Non-ionizing Radiation Hazards With the High-Power X-Band Transmitter

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This article describes the results of a survey made to determine if any personnel hazard due to non-ionizing (microwave) radiation would be present when operating the 400-kW X-band transmitter at the Mars (DSS 14) station. This survey showed no significant hazards due to non-ionizing radiation.

I. Introduction

Traditionally, any time a DSN station is reconfigured in such a manner as to change its power output, operating frequency, or microwave configuration that in turn may alter its radiation pattern, a survey is conducted to determine if any personnel hazards are present. The Developmental Support Group, Section 335, has, in general, been responsible for these measurements.

Although the normally accepted level of non-ionizing radiation for safety is 10 mW/cm^2 (Ref. 1), there is some argument in favor of a lower power density standard for normal working conditions. JPL has used a power density of 1.0 mW/cm^2 as a working limit for personnel safety (Ref. 2).

In preparation for the MJS'77 mission, a 400-kW X-band (8495 MHz) CW radar has been installed on the DSS 14 64-m antenna. This radar is to determine the structure of the rings of Saturn in preparation for spacecraft encounter. This high-power radar installation represents a significant extension of the capabilities of DSS 14, and previous experience with high-power X-band operation of the DSS 13 100-kW X-band transmitter on the 9-m antenna has indicated a possibility of hazardous radiation levels (Ref. 3).

II. Procedure

Since this survey was conducted for the sole purpose of determining if any personnel hazards exist due to non-ionizing radiation, an isotropic survey probe was used. Although other techniques, such as a power meter and standard gain horn, are more sensitive than the isotropic probes, the standard gain horn tended to give readings 6 to 10 dB lower. This is because the stray radiation from an antenna does not, in general, present a plane wavefront to the signal gain horn. The isotropic probe has a much smaller aperture so the phase error across the measurement aperture is not significant.

The Narda Model 8315 power density meter and the Narda Model 8321 isotropic probe were used to conduct this survey. The minimum detectable signal with these instruments is approximately 0.1 mW/cm^2, giving a safety factor of 10 over the minimum hazard level. The Narda instruments have a history of reliability, and their usage is approved by the JPL Safety Office. In addition, two instruments were used in some instances as a cross-check. A catastrophic failure of one instrument (not due to a fault within the instrument) prevented complete redundancy throughout this survey.

This survey was conducted in two parts. The first part was with the antenna in the stowed (zenith) position, and a survey of work locations, both on the antenna and at the station in general, was made. Also, normally used access routes (ladders, stairways, sidewalks, etc.) were searched for possible hazards. The second part of this survey was conducted with the antenna in several positions representing beginning, mid-point, and end of a Saturn track (planet rise, meridian crossing, and set). During the second part of this survey, no checks were made of the antenna structure itself.

III. Results

The results of the first part of the survey with the antenna in its stowed (zenith) position are shown in Table 1. The areas in excess of 1.0 mW/cm^2 are confined to the Module III area of the cone. This is the area immediately below the feed cones and is primarily used for receiver equipment. These "hot spots" are associated in all cases with hatches and doorways. All areas below the surface of the antenna were "cold," and no hazardous spots were detected.

Table 2 gives the observed data of that portion of the survey with the antenna in typical Saturn tracking positions. The significant feature is the lack of stray microwave radiation. At the conclusion of this test, the antenna was raised to zenith with the probe held in one spot to determine if spill-over or hyperboloid/quadripod scatter could cause a radiation hazard. No significant signals were detected during this test.

IV. Conclusions

Based on the data in Tables 1 and 2, the operation of an X-band 400-kW transmitter on the DSS 14 64-m antenna will not result in any hazard to personnel if personnel are restricted to areas below the antenna surface during high-power operations. By more effectively sealing the hatches and doors in the Module III area, it would be possible to allow personnel to work in the Module II and III areas without hazard during high-power X-band radiation.

References

1. *Safety Level of Electromagnetic Radiation with Respect to Personnel*, USAS C95.1-1966, United States of America Standards Institute, 1966.
2. *Radiation Precautions in the Deep Space Instrumentation Facilities*, EPD-108, Aug. 1, 1962 (JPL internal document).
3. Kolbly, R. B., *Non-Ionizing Radiation Hazard Survey at Venus 9 Meter Antenna*, IOM 335C-71-060, Oct. 15, 1971 (JPL internal document).

Table 1. DSS 14 radiation survey (antenna at zenith)

Location	Transmitter power, kW	Measured value, mW/cm²	Expected value at 300 kW, mW/cm²
Module III area			
Right access door	100	0.1	0.3
Left access door	100	0.3	0.9
XKR cone access hatch	200	2.0	3.0
SMT cone access hatch	150	0.8	1.6
Room area in general	150	<0.1	0.1
RF connector at TWT	150	1.5	1.5[a]
Hatch near harmonic filter (unused)	200	5.0	7.5
Central hub area (overhead)	300	0.7	0.7
Module II area			
Transmitter bay doors	300	0.2	0.2
Room work areas (overall)	300	<0.1	<0.1
Hub area			
Surface access door	300	0.1	0.1
Ladder area	180	<0.1	<0.1
Lower hub area	300	<0.1	<0.1
Elevation axis catwalk	300	<0.1	<0.1
Elevation bearing platform	300	<0.1	<0.1
Stairway above elevation bearing	300	<0.1	<0.1
Elevation drive platform	300	<0.1	<0.1
Lower elevation drive platform	300	<0.1	<0.1
Filter house area	300	<0.1	<0.1
Azimuth platform	300	<0.1	<0.1
Maser compressor area	300	<0.1	<0.1
Stairway to ground	300	<0.1	<0.1
Walkway to control building	300	<0.1	<0.1
Control room	300	<0.1	<0.1
Butler building general area	300	<0.1	<0.1
Generator building (G-81)	300	<0.1	<0.1

[a]Not a function of transmitter power.

Table 2. DSS 14 radiation survey (tracking positions)[a]

Location	Saturn rise (Az = 84.0°, El = 10.8°), mW/cm²	Saturn meridian crossing (Az = 180.0°, El = 76.0°), mW/cm²	Saturn set (Az = 282.0°, El = 10.8°), mW/cm²
DSS 14 control room	<0.1	<0.1	<0.1
Walkway to 64-m antenna	<0.1	<0.1	<0.1
64-m antenna chain perimeter	<0.1	<0.1	<0.1
Directly below disk lip	0.10	<0.1	0.12
Steps to heat exchanger	0.15	<0.1	<0.1
30 m (100 ft) on dish axis	<0.1	<0.1	<0.1
15 m (50 ft) east of G-83 heat exchanger	0.12	<0.1	<0.1
Building G-82	<0.1	<0.1	<0.1
MG Set and G-82 area	<0.1	<0.1	<0.1
West wind tower	<0.1	<0.1	<0.1
G-81 (power house)	<0.1	<0.1	<0.1
SSE Butler building	<0.1	<0.1	<0.1
Front of control building	<0.1	<0.1	<0.1
Road to guard station	<0.1	<0.1	<0.1
Guard station	<0.1	<0.1	<0.1
Road to rear of control room	<0.1	<0.1	<0.1

West survey marker plate antenna plunge test (Az = 282.0°, 10.8 <El <87°): <0.1 mW/cm² (weak signal ≈0.1 mW/cm² as hyperboloid went out of view ≈22° elevation)

[a] $P_{T\,Radiation} = 300$ kW.