# Development of a Bird Net Cover for DSN Beam-Waveguide Antennas

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*This article discusses the development of a net designed to keeps birds out of the 34-m beam-waveguide antenna opening on the dish surface. Test results on a prototype net showed that the net did not deteriorate when 20 kW at 7.165 GHz were transmitted through it. When dry, the worst-case net contribution to the system-noise temperature was measured to be 0.04 K and 0.18 K at 8.425 GHz and 32 GHz, respectively. When wet, the worst-case net contributions were 0.4 K at 8.425 GHz and 3 K at 32 GHz.*

## I. Introduction

A serious problem at overseas beam-waveguide (BWG) antennas is birds getting inside the BWG opening. Since birds are blackbody noise-temperature radiators, they cause noise-temperature increases and fluctuations whenever they fly through any portion of beam of the downlink signal in the BWG system. Also, the bird droppings on BWG mirrors create a bigger problem. A way to keep birds out of the BWG system is to cover the BWG opening with a low-loss net. It is required that the net be able to withstand high power radiation when the uplink signal transmits through it and also that it contribute negligible (less than 0.2-K) increases in the system-noise temperatures at any of the operating frequency bands. In the following, the design of the net that was developed and tested at DSS 13 is described. Henceforth in this article, the term system temperature will be used. It is synonymous with the terms system-noise temperature and operating-system temperature.

## II. Description of the Net Cover

Figure 1 shows the prototype net being installed at the BWG opening on the dish surface at DSS 13. The wooden outer ring that holds the net taut is about 2.438 m (8 ft) in diameter, or about the same diameter as the base of a Cassegrain cone. Figure 2 shows a bird's-eye view of the installed net, and Fig. 3 shows a close-up view of the design features of the net. The grid size is 3.81 by 3.81 cm (1.5 by 1.5 in.). The net was woven with a 0.46-mm (0.018-in.)-diameter nylon filament thread. Different depth slots in the outer wooden ring force orthogonal weaves to be noncontacting (see Fig. 3). These orthogonal threads were purposely made to be noncontacting so that water from rain would drip off more quickly than it would for conventional nets, where orthogonal rows have contact points at the four corners

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The research described in this publication was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

