrolled limits at all frequencies above 3 MHz. The averaging period for Occupational/Controlled Environments is six minutes for exposure to frequencies below 15 GHz. The averaging time decreases as the frequency increases from 15 GHz to 300 GHz. The FCC does not allow time averaging for General Population/Uncontrolled Environments. The MPE limits are the same for both the electric field and the magnetic field.

The FCC provides definitions for the two types of exposure and attempts to define when they apply. A simplified view, endorsed by the Occupational Safety and Health Administration (OSHA), is that the more restrictive General Population/Uncontrolled limits apply unless:

- The organization is operating under a written RF safety program.
- The individuals that may be exposed to levels above the General Population/Uncontrolled limits have received RF safety training.

A current Notice of Proposed Rulemaking is aimed at further defining when an organization is allowed to use the higher MPE limits for Occupational/Controlled exposure. The terms *fully aware* and *exercise control* are referred to in the current FCC Regulations when defining the requirements for establishing an Occupational/Controlled environment. The Notice further defines these two important terms.

The phrase *fully aware* refers to workers that:

- Have received both written and verbal information regarding RF radiation.
- Have received training that includes how to control or mitigate RF radiation exposure.

The phrase *exercise control* refers to workers that:

- Understand how to use administrative controls to reduce their exposure level. Administrative controls include time averaging.

- Understand how to use engineering controls to reduce their exposure level. Engineering controls include Personal Protective Equipment (PPE), specifically RF personal monitors and RF protective clothing.

Both of the FCC's MPE limits are shown in the tables below. Limits are spatially averaged over the whole body. The Occupational/Controlled limits are time averaged over six minutes for frequencies below 15 GHz.

Tables 1A and 1B. FCC Regulations MPE Limits

Table 1A. Occupational/Controlled exposure

Frequency (MHz)	Power Density (S) (mW/cm^2)
0.03—3	100
3—30	$900/f^2$
30—300	1.0
300—1,500	f/300
1,500—100,000	5.0

Table 1B. General Population/Uncontrolled exposure

Frequency (MHz)	Power Density (S) (mW/cm^2)
0.03—1.34	100
1.34—30	$180/f^2$
30—300	0.2
300—1,500	f/1500
1,500—100,000	1.0

Occupational Safety and Health Administration (OSHA)

OSHA still has an outdated standard on its books that is based on the first American National Standards Institute (ANSI) standard developed in the 1960s. This is a single-tier standard that suggests limiting exposure to 10.0 mW/cm^2 at all frequencies. The FCC limits are far more restrictive. Under the "General Duty" clause of its regulations, OSHA has been using modern, "consensus" standards, such as the FCC's, as a model for enforcement. OSHA defined its position relative to the FCC regulations in a reply to an official request from the Personal Communications Industry Association (PCIA) in October 1998. In essence, OSHA went on record stating that while it was not relinquishing its role as the agency responsible for worker health, organizations that satisfy FCC requirements would also satisfy OSHA requirements. For this reason, ***only FCC MPE limits are considered in this RF Safety Report.*** Refer to *Appendix B: OSHA/PCIA Correspondence,* for more details. This may be the official position of OSHA, but the evaluator could not identify the corresponding compliance directive. Therefore, local OSHA offices may not be aware of it.

Deleted: 8/24/2005

MPE Limits for NAIC

The facilities surveyed do not qualify to use the FCC's higher MPE limits for Occupational/Controlled exposure. This is because the facility does not operate under an RF safety program. ***NAIC will qualify to use the higher Occupational/Controlled MPE limits in areas not open to the public when it develops and implements an RF safety program.*** An important component of this safety program is the training of all personnel that may work in areas where significant RF fields may exist.

The exposure limits for the Arecibo Observatory vary with frequency as shown in the second chart (General Population/Uncontrolled exposure) on the previous page. These exposure limits are one-fifth of the limits for Occupational/Controlled exposure above 3 MHz. The two previous charts were used to develop the MPE limits for the NAIC shown in the table below.

Table 2. MPE Limits for NAIC

Frequency/System	Power Density (S)	
	General Population/ Uncontrolled	Occupational/Controlled
430-MHz radar	**0.287 mW/cm²**	**1.43 mW/cm²**
2380 MHz CW	**1.0 mW/cm²**	**5.0 mW/cm²**

Section
2

Measurements and Test Methodology

Measurements Compared to FCC Regulations

RF Survey Equipment and Measurement Techniques

RF Survey Equipment

The RF survey equipment used to make the measurements in this report was manufactured by Narda Safety Test Solutions, an L-3 Communications Corporation company located in Hauppauge, New York. The consultant is very familiar with this equipment and its operation. The equipment is comprised of a probe (the sensor), a meter, a cable, and a shielded bag used as a "zero field" reference.

The equipment was in excellent operating condition. Both the meter and the primary probe (S/N 12031) had been last calibrated in September 2002 at the time the first survey was conducted in November2003. The other probe was last calibrated in November 2001. The manufacturer recommends a maximum calibration interval of two years.

The thermocouple sensors in the 8721 series probes are ideal for making measurements of both CW and pulsed systems, such as the 430-MHz radar.

