

Interoffice

NATIONAL RADIO ASTRONOMY OBSERVATORY

TUCSON, ARIZONA

March 31, 1977

*25 Meter Millimeter Wave Telescope
Memo # 84*

To: Hein Hvatum

From: M. A. Gordon

Subject: March 30 visit to ESSCO Corporation

The purpose of this memorandum is to summarize candidly the discussions between NRAO and ESSCO personnel, as I remember them. Present were

ESSCO:

Albert Cohen,	President
Dr. Sam Hensel,	Sales Manager
Gene Rhoades,	Servo Engineer
Allen Rohwer,	Mechanical Engineer
Dr. C-S Wang,	Marketing Manager

NRAO:

Dr. M. A. Gordon,	Project Manager
Dr. S. von Hoerner,	Scientist and Member of Working Group
G. R. Peery,	Head, Engineering Division
W-Y Wong,	Structural Engineer

The greater part of the morning was spent in Al Cohen's office, where he described his concept of high-precision systems. In addition, discussions occurred on a variety of specific subjects. The latter part of the morning was devoted to inspection of their facilities.

1. ESSCO Philosophy. Cohen felt that the impediments to construction of high precision antennas could be divided into panel surfaces, panel setting, membrane transmission, and back-up structure. He feels that soon ESSCO will be able to manufacture panels of virtually zero error, which can then be set by optical techniques. Somewhat further in the future are enclosures having good transparency to 1000 GHz. Adequate back-up structures can be achieved by limited application of homology ("a push here, a pull there"), without resorting to a full-blown homologous optimization of a truss structure, and by taking full advantage of the illumination taper.

Essential to achieving these performance levels is control of the telescope environment, a closed radome in which air is rapidly circulated to minimize temperature gradients between structural

components. The small transmission loss of the membrane is the unavoidable price of good performance at extremely high frequencies.

In addition, the subreflector and quadrapod support must be designed for minimum aperture blockage. Elements of this design include placing the quadrapod feet as close to the dish rim as possible to minimize shadowing, and using spars having low RF backscatter (ogival cross-sections, etc.). Standing waves can be tuned out by an adjustable cone placed in the center of the sub-reflector.

2. An ESSCO Problem. Because of the small size of the company, Al Cohen cannot devote a large effort to research new concepts. There is insufficient capital and cash flow to fund many new programs. Instead, he must choose each new R and D program carefully, and be content with the long time required to investigate the particular program chosen.

He feels that is ironic that an American Company must rely on foreign contracts for money to pursue new techniques. Why doesn't the NRAO, which has much to gain from them, fund some of these novel concepts of ESSCO, rather than the often unimaginative programs suggested by the large companies (Philco-Ford), which abound in development money? In short ESSCO needs, and NRAO should supply, development money for specific projects. (No mention was made of ESSCO's failure to respond to the RFQ for the 140-ft subreflector, or of our panel procurement effort with ESSCO, or of the 45-ft telescope).

3. Where ESSCO Can Help NRAO. Cohen understands that the NRAO has selected an astrodome and a completely homologous back-up structure. Accepting but not agreeing with that decision, he would welcome development contracts for 25- μ m panels and for membranes.
4. The 40- μ m ESSCO Panel. ESSCO engineers and the NRAO now agree on the accuracy of the ESSCO panel procured in 1976: that the RMS error seen by incoming radiation is approximately 60 μ m. The difference between their earlier claim of 1.58 mils (40 μ m) and this figure is not understood, although damage in the shipment to NRAO is a possibility. (25-Meter memo 81 by S. von Hoerner describes the reconciliation in detail.)

Cohen describes this panel as one of the last produced in the production run for the UMass telescope, and notes that these panels all have RMS values between 55 and 60 μ m.

5. Epoxy Creep. We asked whether ESSCO had ever detected changes in surface panels due to creep of the epoxy bond between rib and surface. Cohen replied that in the 6 years ESSCO had used epoxy, no creep had yet been observed -- but he noted that perhaps 6 years was too short for this effect to occur. Cohen stressed that one advantage of inexpensive panels is that they could be changed every few years to offset such effects.

One problem with epoxy is its exothermic curing. The heat causes the aluminum to push outward over the backup rib, causing a slight ridge. For better precision, these high spots could be polished away.

6. The ESSCO Panel-measuring Machine. This machine consists of a large (~10 x 20 ft) granite slab, on which travels an overhead beam and probe. Cohen claims typical measurement accuracy is 12 μm , which they do not remove from the accuracies quoted for their panels. Presumably, they would argue that actual panel precision is

$$(\sigma_{\text{measure}}^2 - \sigma_{\text{error}}^2)^{1/2}$$

Cohen describes the machine's value as \$150K.

