CHAPTER —

SPECIFICATIONS

01 INTRODUCTION

01.1 General Statement of Work

The work described herein shall consist of the furnishing of labor, materials, services, drawings, data, detailed specifications, test documents, and other items required for the detailed design, manufacture, assembly on site, alignment, and testing of antennas for the VLBI array antenna system.

01.2 Objectives of the Program

The objectives of the effort under this subcontract are the following:

- The design of an antenna that meets the operating parameters and requirements set forth in this specifiction.

- The design for an antenna that is optimized for production of a quantity of ten (10) antennas, taking advantage of economies that may be realized by maximum duplication and standardization of parts, use of tooling to minimize labor, and simplification of assembly effort. Since assembly of the antennas will be at ten widely separated sites geographically, antennas shall be designed for manufacture and shipping in such modules as will minimize shipping and assembly costs to the extent possible.

- A design that takes into consideration ease of maintenance and the reliability of components to minimize maintenance.

- The manufacture of antennas using the techniques and tooling developed and specified in the design effort.

- The assembly and alignment of the antennas according to the specifications and procedures set forth during the design stage.

- The performance of acceptance tests according to the acceptance documents prepared in the design stage to establish that antennas meet the specified performance requirements.

02 DESIGN AND PERFORMANCE PARAMETERS

The antenna system for which this antenna is designed consists of ten (10) antennas with 25-meter diameter reflectors located at ten (10) sites, widely separated geographically. Design parameters are therefore set forth for climatic conditions which may not exist at each station.

The antenna shall be an elevation over azimuth configuration, with a 25-meter diameter solid surface paraboloid of revolution as the main reflector. The observing systems to be used shall be both Cassegrain and prime focus. The Cassegrain observing system shall be considered the normal mode of operation, and a clear opening of approximately 4 feet in diameter will be required at the apex of the feed legs symmetrical about the reflector axis.

The antenna shall be of wheel and track design and shall meet the following mechanical and operating parameters and conditions.

02.1 Mechanical Parameters

- Diameter: 25 meters (82.02 feet)
- Focal Length: 9 meters (29.53 feet)
- f/D: 0.36

(An alternate f/D of 0.32, with focal length of 8 meters, is under consideration.)

- Sky Coverage: Elevation +5° to 125° ; Azimuth ± 270°

- Operational Frequencies: Cassegrain: 43 GHz, 22 GHz, 15 GHz, 10.7 GHz, 8.46 GHz, 5 GHz, 2.3 GHz, 1.4/1.7 GHz.

- Prime Focus: 611 MHz, 325 MHz.

- Surface Accuracy: Installed rms of 0.45 mm (0.018 inches), including manufacturing, alignment, gravity, operating wind and thermal errors under the specified precision operating conditions. Peak deviation from the best fit design surface of revolution shall not exceed 1.40 mm (0.055 inches) under precision operating conditions.

- Reflector Surface: The reflector surface shall be a surface of revolution which approximates a parabola but which is shaped to increase gain. The maximum deviation of any point on the shaped surface will not exceed 30 mm (1.2 inches) from the basic parabola; coordinates will be furnished later. Panels shall be individually adjustable, doubly curved, solid surface aluminum panels. The panels must withstand either a 20 lb/sq ft uniform load or a concentrated load of 250 lbs over a 6-inch square area without suffering permanent deformation.

- Panel Gap: Spacing between panels shall be 2 mm (0.80 inches) ± 0.75 mm (0.030 inches).

- Axis Alignment:

  Azimuth axis tilt to plane perpendicular to gravity: maximum error of 15 arcseconds.

  Total azimuth axis runout: 10 arcseconds maximum error.

  Azimuth axis nonrepeatability: 4 arcseconds maximum.

  Orthogonality elevation to azimuth: 15 arcseconds maximum error.

Orthogonality of Collimation Axis to Elevation Axis: 15 arcseconds maximum error.

Subreflector axis to collimation axis: the structure of the apex of the feed legs must locate the center of the opening coincident within 0.1 inches and the axis of the opening parallel within 30 arcseconds of the collimation axis of the reflector.

- Counterbalancing: Overbalanced to allow the antenna to return to zenith with no drive power under no wind, noise, no snow conditions.