Table 3. RF Survey Equipment Used in Survey of NAIC

DESCRIPTION	MODEL	SERIAL NO.
RF Survey Meter	8715	12009
Electric Field Probe, 300 MHz to 50 GHz, 20 mW/cm² full scale	A8721D	12031
Electric Field Probe, 300 MHz to 50 GHz, 20 mW/cm² full scale	A8721D	04028
Electric Field Probe, 300 kHz to 3 GHz, 100 µW/cm² full scale	8760D	06008

T
h

In addition to the equipment listed above, the NAIC owns a Model 8721 probe and a Model 8718 meter. The Model 8721 probe is very similar to the two Model 8721D probes used by the consultant. The major difference is that this older probe does not have the additional 750 MHz calibration point. This makes the span between calibration frequencies very large when attempting to determine a

Deleted: 8/24/2005

correction factor for 430 MHz since the sensitivity of the probe changes rapidly with frequency in this frequency range. The NAIC instruments had recently been calibrated and the readings were compared at several points to provide additional validation of the measurements taken with the equipment listed in the table above.

Probe serial number 12031 was used to make all the measurements on the first day of the survey (Saturday, November 15, 2003). This probe failed to zero properly on Sunday, the second day of the survey. It was later determined that the sensor had opened. This type of failure does not indicate that the readings taken on the first day were compromised in any way. Due to the failure of the primary probe, probe serial number 04028 was used to make measurements on the second day of the November survey. The different calibration data for the two probes is the reason that two different correction factors are used to adjust the raw data indicated on the meter. The probe was repaired and calibrated in January 2004. This probe was used exclusively during the February survey.

The Narda Safety Test Solutions Model 8715 Survey Meter is used with all 8700 series probes. It has spatial-averaging capability.

These are two Narda Safety Test Solutions 8700 series probes. The smaller probe is the Model A8721D that was used to survey the NAIC facilities. It operates over a frequency range of 300 MHz to 50 GHz. The full-scale rating is 20 mW/cm².

Model A8721D Probe

Deleted: 8/24/2005

Measurement Range

The Model A8721D probe is rated for use from 300 MHz to 50 GHz. The full-scale measurement range of the probe is 20 mW/cm². The probe has a dynamic range of approximately 30 dB (1000:1) which means that it can accurately measure RF fields as low as 0.02 mW/cm². With care and frequent zeroing, field level measurements as low as 0.01 mW/cm² are possible.

The ultra-sensitive Model 8769D probe has a full-scale measurement range of 100 µW/cm². It also has a dynamic range of approximately 30 dB, which means that this probe can be used to accurately measure RF field levels as low as 0.1 µW/cm² generated by the S-Band system. .This is equal to 0.01 percent of the MPE limits for General Population/Uncontrolled exposure.

Although the probe is rated for use at 430 MHz, it would tend to overestimate field levels from pulsed systems such as the subject radar, although the overestimation is not as severe with the very wide pulses typically used with the special 430 MHz radar at Arecibo.

Measurement Technique

The arm holding the probe was constantly moved in a "windmill" fashion to cover the largest possible volume while walking throughout the grounds. More careful measurements were made whenever significant field levels were found. The probe and meter combination were zeroed frequently to compensate for zero drift. Zero drift can become a measurement artifact when using thermocouple probes such as the Model 8721D in an environment where the temperature varies. The presence and absence of cloud cover during the survey at the NAIC was a constant concern in areas where weak fields were being measured since the magnitude of the zero drift is similar to the actual field levels.

The frequent zeroing gives confidence to the field measurements that are reported in this RF safety report. Spatially-averaged measurements were made in areas with significant RF fields.

Measurement Uncertainty

The major component of measurement uncertainty for a probe is normally its frequency deviation. The Model A8212D probe is calibrated at 16 different frequencies to guarantee that the frequency deviation—error versus frequency—is within specification. The maximum frequency deviation for this model probe is ±1.25/-3.0 dB over the entire band of 300 MHz to 50 GHz. The maximum deviation is ±1.25 dB from 1 GHz to 50 GHz. This means that the probe is quite flat above 1 GHz but tends to be insensitive at the low end of its frequency range. The other factors that contribute to measurement uncertainty are less significant.

Since one of the 16 calibration frequencies is 2,450 MHz, measurements made of the 2,380 MHz S-Band system could be made with limited uncertainty due to instruments. These two frequencies are so close that it would be appropriate to use the correction factor for 2,450 MHz to eliminate frequency deviation from the amount of uncertainty.

Deleted: 8/24/2005

At 430 MHz, the amount of measurement uncertainty due to frequency deviation is greatly reduced by using a correction factor derived using linear interpolation based on the correction factors for the two closest calibration frequencies, 300 MHz and 750 MHz. These correction factors are shown in Table 4.

Table 4. Probe Frequency Correction Factors

Frequency	**Probe Serial Number**			
Cal. Date	**Sept. '02**	**Jan.'04**	**Nov. '01**	**Mid-2003**
	12031 (RFSS)		**04028** (RFSS)	**17038** (NAIC)
300 MHz	1.44	1.56	1.26	1.61
430 MHz#	**1.38**	**1.44**	**1.19**	**~1.55**
750 MHz	1.22	1.13	1.00	N/A
1,700 MHz	Not required		Not required	1.02
2,450 MHz*	**1.05**	**0.94**	**1.10**	**.95**

#Derived from correction factors for two nearest calibration frequencies.
* Use the correction factor for 2,450 MHz for measurements made at 2,380 MHz.

