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Deep Space Communications Complex Subsystem Functional Requirements

Antenna Mechanical Subsystem (1991 through 1997)

Released by:

B. Citrom
TDA Document Control

Prepared by:

W. Scherr
Antenna Subsystem Engineer

Approved by:

E. L. McKinley
TDA Engineering Manager

Jet Propulsion Laboratory
California Institute of Technology

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DOCUMENT CHANGE NOTICE

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Purpose of Change: Adding Module 3.9, 34-m High-Speed Beam Waveguide Antenna Assembly.

Instructions: Insert the changed pages indicated in the document change log and remove the superseded pages.

(▌) Indicates area of actual change on changed or added page(s).

Authorization: [signature] 3/8/95
C. Yung
Subsystem Engineer
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DOCUMENT CHANGE LOG

Date	Effective Pages	Status
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Date	Effective Pages	Status

Contents

Contents (Continued)

Contents (Continued)

Contents (Continued)

Section 1
Introduction

1.1 Purpose and Scope

This document defines the Deep Space Network (DSN) functional and performance requirements for the Antenna Mechanical Subsystem (ANT) for the period 1991 through 1997. There are six types of antennas and three types of controllers in use or anticipated. Section 3 is divided into modules which define the requirements for each type of antenna or controller. The requirements defined in Sections 1, 2, 4, 5, and 6 are applicable to all types of antennas and equipment.

1.2 Revision and Control

Future issues of this document will be controlled by the change control process described in Reference Document (1), 820-20. Modifications of the requirements specified herein may be accomplished only through a defined proposal process, with ultimate approval by the DSN Systems Engineering Manager. The procedure for submitting change proposals is given in Document 820-20.

1.3 Applicable Documents

The requirements established in this document have been derived from guidelines and criteria contained in the following documents:

821-8	DSN System Requirements - Radio Science System (1979-1983)
821-10	DSN System Functional Requirements - Mark IVA VLBI System (1988-1995)
821-11	DSN System Functional Requirements - Mark IVA DSN Test Support System (1984-1988)
821-14	DSN System Functional Requirements - Mark III-77 and Mark IVA Frequency and Timing Subsystem (1981-1986)
821-18	DSN System Functional Requirements - Mark IVA Monitor and Control System (1984-1987)

821-19	DSN System Functional Requirements - DSN Tracking System (1988-1992)
821-23	DSN System Functional Requirements - Command System (1991-1996)
821-25	DSN System Functional Requirements - Mark IVA Telemetry System (1992-1995)
828-1	DSN System Functional Requirements - Radio Frequency System (TBS)
890-131	Mark IVA DSN - DSCC General Data Flow Standards
890-134	Mark IVA DSN - DMC Operator Interface Description
890-138	DSCC Requirements and Standards for Mark IVA Level 2 Maintenance Support
DP 512177	Integrated Circuit Designation System, Standard Procedure

1.4 Reference Documents and Standards

The following documents are referenced in the text of this document. The equipment, software, and interfaces of the ANT shall meet the requirements set forth therein.

(1)	820-20	DSN General Requirements and Policies through 1985, Volume 2
(2)	810-3	TDA Standard Practice - Glossary of Deep Space Network Terms and Abbreviations
(3)	890-88	DSN Engineering Change Management Operations Manual
(4)	810-10	DSN Standard Practice - DSN Engineering Review Program
(5)	828-1	DSN System Functional Requirements Radio Frequency System (TBS)
(6)	820-17	DSN System Requirements - Detailed Hardware Interface Design

(12)	824-38	DSCC Tracking Subsystem Functional Requirements (1992 through 1996)
(13)	810-27	DSN Standard Practice - Technical Manual Requirements
(14)	890-213	Goldstone Safety and Environmental Protection Manual
(15)	D-4000	JPL Software Management Standard Package
(16)	DSN STD-00001	DSN Standard Design Requirements - DSN/GCF/NOCC Equipment
(17)	820-34	Functional Requirements - Mark IVA Deep Space Network 26m Tracking and Communications Subnet

1.5 Abbreviations

Abbreviations used in this document are defined after the first textual use of the technical term. Abbreviations and acronyms approved for use by the JPL Office of Telecommunications and Data Acquisition (TDA) are listed in Reference Document (2), 810-3. However, for reader convenience, the abbreviations used throughout this document are given in Appendix A.

1.6 Implementation Requirements

1.6.1 Scheduling

Appendix B of this document lists the priorities and need dates for initial operational capability of the ANT.

1.6.2 Progress Reporting

The changes and additions to the ANT described in this document are to be implemented under the Engineering Change Management System. Progress reporting shall be in accordance with Reference Document (3), 890-88.

1.6.3 Reviews

Functional and detail design reviews shall be conducted periodically during the design and implementation of the ANT in accordance with Reference Document (4), 810-10. Other reviews shall be conducted, as necessary, to verify planned operational capability and progress.

Section 2

Functional Description

2.1 Functions

The DSS Antenna Mechanical Subsystem (ANT) (1991 through 1997) is used by the DSN Telemetry, Radio Science, VLBI, Command, Radar, and Tracking Systems to perform the following functions:

(1) Collect and focus radio frequency (RF) energy.

(2) Point to a target.

(3) Provide physical and environmental support for components of other subsystems.

(4) Provide signals to, and accept signals from, other subsystems in the Deep Space Station (DSS).

2.2 Key Characteristics

The key characteristics of the DSS ANT are as follows:

(1) Provides primary and secondary reflectors which collect and focus the incoming RF energy and outgoing RF energy into/from any one of several feed horns.

(2) Provides fixed and moving structures which support the reflectors and other components of the subsystem.

(3) Provides drives which move portions of the structure in response to pointing commands.

(4) Provides servo electronics which accept various control signals and condition the signals into pointing commands.

(5) Provides angle displays and outputs which indicate the estimated RF beam position. These are calculated from the shaft position encoders and modified with system error corrections, atmospheric refraction corrections, squint corrections (caused by subreflector lateral motion), and other predictable anomalies.

(6) Provides antenna (and Master Equatorial) axis angle readouts which indicate the "as-installed" mechanical orientation of the structure.

(7) Provides subreflector axis readouts in inches (or meters) which indicate the "neutral" mechanical position of the lateral (X and Y), and radial (Z) positions and rotation axis, referenced to fixed permanent objects, providing failure recovery without need for a new alignment.

(8) Provides physical mounting structure and necessary environment for components of other subsystems which are required to be antenna-mounted, such as the Receiver-Exciter, Antenna Microwave, and Transmitter.

(9) Provides subsystem controllers which automatically control all operational aspects of the antenna, including monitoring of its performance. The subsystem controllers:

  (a) Provide monitor data to, and receive control data from, the DSCC Monitor and Control Subsystem (DMC).

  (b) Perform a form of automatic scanning to track a radio source and obtain pointing offset data for refinement of antenna position.

  (c) Perform a preprogrammed scan to efficiently acquire a signal.

  (d) Store and utilize system error tables and models which improve the performance of the antennas.

(10) Provides a standard port that allows control of each antenna for maintenance.

(11) Performs on-line diagnostics (level 1) and, when requested, off-line failure location diagnostics (level 2).

(12) Records important antenna parameters and measurements for post-pass analysis.

2.3 Functional Operations

The ANT at each DSCC functions as a large-aperture collector which focuses the incoming RF energy into the mouth of a feed horn. (The feed horn is a part of the Antenna Microwave Subsystem, not included in this document.) Transmitted RF energy radiated from the feed horn is focused into a narrow conical beam. The ANT points the estimated position of the RF beam at the predicted target location by a series of drive motors and gear trains which rotate the movable portions of the structure that support the reflectors, position sensors, and related electronics. Table 2-1 lists the deep space stations with their respective antenna diameters, types of antenna motion, and type of optics.

Electronic controllers are used to process the angle or position-error signals. These signals are available from several sources and are provided to the drive motor controls.

Table 2-1. Deep Space Station Antenna Sizes and Types

Type of DSS Reflector	Diameter (meter)	Type of Mount	Primary
12	34 STD	HA-Dec	Parabolic
24*	34 BWG	Az-El	Shaped
14	70	Az-El	Shaped
15	34 HEF	Az-El	Shaped
16	26	X-Y	Parabolic
17	9	X-Y	Parabolic
42	34 STD	HA-Dec	Parabolic
34*	34 BWG	Az-El	Shaped
43	70	Az-El	Shaped
45	34 HEF	Az-El	Shaped
46	26	X-Y	Parabolic
61	34	HA-Dec	Parabolic
54*	34	Az-El	Shaped
63	70	Az-El	Shaped
65	34	Az-El	Shaped
66	26	X-Y	Parabolic

*During the period 1992 through 1995, it is planned to design and build three 34-m beam waveguide Az-El antennas. The new antennas will be designated DSS 24, DSS 34, and DSS 54.

Pointing angles are computed from externally supplied predicts of the RF source position and are corrected for systematic and environmental errors; the antenna structure is pointed to those corrected angles. Once the receiver has acquired a signal, feedback derived from received power measurement may be used to further minimize pointing error (CONSCAN).

The ANT provides physical support for, and (where required) maintains proper alignment of, components of other subsystems. It also provides electrical power, heating, cooling, and protection from the elements for components of other subsystems which are installed on the antenna or in the antenna pedestal.

The functions and interfaces of the ANT for the 1991 through 1997 era are shown in Figure 2-1.