- Drive Requirements: Azimuth and elevation drives shall have a capability of driving the antenna at a velocity of 120° per minute in azimuth and 20° per minute in elevation, with the reflector in any attitude under the specified operating conditions. Azimuth and elevation drives shall drive the antenna at sidereal tracking rates with an accuracy as specified in paragraph ____ below.

Under the conditions described as Precision (Primary) and Normal (Secondary) operating conditions below, acceleration to full speed shall be accomplished in less than 2 seconds of time. A longer acceleration time will be allowed in certain special condition as set forth below.

02.2 Operating Parameters and Conditions

- General: Antenna will be exposed to the elements at various sites and under various climatic conditions, with some sites perhaps as high as 8000 ft above mean sea level. The antennas are to be designed for a life expectancy of 20 years. No damage to the operating components of the antennas must occur due to airborne sand or dust or accumulation of frozen or liquid water.

- Precision (Primary) Operating Conditions: The antenna shall meet the required precision pointing and surface accuracies under the following conditions:

- Temperature range: -18° C (0° F) to +30° C (86° F)

- Rate of change of ambient air temperature is no greater than 2° C per hour.

- No parts of the telescope structure differ in temperature more than 3.5° C (6.3° F).

- The relative humidity is between 0 and 50%.

- The wind at 12 m elevation is no greater than 6 m/sec, with gusts of ± 1 m/sec superimposed. Wind from any direction with the reflector in any attitude.

- No snow or ice load.

Normal (Secondary) Operating Conditions - The antennas must continue to operate under "normal" operating conditions but it is understood that the pointing, tracking and surface accuracies set forth under precision operation will not be achieved. Normal operation must be possible under the following conditions:

- Ambient air temperature: 30° C (-22° F) to +40° C (104° F).

- Relative humidity: 0 to 98%.

- Rain rate: 4 p to 5 cm (2 in) per hour

- Ice and snow load: None

- Wind (measured at 12 m elevation) velocity up to 18 m/sec, with gusts of ± 2.5 m/sec superimposed. Wind may be from any direction; reflector in any position. A special condition will be provided which will allow the antenna to operate in winds to 24 m/sec, but for which the acceleration time to full speed may be 4 secs of time and maximum speed may be allowed to fall to 60°/min in azimuth for the worse case of wind direction and antenna attitude.

Requirements to be met in moving to stow and in the stowed position.

- Slew to stow: The antenna shall be capable of being slewed to the stow position in elevation in winds of 60 mph (26.8 m/sec) with all exposed surfaces of the structure coated with 1 cm radial thickness of ice. The slew rate may fall to 10°/minute.

- Slew to dump snow: The antenna shall be capable of dumping snow by slewing of 20°/min to any position 5° above the horizon, with a wind of 25 mph from any direction and with an original snow load in the reflector of 4 lbs/ft^2. No damage or overload shall occur to either structure, drives or brakes.

- Survival: The antenna is to be designed to survive in the zenith position in winds of 110 mph with 1 cm of radial ice on all exposed surfaces. When loaded under these conditons, design yield stresses of materials shall not be exceeded and no permanent deformation shall occur. Stow brakes shall be provided capable of holding the antenna in the zenith position when subjected to the design survival loading.

02.3 The Antenna Performance

02.3.1 Surface accuracy. Under the precision operating conditions specified in 02.2 above, the rms of the deviations from the design parabola shall not exceed 0.45 mm (0.018 inches). This rms shall include the manufacturing rms, the panel setting rms, gravity effects and wind and thermal effects. The panel setting rms, however, may be calculated by permitting translation of the design surface along the collimation axis and rotation of the design surface about an axis perpendicular to the collimation axis and parallel to the elevation axis. Gravity effects may be calculated from an elevation angle which is 30° from the zenith.

Under these same conditions the peak deviation of the surface from the design parabola shall not exceed 1.5 mm (0.060 inches).

02.3.2 Pointing and tracking errors. The pointing error is defined as the difference between the commanded position of the antenna and the position of the main beam of the reflector. Tracking error is a part of the pointing error and includes the effects of the servo update rate and axis velocity as determined by axis position. The repeatable pointing error is due to gravity deformation, axis alignment error, encoder offset, bearing runout, bearing alignment, and similar errors. The nonrepeatable pointing error is due to wind forces and gusts, acceleration forces, effects of temperature differences and temperature changes, encoder resolution, encoder error, data converter errors, servo and drive errors, position update rate, bearing nonrepeatability and random errors. The repeatable pointing error for this antenna shall not exceed 3 minutes of arc.

