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IN REPLY REFER TO:

25 Meter Millimeter Wave Telescope
Memo #93

April 26, 1977

Dr. Sebastian Von Hoerner
National Radio Astronomy Observatory
Green Bank, West Virginia 24944

Dear Sebastian:

Thank you for your letter of April 1, 1977 and the enclosures you so kindly sent to us. We sincerely appreciate your forethought in preventing any new misunderstandings between ESSCO and NRAO with regard to stiffness vs homologous deformations concepts. The concepts have long been clear to us, and we hope that any misconceptions have now been put to rest.

We have briefly reviewed the enclosures that you sent, and although we tend to agree with and admire your technical approaches, we do have several different ideas. A few comments are presented below for your consideration:

1. You have equated radome enclosed operation to "night" operation, and thus your direction is turned toward an astrodome type configuration. I would suggest that this equality is not so, in that many possibilities exist for controlling an enclosed environment. A more exhaustive study on how well one could actually control the internal environment for the radome case (and more specifically, how that controlled environment would affect the antenna) would be enlightening. For example, as the environment becomes totally controlled, your thermal limit would tend to disappear. Aside from the contribution to rms surface errors, what pointing and repeatability accuracy do you confidently predict for an exposed system operating over extended periods of time?

2. We seem not to agree on the disadvantages/advantages of a radome enclosed system. In our estimates, the additional cost of the radome is more than offset by the decrease in antenna cost versus an exposed telescope design and its control system. In addition, it appears that you have not considered another advantage of the radome enclosure which permits a significant reduction in the aperture blockage of the antenna. Our view is that the radome blockage is essentially offset by the reduced subreflector support blockage, and membrane losses can be more than offset by a 10% to 15%

increase in the reflector diameter. You may have noticed that our nominal 40-foot antenna is actually 45 feet in diameter, our 60-foot is actually 66 feet, etc. The cost of these increases has typically been insignificant within the enclosed environment, whereas the cost and the performance loss would be much larger for a similar diameter increase for the exposed case. We call this our "equivalent antenna" evaluation and therefore do not agree with your estimate of a 25% net loss, which you attribute to the radome. In contrast, we anticipate a cost and performance benefit.

3. You indicate that with an exposed antenna you expect to have ten hours of night operation. This number may be optimistic since several hours are required after sundown before any stabilization occurs, and instability occurs again several hours before sunrise. Incidentally, we have observed that on some nights, the thermal problems have never disappeared. We are therefore at a loss to scientifically predict what number of hours per night (if any) during what part of the year would indeed be available; if we were to guess (without being held contractually), we would probably choose a figure closer to five hours. We thus feel that a radome would probably extend the duration of the best performance by a factor of five for observations at the shorter wavelengths, and perhaps higher when fine accuracy is required or when more stubborn thermal instabilities and other environmental effects (snow, etc.) are considered. We are still not sure that you can point the exposed antenna, during prolonged time periods, with the required accuracy and repeatability at the shortest wavelengths (1 mm).

4. Combinations of variable winds and thermal constraints appear to present more problems to us than to you. Your view is that combinations of wind and thermal instabilities "smooth" each other. Our experience, albeit not exhaustive, indicates the reverse. Is it possible that cooler parts of the structure are cooled further while other parts of the structure are warmed differently?

5. Our respective evaluations of the cost elements also appear to be significantly different. We, of course, do not have to design antennas specifically for survival stability, and in addition, we seem not to agree that the homologous structure can be built as inexpensively as any other structure. We strive for light tapered weight with stiff backstructures of a box beam configuration, utilizing thin skin aluminum for both backstructures and surfaces. Our costs, including pedestal, drive and servo system, seem significantly lower for the complete antenna and radome than your estimates.