7. Proposal For a 25-M Telescope of RMS 70 μm . He feels that it is impossible to reach our goal without a radome. He proposes to extend the design of the Swedish 66-ft telescope to 84-ft by stiffening and extending the backup ribs, by using high precision panels and setting techniques, and by taking full advantage of the cosine² illumination taper. The price would be nearer to \$5M, rather than to the \$9M of our design. He agreed that we'd have to put up with non-ideal resonances in the membrane, but he felt that there is no other way to achieve our design goal.
8. Optical Setting Technique. Cohen feels that future surfaces will be obtained in the following way. First, the high precision panels will be measured and adjusted using optical techniques such as the Hartmann test. Then, setting will be effected by using mirrors implanted in the panels over the adjustment jacks. The surface will be set optically so that light beams reflected from the corners will appear in proper position at the focus. At other attitudes, the jacks would be automatically adjusted to maintain this original precision.

Sebastian noted that this procedure would indeed produce correct

angular alignment of panels, but might not produce accurate distance information. (I perceived no resolution to this issue in the discussion which followed.)

9. Panel Development Contract. ESSCO would welcome an NRAO contract to develop 25- μ m panels, which they estimate would take about 6 months. Should we wish to pursue this, NRAO should write down specific goals and measurement techniques, Cohen would then respond with a price.
10. My Personal Observations. I was extremely impressed with the simple fabrication techniques used by ESSCO. The same design simplicity appeared in panel fabrication, in panel-measuring, in radome construction, and in the antenna range. Surely these techniques bring substantial cost advantages with them.

On the other hand, I found it difficult to assign novel concepts to reality or to hopes for the future. The optical setting technique is an excellent example: has Cohen really thought it through, or is he merely brain-storming? Also, has ESSCO really produced 25- μ m panels or are they merely within reach?

There are occasional credibility gaps. Cohen told us that all UMass panels have RMS errors lying between 55 and 60 μ m. Yet, I know that the panel markings actually range between 1.50 and 3.00 mils (38 and 75 μ m). Cohen told us that all ESSCO dishes have performed a factor of 2 better than their contractual RMS goal. Yet I understand that the Brazil dish didn't do this, nor did the Helsinki dish. There is no way to know about the Swedish and UMass dishes until they mount high-frequency receiving systems. Also, Al Cohen told us that he has made it a company policy not to contact NSF regarding our proposal or others. Yet, a few weeks ago he told Buck Peery of a 10-page letter which he'd sent to NSF or to somebody close to NSF.

And then there is the unusual manner of understanding issues. Al Cohen reminded us that Barry Turner's comment in Grenoble had unfairly hurt ESSCO's reputation. Yet, even ESSCO acknowledges that the ESSCO panel is 50% worse than they had claimed -- thereby completely vindicating Barry Turner. To date, I know of no apology from Cohen to Turner for Cohen's angry protest to Dave Heeschen. Instead, he seems to use the issue as a lever to obligate the NRAO to additional contracts.

The nature of the discussions and comments during our meeting underlined, in my mind at least, a major distinction between NRAO and ESSCO approaches to telescope design. ESSCO relies upon a combination of instinct, experience, and imagination to produce results. Hard-core calculation is minimal, probably because of its expense. Yet, their results are impressive at least in potential and hopefully in performance. We, on the other hand, use the more academic approach of highly-sophisticated mathematical analysis to overcome our (comparatively) limited experience. It's too bad we cannot work together in view of our complimentary abilities.