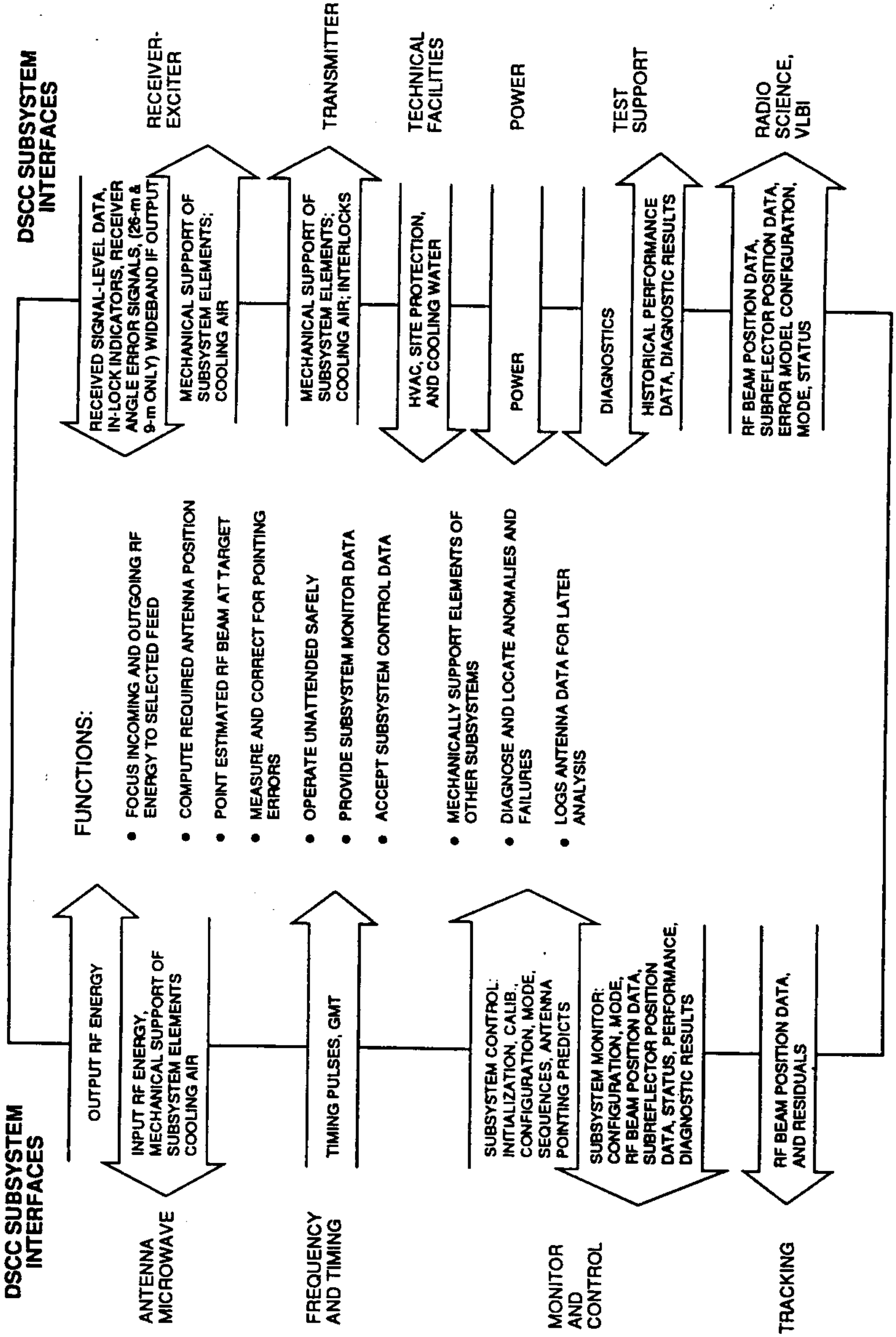

Figure 2-1. DSCC Antenna Mechanical Subsystem (1991 through 1997 Era), Functions and Interfaces

Section 3

Functional and Performance Requirements

The Deep Space Network (DSN) utilizes up to six different types of antennas: a 70-m azimuth-elevation, a 34-m high efficiency, a 34-m beam waveguide, a 34-m standard, a 26-m X-Y, and a 9-m X-Y. During the 1991-1992 period, all the 34-m antennas and the 70-m antenna will be controlled by an Antenna Pointing Assembly and, starting in 1993, the two X-Y antennas will be controlled by a Metric and Pointing Assembly, as shown in Figure 3-1.

Since there are several major assemblies to define, this section is partitioned into separate modules to allow the individual assemblies to be characterized and upgraded without the need to update the entire document.

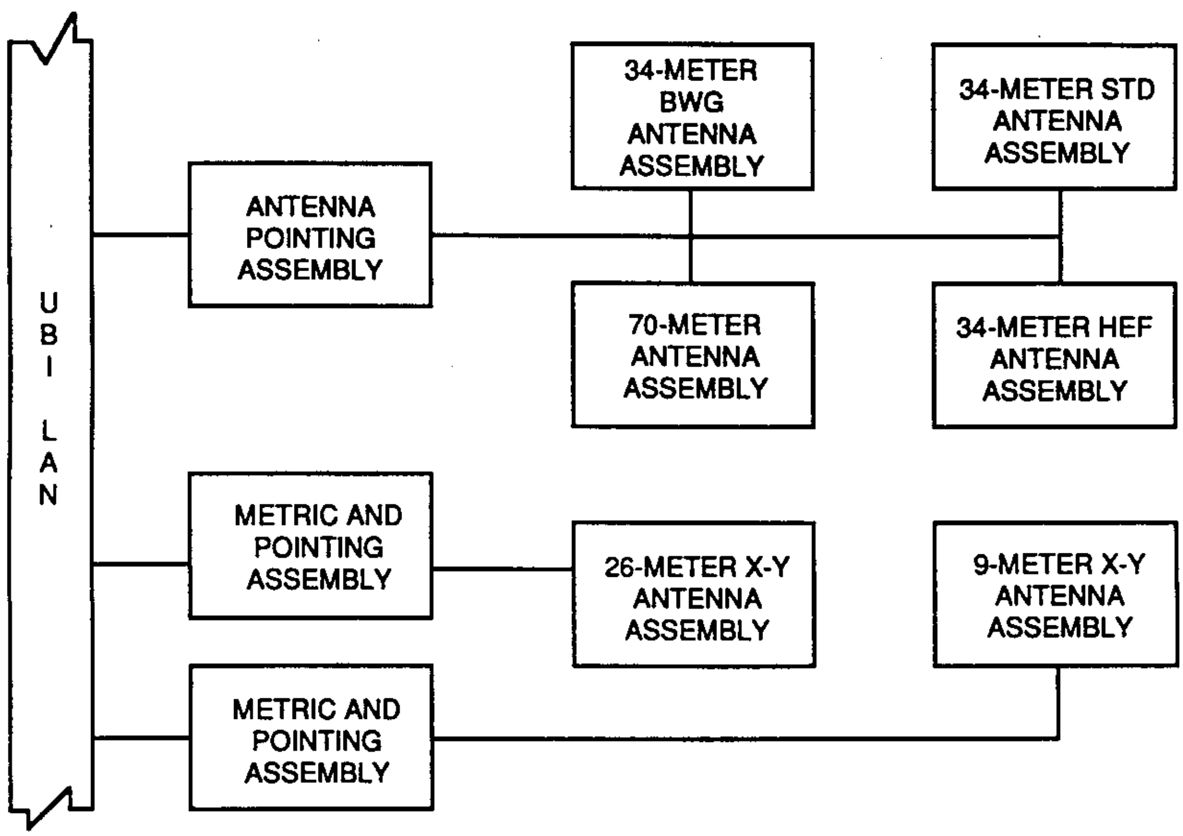

Figure 3-1. Antenna Mechanical Subsystem (1991-1993)

During the period 1993 through 1997, the existing 70-m and 34-m HEF antennas at each DSCC and the 34-m beam waveguide antenna to be added at each DSCC will be controlled from the DMC via the SPC LAN through a new Antenna Control Group assigned to each of these antennas. Their connection to the Antenna Pointing Assembly (APA) will be deleted. The 34-m STD antenna will continue to be connected to the APA until removed from service, as planned during the 1998/1999 period. The 26-m and 9-m antennas will continue to be operated through the Monitor and Pointing Assemblies (MPAs). Thus, the block diagram for the ANT will be as shown in Figure 3-2 after the above work is completed.

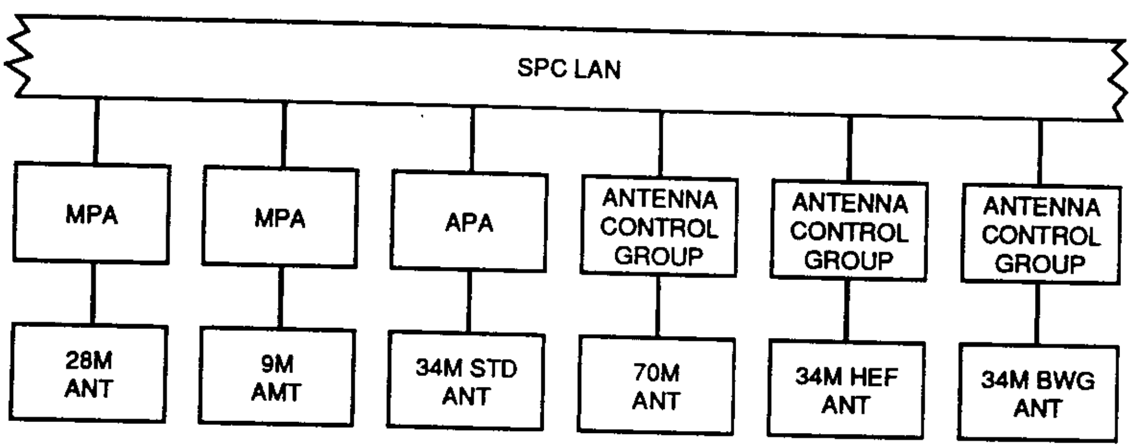

Figure 3-2. Antenna Mechanical Subsystem (1993-1997)

Module 3.1

70-m Az-El Antenna Assembly

3.1.1 General

The 70-m antenna consists of: a shaped primary reflector 70-m in diameter, a shaped subreflector which is rotatable and tilted from its axis of rotation, a cone-support structure, and three cone assemblies in which various feed systems may be mounted. As the tilted subreflector is rotated, it directs the RF beam into one of the three feed cones. (The feed systems within the cones are a part of the Antenna Microwave Subsystem (UWV) and are not included in this document.)

The antenna rotates in azimuth on three hydrostatically supported pads which slide on a runner and in elevation on a horizontal axis supported on a series of elevation axis bearings. There is also an instrument tower on which is mounted a Master Equatorial (ME) instrument which, by the use of an autocollimator can control the antenna to track the ME position. The ME provides position readouts with the same accuracy and resolution as the antenna's readouts.

3.1.2 Focus of RF Energy

3.1.2.1 Surface Tolerance

The 70-m antenna shall have a combined surface tolerance of all reflectors and their alignment equal to 0.030 inches RMS when measured at the rigging angle, nominally 45 degrees with no wind.

3.1.2.2 Gravity Loss

At 10 and 80 degrees, the combined surface tolerance shall not exceed 0.036 inches RMS with no wind.

3.1.3 Antenna Motion

The antenna shall be capable of motion in the azimuth and elevation axes. Servo motors and gear reducers shall be provided to provide these motions.

3.1.3.1 Slew Rate

The minimum slew rate in each axis shall be 0.25 deg/sec.

3.1.3.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to $\geq$0.25 deg/sec.

3.1.3.3 Acceleration

The acceleration in each axis shall be ≥0.2 deg/sec^2.

3.1.3.4 Deceleration

The deceleration (braking) in each axis shall be ≥2.5 deg/sec^2.

3.1.3.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position in a 50-mph wind from any direction.

3.1.3.6 Motion Limits

The antenna shall be able to move to any position as specified below.

3.1.3.6.1 Azimuth. Azimuth operational limits shall be no less than ±265 deg from cable wrap center.

3.1.3.6.2 Elevation. Elevation operational limits shall be ≤6 deg and ≥89.5 deg.

3.1.3.7 Antenna Mechanical Subsystem Pointing

The Antenna Mechanical Subsystem shall maintain the pointing of the RF beam to the predicted position of a sidereal target, without signal-level feedback (i.e., blind pointing) under the following wind conditions (the standard deviations assume a Rayleigh distribution of the beam radial error):

(1) ≤0.0013 deg, mean, in a 10-mph wind from any direction.

(2) ≤0.0027 deg, mean, in a 20-mph wind from any direction.

(3) ≤0.0043 deg, mean, in a 30-mph wind from any direction.