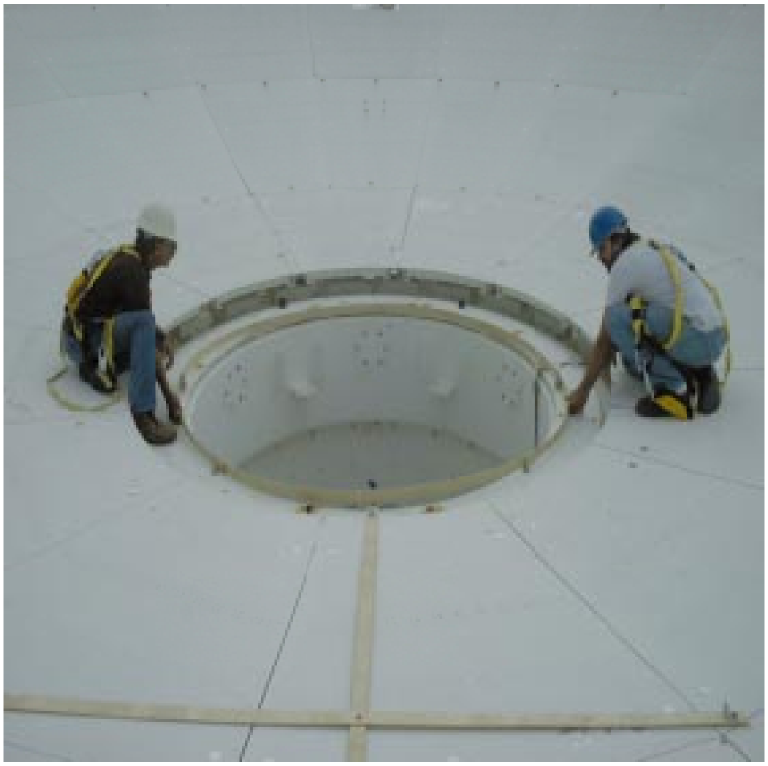

**Fig. 1. The prototype bird net being installed on the BWG opening at the dish surface.**

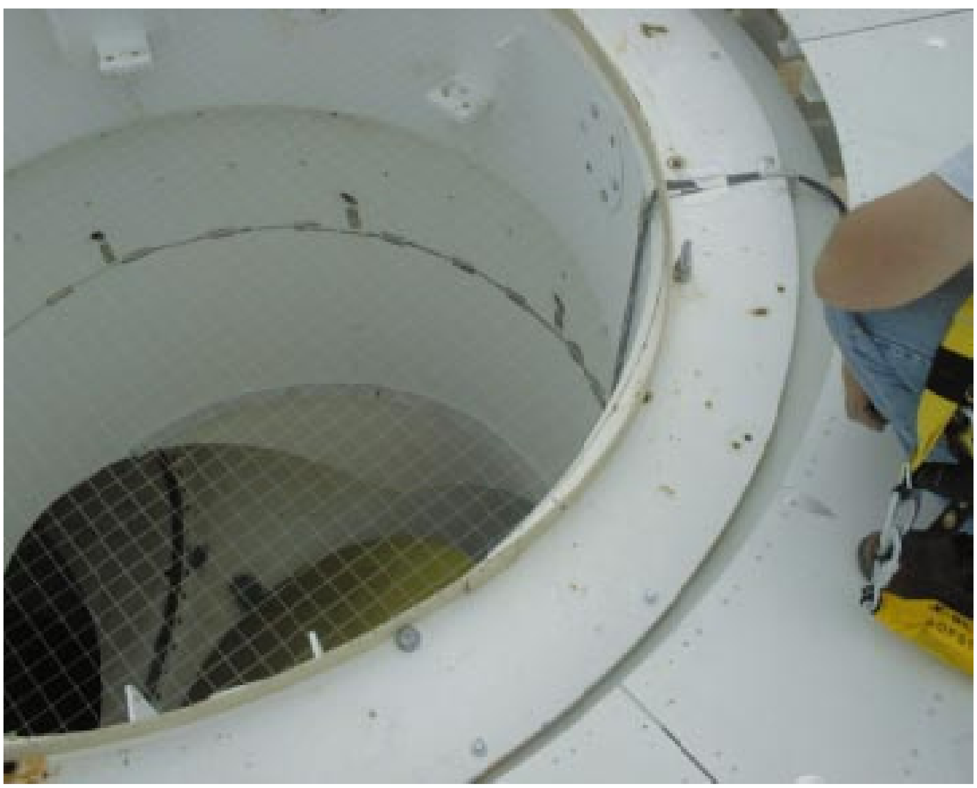

**Fig. 2. A bird's-eye view of the installed bird net.**

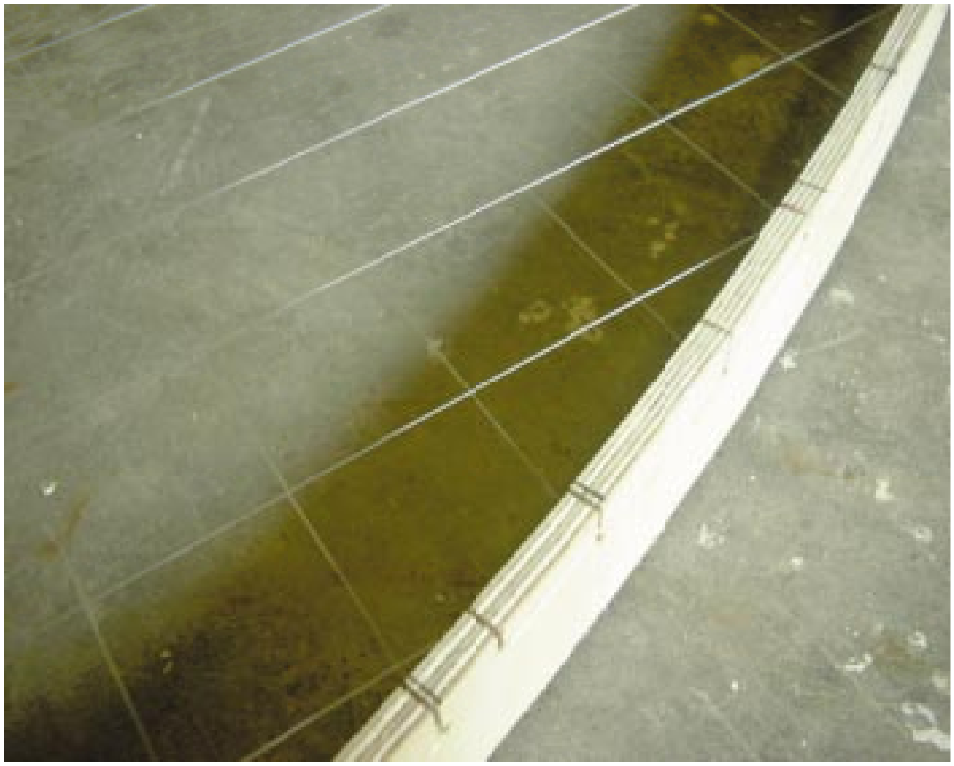

**Fig. 3. A close-up view of the bird-net design features.**

of the grid. The prototype net shown in the figures has a wooden retaining ring, but, for durability reasons, the final implemented net will have the outer ring fabricated from aluminum. The JPL design is such that, if deterioration of the net threads does occur within 6 months or sooner, the deteriorated net can be removed easily, and a spare net can be installed quickly in its place.

## III. Test Results

After 20 kW of continuous-wave (CW) power at 7.165 GHz was radiated out the BWG antenna for 10 minutes on July 29, 1999, the net was inspected for damage. No deterioration of the net was observed. On two test days of the following week (August 5 and 7, 1999), with clear-sky conditions, system temperatures were measured with and without the net. Radiometer system gain changes were corrected by performing "mini-cals," where the term mini-cal is a radiometer calibration sequence [1,2]. The computer is programmed to allow a mini-cal to be performed whenever a predetermined function key (on the keyboard) is pressed. Typically, three mini-cals are performed in sequence and then system temperatures are averaged manually after the tests. The variations of system temperatures due to weather changes were corrected through the use of atmospheric noise temperatures measured by the advanced water vapor radiometer (AWVR) at DSS 13. After making these corrections, the average measured degradations due to the bird net were 0.01 K at 8.425 GHz and 0.1 K at 32 GHz. The measured worst-case degradations were 0.04 K at 8.425 GHz and 0.18 K at 32 GHz (see Table 1). The AWVR data proved invaluable for correcting system temperature for these types of tests, in which configuration changes took about 30 to 45 minutes. Without these corrections for atmospheric noise-temperature changes and corrections for radiometer gain changes (through the use of mini-cals), before and after test configuration changes, the test results would have shown that installation of the net caused a lowering rather than an increasing of the actual system temperatures.

