July 27, 2012

Mr. Robert Kerr, PhD
Director, Arecibo Observatory
HC 03 Box 53995
Arecibo, P.R. 00612

Re: Feed Platform Rotating Floor

Dear Dr. Kerr:

At your direction we have performed site investigations and an analysis to assess the state of good repair for the feed platform rotating floor that supports various receivers used as a part of the Arecibo Radio Telescope. It is our understanding that concerns about observed wear patterns and a desire to install additional receivers on this floor were the factors leading to this investigation.

As a large and highly complex machine, the Arecibo Telescope is composed of a large number of interconnected parts. Any investigation of a specific element of this instrument requires both an analysis of the element and an evaluation of the structure supporting the element. This report will address: 1) A detailed structural evaluation of the structural condition of the rotating feed platform floor; 2) A general evaluation of the feed module support structure; 3) A general evaluation of the effect of adding additional loads on the main supporting truss elements and cables.

During our site investigations we noted an approximately 1/8" deep groove located on each side of the downhill side of the member surrounding the rotating portion of the rotating floor. This groove appears to have been the result of contact with the lower edge of the aluminum channel forming the outer circumference of the rotating floor structure. Observations were made with the floor rotating in a level condition and with a stationary floor with the dome located at maximum azimuth. In general the floor was found to rotate smoothly while level and no significant contact with the stationary structure was noted. The gap between the rotatory and stationary floor elements appeared to be reasonably uniform. With the dome tilted to 19.6 degrees, the clearance was observed to reduce to nearly zero in the areas exhibiting wear. This would be consistent with the platform shifting "downhill."

Observatory personnel provided original design drawings and fabrication drawings for our review. It was noted that during the mechanical design of the floor rotating systems that revisions were made to the conceptual level mechanical design shown on the 1992 Ammann & Whitney drawings. The original design intent provided a rigid aluminum collar near the upper surface of the floor and maintained lateral stability through the use of 12 horizontal cam rollers. The as-built mechanical design provided a bent aluminum C10 channel to contain the floor and large, spring loaded idler wheels at two, downhill locations. At a later date, two additional sets of idler wheels were installed at two, uphill locations. The observed wear pattern is occurring on the surface of the bent aluminum channel added during the mechanical design. It is Ammann & Whitney's conclusion that this channel is not a structural supporting element but was provided to

help centralize the floor during rotation at varying azimuths. The observed wear was determined to not be an area of structural concern.

Observatory personnel noted that there is a continuing issue with flexibility of the idler wheel system. Noting that the idler wheels react off of a cantilevered portion of the bent C10 centralizing ring, we recommend that shims and bolts be used to connect the upper flange of this C10 to the stationary floor plate which should provide additional stiffness to the idler system.

A review of documentation indicates that the current array of receivers located on the rotating feed platform floor results in a total rotating floor weight of 12,200 pounds (note that for our analysis we have added 200 pounds to the documented 12,000 pound existing load to account for the proposed Alpha receiver aperture). This exceeds the original design loading of 10,000 pounds by 20%. We note that extensive reinforcement was added below the stationary support floor structure to address excessive deflections that resulted from notching of support beams to accommodate the C10 centralizing ring beam. The original structure plus this reinforcement is adequate to support the increased loading.

We have also noted that there are deep, mid-span notches in the stationary floor diagonal elements where drive motors were installed. We recommend that the added reinforcing elements be connected to act compositely with the original structural elements to further stiffen the support floor.

We note at this point, that current data indicates that the total weight of the Gregorian Dome system (excluding 10,000 pounds for heat exchangers) is 200,000 pounds which exceeds the original design limit of 170,000 pounds by approximately 20%. It is reasonable to assume that this additional weight is distributed throughout the feed module structure and that this system is subject to stresses that exceed 120% of our original design loads. As part of this investigation we have identified critical members in the feed module truss structure and have determined that existing member sizes and connections are adequate to resist this increase in loading.

In March of 2010, following a fracture in a major member of the triangular platform, Ammann & Whitney performed an analysis of the triangular platform and the rotating feed arm. During that investigation we noted that the current sum of the dome plus heat exchanger weight of 210,000 pounds and the operational unbalanced over-turning moment of 20,000,000 foot pounds exceeded maximums identified on the original contract drawings as safe values (170,000 pound dome weight and 11,400,000 foot pounds on the 1992 Gregorian Upgrade Drawings). Subsequent to this analysis, Ammann & Whitney provided a design for the reinforcement of critical members to allow safe operation at the increased weight and moment. The values of 210,000 pounds (the sum of the dome plus heat exchangers) and 20,000,000 foot pound unbalanced moment should be considered as absolute maximum operational parameters.

In summary, we make the following recommendations:

- No work needs to be performed to address the observed wear patterns since the affected member is not a structural supporting element
- We recommend that connections be made between the C10 flange at idler wheel locations and between the notched beams at the drive motor locations to increase the stiffness of the rotating floor's lateral support system
- Installation of a 200 pound aperture plate on the existing Alpha receiver is acceptable
- Given that existing loads on the feed module floors appear to exceed original design values by 20% we recommend that no net increase in weight be allowed at any location supported by this structure (except as noted in the bullet above)
- If any net increases in loading are to be installed within the feed module we would recommend a complete analysis and possible strengthening of the feed module support structure
- Regardless of the analytical results for the feed module support structure, we do not recommend exceeding the operational moment limits for the reinforced triangular support platform

Please feel free to contact me via email (jstahmer@ammann-whitney.com) or at 212-462-8583 should you have any questions about either this report or the attached sketches.

Very truly yours,

Joel L. Stahmer PE
Vice President

Encl.

Cc: J. Gould, A&W