(4) ≤0.0067 deg, mean, in a 45-mph wind from any direction.

NOTE

Pointing accuracy over the entire tracking rate TBD.

3.1.4 Antenna Angle Readouts

Angle readouts of the antenna's position shall be provided on the main axes with the following capabilities:

3.1.4.1 *Readout Resolution*

The angle readouts shall provide a resolution of at least 0.021 millidegrees (24 bits).

3.1.4.2 *Readout Accuracy*

The angle readouts shall provide an accuracy of no less than ±0.343 millidegrees (20 bits).

3.1.4.3 *Displays*

Displays shall be provided which read from 000.000 to 359.999 deg.

3.1.5 *Master Equatorial Angle Readouts*

Angle readouts of the ME's position shall be provided with the following capabilities:

3.1.5.1 *Readout Resolution*

The angle readouts shall provide a resolution of at least 0.021 millidegrees (24 bits).

3.1.5.2 *Readout Accuracy*

The angle readouts shall provide an accuracy of no less than ±0.343 millidegrees (20 bits).

3.1.6 *Subreflector Motion*

The subreflector shall be mounted on a positioner which allows it to be moved ±6.00 inches in each of three axes (axial, x, y) to optimize the focusing of the optics.

3.1.6.1 *Position Readouts*

Position readouts shall be provided to allow remote monitoring of the subreflector position.

3.1.6.2 *Remote Control*

Remote control of the subreflector position shall be provided.

3.1.6.3 *Drive Speed*

The speed of the positioner drives shall allow the subreflector to keep up with the programmed position when the antenna is driven at the maximum slew rate.

3.1.6.4 Location Accuracy

The positioner shall be able to locate the subreflector within ±0.010 inches of the assigned position relative to the quadripod center for each of the three axes.

3.1.6.5 Rotation Speed

The subreflector shall be capable of rotating at any antenna elevation position at a rate of >0.04 deg/sec and shall have an acceleration/deceleration of 1.0 deg/ sec/sec.

3.1.6.6 Rotation Duty Cycle

The subreflector rotational drives shall be designed to permit the subreflector to be rotated approximately 120 degrees every four minutes during a single 12-hour track once a week.

3.1.6.7 Position Readout Resolution

The subreflector rotation shall be provided with position readouts with ±0.0022 degree resolution.

3.1.6.8 Rotation Accuracy

The positioning accuracy of the subreflector rotation shall be within 0.030 degree.

3.1.7 Monitor and Control Requirements

The 70-m antenna shall be monitored by and controlled from the Antenna Control Group, as defined in Module 3.5 of this document.

3.1.8 Electrical Interface Requirements

3.1.8.1 Microwave Subsystem

An interface with the Microwave Subsystem (UWV) shall be provided for radio frequency transfer as defined in Reference Document (5), 828-1.

3.1.8.2 Equipment Support

Interfaces with the receiver, transmitter, and UWV shall be provided for support of their equipments, including cooling air and water, power, and mechanical position and alignment.

3.1.8.3 Transmitter Interlocks

An interface with the transmitter shall provide a contact that is closed when (1) the antenna is above selectable elevations through various azimuth positions, and (2) when the mirror positions are correct for the transmitter selected. Reference Document (6), 820-17, TRK 2-TBS, will define this interface.

3.1.8.4 Time

Acceptance of epoch time (1 pps and 100 pps) shall be in accordance with Reference Document (6), 820-17, Module DFT 10-104.

3.1.9 Safety Requirements

3.1.9.1 Antenna and Personnel Protection

Adequate guards, sensing devices, and interlocks shall be provided to protect the antenna from damage and to protect personnel located on the antenna from injury during any reasonable equipment failure.

3.1.9.2 Fail-Safe Operation

Each device or sensor shall operate in a fail-safe mode so that, if the device fails, the antenna and personnel will be protected.

3.1.9.3 Brakes

Brakes shall be provided to secure the antenna in any position during a 70-mph wind from any direction.

3.1.9.4 Locking Devices

Brakes and/or locking devices shall be provided to ensure survival in the stowed position during a 100-mph wind from any direction.

3.1.9.5 RF Isolation

The antenna shall be designed to provide adequate isolation and shielding to allow safe, continuous personnel access to all areas behind the primary reflector during $\leq$1000-kW transmission.

3.1.9.6 Service Access

Ladders, walkways, etc., shall be provided to allow safe access by personnel to all areas of the antenna which require servicing or maintenance.

3.1.9.7 Seismological Requirements

The 70-m antenna shall comply with the Seismological requirements defined in the Universal Building Code for Zone 4.

3.1.10 Support of Other Subsystems

3.1.10.1 Space

The 70-m antenna shall provide space and physical support in correct alignment for components of other subsystems in the cones and cone-support structure.

3.1.10.2 Temperature Control

Equipment spaces shall be maintained at a temperature of 24±3 degree C.

3.1.10.3 Power

Power shall be provided at 60-Hz to equipment in the equipment spaces as follows:

(1) 120V single-phase

(2) 120V/208V three-phase

(3) 277/480V three-phase

3.1.11 Environmental Requirements

The 70-m Az-El antenna and all its components shall be designed and built to operate continuously in the environment defined in Section 4 of this document.

Module 3.2

34-M High-Efficiency Antenna Assembly

3.2.1 General

The 34-m high-efficiency (HEF) antenna consists of: a shaped primary reflector 34 meters in diameter, a shaped subreflector, and a cone assembly in which the feed system is mounted. (The feed system is a part of the Antenna Microwave Subsystem (UWV) and is not covered in this document.) The antenna shall rotate in azimuth on wheels and a track and in elevation on a horizontal shaft.

3.2.2 Focus of RF Energy

3.2.2.1 Surface Tolerance

The antenna combined surface tolerance of all reflectors and their alignment shall be ≤0.020 inches RMS when measured at the rigging angle, nominally 45 deg with no wind.

3.2.2.2 Gravity Loss

The combined surface tolerance of the antenna at elevations of 10 deg and 80 deg shall not exceed 0.024 inches RMS with no wind.

3.2.3 Antenna Motion

The antenna shall be capable of motion in the azimuth and elevation axes. Servo motors and gear reducers shall be provided to produce the following motions.

3.2.3.1 Slew Rate

The minimum slew rate in each axis shall be 0.8 deg/sec.

3.2.3.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to ≥0.4 deg/sec.

3.2.3.3 Acceleration

The acceleration in each axis shall be ≥0.4 deg/sec^2 up to a rate of 0.4 deg/sec.

3.2.3.4 Deceleration

The deceleration (braking) in each axis shall be ≥5.0 deg/sec^2.

3.2.3.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position in a 50-mph wind from any direction.

3.2.3.6 Motion Limits

The antenna shall be capable of moving to any position within the following limits.

3.2.3.6.1 ***Azimuth***. Azimuth operational limits shall be no less than ±225 deg from cable wrap center.

3.2.3.6.2 ***Elevation***. Elevation operational limits shall be ≤6 deg and ≥89.5 deg.

3.2.3.7 Antenna Mechanical Subsystem Pointing

The Antenna Mechanical Subsystem (ANT) shall maintain the pointing of the RF beam to the predicted position of a sidereal target, without signal-level feedback (i.e., blind pointing) under the following wind conditions (the standard deviations assume a Rayleigh distribution of the beam radial error):

(1) ≤0.002 deg, mean, in a 10-mph wind from any direction.

(2) ≤0.006 deg, mean, in a 20-mph wind from any direction.

(3) ≤0.011 deg, mean, in a 30-mph wind from any direction.

NOTE

Pointing accuracy over the entire tracking rate TBD.

3.2.4 Angle Readouts

Angle readouts shall be provided with the following capabilities.

3.2.4.1 Readout Resolution

Angle readouts shall provide a resolution of at least 0.021 millidegrees (24 bits).

3.2.4.2 Readout Accuracy

Angle readouts shall provide an accuracy of no less than ±0.343 millidegrees (20 bits).

3.2.4.3 Displays

Displays shall be provided which read from 000.000 to 359.999 deg.

3.2.5 Subreflector Motion

The subreflector shall be mounted on a positioner which allows it to be moved in each of three axes (axial, x, y) to optimize the focusing of the optics as the antenna is rotated through any specified position.

3.2.5.1 Position Readouts

Position readouts with a resolution of 0.001 inches shall be provided to allow remote monitoring of the subreflector position.

3.2.5.2 Remote Control

Remote control of the subreflector position shall be provided.

3.2.5.3 Drive Speed

The speed of the positioner drives shall allow the subreflector to keep up with the programmed position when the antenna is driven at the maximum slew rate.

3.2.5.4 Location Accuracy

The positioner shall be able to locate the subreflector within ± 0.010 inches of the assigned position relative to the quadripod center for each of the three axes.

3.2.6 Monitor and Control Requirements

The 34-m HEF antenna shall be monitored and controlled from the Antenna Control Group, as defined in Module 3.5 of this document.

3.2.7 Electrical Interface Requirements

The 34-m HEF antenna shall provide interfaces with the equipment listed below.

3.2.7.1 Microwave Subsystem

When interfacing with the Microwave Subsystem, radio frequency transfer shall be as defined in Reference Document (5), 828-1.

3.2.7.2 Subsystems and Their Utilities

The Receiver, Transmitter, and Microwave Subsystem, their support equipment, including cooling air and water, power, and mechanical position, shall be provided by the 34-m antenna.

3.2.7.3 Transmitter

With the transmitter(s), a switch shall close when the antenna is above selectable elevations through various azimuth positions.

3.2.7.4 Time Increments

Acceptance of epoch time, 1 pps and 100 pps, in accordance with Reference Document (6), 820-17, Module DFT 10-102.

3.2.8 Safety Requirements

3.2.8.1 Antenna and Personnel Protection

Adequate guards, sensing devices, and interlocks shall be provided to protect the antenna from damage and to protect personnel located on the antenna from injury during an equipment failure.

3.2.8.2 Fail-Safe Operation

Each device or sensor shall operate in a fail-safe mode so that, if the device fails, the antenna and personnel will be protected.

3.2.8.3 Brakes

Brakes shall be provided to secure the antenna in any position during a 70-mph wind from any direction.

3.2.8.4 Locking Devices

Brakes and/or locking devices shall be provided to ensure survival in the stowed position during a 100-mph wind from any direction.

3.2.8.5 RF Isolation

The antenna shall be designed to provide adequate isolation and shielding to allow safe, continuous personnel access to all areas behind the primary reflector during ≤25-kW transmission.

3.2.8.6 Service Access

Ladders, walkways, etc., shall be provided to allow safe access by personnel to all areas of the antenna that require servicing or maintenance.

3.2.8.7 *Seismological Requirements*

The 34-m HEF antenna shall comply with the seismological requirements defined in the Universal Building Code for Zone 4.

3.2.9 *Support of Other Subsystems*

3.2.9.1 *Space*

The 34-m HEF antenna shall provide space and physical support in correct alignment for components of other subsystems in the pedestal of the structure.

3.2.9.2 *Temperature Control*

The pedestal space shall be maintained at a temperature of 24±3 degree C.