It is assumed that measurements made with the consultant's Model 8721D probes have an uncertainty of ±1.5dB (±41 percent) at 430 MHz and of ±1.0 dB (±25 percent) at 2,380 MHz after the correction factors in the table above have been applied.

Therefore, in order to demonstrate compliance with the applicable FCC MPE limits, the RF field measurements should be less than 59 percent* of the limits after the appropriate correction factor (from Table 4 above) has been applied.

*The figure of 59 percent is based allowing for a measurement uncertainty of ±1.5dB, which is equal to ±41 percent of the measured value, after adjustment for the frequency deviation of the probe.

RF Measurements

RF field measurements were made in various locations over three days under different operating conditions. The test conditions are described below.

Test Conditions

Saturday, November 15, 2003
The 430-MHz radar system was in operation conducting experiments with typical operating parameters.

- The system was rotating with the direction reversing.
- The line feed was tilted at 15º. This is normally the maximum tilt angle that is used.
- The power was at 1.5 MW and 4 percent duty, i.e. 60 kW average power.
- The pulse width ranged form 300 to 400 µs (microseconds)
- Both feeds were receiving energy. Therefore, there was 30 kW into the line feed and 30 kW into the Gregorian feed.

Sunday, November 16, 2003
The 430-MHz radar system was in operation. The system was under the control of the personnel conducting the RF survey.

- The line feed tilted at 19.6º, the maximum tilt angle possible.
- The power was at 1.5 MW and 4 percent duty, i.e. 60 kW average power.
- The pulse width ranged from 300 to 400 µs (microseconds)
- All of the power (60 kW) was directed into the line feed.

Tuesday, February 17, 2004
The 430-MHz radar system was in operation. The system was under the control of the personnel conducting the RF survey.

- All measurements were made under the reflector of the antenna. The initial measurements made in November were considered incomplete and were replaced by the data taken during this survey.
- The line feed was tilted in 2º increments from approximately 1º to 19.6º, the maximum tilt angle possible.
- The average power was 25 kW.
- The pulse width ranged from 300 to 400 µs (microseconds)
- All of the power was directed into the line feed.

Tuesday, February 17, 2004
The S-Band CW system was in operation. The system was under the control of the personnel conducting the RF survey.

- The line feed was tilted at 19.6º, the maximum tilt angle possible for all of the measurements except for some of the measurements near the center hole under the dish.
- The output power was 513 kW.
- All of the power was directed into the Gregorian feed.

Personnel

NAIC and Cornell personnel accompanied the consultant during all the measurements and the review of the facilities and hardware. The personnel involved were:

Table 5. NAIC and Cornell Personnel Participating in RF Survey

Name	Title
Reinaldo Velez	Spectrum Manager, NAIC (November survey only)
Edgar Castro	Head of Electronics Department, NAIC
Thomas McGiff	Radiation Safety Officer, Cornell

RF Field Levels

Field Measurements at the Facility

Tables 6 and 7 provide a summary of the RF field levels that were measured during the survey, the measurement conditions including tilt angle and azimuth angle, and the predicted maximum RF field levels at full power. The predicted maximum field levels are calculated from the observed meter readings by applying a probe frequency correction factor and multiplying by the ratio of maximum power to power used during the survey. An indicated raw value of "NMF" means that the field level was below the measurement threshold of the instrument, which is 0.01 mW/cm². There is no predicted maximum power for these areas.

A convention was established to indicate azimuth angle for the purposes of these measurements. An angle of zero degrees (0º) means that the line feed is pointed directly at the point being measured. This also means that the Gregorian feed is at its closest point to the surveyor when the azimuth angle is 180º.

The predicted maximum exposure is simply calculated for each survey point by comparing the predicted maximum field level to the Maximum Permissible Exposure (MPE) level in the 1997 FCC Regulations for both General Population/ Uncontrolled exposure and Occupational/Controlled exposure.

Time averaging was not taken into consideration in the RF levels reported in Tables 6 and 7. Time averaging could be taken into account for occupational exposure situations if a formal RF safety program is implemented. The time-averaged RF field levels would be much lower than predicted maximum field levels shown in Tables 6 and 7 for most locations providing that the feed is moving in azimuth. The exceptions are all locations on the platform and under the reflector, where the rotation would not make a significant difference under most conditions. Values in the tables shown with an "X" indicate multiples of the MPE limits, i.e. 2X means 200 percent of the limit.

Field Levels Outside the Observatory

Measurements were attempted along the main road of the observatory and in areas outside the facility while the S-Band system was operating at half power. The ultra-sensitive Model 8760D probe was used to attempt these measurements. In addition to the measurements along the main road inside the observatory grounds, the parking area outside the main gate and several points along the public road that leads to the observatory as far as a half-mile from the main gate were measured. The RF field levels in all of these areas were below the minimum measurement threshold of the instrument, which means that the fields were less than 0.01 percent of the MPE limits for General Population/ Uncontrolled exposure. This field level is below the typical field levels found in many urban environments.