**Table 1. Results of bird-net tests.**

| Frequency, GHz | Average degradation,[a] K |
|---|---|
| 8.425 | $0.01 + 0.03/-0.0$ |
| 32 | $0.10 \pm 0.08$ |

[a] The tolerances are worst-case deviations from the average.

To simulate rain, water was sprayed on all parts of the net using a spray bottle. As shown in Figs. 4 and 5, the worst increase of system temperature due to this simulated rain water was 0.4 K at 8.425 GHz (X-band) and 3 K at 32 GHz (Ka-band). It took about 15 minutes for the X- and Ka-band system temperatures to return to their completely dry-state values. As shown in Fig. 5, the Ka-band system-temperature degradation was only 1.5 K after 3 minutes of drying.

It is of interest to compare the above results with those from tests performed about 15 months earlier (May 15, 1998) on a fish net that was purchased commercially from a bass fishing sporting goods store in Springfield, Missouri. This particular commercial net was woven from a nylon monofilament having a diameter of 0.254 mm (0.010 in.) and a square grid size of 1.02 by 1.02 cm (0.4 by 0.4 in.). The dry-net noise-temperature contributions on the average were about $0.05 \pm 0.02$ K at 8.425 GHz and $0.2 \pm 0.1$ K at 32 GHz. The wet noise-temperature contributions were 0.4 K at 8.425 GHz and 8 K at 32 GHz. The required drying times for the fish net to return to the dry-state values were about the same or slightly longer than the drying times of the JPL-designed bird net.

Comparisons of the noise-temperature test results show that at 32 GHz the dry and wet contributions of the JPL-designed net are lower than those of the commercial net. The lower degradations are attributed to the larger grid size (3.8 by 3.8 cm) of the JPL-designed bird net as compared with the grid size (1.02 by 1.02 cm) of the commercial fish net.