3.2.9.3 *Power*

60-Hz power shall be provided to equipment in the pedestal as follows:

(1) 120V, single-phase

(2) 120V/208V, three-phase

(3) 277/480V, three-phase.

3.2.10 *Environmental Requirements*

The 34-HEF antenna and all its components shall be designed and built to operate continuously in the environment as defined in Section 6 of this document.

Module 3.3

34-m Beam Waveguide Antenna Assembly

3.3.1 General

The 34-m beam waveguide (BWG) antenna consists of: a shaped primary reflector 34 meters in diameter, a shaped subreflector, a series of mirrors to direct the RF energy around the azimuth and elevation axes through a shielding tube to a series of fixed feedhorns mounted in the pedestal of the antenna. The antenna rotates in azimuth on wheels and a track, and in elevation on a horizontal shaft. (The feed systems are a part of the Antenna Microwave Subsystem (UWV) and are not discussed in this specification.)

3.3.2 Radio Frequency Requirements for the 34-m BWG Antenna Mechanical Subsystem

3.3.2.1 Surface Accuracy

The antenna shall provide a combined primary, secondary, and BWG reflector surface RSS of $\leq$0.024 inches at the rigging angle, nominally 45 degrees, with no wind, and a combined RSS of $\leq$0.0265 in any elevation position from 10 to 80 degrees with no wind.

3.3.2.2 Noise Contribution

The antenna shall be designed so that the zenith microwave noise contribution generated by the antenna, including BWG components, at either S-, X-, or Ka-band due to all spillovers, leakages, and scattering I^2R losses, including any dichroic reflector, is as follows:

S-band	16K
X-band	9K
Ka-band	12K

3.3.2.3 Efficiency

The antenna shall be designed to the following microwave area efficiency requirements, with the understanding that other subsystem equipment may be required to perform these measurements. The following efficiencies include all antenna elements, except the microwave feed I^2R losses and voltage-standing wave ratio (VSWR).

Elevation/Band-GHz	2.3	8.4	32
10°	76%	76%	36%
45°	76%	77%	41%
80°	76%	76%	36%

3.3.3 Accuracy, Precision, and Stability Requirements

3.3.3.1 Path Length Stability

The antenna shall be designed to provide a one-way path length stability to limit the uncertainty of the antenna contribution to the phase residuals such that the Allan deviation of the antenna contribution to the signal is less than 2.7×10^{-15} (4.0×10^{-16} as goal) for sample intervals of 1,000 to 10,000 seconds under the following conditions:

Wind	- no higher than 10 mph
Weather	- clear, cloudless conditions
Gravity	- from 20° to 88° antenna elevation angles

3.3.3.2 Antenna Mechanical Subsystem Pointing

The Antenna Mechanical Subsystem (ANT) shall maintain the pointing of the RF beam (above 10 degrees elevation) to the predicted position of a sidereal target, without signal-level feedback (i.e., blind pointing) under the following wind conditions (assuming a Rayleigh distribution of the beam radial error):

(1) ≤0.002 deg, mean, in a 10-mph wind from any direction

(2) ≤0.006 deg, mean, in a 20-mph wind from any direction

(3) ≤0.011 deg, mean, in a 30-mph wind from any direction.

NOTE

Pointing accuracy over the entire tracking rate TBD.

3.3.3.3 Angle Encoders

Angle encoders shall be provided with a precision of 0.00005 degrees.

3.3.4 Antenna Motion

The antenna shall be capable of motion in the azimuth and elevation axes. Servo motors and gear reducers shall be provided to provide these motions.

3.3.4.1 Slew Rate

The minimum slew rate in each axis shall be 0.8 deg/sec.

3.3.4.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to ≥0.4 deg/sec.

3.3.4.3 Acceleration

The acceleration in each axis shall be ≥0.4 deg/sec^2 up to a rate of 0.4 deg/sec.

3.3.4.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to ≥0.4 deg/sec.

3.3.4.3 Acceleration

The acceleration in each axis shall be ≥0.4 deg/sec^2 up to a rate of 0.4 deg/sec.

3.3.4.4 Deceleration

The deceleration (braking) in each axis shall be ≥5.0 deg/sec^2.

3.3.4.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position in a 50-mph wind from any direction.

3.3.4.6 Motion Limits

The antenna shall be capable of moving to any position within the following limits.

3.3.4.6.1 ***Azimuth.*** Azimuth operational limits shall be no less than ±225 deg from the cable wrap center.

3.3.4.6.2 ***Elevation.*** Elevation operational limits shall be ≤6 deg and ≥89.5 deg.

3.3.5 Monitor and Control Requirements

The 34-m BWG antenna shall be monitored by and controlled from the Antenna Control Group, as defined in Module 3.5.

3.3.6 Subreflector Motion and Azimuth-Mirror Motion

The subreflector shall be mounted on a positioner which allows it to be moved in each axis (axially, X, Y) to optimize the focusing of optics.

3.3.6.1 Readouts

Position readouts shall be provided to allow remote monitoring of the subreflector position with a 0.001-inch resolution.

3.3.6.2 Remote Control

Remote control of the subreflector position shall be provided.

3.3.6.3 *Drive Speed*

The speed of the positioner drives shall allow the subreflector to keep up with the programmed position when the antenna is driven at the maximum slew rate.

3.3.6.4 *Accuracy*

The positioner shall be able to locate the subreflector within ±0.010 inches of the assigned position relative to the quadripod center for each of the three axes.

3.3.6.5 *Azimuth-Mirror Rotation*

The lowest mirror of the BWG system located in the pedestal shall be rotatable in azimuth so that the RF energy is directed into (or out of) any one of at least four feed ports.

3.3.6.5.1 *Rotation Speed*. The lowest reflector shall be able to rotate from any feed port to any other port and lock in no more than 2 minutes.

3.3.6.5.2 *Position Repeatability*. The pedestal mirror shall be moved and return to any one of the four feed positions to within ± 10 arc seconds.

3.3.6.5.3 *Position Commanding and Reporting*. The pedestal mirror assembly shall be commanded to move to any one of its four positions and report its status by way of the ACG as requested by the DMC. The nomenclature of the positions is in the ACG/DMC interface agreement.

3.3.6.5.4 *Feed Selection Control*. Feed selection shall be controlled from the DMC via the ACG.

3.3.7 *Electrical Interface Requirements*

The 34-m BWG antenna shall provide the interfaces listed below.

3.3.7.1 *Microwave Subsystem*

An interface shall be provided with the Microwave Subsystem for radio frequency transfer, as defined in Reference Document (5), 828-1.

3.3.7.2 *Interlocks to Transmitter*

A switch closure shall be provided when (1) the antenna is above selectable elevations through various azimuth positions, and (2) the mirror positions are correct for the transmitter selected. Reference Document (6), 820-17, Module TRK 2-TBS, will define this interface.

3.3.7.3 *Interlock from Transmitter*

The transmitter shall provide a switch closure when the transmitter is radiating out the feed horn. This will prevent the pedestal mirror assembly from moving when the transmitter is radiating.

3.3.7.4 *Timing and Time Pulses*

Acceptance of epoch time, 1 pps and 100 pps, shall be in accordance with Reference Document (6), 820-17, Module DFT 10-TBS.

3.3.8 *Safety Requirements*

The 34-m BWG antenna shall incorporate the safety features listed below.

3.3.8.1 *Protective Devices*

Adequate guards, sensing devices, and interlocks shall be furnished to protect the antenna from damage, and personnel located on the antenna from injury, during an equipment failure.

3.3.8.2 *Fail-Safe Operation*

Each device or sensor shall operate in a fail-safe mode so that, if the device fails, the antenna and personnel will be protected.

3.3.8.3 *Brakes*

Brakes shall be provided to secure the antenna in any position during a 70-mph wind from any direction.

3.3.8.4 *Locking Devices*

Brakes and/or locking devices shall be provided to ensure survival in the stowed position during a 100-mph wind from any direction.

3.3.8.5 *RF isolation*

This antenna shall provide adequate isolation and shielding to allow personnel safe, continuous access to all areas behind the primary reflector and outside the shroud during ≤25-kW transmission.

3.3.8.6 *Service Access*

Ladders, walkways, etc., shall allow safe access by personnel to all areas of the antenna that require servicing or maintenance.

3.3.8.7 *Earthquake Safety*

The seismological requirements defined in the Universal Building Code for Zone 4 shall be met.

3.3.9 *Operational Requirements*

3.3.9.1 *Design Life*

The antenna shall have a design life of ≥20 years for mechanical equipment and ≥10 years for electronic equipment.

3.3.9.2 *Availability*

Availability shall be 0.997 during both normal track and 0.998 during critical tracks.

3.3.9.3 *Mean Time Between Failures*

Mean time between failures (MTBF) shall be 1000 hours for mechanical equipment and 3000 hours for electronic equipment.

3.3.9.4 *Mean Time to Restore*

Mean time to restore (MTTR) shall be 6 hours for mechanical equipment and of 15 minutes for electronic equipment.

3.3.9.5 *Internal Diagnostics*

Internal diagnostics shall be capable of locating a failure to the lowest replaceable element (LRE).

3.3.9.6 *Equipment Mounting Space*

Adequate weather-protected space shall be provided in the pedestal to install (1) six feed systems, including the S-X feed system from the 34-m standard antenna, and (2) other equipment which is required to be in close proximity to the feeds.

3.3.9.7 *Temperature Control*

The pedestal space shall be maintained at a temperature of 22 ±4 degree C.

3.3.9.8 Power

Power shall be provided for the guest subsystem equipment as follows:

(1)	120V	single-phase
(2)	120/208	three-phase
(3)	277/480V	three-phase

3.3.10 Environmental Requirements

The 34-m BWG antenna shall operate satisfactorily under all of the environmental conditions defined in Section 6 of this document.

Module 3.4

34-M Standard Antenna Assembly

3.4.1 General

The 34-m standard antenna shall consist of a parabolic primary reflector 34 meters in diameter, a hyperbolic subreflector, and a fixed cone on the surface of the antenna in which the feed systems are mounted. (The feed systems are a part of the Antenna Microwave Subsystem (UWV) and are not discussed in this specification.)

The antenna shall rotate in hour-angle on a shaft aligned with the earth's axis of rotation and in declination on an orthogonal shaft.

3.4.2 Focus of RF Energy

3.4.2.1 Radio Frequency Performance

The antenna shall have a combined surface tolerance of all reflectors and their alignment equal to 0.060 inch RMS when measured at the rigging angle, nominally ± 10 deg declination and 360 deg in hour angle with no wind.

3.4.2.2 Gravity Loss

The combined surface tolerance shall be ≤ 0.075 throughout the design travel range with no wind.

3.4.3 Antenna Motion

The antenna shall be capable of motion in the hour angle and declination axes. Servo motors and gear reducers shall be provided to provide these motions.

3.4.3.1 Slew Rate

The minimum slew rate in each axis shall be 0.25 deg/sec.

3.4.3.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to ≥ 0.25 deg/sec.

3.4.3.3 Acceleration

The acceleration in each axis shall be ≥ 0.25 deg/sec/sec.