Table 6. RF Field Levels Generated by 430-MHz Radar

DP U-	Location	Angle (º)		Meter[1]	Max[2]	Percent MPE[3]	
		Az.	Tilt	mW/cm²		Gen P.	Occup.
Data points 1-14 measured with 60 kW split equally between both Gregorian and Line feeds.							
1	Operations building, front	Rotating	Rotating	NMF			
2	Lewis Building	Rotating	Rotating	NMF			
3	Edge of dish, entrance road	0	15.0	0.02	0.138	48.1%	9.6%
4	Edge of dish, entrance road	180	15.0	NMF			
5	Catwalk	Rotating	Rotating	0.02	0.138	48.1%	9.6%
6	Tower 12, top of tower	180	15.0	1.43	9.867	34.4 X	6.9 X
7	Tower 12, bottom of top section	0	15.0	1.06	7.314	25.5 X	5.1 X
8	Tower 12, bottom of top section	180	15.0	0.045	0.311	108.3%	21.7%
9	Rotary Joint	Rotating	Rotating	0.02	0.138	48.1%	9.6%
10	Over carriage house, on catwalk	Rotating	Rotating	0.03	0.207	72.2%	14.4%
11	Below waveguide under catwalk	Rotating	Rotating	3.5	24.150	**84 X**	**16.8 X**
12	Catwalk, over dome	Rotating	Rotating	0.02	0.138	48.1%	9.6%
13	Gregorian, inside door	Rotating	Rotating	10	69.000	**240 X**	**48 X**
14	430-MHz transmitter room	Rotating	Rotating	0.02	0.138	48.1%	9.6%
Data points 15-22 measured with 60 kW into the Line feed.							
15	Visitor Center Viewing Area	180	19.6	0.13	0.387	134.9%	27.0%
16	Visitor Center Viewing Area	0	19.6	NMF			
17	Visitor Center Viewing Area	Other	19.6	NMF			
18	Visitor Center Viewing Area	180	15.0	0.05	0.149	51.9%	10.4%
19	Tower 4 guard shack	0	19.6	0.02	0.060	20.8%	4.2%
20	Tower 4 guard shack	180	19.6	0.05	0.149	51.9%	10.4%
21	Tower 4 guard shack	0	15.0	NMF			
22	Tower 4 guard shack	180	15.0	NMF			
Data points 23-28 measured with 25 kW into the Line feed.							
23	~ 30 ft. from center hole	N/A	8.8	0.01	0.086	30.1%	6.0%
24	Center hole, highest point found	N/A	8.8	0.01	0.086	30.1%	6.0%
25	Center hole, highest point found	N/A	11.0	0.02	0.173	60.3%	12.1%
26	Center hole, highest point found	N/A	13.0	0.03	0.259	90.4%	18.1%
27	Center hole, highest point found	N/A	15	0.05	0.432	150.7%	30.1%
28	Center hole, highest point found	N/A	17	0.02	0.173	60.3%	12.1%

Notes for Tables 6 and 7:

1. Meter readings are the actual values indicated in the meter. These readings do not include a correction for frequency deviation or a correction to compensate for the system not being operated at full power.
2. The predicted maximum field levels are calculated from the observed meter readings by applying a probe frequency correction factor and multiplying by the ratio of maximum power to power used during the survey.

Deleted: 8/24/2005

Notes for Tables 6 and 7 (continued):

3. Values in the tables shown with an "X" indicate multiples of the MPE limits, i.e. 2X means 200 percent of the limit. (Notes for Tables 6 and 7 continued on next page.)
4. An indicated raw value of "NMF" means that the field level was below the measurement threshold of the instrument, which is 0.01 mW/cm². There is no predicted maximum power for these areas.
5. The meaning of the red, orange, and yellow highlighting is explained on page 22.

Table 7. RF Field Levels Generated by S-Band CW System

DP S-	Location	Angle (º)		Meter[1]	Max[2]	Percent MPE[3]	
		Az.	Tilt	mW/cm²		Gen P.	Occup.
1	Visitor Center Viewing Area	180	19.6	0.1	0.183	18.3%	3.7%
2	Visitor Center Viewing Area	0	19.6	0	0.000	0.0%	0.0%
3	Visitor Center Viewing Area	180	19.6	0	0.000	0.0%	0.0%
4	Tower 4, ground level	180	19.6	0.28	0.513	51.3%	10.3%
5	Tower 4, guard shack level	180	19.6	0.35	0.641	64.1%	12.8%
6	Behind ground screen	0	19.6	0.11	0.202	20.2%	4.0%
7	Edge of dish: 10 ft behind	0	19.6	0.09	0.165	16.5%	3.3%
8	Edge of dish, inside reflector	0	19.6	1.5	2.749	275%	55.0%
9	Edge of dish, inside reflector	180	19.6	0.06	0.110	11.0%	2.2%
10	Tower 8, on platform at base	180	19.6	0.04	0.073	7.3%	1.5%
11	Tower 8, tie-down area	180	19.6	0.01	0.018	1.8%	0.4%
12	Under dish, ~30' from center hole	N/A	19.6	0.02	0.037	3.7%	0.7%
13	Under dish, edge of center hole	N/A	19.6	0.01	0.018	1.8%	0.4%
14	Under center hole of dish	N/A	19.6	1.7	3.115	312%	62%
15	Tie down 4, platform	0	19.6	2.5	4.581	458%	92%
16	Tie down 4, platform	N/A	1	0.12	0.220	22.0%	4.4%
17	Under dish, ~30' from center hole	N/A	1	0.07	0.128	12.8%	2.6%
18	Under center hole of dish	N/A	1	4.5	8.246	825%	165%
19	Control room deck	180	19.6	0.01	0.018	1.8%	0.4%