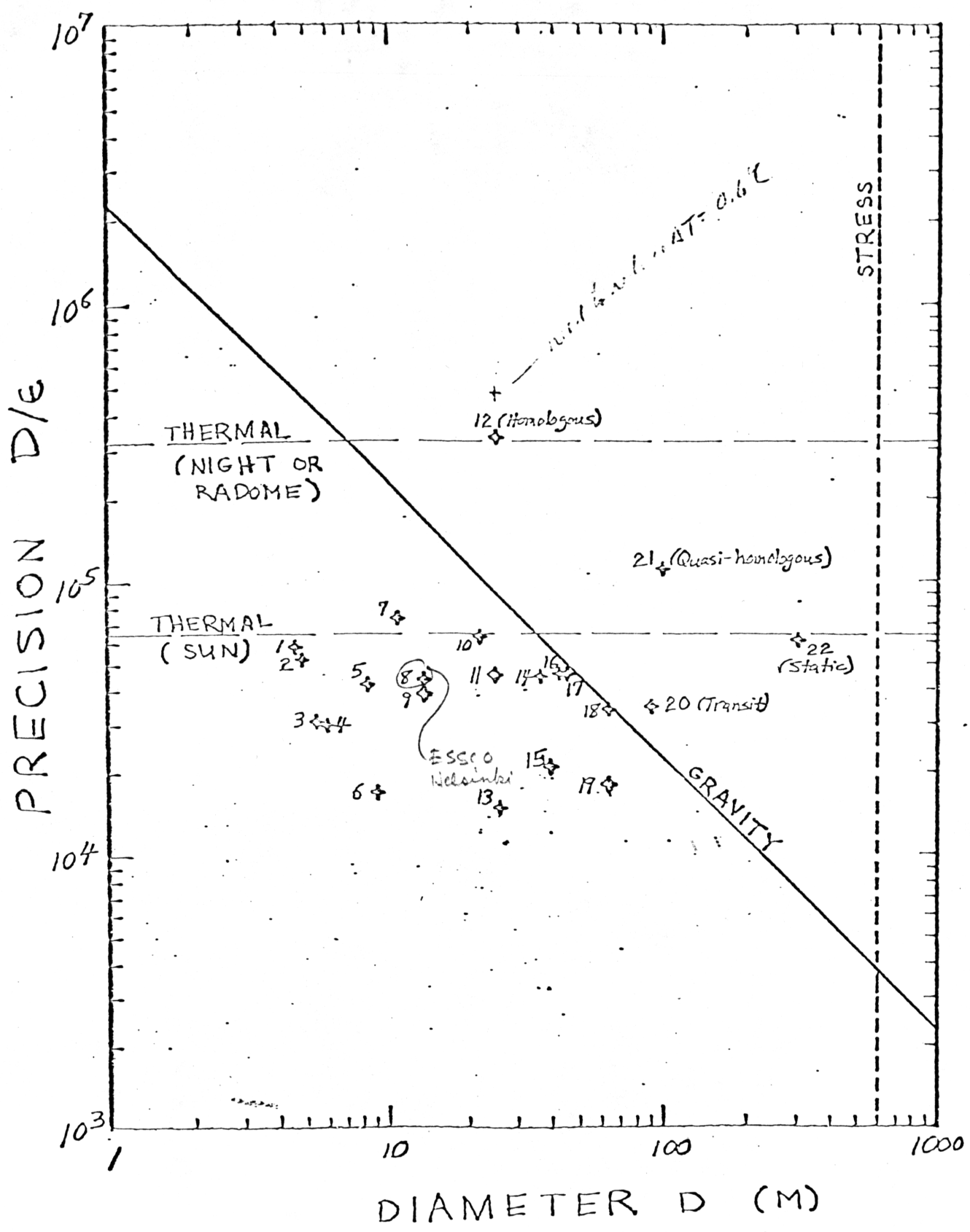
Clearly ESSCO is an innovative company with whom we should deal. Unfortunately, Cohen's complex personality can make those dealings painfully difficult. But, I suggest that we negotiate a contract for improved panel design and let the results speak for themselves.

xc: 25-Meter Working Group
A. Cohen

all: for your info

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FIGURE 1



Nighttime limit assumes $\Delta T = 0.8^\circ\text{C}$ typical temperature difference from one part to another
 observations: $\sigma = 0.37 \text{ m} (D/100\text{ms}) (\Delta T/^\circ\text{C})$

*measured, not predicted except
for 25-m telescope*

TABLE I
RADIOMETRIC ANTENNA TOLERANCES

Number	Antenna	D (m)	ϵ (mm)	D/ ϵ
1	Aerospace	4.6	0.079	58,000
2	MWO	4.9	0.093	52,000
3	JPL	5.5	0.18	31,000
4	Mitaka, Japan	6.0	0.20	30,000
5	MIT	8.5	0.20	42,000
6	DRTE	9.1	0.53	17,000
7	NRAO-Tucson	11.0	0.15	73,000
8	Helsinki	13.7	0.31	44,000
9	MacKenzie	13.7	0.35	39,000
10	Lebedev-Crimea	22.0	0.35	63,000
11	NRAO-VLA	25.0	0.54	46,000
12	NRAO (Homology Design)	25.0	0.075	333,000
13	NRAO-Green Bank	25.9	1.75	15,000
14	NEROC	36.6	0.82	45,000
15	OVRO	39.6	1.9	21,000
16	NRAO-Green Bank	42.7	0.92	46,000
17	ARO	45.7	1.0	46,000
18	JPL	64.0	1.9	34,000
19	CSIRO	64.0	3.6	18,000
20	NRAO-Green Bank (Transit)	91.4	2.6	35,000
21	MPIR (Quasi-homologous)	100	0.9	111,000
22	NAIC (Static reflector)	305	5	61,000