3.4.3.4 *Deceleration*

The deceleration (braking) in each axis shall be ≥5.0 deg/sec/sec.

3.4.3.5 *Drive to Stow*

The drives shall be capable of moving the antenna to the stowed position in a 50-mph wind.

3.4.3.6 *Motion Limits*

The antenna shall be capable of moving to any position within the limits defined below.

3.4.3.6.1 *Hour Angle*. Hour-angle hardware limits shall be no less than ±102 degrees from zenith, except where necessary to prevent the antenna from contact with the ground.

3.4.3.6.2 *Declination*. Declination hardware limits shall be equatorial horizon, less 5 degrees, and the visible pole, less 2 degrees.

3.4.4 *Angle Readouts*

Angle readouts shall be provided with the following three chacteristics.

3.4.4.1 *Readout Resolution*

Angle readouts shall provide a resolution of at least 0.34 millidegrees (20 bits).

3.4.4.2 *Readout Accuracy*

Angle readouts shall provide an accuracy of no less than ±2.75 millidegrees (17 bits).

3.4.4.3 *Displays*

Displays shall be provided which read from 000.000 to 359.999 degrees.

3.4.5 *Subreflector Motion*

The subreflector shall be mounted on a positioner which allows it to be moved in each of three axes (axial, x, y) to optimize the focusing of the optics.

3.4.5.1 *Readouts*

Position readouts with a resolution of 0.001 inches shall be provided to allow remote monitoring of the subreflector position.

3.4.5.2 Remote Operation

Remote control of the subreflector position shall be provided.

3.4.5.3 Drive Speed

The speed of the positioner drives shall allow the subreflector to keep up with the programmed position when the antenna is driven at the maximum slew rate.

3.4.5.4 Accuracy

The positioner shall be able to locate the subreflector within ±0.010 inches of the assigned position for each of the three axes.

3.4.6 Monitor and Control Requirements

3.4.6.1 Operation

Unattended operation shall be provided from the DMC via the APA.

3.4.6.2 Interfaces

All interfaces shall be provided with the APA, as defined by Reference Document (7), 820-16.

3.4.6.3 Transmission Time

All angle position, error correction, residual, offset and subreflector position data blocks shall be capable of being transmitted at 1 second with time tags.

3.4.6.4 Time-Tagging

Each position readout, status message, event message, etc., shall be time-tagged to within 0.1 second of actual occurrence.

3.4.6.5 Display Angle

Angle position displays shall be from 0 to 359.999 degrees.

3.4.6.6 Data Transmission Standards

All messages to the DMC via the APA shall be in accordance with Reference Documents (8), 890-132, and (9), 890-133.

3.4.6.7 Diagnostics

Self-contained test and diagnostic capability shall be provided.

3.4.7 Electrical Interface Requirements

3.4.7.1 Microwave Subsystem

An interface shall be provided with the Microwave Subsystem for radio frequency transfer, as defined in Reference Document (18), 828-1.

3.4.7.2 Transmitter Interlocks

A switch closure shall be provided when the antenna is above selectable elevations through various azimuth positions. Reference Document (15), 820-17, TRK 2-101 defines this interface.

3.4.7.3 Timing and Timing Pulses

Acceptance of epoch time, 1 pps and 100 pps, shall be in accordance with Reference Document (6), 820-17, Module DFT 10-103.

3.4.7.4 Antenna-Pointing Assembly

All interfaces with the APA shall be as defined in Reference Document (7), 820-16, TRK 2-107. All event, alarm, and error messages and all OCIs shall meet the requirements of Reference Documents (8), 890-132, and (9), 890-133.

3.4.8 Safety Requirements

3.4.8.1 Protectives Devices

Guards, sensing devices, and interlocks shall be provided to protect the antenna from damage, and personnel located on the antenna from damage or injury, during an equipment failure.

3.4.8.1.1 Fail-Safe Feature. Each device or sensor shall operate in a fail-safe mode so that, if the device fails, the antenna and personnel will be protected.

3.4.8.2 Brakes

Brakes shall be capable of securing the antenna in any position during a 70-mph wind from any direction.

3.4.8.3 *Locking Devices*

Brakes and/or locking devices shall be furnished to ensure survival in the stowed position during a 100-mph wind from any direction.

3.4.8.4 *RF Isolation*

The design shall provide adequate isolation and shielding to allow personnel safe, continuous access to all areas behind the primary reflector during ≤25-kW transmission.

3.4.8.5 *Service Access*

Ladders, walkways, etc., shall allow safe access by personnel to all areas of the antenna that require servicing or maintenance.

3.4.8.6 *Earthquake Safety*

The 34-m antenna shall comply with the seismological requirements defined in the Universal Building Code for Zone 4.

3.4.9 *Support of Other Subsystems*

3.4.9.1 *Mounting Space*

The 34-m HEF antenna shall provide space and physical support in the cone in correct alignment for components of other subsystems in the pedestal of the structure.

3.4.9.2 *Equipment Cooling*

The equipment space in the cone shall be maintained at a temperature of 24±3 degree C.

3.4.9.3 *Power*

60-Hz power shall be provided to equipment on the antenna at the following voltages:

(1) 120V single-phase

(2) 120V/208V three-phase

(3) 277/480V three-phase

3.4.10 *Environmental Requirements*

The 34-m standard antenna and all its components shall be designed and built to operate continuously in the environment defined in Section 7 of this document.

Module 3.5

Antenna Control Group

3.5.1 General

The Antenna Control Group (ACG) consists of one or more electronic assemblies which enable the antenna to perform its functions. A conceptual block diagram is shown in Figure 3.5-1.

3.5.2 Functional Description

3.5.2.1 Antenna LAN Interface Function

The antenna LAN interface function shall provide the communication between the ACG electronics and the rest of the SPC via the SPC LAN and shall provide a special user port in the SPC and connection to the Data Storage Assembly in the SPC.

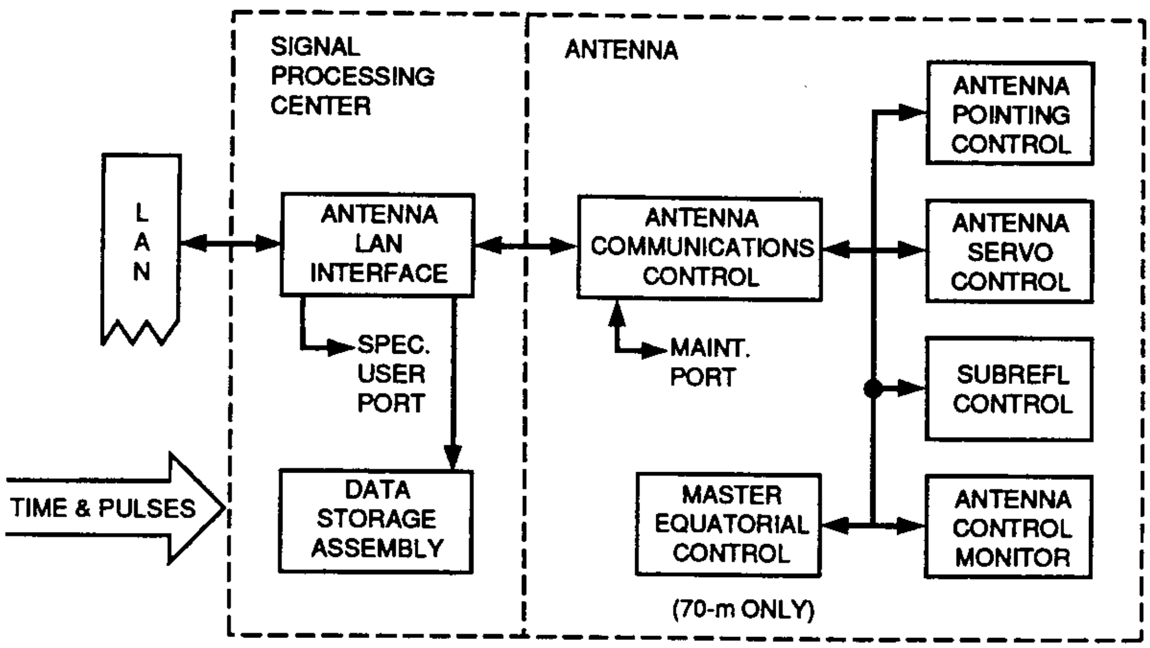

Figure 3.5-1. Antenna Control Group - Functional Configuration

3.5.2.2 *Antenna Communications Control Function.*

The antenna communications control function shall perform the assembly, formatting, and transmission of all periodic and aperiodic messages to all the other subsystems in the SPC. Incoming data (such as predicts, signal-level reports, and directives) shall be directed to the using function within the ACG. A maintenance port in the antenna area shall also be provided.

3.5.2.3 *Antenna Pointing Control Function*

The antenna pointing control function shall perform coordinate conversions, calculation of offsets to compensate for systematic and refraction errors, storage of system error tables and constants, convert predicted sky positions to antenna pointing positions, and supply these to the antenna servo control.

3.5.2.4 *Antenna Servo Control Function*

The antenna servo control function shall perform all functions associated with pointing the antenna at the target. This includes accepting position commands, comparing the actual antenna position with the commanded position, and issuing drive commands to the servos to maintain the antenna pointed at the commanded position.

3.5.2.5 *Subreflector Control Function*

The subreflector control shall determine the antenna position, determine the optimum subreflector position, compare the actual position with the optimum value, and issue move commands to the subreflector drives. In addition, the subreflector controller shall control the feed selection mechanisms on the 70-m and 34-m BWG antennas.

3.5.2.6 *Antenna Control and Monitor Function*

The antenna control and monitor function shall continuously monitor the operating performance of the antenna and all the electronic equipment, compare the measured values with pre-established standards and limits, and take appropriate action in the event of an out-of-limit condition malfunction. This function also includes control of sequences of actions for start-up, configuration, operation, and shut-down of the antenna, and performance of off-line diagnostics and anomaly location when so directed.

3.5.2.7 *Master Equatorial Control Function (70-m Only)*

The master equatorial control shall perform the same functions as the servo control for the master equatorial instrument. When in the precision mode, the antenna structure shall be slaved to the master equatorial instrument via the autocollimator.

3.5.2.8 Recording Function

The recording function shall make a permanent removable record of important antenna parameters for problem analysis or to provide additional information to special users regarding antenna performance.

3.5.3 Detailed Description of Functions

3.5.3.1 Monitor and Control Requirements

Monitor and control of the antenna operation shall be by means of operator directives from a single operator, predicts, and other data sent from the DMC and by messages and displays sent to the DMC via the local area network (LAN). These data shall meet the following requirements.

3.5.3.1.1 Data Standards. All operator directives, messages, and displays shall be in accordance with Reference Documents (8), 890-132, and (9), 890-133.

3.5.3.1.2 Message Commonality. Messages to and from different antenna types shall be the same for the same or similar information.

3.5.3.1.3 Configuration Table. The ACG shall utilize a configuration table from which a given configuration may be called by a single operator directive. The table, including default values, shall be able to be modified and appended from the DMC.