Analysis of RF Field Levels

The analysis of the RF fields must be made in comparison to two sets of FCC MPE limits. The MPE limits for Occupational/Controlled exposure factor in a six minute time averaging period. Thus, for situations where there are significant RF fields only when the energy is directed towards the work point and the platform and feed(s) are rotating, the time-averaged exposure for the worker is far lower than what is indicated in Tables 6 and 7. Therefore, if workers wear appropriate RF personal monitors, as described and recommended in Section 3 of this report, they would be able to determine whether the exposure situation is continuous or only transient as the feed rotates. This also assumes that the NAIC develops and implements an RF safety program so that the appropriate areas of the facility are controlled and therefore eligible to use the higher MPE limits for Occupational/ Controlled exposure. The higher MPE limits for Occupational/Controlled exposure are not only a matter of compliance with FCC regulations but also a true

Deleted: 8/24/2005

safety concern. The goal is to never allow personnel a time-averaged exposure that exceeds these limits.

The second set of limits is solely an issue of compliance with FCC Regulations. It is possible to exceed the MPE limits for General Population/Uncontrolled exposure at the Visitor Center with the 430 MHz radar when the tilt angle exceeds 15º and the energy is directed in azimuth towards the Visitor Center. Since time averaging is never allowed in uncontrolled areas unless the situation is controlled by equipment design and is independent of human behavior, such as in a radar, the rotating feed does not help reduce the exposure level in the eyes of the FCC unless the NAIC were to guarantee that rotation would never stop. Given the experimental nature of the work performed at the NAIC, this would appear to be a risky assumption.

The measurement points in Tables 6 and 7 where it is possible to exceed the FCC MPE limits for General Population/Uncontrolled exposure but most likely would not be a serious safety risk providing that the platform and/or personnel were moving are highlighted in yellow. There is one area under the center hole of the reflector (data point #S-18) where it is possible to exceed the Occupational/Controlled MPE limits when the S-band radar is operating at full power but since the fields are highly variant spatially, individuals that are continuously moving, even if they are always under the center hole, would most likely not exceed the MPE limits on a time-averaged basis.

The measurement points in Tables 6 and 7 where RF safety is a very serious concern are highlighted in red. *There are no red areas shown for the S-Band CW system because no measurements were attempted anywhere on the platform or catwalk.*

The catwalk and all other areas within 10 feet of the waveguide are potentially dangerous should a leak occur in the waveguide. For this reason, Table 6 has the catwalk highlighted in orange.

Deleted: 8/24/2005

Section

3

Risks and Recommendations

The Gregorian Dome and Waveguide Leaks are Concerns

Overview

There are always risks associated with high-power RF transmission equipment. The goal is always to understand and manage operations so that risks are minimized. ***The RF field levels in the vicinity of the platform and especially the Gregorian dome are extremely dangerous when the S-Band system is transmitting. Even when the lower-power 430-MHz radar system is transmitting, the RF field levels inside the Gregorian dome are 40 to 50 times the MPE limits for Occupational/Controlled exposure when the full power of the system is directed into this feed. The other concern is leaks due to acute hardware failure, especially from a break in the flexible waveguide.*** RF field levels on the ground around the reflector are generally low. RF fields under the reflector at the center hole and at the tie-down points are significant under certain operating conditions when the S-Band system is in operation.

Formatted: Font: Bold

Risks

Risks for Arecibo Observatory

RF safety risks at this facility are modest. However, the very large transmitters are capable of generating extremely high RF fields when the energy is concentrated in small areas.

Therefore, the identified potential RF hazards at the Arecibo Observatory are:

- Inside the Gregorian dome whenever the Gregorian feed is in use.
- Anywhere within 10 feet of a leak in the flexible waveguide used to conduct the 430-MHz energy from the transmitter to the feeds on the platform. The potential for exposure to a leak exists along the entire catwalk.
- Anywhere above the reflector when the S-Band CW system is transmitting.

Deleted: 8/24/2005

- At the higher sections of the three towers under certain operating conditions. This area would not be dangerous providing the feed is not stopped with the energy directed at the tower.

- The area adjacent to the slotted length of waveguide that runs under the walkway on the azimuth arm of the platform.

- Underneath the reflector near the openings in the reflector surface when either the 430 MHz radar or the S-band CW is transmitting. The breaks in the reflector are located in the center and near three tie-down points. The risks are modest and only occur under worse case conditions.

The RF field levels at the Visitor Center are well below the FCC's MPE limits for General Population/Uncontrolled exposure under most operating conditions. The RF field levels may exceed those limits when the line feed is pointed away from the observation deck at the highest possible tilt angle of 19.6º. Although these field levels are not a health concern, they are a concern in terms of FCC compliance and public relations.

Medical Device Interference

Medical Device Interference is a risk that is very difficult to quantify but cannot be ignored at the NAIC. This risk exists for both NAIC personnel and visitors. The numbers and types of implanted and external medical devices, such as pacemakers, pumps, and defibrillators, have increased dramatically in recent years. These devices can malfunction in RF fields that are several orders of magnitude below the MPE limits imposed by the FCC. In many cases, devices will only be susceptible to certain frequencies, which is why incidents of malfunction do not occur too often. At the NAIC, the 430-MHz radar is of particular concern because interference can occur as a result of peak energy levels while the impact on humans is based on average field levels.