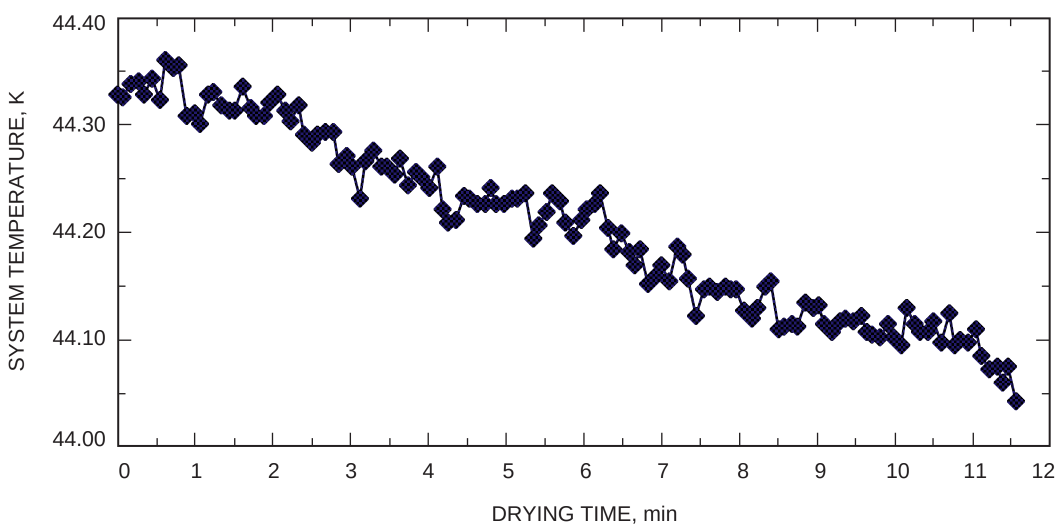


**Fig. 4. Wet-net system temperature at 8.425 GHz as a function of drying time.**

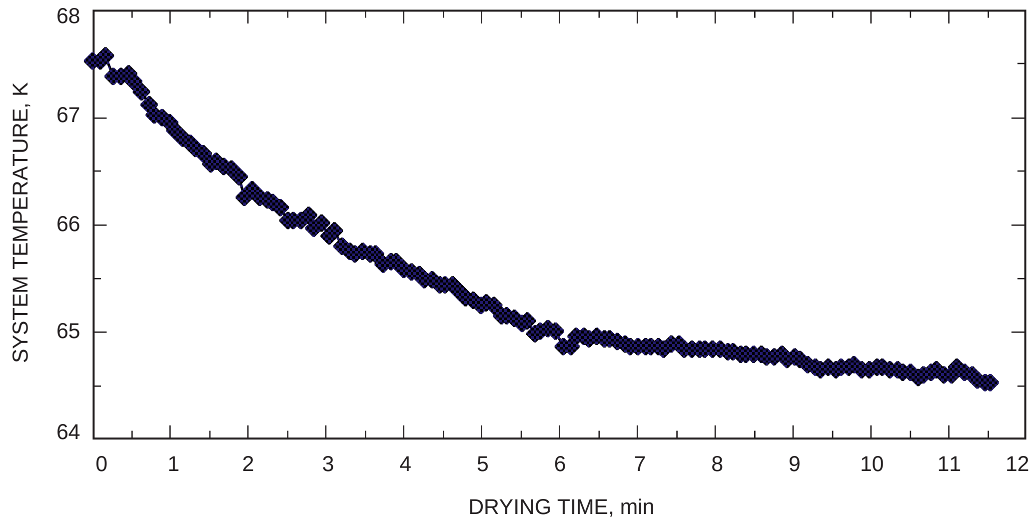


**Fig. 5. Wet-net system temperature at 32 GHz as a function of drying time.**

## IV. Concluding Remarks

It is concluded from the test results that the JPL-developed bird-net contributions to system temperatures at both 8.425 and 32 GHz are sufficiently small for operational use. The advantages of having a net that keeps birds and their droppings out of the BWG system outweigh the disadvantage of a wet net taking 15 minutes to be restored to the original dry system-temperature values. The JPL-designed net is believed to have a durability of 6 months or more and can be replaced quickly with a spare net that is already assembled.

A decision has been made to copy this net design with an aluminum outer ring for the DSN BWG antennas in Spain and Australia. For reasons thought to be related to the dryer and milder weather conditions at Goldstone, birds flying into a BWG antenna opening on the dish surface has not been a problem at DSS 13.

# Acknowledgments

The authors are grateful to Dan Kelley of Allied Signal for fabricating the outer ring net holder and to the DSS-13 crew for assisting with the installations and configuration changes required for the tests. The authors thank Charles Stelzried of the TMOD Technology Program Office for advice given on the use of mini-cals in the test procedures; Steve Keihm of the Microwave and Lidar Technology Section for furnishing advanced water vapor radiometer atmospheric-noise-temperature data for the test dates involved; and Rick Cirillo of the Communications Ground Systems Section for his assistance on the earlier bird-net tests at DSS 13.

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