3.5.3.1.4 Cold Starts. With a single operator directive, the ACG shall bring the antenna from a cold start to operational readiness within 2 minutes for the 34-m antennas and within 5 minutes for the 70-m antennas, assuming no startup anomalies.

3.5.3.1.4.1 Anomaly Identification. Should an anomaly occur, the location of the fault shall be provided along with recovery alternatives, if any.

3.5.3.1.4.2 Anomaly Recovery. When the recovery from an anomaly is accomplished, the sequence shall continue without restarting.

3.5.3.1.5 Macro Directives. Sequences of directives which are often repeated (such as rotating the 70-m subreflector, driving to stow, etc.) shall be provided in a single operator directive which, without operator intervention, causes the ACG to perform the correction sequence of actions, monitor the responses to the various actions, and perform the next action until the sequence is completed.

3.5.3.1.6 Configure Sequence. With a single operator directive, the ACG shall (without intervention) request and accept predicts for impending tracks and (within 2 minutes) shall configure the antenna for the next track in sequence, select the appropriate default values for calculated or stored functions, and perform any calibrations necessary to ensure antenna performance within specification.

3.5.3.1.7 ***Antenna Motion.*** At the operator's direction, the antenna shall move to the predicted signal-acquisition position.

3.5.3.1.8 ***Acknowledgments.*** Each directive received by the ACG shall be acknowledged within 1 second.

3.5.3.1.8.1 ***Delayed Responses.*** If completion of a response cannot be immediate, a message indicating that the appropriate action is in process shall be sent and another message sent when the item is completed.

3.5.3.1.8.2 ***Extended Responses.*** If performance of a response will take longer than 10 seconds, a message shall be sent indicating that the action is in process and providing the estimated time for completion.

3.5.3.1.8.3 ***Interruptions.*** Should the antenna have a problem which precludes completion of a directed action, the DMC shall be informed of the problem and provided with suggested alternatives, if any.

3.5.3.1.9 ***Event Messages.*** Event messages shall be sent within one second, notifying the DMC of all status and configuration changes.

3.5.3.1.10 ***Language.*** All messages shall describe the status or event in plain English and shall not require the DMC operator to use look-up tables or lists.

3.5.3.1.11 ***Help Messages.*** Concise help messages shall be available when requested. These shall explain what operator commands are available for a given operation and provide expanded explanations of event messages.

3.5.3.1.12 ***Time-Tagging.*** All status, event, warning and alarm messages shall be time-tagged to an accuracy of ± 1.0 second of the actual time of the event.

3.5.3.1.13 ***Repeat Messages.*** A given event shall cause only a single message to be sent to the DMC.

3.5.3.1.14 ***Periodic Reports.*** The ACG shall generate periodic reports to provide antenna status and position for users who need this data. These reports shall be in accordance with Reference Document (7), 820-16.

3.5.3.1.15 ***Graphic Displays.*** The ACG shall generate an overall graphic display for the DMC which shows synoptic high-level status and configuration of the antenna and each of its major assemblies.

3.5.3.1.16 ***Detailed Displays.*** The ACG shall generate displays showing detailed monitor and control, performance, and status information.

3.5.3.1.17 ***Fault Isolation***. In the event of a malfunction, and when so directed, the ACG shall locate the fault to the lowest replaceable module and report this to the DMC operator.

3.5.3.1.17.1 ***Alternate Operating Modes***. If there is a built-in alternative capability, this shall be suggested to the DMC operator.

3.5.3.1.18 ***Data Storage***. The ACG shall store all configuration and prediction data in non-volatile memory and provide the capability to automatically restart within 30 seconds after a power outage up to the point of actual antenna motion.

3.5.3.1.19 ***Shutdown***. With a single command, the ACG shall provide the capability to prepare the antenna for power shutdown for an indefinite time and perform that shutdown.

3.5.3.1.20 ***Time and Timing Data***. The ACG shall accept time and timing signals in accordance with Reference Document (6), 820-17.

3.5.4 Tracking

3.5.4.1 Tracking Modes

The antenna shall follow the predicts provided in one of the formats listed below:

(1) Spacecraft, using predicts as defined in Reference Document (7), 820-16, Module TRK 2-205

(2) Local, using predicts as defined by multiple points of topocentric hour angle/ declination or azimuth/elevation, range, day of year, and time. Up to 1000 data points shall be accepted, stored, and utilized.

(3) Sidereal, using predicts defined by geocentric right ascension, declination, range, day of year, and time. Up to 1000 sets shall be accepted, stored, and utilized.

(4) Planetary, using predicts defined by three groups of geocentric right ascension, declination, range, day of year, and time, from 0.1 hour to 48 hours apart to define a planetary trajectory. Up to 255 groups of these predicts shall be accepted, stored, and utilized.

(5) Cross-support, using geocentric improved inter-range vectors (IIRV), as defined in Reference Document (10), 820-13, Module TRK 2-17.

(6) Slave, by utilizing a series of improved IIRVs, as defined above. These messages may be received as often as once a minute and become valid approximately 1 minute after receipt.

3.5.4.2 *Slave Data Output*

The ACG shall (when directed to do so) generate and transmit IIRV messages as defined in paragraph 3.5.4.1(6), showing its anticipated position. These messages shall be sent once a minute and shall become valid approximately 1 minute after transmission.

3.5.4.3 *Offsets*

The ACG shall be able to accept offsets in time, rate, or position in the selected coordinate system for each of the above predict sets.

3.5.4.4 *Time Correction Storage*

Each time a set of predicts is accepted, the UT1-UTC correction value (if provided) shall be stored in non-volatile memory for possible recall by special users.

3.5.5 RF Beam Pointing

The ACG shall perform the operations necessary to maintain the RF beam of the antenna pointed at the predicted position of the target within the tolerance specified for each antenna type without signal-level feedback (blind pointing).

3.5.6 CONSCAN

The ACG shall perform the functions necessary to CONSCAN the antenna. The RMS signal-level variation after acquisition shall be no more than the following values at any sky position above 20 degrees elevation:

S-band	0.10 dB
X-band	0.10 dB
Ka-band	0.10 dB

3.5.7 Search Patterns

The ACG shall provide the option for three search patterns to scan near the predicted location to rapidly locate the spacecraft: Az-El (raster), spiral-scan, and an operator-defined pattern.

3.5.7.1 *Scan Cancellation*

When the DMC so directs, the antenna shall halt the scan and continue moving along the predicted path, as corrected by the offsets which were in effect at the time the DMC halted the scan.

3.5.8 Cross-Scan

When directed to do so, the ACG shall cause the antenna to perform a cross-scan (in EL-XEL) to center the antenna on the target, using power-level data supplied for each point.

3.5.8.1 Default Settings

Standard (default) step sizes and dwell times shall be provided for S-, X-, and Ka bands.

3.5.8.2 Change of Defaults

The ACG shall accept changes to the default values.

3.5.8.3 Return to Track

At the completion of the cross-scan procedure, the antenna shall continue along the predicted track, as modified by the calculated offsets.

3.5.9 Antenna and Personnel Protection

Protection of the antenna and personnel on the antenna shall be continuously provided as an independent function internal to the antenna and shall remain functional in the event of failure of any other subsystem element.

3.5.9.1 Fail-Safe Feature

Failure within the protection function shall be "fail-safe" so that the antenna and personnel are always protected. The DMC shall be notified of any change in status. Fail-safe is defined as having each element in the system in place and providing an overt "OK to operate" indication.

3.5.9.2 Wind Loads

Monitoring of items in the antennas shall include, but not be limited to, side-wind loading (70-m only).

3.5.10 Efficiency Optimization

The efficiency optimization function shall be performed by reading the position of the antenna, calculating the optimum location of the subreflector for that antenna position from stored algorithms, and issuing commands to relocate the subreflector.

3.5.10.1 Position-Reporting

The position of the subreflector shall be monitored and reported.

3.5.11 Special User Data

The ACG shall provide monitor data to a special user's port in the SPC to allow use of the antenna for purposes such as radio astronomy, SETI, antenna calibration, holography, or solar system radar.

3.5.11.1 Safety Responsibility

While this capability is enabled, the DMC shall maintain responsibility for the safety of the antenna.

3.5.12 Maintenance Port

A port shall be provided at the antenna for off-line maintenance purposes or as an alternate control point if the DMC fails.

3.5.12.1 Alternate Control

When control of the antenna is assumed by this port, the DMC shall no longer have control of the antenna, and the port user must return control of the antenna to the DMC.

3.5.12.2 Required Displays

A display, "only local access permitted", shall be provided if an operator directive is attempted by the DMC.

3.5.12.3 Remote Display

Each operator directive and response generated by the maintenance terminal shall be displayed at the DMC.

3.5.13 Special User and Maintenance Port Data

Both of the ports defined in paragraphs 3.5.11 and 3.5.12 shall be provided data at the following defined sample rates, which (as a minimum) contain the following:

(1) 1/1 second: Encoder readouts, including Master Equatorial (M/E) readouts on the 70-m antennas in Az-El and Ha-Dec, subreflector position readouts, and status. These reports shall be time-tagged to an accuracy of ± 0.1 second.

(2) 1/5 seconds: Predicted angles and all corrections and offsets in Az-El and Ha-Dec for the antenna and the M/E. Predicted and actual positions and corrections in X, Y, and Z for the subreflector.

(3) 1/30 seconds: Tracking mode and status, autocollimator in use, and status (70-m), all voltages, currents, pressures, flows, temperatures, and levels.

(4) 1/60 seconds: Weather data.

(5) As they occur: All status, event, warning, and alarm notices.

3.5.14 Local Control

Each funtion of the antenna shall be locally controllable, without the use of the maintenance port and with the necessary indicators, to enable maintenance and manual operation and testing in the event of controller failure.

3.5.15 Performance Recording

The ACG shall record (on a non-volatile device with removable media in the control building) all parameters which could be required to enable reconstruction of failures, pointing problems, etc.

3.5.15.1 Scope of Data

These data shall include, but not be limited to all the data supplied to, the special user and maintenance ports and at the rates specified above.

3.5.15.2 Message Recording

All commands and status, event, warning, and alarm messages shall also be recorded as they occur with time tags which are accurate to within ± 0.1 second of the actual time of the event occurrence.

3.5.15.3 Storage Capacity

The recording device shall have a capacity adequate to store at least a full week's data on each medium, as specified above.

3.5.16 General Software Requirements

The following general requirements shall be complied with in the design and construction of the ACG.

3.5.16.1 Software

Common software available through Software Production Management and Control (SPMC) shall be used (where possible) to minimize the size of the programs and to preclude software changes when making minor value corrections.

3.5.16.2 Software Operators Manual

The Software Operators Manual shall comply with Reference Document (11), 890-208.

3.5.17 Operational Requirements

The ACG hardware and software shall meet all the requirements defined in Section 6 of this document.

Module 3.6

Antenna Metric and Pointing Assembly (26-m and 9-m Antenna)

The Metric and Pointing Assembly (MPA), which monitors and controls either the 26-m and 9-m antenna, provides a composite of antenna and tracking functions, many of which are external to the antennas per se. The functional requirements for this unit are contained in Reference Document (12), 824-38.