Recommendations

Overview

The major requirements are to:

1. Ensure safety from hazardous RF fields for personnel working at the Arecibo Observatory.

2. Insure that the RF field levels in all areas where visitors may be present are below the FCC's MPE limits for General Population/Uncontrolled exposure.

3. Allow the greatest amount of operational flexibility without compromising personnel safety.

Deleted: 8/24/2005

Specific Recommendations

The current practice is to prohibit personnel from being in certain areas during transmitter operation. Yet, some restrictions are based on inaccurate assessments of the actual and the potential RF fields that might be present. There is anecdotal evidence that personnel have gone into some areas where high RF fields have been present. The recommendations below are designed to achieve the three goals described above.

Visitor Center

The line feed should not be operated at a tilt angle greater than 15º when there is the potential for visitors to be present on the observation deck.

The observatory should consider installing a fixed RF monitor on the observation deck of the Visitor Center. This monitoring system is not required for compliance or safety but it may be desirable from a public relations point of view in light of some recent newspaper articles about the observatory.

The observatory should consider installing caution signs regarding medical device interference. The wording of these signs deserves considerable thought. The goal is to caution visitors that have implanted or external medical devices without causing undue concern with other visitors. People that have such medical devices are usually warned to avoid places where significant RF energy might be present so such a sign should not surprise them.

Rim Road and Guard Shack

There is no need to restrict access to any part of the rim road or to the guard shack during transmitter operations.

Towers

Personnel should not be allowed to go more than halfway up any of the towers during transmitter operation unless they are wearing an approved RF personal monitor.

Catwalk & Other Areas Adjacent to the 430-MHz Waveguide

Personnel should not be allowed to go on the catwalk or anywhere else within 10 feet of the waveguide during 430-MHz transmitter operations unless they are wearing an approved RF personal monitor. Personnel should not be allowed to go on the catwalk during S-Band CW system operation.

Platform

Personnel should not be allowed to go anywhere on the platform during S-Band CW transmitter operations. Personnel may be allowed on the platform during 430-MHz radar operation if they wear an approved RF personal monitor.

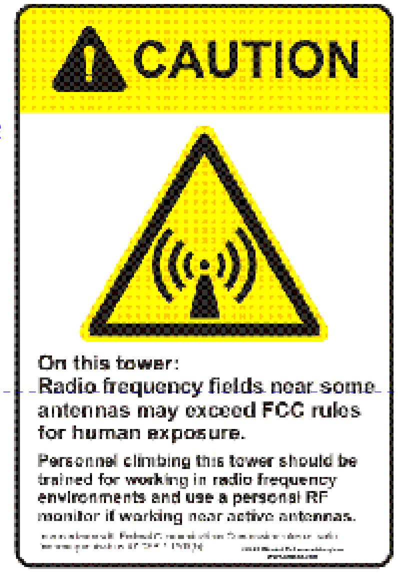
Gregorian Dome

Personnel should never be allowed inside the Gregorian dome during any transmitter operations involving the Gregorian feed.

Underneath the Reflector

Personnel should not be allowed to go underneath the reflector during transmitter operations as the site was configured during the survey unless they are wearing an approved RF personal monitor.

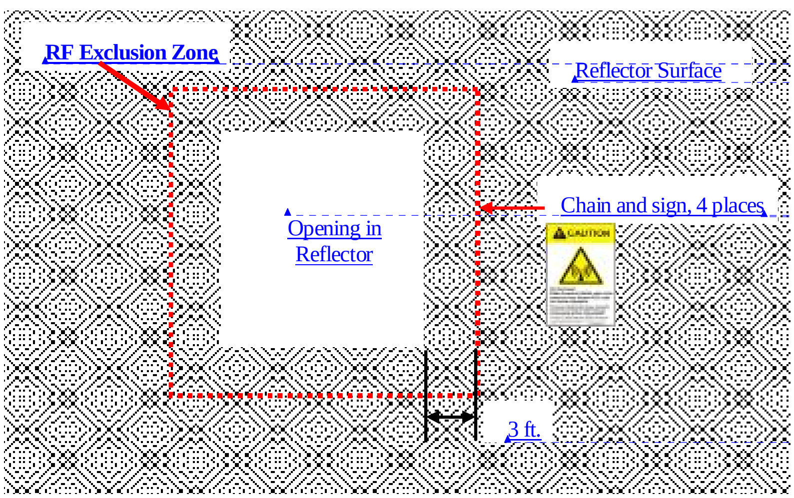
This recommendation is designed to prevent personnel from inadvertently entering areas underneath the reflector where there are large openings that allow significant levels of RF energy to reach the ground below the reflector. There are four areas where this occurs—underneath the center hole and underneath the three tie-down holes. The areas of concern extend 2 to 3 feet in every direction beyond the area below each hole since the platform and the two feeds do not remain centered over the reflector.



The alternative to classifying the entire area under the reflector underneath the reflector as an RFR site is to ***clearly*** identify the four areas described above as RF exclusion zones. The recommended approach is to use chains with signs hanging from the chains on each side of each exclusion zone. The recommended sign for these exclusion zones is the CAUTION sign shown here.

