

National Radio Astronomy Observatory

Very Large Array
August 8, 1980

To: H. Hyatum

From: W. G. Horne

VLB ARRAY MEMO No. 12

Subject: VLBA Design Study

In our conversation of August 4, 1980, you requested that I render some assistance to you in the preparation of Sections VII and VIII of the VLBA Design Study Report by giving you my comments on specific sub-subject set forth in Kellerman's outline of May 22, 1980. The following is an attempt to do so in the limited time available. Notations refer to the notations used in Kellerman's outline:

Section VII

(1) Site personnel are required to perform duties consisting of the following:

- (a) Operational duties consisting of insertion of operating programs or connection at site control element (computer) to Array Operations Centers; changing and forwarding of recording tape, security and precautionary oversight; emergency intervention in the operational process and routine start-up and shut-down procedures.
- (b) Preventive maintenance and routine servicing of operational equipment.
- (c) First level repair of malfunctioning equipment.

It is not anticipated the local site personnel would have either training equipment or the necessary number or personnel to perform major equipment repair or major overhaul schedule servicing and overhaul. These services would be provided from a central site or sites by specialized technicians with assistance from the local site personnel.

Based on operating experience at the VLA it is estimated that routine maintenance and servicing at each antenna will require the following man hours per year in the following categories:

Antenna structural and mechanical	234 man hours
Antenna servo cleaning and testing	36 man hours
Antenna heating and air conditioning	24 man hours
Cryogenics servicing	80 man hours
Receiver system servicing	110 man hours

Total routine maintenance and servicing 484 man hours

Unscheduled repair of damaged or malfunctioning equipment is estimated to require the following man hours:

Antenna structural and mechanical	148 man hours
Antenna servo and drives	78 man hours
Antenna electrical	54 man hours
Antenna heating and air conditioning	24 man hours
Cryogenics system	150 man hours
Receiver system repair and mod.	540 man hours
	<u>1095 man hours</u>

If each site operates a three shift operation, 360 days per year with only one operational man on duty a total of 8640 operating hours are possible. Assuming a basic time of 2080 hours per man year less 248 hours vacation, holiday, and sick leave 4.72 men are required for only operational duties. It would appear then that 5 men to perform shift operational duties plus 1 man assigned to the basic maintenance duties whose normal working period would be a standard daytime 5 day week would be required to operate the station. During break downs a repair crew of 2-3 men could be utilized made of the operating technician, the service technician and of off-duty operating technician whose shift would probably be cancelled by the break down. For major repair requiring personnel with special training, special equipment or major replacement parts, 2 service centers where larger groups of technicians or mechanics are stationed would be utilized. The present Green Bank and Socorro installation and/or the Array Operations Center could serve this purpose.

Section VII

(4) Manpower for maintenance and repair has been discussed in Section VII, 1 above. A summary would say that preventive maintenance and minor repair would be performed by site personnel with major repair and repair requiring special trained personnel being performed by a mixture of site personnel and personnel dispatched from one of two centralized service centers. Examples of special trained would be certified welders, millwrights, hydraulic technicians, cryogenic technicians, servo technicians, and electronic technicians. It is anticipated that a typical repair task would require dispatch from the service center of 2 or 3 technicians or mechanics and that each site would require such service approximately 8 times a year.

The major portion of spare parts stocks would be at the service centers with only small components whose failure rate are fairly high being maintained at each field site. Those parts whose expected MTBF rates exceed one year would be stocked at one or both of the service centers in order to minimize the capital investment made in spare parts. While the proposed service centers (Green Bank and Socorro) are fairly remote, an Array Operation Center and the selected field sites could be located so that transportation and delivery problems could be minimized.

The preceding comments must be modified however, in the cases of the Spain and Hawaii sites. Stocks of spare parts at both sites will have to exceed those at continental field sites due to shipping difficulty (axis bearings, feed mount) whose expected MTBF is in the range of 10 to 20 years which should only be stocked at one location. Personnel level at the Spain site would be increased in order to provide more skills and to reduce or obviate travel of personnel from a service center to that site. The same provision would apply to the Hawaii site unless the millimeter wave project receives prior authorization in which case the joint use of special skilled personnel is feasible.

One other instance needs consideration - that of new, replacement or modified equipment. Since receiving equipment used in radio astronomy is subject to continuing improvement and advancement it is anticipated that the engineering and procurement of such equipment will be performed at an NRAO central site with assembly and testing at one or more of the service centers. Installation of new or replacement equipment or modification of existing equipment would be performed at the field site by personnel from the service center.

Section VII

(10)-For personnel convenience, user travel convenience, communication flexibility and service convenience an Array Operations Center location at one of the midwest field sites should be considered.

Section VIII

(2A) Assuming that all antenna for the VLBA are procured from one supplier the minimum cost for the various structural, mechanical and drive components will be obtained by placing orders for all material at one time. Based on experience with the VLA antenna program unit cost for components will be approximately 80 percent of the unit costs for a single antenna so it would be advisable to let the antenna contract for all antennas at one time. Experience with one antenna will however, be possible as fabrication, erection and testing (particularly erection and testing) will be performed sequentially since the antenna contractor will prefer to use basically the same erection crew in order to take advantage of the crew learning curve. A secondary reason for contractor preference for sequential erection and testing is that contractors have available only 2 or 3 trained erection crews, erection tools for the crews and technical personnel to perform the testing. The sequential erection and acceptance testing will enable any antenna design or detail errors and any assembly problems or misfits to be identified while its impact is still minimal.

This approach will not provide operational and performance testing of the receiving system of the antenna prior to the completion of acceptance of all antennas but does avoid the increased cost of the prototype antenna (an increase estimated at \$300,000.) and the increased cost of the remainder of the antennas due to escalation for a period of approximately 18 months. If performance testing is considered advisable it would be economically more practical to place the contract for all antennas at one time and to prototype the operational and

observational electronics while leaving the antennas non-operational for the desired testing period.

Section VIII

(4) Materials and Supplies

An estimate of spare parts necessary to support and maintain operations with no serious downtime and under the assumptions as previously set forth in Section VII (4) would be as follows:

Antenna Structure, Mech. Servo	\$275,000.
Cryogenics	35,000.
Electronics	-0-
Computer	-0-

Operating material and supplies are estimated to cost \$56,000 per year including both consumable items such as oil, greases, paint and tools and replacement items such as mechanical and electrical equipment. This estimate does not include items such as receiving electronics, computer repair and maintenance, electric power, magnetic tapes, and station supplies.