Module 3.7

26-M X-Y Antenna Assembly

3.7.1 General

The 26-m X-Y antenna consists of: a parabolic primary reflector 26 meters in diameter, a hyperbolic subreflector, a fixed cone mounted on the surface of the antenna in which the feed systems are mounted. (The feed systems are a part of the Antenna Microwave Subsystem (UWV) and are not covered by this specification.) The antenna rotates in the X axis on a shaft aligned with true north and south, and in the Y axis on a shaft aligned with true east and west.

3.7.2 Surface Tolerance

The antenna shall have a combined surface tolerance of all reflectors and their alignment equal to 0.040 inches RMS when measured at the rigging angle, nominally at zenith with no wind.

3.7.3 Antenna Motion

The antenna shall be capable of motion in the X and Y axes. Servo motors and gear reducers shall be provided to provide these motions.

3.7.3.1 Slew Rate

The minimum slew rate in each axis shall be 3.0 deg/sec.

3.7.3.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to $\geq$3.0 deg/sec.

3.7.3.3 Acceleration

The acceleration in each axis shall be $\geq$5.0 deg/sec/sec.

3.7.3.4 Deceleration

The deceleration (braking) in each axis shall be $\geq$25.0 deg/sec/sec.

3.7.3.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position in a 60-mph wind.

3.7.3.6 Motion Limits

The antenna shall be capable of moving to any position within the following limits.

3.7.3.6.1 *X Axis*. The X axis operational limits shall be no less than ±85 degrees from zenith.

3.7.3.6.2 *Y Axis*. The Y axis operational limits shall be ±76 degrees from zenith.

3.7.4 Angle Readouts

3.7.4.1 Readout Resolution

Angle readouts shall provide a resolution of at least 1.37 millidegrees (18 bits).

3.7.4.2 Readout Accuracy

Angle readouts shall provide an accuracy of no less than ±2.75 millidegrees (17 bits).

3.7.4.3 Displays

Displays shall be provided for each axis which read from 0.000 to 90.000 degrees from local vertical.

3.7.5 Monitor and Control Requirements

At the present time, the 26-m antennas are controlled from the local Antenna Control Console. There is no connection with the SPC. Thus, there are no specific requirements for monitor and control. It is planned to provide a Metric and Pointing Assembly (MPA) for the 26-m antennas during 1993. The functional requirements for the MPA are defined in Reference Document (12), 824-38.

3.7.6 Interface Requirements

The 26-m X-Y antennas shall provide interfaces with the equipment listed below.

3.7.6.1 Subsystems and Their Utilities

The Receiver, Transmitter, and Microwave Subsystems, their support equipment, including cooling air and water, power, and mechanical position shall all interface with the 34-m antenna.

3.7.6.2 *Transmitter*

With the transmitters, a switch shall close when the antenna is above selectable elevations through various azimuth positions.

3.7.7 *Safety Requirements*

3.7.7.1 *Protective Devices*

Adequate guards, sensing devices, and interlocks shall be furnished to protect the antenna from damage and personnel located on the antenna from injury during any reasonable equipment failure.

3.7.7.2 *Fail-Safe Feature*

Each device or sensor shall operate in a fail-safe mode so that if the device fails, the antenna and personnel will be protected.

3.7.7.3 *Brakes*

Brakes shall secure the antenna in any position during a 70-mph wind from any direction.

3.7.7.4 *Locking Devices*

Brakes and/or locking devices shall ensure survival in the stowed position during a 100-mph wind from any direction.

3.7.7.5 *RF Isolation*

Adequate isolation and shielding shall allow personnel continuous access to all areas behind the primary reflector during $\leq$20 kW transmission.

3.7.7.6 *Service Access*

Ladders, walkways, etc., shall allow safe access by personnel to all areas of the antenna which require servicing or maintenance.

3.7.7.7 *Earthquake Safety*

The seismological requirements defined in the Universal Building Code for Zone 4 shall be met.

3.7.8 Support of Other Subsystems

3.7.8.1 Mounting Space

The 26-m X-Y antennas shall provide space and physical support in correct alignment for components of other subsystems in the electronics room.

3.7.8.2 Equipment Cooling

Components in the electronics room shall be maintained at 24±3 degree C.

3.7.8.3 Utility Requirements

The antenna shall provide cooling water and, if necessary, electrical power as follows:

(1)	120V	single-phase
(2)	120V/208V	three-phase
(3)	277/480V	three-phase.

3.7.9 Environmental Requirements

The 26-m antenna shall be designed and built to operate continuously in the environment defined in Section 6 of this document.

Module 3.8

9-M Antenna Assembly

3.8.1 General

The 9-m X-Y antenna consists of: a parabolic primary reflector 9 meters in diameter, a hyperbolic subreflector, and a fixed cone mounted on the surface of the antenna in which the feed system is mounted. (The feed system is a part of the Antenna Microwave Subsystem (UWV) and is not covered by this specification.) The antenna rotates in the X axis on a shaft aligned with true east and west, and in the Y axis on a shaft aligned with true north and south.

3.8.2 Surface Tolerance

The antenna shall have a combined surface tolerance of all reflectors and their alignment equal to 0.030 inches RMS when measured at the rigging angle, nominally at zenith with no wind.

3.8.3 Antenna Motion

The antenna shall be capable of motion in the X and Y axes. Servo motors and gear reducers shall be provided to provide these motions.

3.8.3.1 Slew Rate

The minimum slew rate in each axis shall be ≥3.0 deg/sec.

3.8.3.2 Tracking Rate

The tracking rate in each axis shall be from 0.0001 to ≥3.0 deg/sec.

3.8.3.3 Acceleration

The acceleration in each axis shall be ≥5.0 deg/sec/sec.

3.8.3.4 Deceleration

The deceleration (braking) in each axis shall be ≥25.0 deg/sec/sec.

3.8.3.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position in a 60-mph wind.

3.8.3.6 *Motion Limits*

The antenna shall be capable of moving to any position within the following limits.

3.8.3.6.1 *X Axis*. The X axis operational limits shall be no less than ±87 degrees from zenith.

3.8.3.6.2 *Y Axis*. The Y axis operational limits shall be ±80 degrees from zenith.

3.8.4 Angle Readouts

3.8.4.1 Readout Resolution

Angle readouts shall provide a resolution of at least 1.37 millidegrees (18 bits).

3.8.4.2 Readout Accuracy

Angle readouts shall provide an accuracy of no less than 2.75 millidegrees (17 bits).

3.8.4.3 Displays

Displays shall be provided which read from 000.000 to 359.999 degrees.

3.8.5 Monitor and Control Requirements

At the present time, the 9-m antenna is controlled from the local Antenna Control Console. There is no connection with the SPC. Thus, there are no specific requirements for monitor and control. It is planned to provide a Metric and Pointing Assembly (MPA) for the 9-m antenna during 1993. The functional requirements for the MPA are defined in Reference Document (12), 824-38.

3.8.6 Interface Requirements

The 9-m X-Y antenna shall provide interfaces as follows.

3.8.6.1 Subsystems and Their Utilities

The Receiver, Transmitter, and Microwave Subsystem, their support equipment, including cooling air and water, power, and mechanical position shall be provided by the 9-m antenna.

3.8.6.2 Transmitter

A switch closure shall be provided to the transmitter when the antenna is above selectable elevations through various azimuth positions.

3.8.7 Safety Requirements

3.8.7.1 Protective Devices

Adequate guards, sensing devices, and interlocks shall be provided to protect the antenna from damage, and personnel located on the antenna from injury during an equipment failure.

3.8.7.2 Fail-Safe Feature

Each device or sensor shall operate in a fail-safe mode so that if the device fails, the antenna and personnel will be protected.

3.8.7.3 Brakes

Brakes shall be provided which are capable of securing the antenna in any position during a 70-mph wind from any direction.

3.8.7.4 Locking Devices

Brakes and/or locking devices shall be provided to ensure survival in the stowed position during a 100-mph wind from any direction.

3.8.7.5 RF Isolation

Adequate isolation and shielding shall be provided to allow personnel safe, continuous access to all areas behind the primary reflector during 20-kW transmission.

3.8.7.6 Service Access

Ladders, walkways, etc., to allow safe access by personnel to all areas of the antenna which require servicing or maintenance.

3.8.7.7 Earthquake Safety

The 9-m antenna shall comply with the seismological requirements defined in the Universal Building Code for Zone 4.

3.8.8 Support of Other Subsystems

3.8.8.1 Pedestal Design

The 9-m X-Y antenna shall provide space and physical support in correct alignment for components of other subsystems in the cone and electronics room.

3.8.8.2 Equipment Cooling

Equipment in the cone and electronics room shall be maintained at 24±3 deg C.

3.8.8.3 Utility Requirements

The antenna shall provide cooling water, if necessary, and electrical power as follows:

(1) 120V single-phase

(2) 120/208V three-phase

(3) 277/480V three-phase.

3.8.9 Environmental Requirements

The 9-m antenna shall be designed and built to operate continuously in the environment defined in Section 6 of this document.

Module 3.9
34-m High-Speed Beam Waveguide Antenna Assembly

3.9.1 General

The 34-m High-Speed Beam Waveguide (HSB) antenna assembly consists of: a shaped primary reflector 34 meters in diameter, a shaped subreflector, a series of mirrors to direct the RF energy around the azimuth and elevation axes through a shielding tube to a fixed feedhorn mounted in the pedestal of the antenna. The antenna rotates in azimuth, on wheels and a track, and in elevation, on a horizontal shaft. The Antenna Mechanical Subsystem (ANT) for the 34-m HSB antenna includes the antenna assembly and the Antenna Pointing Controller (APC), which is described in Module 3.5 of this document.

3.9.2 Radio-Frequency Requirements for the 34-m HSB Antenna Mechanical Subsystem

The feed system is part of the Antenna Microwave Subsystem (UWV) and, therefore, its requirements are not included in this performance specification. However, the radiation pattern of the feedhorn affects the noise contribution and aperture efficiency of the antenna elements. For this reason, specific feedhorns are listed.

3.9.2.1 Surface Accuracy

The antenna shall provide an overall antenna distortion RSS of ≤ 0.047 inches with no wind, in any elevation position from 5 to 90 degrees. This distortion shall include the combined effects of the primary, secondary, and beam-waveguide mirror reflector surfaces and any reflector-support structures.

3.9.2.2 Noise Contribution

The antenna shall be designed so that the zenith microwave noise contribution generated by the antenna at the feed focal point, including BWG components, all spillovers, leakages, scattering losses, I^2R losses, and measurement error is as follows:

S-band (2.2 to 2.3 GHz)	≤ 56K (standard DSN 21.5 dB horn)
X-band (7.2 to 8.4 GHz)	≤ 17K (standard DSN 29 dB horn)

3.9.2.3 Aperture Efficiency

The antenna shall be designed to meet the following microwave aperture efficiency requirements; these include only the contributions of antenna mechanical subsystem elements:

S-band (2.2 to 2.3 GHz)	≥ 50% (standard DSN 21.5 dB horn)
X-band (7.2 to 8.4 GHz)	≥ 63% (standard DSN 29 dB horn)

3.9.2.4 *RF Power Input*

The ANT shall be designed to accept RF power input from the UWV of ≤ 25-kW at frequencies up to 8.4 GHz.