It is recommended that each exclusion zone extend out 3 feet in each direction beyond the size of the opening in the reflector. A schematic representation of this recommendation is shown in Figure 1.

Figure 1. RF Exclusion Zone Underneath Reflector Openings



Formatted: Font: Bold, Italic

Formatted: Font: 12 pt, Bold

Formatted: Body Text Indent, Centered

Deleted: Catwalk & Other Areas Adjacent to the 430-MHz Waveguide¶
Personnel should not be allowed to go on the catwalk or anywhere else within 10 feet of the waveguide during 430-MHz transmitter operations unless they are wearing an approved RF personal monitor. Personnel should not be allowed to go on the catwalk during S-Band CW system operation.¶
Platform¶
Personnel should not be allowed to go anywhere on the platform during S-Band CW transmitter operations. Personnel may be allowed on the platform during 430-MHz radar operation if they wear an approved RF personal monitor.¶
Gregorian Dome¶
Personnel should never be allowed inside the Gregorian dome during any transmitter operations involving the Gregorian feed.¶

Formatted: Font: 12 pt

Formatted: Font: Bold

Formatted: Font: Times New Roman, Bold, Font color: Blue

Formatted: Font: Times New Roman, Font color: Blue

Formatted: Font: Times New Roman, Font color: Blue

Formatted: Centered

Formatted: Font: Times New Roman, Font color: Blue

Formatted: Font: Times New Roman, Font color: Blue

Deleted: 8/24/2005

Summary of Recommendations

Formatted: Heading 3

Table 8 provides a summary of the access recommendations for the NAIC during transmitter operations.

Table 8. Summary of RF Safety Access Recommendations

Location	430 MHz Radar	S-Band CW System
Visitor Center	No visitors if tilt angle is >15º	No Restrictions
Rim Road & Guard Shack	No Restrictions	No Restrictions
Under the Reflector except Exclusion Zones	No Restrictions	No Restrictions
Towers	Wear RF Monitor above mid level	Wear RF Monitor above mid level
Under the Reflector in Exclusion Zones	Wear RF Monitor	Wear RF Monitor
Catwalk	Wear RF Monitor	No Access Allowed
Areas near waveguide*	Wear RF Monitor	N/A
Platform	Wear RF Monitor	No Access Allowed
Gregorian Dome	No Access Allowed	No Access Allowed

Formatted Table

*This includes all areas within 10 feet of waveguide in addition to the catwalk.

RF Personal Monitors

RF personal monitors are an ideal solution for RF environments where substantial levels of RF energy may be present, where conditions are subject to rapid change, or where the actual RF field levels may not be well known for all conditions. The Arecibo Observatory satisfies all of these criteria. Field levels at all locations under all conditions are not fully known. Equally important, conditions are constantly changing because this is a research facility and are subject to change at any time due to a hardware failure, especially a waveguide leak.

The only RF personal monitors that are suitable for the RF environment at the Arecibo Observatory are the FCC versions of the Nardalert XT series. The two appropriate models are:

1. **Model A8860**: This model incorporates a data-logging capability.

Deleted: 8/24/2005

2. **Model A8862**: This model does not have the data-logging feature but is otherwise identical to the Model A8860.

Both of these monitors operate from 100 kHz to 100 GHz. Their sensitivity is frequency dependent in accordance with the FCC's MPE limits for Occupational/Controlled exposure. The LED indicators and audible and vibrator alarms are activated in terms of percentage of the exposure limits for Occupational/Controlled exposure.

Nardalert XT RF Personal Monitor

Area Monitor

Should it be decided to install an area monitor on the observation deck of the Visitor Center, it is important to use a monitor suitable for the RF environment. The Narda Safety Test Solutions SMARTS II series, Model A8830, has sensors very similar to the Nardalert XT personal monitors. It operates from 2 MHz to 100 GHz. It has adjustable sensitivity and several options to activate an alarm indicator. It is recommended that if this system is installed, the alarm indicator should not be an external alarm on the observation deck but rather an indication in the control room. The SMARTS II should be installed in the optional weatherproof housing.

Additional Training

A significant number of personnel recently received RF safety training. It is very important to insure that all personnel who work on the platform, climb the towers, or work underneath the reflector receive RF safety training. This includes current personnel and any new hires. In addition, if it is decided to use RF personal monitors in order to improve safety and to allow more flexibility for maintenance operations, it will be important to train the personnel in the proper use of the RF personal monitors.

The NAIC cannot operate under an RF safety program without training its workers. The FCC requires that workers be *fully aware,* which refers to workers that:

- Have received both written and verbal information regarding RF radiation.
- Have received training that includes how to control or mitigate RF radiation exposure.

Training is an integral part of an RF safety program and a prerequisite for the NAIC to qualify as a controlled environment and thus be able to use the MPE limits for Occupational/Controlled exposure.

It is also recommended that RF safety training be taught annually to all personnel who work on the platform, climb the towers, or work underneath the reflector.