6. We recognize the gravitational deflection advantages of the homologous design which perhaps may tend to justify your direction, but do not agree that gravitational deflection is a limiting factor, as you so aptly prove, but can be overcome by either active or passive compensation or by quasi-homologous design, or combinations of the two. We continue to believe that setting techniques, rather than thermal or gravitational deflection aspects, represent the largest obstacle to improved performance, especially in view of the progress we have made in panel manufacture and our ability to incorporate active and passive compensation as the need requires. We are therefore pursuing, within very limited budgets, optical techniques for setting the overall reflector which appear very encouraging. Our approach for the "equivalent antenna", simply stated, is that if we have excellent surface panels and can point the telescope precisely, then we can always embody advances in setting techniques and active/passive compensation, if required, into our existing telescopes or those yet to be produced, within effective cost constraints.

7. Your direction seems to conclude that an astrodome, although the most expensive choice, is the most economical one in terms of observational results per dollar. In view of our estimate of extended duration of performance and our comments above with regard to the radome enclosure, we cannot agree with your conclusion as to the optimum cost/benefit relationship. In contrast, we are fearful that you may not be able to achieve your goals.

8. You barely mention that operation and maintenance on a high mountain site is more convenient and reliable inside a radome. Actually, the protection afforded by the radome enclosure is highly desirable from at least three points of view; we would strongly urge that the benefits of operation, maintenance and especially of reliability within the enclosed environment of a radome be considered in detail.

You mention in your letter that it may bother us that NRAO is doing so much development; in a way, it does. While NRAO has an outstanding group, a large variety of sophisticated computer programs, and certainly is in close contact with astronomers and their needs, we believe that most of these attributes have counterparts in private industry. Imagine the synergistic effects of combining the skills of you and your group with those of ESSCO, for example. That concept has many ramifications which could create a formidable force to be exerted on the problems that face us.

What bothers us is the following situation. As you are aware, ESSCO competes in the world market against such companies as Krupp, for example. You have noted that the iterative procedure developed by you at NRAO was not only used for NRAO designs but "is also being used for a new Bonn design of 30 m diameter (λ = 1.4 m probably) by Krupp". This seems to suggest that American funds in support of NRAO produce results which are utilized by foreign private enterprises in competing against small U.S. firms. An extension of this viewpoint may even be interpreted to indicate that not only does U.S. small business compete with foreign ones, but with its own non-profit publicly funded facilities in the U.S. as well. Be that as it may, your group has accomplished excellent work with which we do hope to be associated.

It would seem to us, Sebastian, that additional meetings, perhaps with more time allowed for definitive technical discussions, are in order. We would, for example, like to pursue deflection analyses of our box beam backstructure configuration with a view towards determining its homologous characteristics and potential. It would indeed be helpful if we could look to NRAO for assistance in analyzing modifications of the box beam structure configuration to perform in a more homologous manner while preserving its simulation (model) simplicity, stiffness and cost effectiveness. We are also in need of support to pursue our reflector panel and radome membrane developments along with our setting concepts.

One last point concerns the panel tolerances that we have been discussing these past several months. You are aware that up to the present we have published our panel tolerance measurements as they pertain to the results of manufacture rather than antenna tolerance theory. We have not subtracted any measurement error nor have any Area of Illumination weighting functions been applied to those measurements. Furthermore, these measurements have not been adjusted with respect to the determination of the final "effective" rms error, as would be proper with regard to a final determination of the reflector efficiency. I refer here to the basic difference between the effective rms error as defined by Ruze, and the rms axial surface deviation. In essence, we have "reserved" all of these factors in the belief that this would represent a conservative and credible approach. These factors should not be overlooked, however, in the overall perspective, since they are indeed significant in design optimization.

We certainly enjoyed your visit to ESSCO and look forward to more technical discussions in the near future. We are hopeful that a closer working re-

lationship between our two organizations can result in a synergistic effect to our mutual beneficial interests.

Sincerely,

ELECTRONIC SPACE SYSTEMS CORPORATION

Albert Cohen
President

AC/tn

cc: Dr. Mark Gordon
Dr. Hein Hvatum

P.S. We are impressed with your "mini-max" antenna concept and would like very much to collaborate on this futuristic development if that is possible.