The nonrepeatable pointing error is divided into two types of error with different statistical behaviour. The first type of nonrepeatable errors behaves correctly, in a statistical sense, with errors changing in magnitude and sense within times up to a minute. Such errors average out fairly well in observations taken over several minutes. Nonrepeating errors of this type, under the precision operating conditions of 02.2 above, shall not exceed 7 arcseconds RSS. This figure shall be derived by making an RSS of all errors of this type with the antenna in any attitude and while tracking a source at the specified sidereal tracking rates. The values of individual errors which contribute to the RSS error budget should be rms values wherever these can be determined. It may only be possible in some cases, such as wind induced distortions of the reflector, yoke if used, alidade and tower, to identify the antenna attitude and wind direction which gives the greatest error (the "worst case"). One-half of such "worst case" error values should be used in the RSS error budget.

The second type of nonrepeatable pointing error is that which usually results from thermally induced distortions of the antenna structure. These errors have time constants typical of the times over which serious temperature changes or temperature differences occur. These times may lie between several minutes and a few hours.

It is possible to control the magnitude of this type of pointing error by reducing the temperature differentials between structural elements by either active or passive (the preferred) measures. Passive measures to be investigated in the design stage shall include antenna point systems to control reflectivity and reradiation from members, sun shields and/or thermal insulation on selected members where effective. After such design efforts have been made, the antenna must, under the precision operation conditions, suffer no peak nonrepeatable pointing errors of this type which exceed 7 arcseconds in magnitude. The antenna design shall assure that temperature differentials do not occur more than 5% of the time which places the antenna outside the precision operating condition.

02.4.3 Slewing motion. Slewing motion is defined as the rapid movement of the antenna about either axis simultaneously or independently. The antenna shall be capable of driving at the rate of 20°/min of time about the elevation axis and 120°/min about the azimuth axis in winds to 18 m/sec with the reflector in any attitude. It shall be possible to slew either axis independently while the other axis is stationary or moving at the tracking rate, or to slew both axes simultaneously. The antenna shall be capable of accelerations of 0.25°/sec^2 about the elevation axis and 1.0°/sec^2 about the azimuth axis except for the special conditions set forth in 02.2 above.

02.4.4 Tracking motion. The antenna shall be capable of tracking a stellar source at the azimuth and elevation rates which correspond to the sidereal rate for the star position and maintaining the pointing accuracy as set forth in 02.3.2 above under precision operating conditions with a command update rate of 10 times/sec. This cone of avoidance near the zenith when in the tracking mode shall have a half-angle less than 2.5°.

03 GENERAL REQUIREMENTS

03.1 Feed legs and apex.

The feed leg supports shall be designed to support either a subreflector of 2.5 m diameter and adjusting mechanism, weighing approximately 1300 lbs, or a prime focus feed of approximately the same weight. The feed legs shall also be designed to support a cable weight of 4 lbs/ft on each leg. The apex structure shall be designed so that a clearance of 18 to 24 inches exists between the bottom of the apex structure and the focal point of the main reflector. Its configuration shall be such that a clear opening of approximately 48 inches diameter exists on the center line of symmetry for the location and attachment of the adjustment mechanism. The feed legs and apex,including a 2.5 m subreflector, shall not cause RF blockage in excess of 6 percent of the total aperture area.

03.2 Vertex equipment room and feed mounts. An approximately circular room with a minimum of 150 sq. ft area, having an inside diameter of approximately 13.75 ft by 7.5 ft height for mounting of feeds and equipment, shall be provided. The floor of this room shall be parallel to the ground with the antenna pointed at zenith and shall be a minimum of 8 ft below the vertex of the antenna. This room shall be provided with the following features:

- Mounting provisions for up to five 2 ft x 2 ft x 7 ft ceiling mounted racks, with a total weight of 2000 lbs.

- An access door for access by personnel and for means of installing racks by use of hoist.

- Thermal insulation and air conditioning to provide 23° C ± 0.5° C (74° F ± 1.0° F) temperature control with an interior heat input of up to 3 kW. A proportional control gas modulated cooling system is recommended. No specific humidity conditions are required.

- The roof of the building shall contain a removable mounting ring for the mounting of feeds. Dimensions of this ring shall be determined in the design stage, but it is anticipated that it will be approximately 8 ft in diameter.