Deleted: <sp>

Deleted: ¶

Formatted: Font: Times New Roman

Deleted: <sp>¶
¶

Deleted: 8/24/2005

NAIC Survey Equipment

The NAIC survey equipment, which is comprised of a Model 8718 meter and a Model 8721 probe, are ideal for the two transmitters at the observatory. That said, there are two upgrades that will make the equipment more accurate and easier to use. Since the equipment was just calibrated, it is reasonable to wait until late 2004 to have these changes implemented.

Meter

The meter should be upgraded by the manufacturer. This upgrade includes updated hardware and all new firmware (internal software) that is much easier to use. The new configuration is covered in a very detailed operations manual that is not available for the current configuration. The battery should be replaced during the upgrade.

Calibration

There are three recommendations involving calibration of the survey equipment:

1. Use the manufacturer's "Express Cal" service to reduce the total turn around time to two weeks plus shipping time.
2. Add a calibration point at 430 MHz.
3. Shift to an 18-month calibration interval for the meter and probe.

Appendices

Appendix A: Survey Data and Calculations

The data that was collected was corrected for probe frequency deviation as discussed in Section 2. The maximum predicted RF fields were calculated from the raw data using the corrected measurements and adjusted for the full output power of the system. The projected maximum field levels for the 430-MHz system are based on feeding all available power into one of the two feeds.

Deleted: 8/24/2005

Deleted: 8/24/2005

Appendix B: Consultant Qualifications

For ten years, Richard R. Strickland was the Director of Business Development for Narda Safety Test Solutions, the world's leading supplier of RF safety measurement and monitoring products. As director of the RF safety business at Narda, Mr. Strickland determined which products were developed and their performance characteristics. He frequently functioned as program manager, as he did with the Nardalert XT RF personal monitor. He initiated the development of RF radiation training courses at Narda and has conducted courses ranging from basic employee awareness seminars to in-depth application specific courses. Audiences have included environmental health and safety professionals, engineers, technicians, attorneys, communications industry professional consulting engineers (PEs), and senior managers of major corporations, government organizations, and professional groups. Mr. Strickland has taught more than eighty public and private seminars on RF radiation safety. In-house course clients include the National Association of Broadcasters, National Public Radio, Sony, Motorola, NYNEX Mobile, ABC, ESPN, the U.S. Army, Bell Atlantic Mobile, Ameritech, Primeco, NORTEL, Texas Instruments, and Northrup-Grumman. He has been both a featured speaker and a member of the radio frequency radiation panel at the National Association of Broadcasters, the Radio Club of America, and the International Wireless Conference and Exposition. He is a member of IEEE SC 28 P1466. The project scope of this group is "Preparation of a guidance document for the development of RF safety programs." Mr. Strickland is the author of numerous articles on RF safety practices and measurement issues.

Recent Customers

Richard Strickland provides advice regarding RF radiation safety to several major companies. Services include RF surveys and RF safety reports, development of RF safety programs, and RF safety training.

Current clients include:

- ABC Television
- ABC Radio Network
- ESPN
- Lockheed Martin Corporation
- NBC Television
- Raytheon
- United States Coast Guard

Deleted: 8/24/2005

Education

- MBA, University of Massachusetts, 1980
- BA Physics, Bridgewater College, 1972
- Advanced (radar & IFF) and basic electronics courses, U.S. Coast Guard

Presentations & Publications

- Articles published in >35 technical publications on RF safety, high-power amplifiers, and radomes.
- Organized and conducted >80 public and in-house training courses
- Featured speaker for numerous professional organizations including NATO, National Public Radio, National Association of Broadcasters, and Radio Club of America

Professional Memberships

- Member of the International Electrotechnical Commission (IEC) Technical Advisory Group (TAG) 106: Methods for the Assessment of Electromagnetic Fields Associated with Human Exposure
- Member of the IEEE CS 28 P1466, guidance document for the development of RF safety programs
- Member of the Association of Federal Communications Consulting Engineers (AFCCE)
- Member of the IEEE and IEEE Antennas and Propagation Society

Awards

- Winner of the R & D 100 Award for the Nardalert XT RF Personal Monitor. Mr. Strickland was the originator of this product. He functioned as project manager and decided on all of its features and design details. The R & D 100 Awards are given annually to the top 100 scientific and technological achievements in the world. They are frequently referred to as "the Nobel Prizes of Applied Research".

Appendix C: OSHA/PCIA Correspondence

Letter from Personal Communications Industry Association (PCIA) to Department of Labor Occupational Safety and Health Administration (OSHA), September 3, 1998

The Personal Communications Industry Association (PCIA) wrote this letter to obtain written confirmation from OSHA concerning that organization's position relative to the FCC's 1997 RF Safety Regulations. The FCC, OSHA, and PCIA met a few days prior to the writing of this letter to try to get a definitive position statement from OSHA. Up until this point, OSHA had been giving out often confusing and conflicting information on what it required for compliance with RF safety regulations, especially within the communications industry.

Letter from Occupational Safety and Health Administration (OSHA) to Personal Communications Industry Association, October 5, 1998

This is OSHA's official response to the PCIA letter dated September 3, 1998. While maintaining its legal rights, the letter in essence clearly states that it will accept full compliance with the FCC's 1997 RF Safety Regulations as fully satisfying OSHA in this area. The letter states "For purposes of construction or maintenance activities, OSHA will consider employers who are in compliance with the FCC standards as they relate to employee RF exposure to be in compliance with OSHA requirements."

Deleted: 8/24/2005