3.9.3 *Accuracy and Precision Requirements*

3.9.3.1 *Antenna Mechanical Subsystem Pointing*

The 34-m HSB antenna assembly, when used with the APC of the ANT defined in module 3.5, shall maintain the pointing of the RF beam (above 10 degrees elevation) to the predicted position over the specified range of tracking rates without signal-level feedback (i.e., blind pointing) under the following wind conditions (a Rayleigh distribution of the beam radial error is assumed):

2.3 GHz	8.4 GHz	
≤0.021	≤0.006	degrees (mean) in a 10-mph wind from any direction
≤0.082	≤0.024	degrees (mean) in a 20-mph wind from any direction

These values include any correction for systematic errors. These pointing accuracies can be verified by measuring a maximum signal-level loss of 0.1 dB at the respective frequencies.

3.9.3.2 *Angle Encoders*

Angle encoders shall be provided that have the capability of reporting pointing angles with a precision of 0.00005 degrees.

3.9.4 *Antenna Motion*

The antenna shall be capable of motion in the azimuth and elevation axes. Servo motors and gear reducers shall be supplied to provide these motions.

3.9.4.1 *Slew Rate*

The minimum slew rate in each axis shall be 2.0 deg/sec elevation and 3.0 deg/sec azimuth.

3.9.4.2 *Tracking Rates*

The tracking rate in each axis shall be from 0.0001 to 2.0 deg/sec (elevation) and from 0.0001 to 3.0 deg/sec (azimuth).

3.9.4.3 *Acceleration*

The acceleration in each axis shall be 0.5 deg/sec^2 (elevation) and 1.0 deg/sec^2 (azimuth).

3.9.4.4 Deceleration

The deceleration (braking) in each axis shall be 5.0 deg/sec^2.

3.9.4.5 Drive to Stow

The drives shall be capable of moving the antenna to the stowed position (90-degree elevation angle) in a 40-mph wind from any direction.

3.9.4.6 Motion Limits

The antenna shall be capable of moving to any position within the following envelope:

3.9.4.6.1 Azimuth. Azimuth operational limits shall be no less than ±300 degrees from the cable wrap center.

3.9.4.6.2 Elevation. Elevation operational limits shall be 5 and 90 degrees.

3.9.5 Monitor and Control Requirements

The 34m HSB antenna shall be monitored and controlled by the APC, as defined in Module 3.5.

3.9.6 Interface Requirements

The 34-m HSB antenna shall provide the interfaces listed below.

3.9.6.1 Microwave Subsystem (UWV)

An RF interface shall be provided with the UWV for radio-frequency transfer as defined in Reference Document (5), 828-1.

3.9.6.2 Interlocks to Transmitter (TXR)

A switch closure shall be provided when the antenna is above selectable elevations through various azimuth positions. Reference Document (6), 820-17, will define this interface.

3.9.7 Safety Requirements

The 34-m HSB antenna shall incorporate the safety features listed below.

3.9.7.1 Protective Devices

Adequate guards, sensing devices, and interlocks shall be furnished to protect the antenna from damage and personnel located on the antenna from injury, during operation or an equipment failure.

3.9.7.2 Fail-Safe Operation

Each device or sensor shall operate in a fail-safe mode so that, if the device fails, the antenna and personnel will be protected.

3.9.7.3 *Brakes*

Brakes shall be provided to secure the antenna in any position during a 50-mph wind from any direction.

3.9.7.4 *Locking Devices in Stowed Position*

Locking devices shall be provided to ensure survival at the stowed position (90 degree elevation angle) during a 100-mph wind from any direction.

3.9.7.5 *RF Isolation*

The ANT shall provide adequate isolation and shielding to allow personnel safe and continuous access to all areas behind the primary reflector and outside the beam waveguide shroud during ≤ 25-kW transmission. The requirements for personnel safety defined in the JPL Safety Manual, Section 4-08-41, "Safety Practices, Radio Frequency Transmitters," shall be met.

3.9.7.6 *Service Access*

Ladders, walkways, etc., shall allow safe access by personnel to all areas of the antenna that require servicing or maintenance and shall comply with the latest OSHA requirement.

3.9.7.7 *Earthquake Safety*

The seismological requirements defined in the Uniform Building Code for Zone 4 shall be met.

3.9.8 *Operational Requirements*

3.9.8.1 *Design Life*

The antenna shall have a design life of 25 years for mechanical equipment and ≥ 10 years for electronic equipment.

3.9.8.2 *Availability*

Overall availability of the ANT shall be at least 0.997 during normal tracking and at least 0.998 during critical tracking.

3.9.8.3 *Mean Time Between Failures*

Mean Time Between Failures (MTBF) shall be ≥1000 hours for mechanical equipment and ≥3000 hours for electronic equipment.

3.9.8.4 *Mean Time to Restore*

Mean Time to Restore (MTTR) shall be ≤2 hours for mechanical equipment and ≤15 minutes for electronic equipment.

3.9.8.5 *Equipment Mounting Space*

Adequate weather-protected space shall be provided in the pedestal to install one UWV feed system and other equipment which is required to be in close proximity to the feed.

3.9.8.6 *Temperature Control*

The pedestal space shall be maintained at a temperature of 22 $\pm$4 deg C.

3.9.8.7 *Power*

Power shall be provided for the guest subsystem equipment as follows:

(1) 120V single-phase

(2) 208V three-phase

(3) 480V three-phase

3.9.9 *Environmental Requirements*

The 34-m HSB antenna shall operate satisfactorily under all of the environmental conditions defined in Section 6 of this document.

3.9.10 *DSN/Army Conversion Requirements*

The ANT equipment shall be designed to allow conversion, either way, between DSN and Army configurations within 72 hours.

Section 4

External Interfaces

4.1 General

This section describes the general input and output signal interfaces between the Antenna Mechanical Subsystem (ANT) and other DSCC subsystems. Detailed interface definitions may be found in Reference Documents (7), 820-16 and (6), 820-17.

4.2 Input Interfaces

The ANT shall receive the following signal inputs from the indicated DSCC subsystem.

4.2.1 Receiver-Exciter Subsystem

The Receiver-Exciter Subsystem (RCV) shall provide the following inputs (Reference Document (7) 820-16, Module TRK-2-103):

(1) Receiver signal-level indication from each closed-loop receiver

(2) Receiver in-lock indicator from each closed-loop receiver

(3) Intermediate frequency (10 to 500 MHz) from any one receiver on an antenna

(4) Angle error signals (26-m and 9-m only, Reference Document (17), 820-34).

4.2.2 Frequency and Timing Subsystem

The Frequency and Timing Subsystem (FTS) shall provide the following inputs (Reference Document (6), 820-17, Modules DFT-10-101, DFT-10-102, DFT-10-103, DFT-10-104):

(1) 1 p/s

(2) 10 p/s

(3) 100 p/s

(4) Binary time (serial)

(5) Binary day of year (serial).

4.2.3 Monitor and Control Subsystem

The Monitor and Control Subsystem (DMC) shall provide the following inputs (Reference Document (7), 820-16, Module MON-5-117):

(1) Tracking mode

(2) Configuration, including feed horn selection at 70-m and 34-m BWG stations

(3) Automatic pointing parameters

(4) Barometric pressure

(5) Temperature

(6) Humidity.

4.2.4 Technical Facilities Subsystem

The Technical Facilities Subsystem (FAC) shall provide the following:

(1) Cooling air

(2) Cooling water.

4.2.5 Power Subsystem

The ANT receives 60-Hz, 3-phase power at 2400, 480, and 120/208V.

4.2.6 Network Support Subsystem

The Network Support Subsystem (NSS) shall provide predicts, as defined in Reference Document (7), 820-16, Module TRK-2-205.

4.3 Output Signal Interfaces

All output interfaces from the ANT shall be as defined in Reference Documents (6) 820-17, and (7), 820-16.

Section 5

Testing

5.1 General

Since the antennas of the Antenna Mechnical Subsystem (ANT) are large structures which are assembled in place, in-process and final testing shall be performed at the installation location. Testing of smaller assemblies and subassemblies may be performed at the factory or other convenient location. All testing shall be conducted in accordance with the interface agreement contained in Reference Document (1), 820-20.

5.1.1 First Model Demonstration Test

The first model demonstration test normally shall be performed at the factory on assemblies which have a stand-alone function, such as the servo electronics, angle data, and antenna control assemblies. It shall use a test stimulus for input, and the output shall be analyzed for correct functional performance. The input and output criteria shall verify that performance and interfaces are as defined. Requirements defined in this document as "shall be designed to" shall be shown to comply with analysis presented at the Detailed Design Review (E-level review).

5.1.2 First Station Assembly On-Site Acceptance Test

The first station assembly on-site acceptance test shall be performed at a station which has a subsystem into which the assembly to be tested can be integrated. Performance shall be evaluated, and interfaces shall be verified at the subsystem level. The test procedure shall define the test requirements and acceptance criteria to satisfy the functional requirements defined in this document. The procedure shall verify that the requirements are met for the operating environment where practical, cabling, man-machine constraints, etc. These test requirements and acceptance criteria shall be used to effect a transfer agreement from Engineering to Operations.

5.1.3 Unit-by-Unit Assembly Acceptance Tests

The unit-by-unit assembly acceptance tests shall be performed by the supplying Cognizant Development Engineer (CDE) to demonstrate to the Subsystem cognizant Operations Engineer (COE) that all follow-on units are equivalent to the first unit. These tests shall be applicable to hardware and (preferably) shall be conducted at the factory. For software, the intent of this step is realized during the DSN Program Library reproduction of pro- grams and documentation which were demonstrated to the Subsystem COE during the First Station Subsystem On-Site Acceptance Test. These tests are intended to be as comprehensive as the First Model Demonstration Test and shall be used to effect a transfer. The Subsystem COE may optionally waive test requirements he believes to be no longer appropriate to production units.

At the successful completion of the test, the subsystem shall be transferred from the CDE to the Subsystem COE. Software shall be an exception, in that it shall be transferred to the Software COE.

5.1.4 Subsystem On-Site Acceptance Test

The entire subsystem is first assembled into an entity at the installation location; subsystem-level testing must be accomplished on site. Since many of the assemblies will have been accepted by prior tests, a successful Subsystem On-Site Acceptance Test shall be construed to include all associated assemblies.

5.2 Test Criteria

5.2.1 General

To ensure that all elements of the ANT described herein satisfy the functional and performance requirements of Section 3, the equipment shall be subjected to a demonstration test.

The demonstration test shall be conducted according to a Demonstration Test Plan that shall be developed as part of the detailed design of the hardware and software, and shall be presented as part of the design review before proceeding into the implementation phase.

5.2.2 Demonstration Test Criteria

The Demonstration Test Plan shall recognize two categories of test criteria: functional criteria and performance criteria. Functional criteria (defined in Section 3) describe in general terms the functions which the subject equipment must perform satisfactorily in order to satisfy the test. The performance criteria defined in Section III describe (in specific terms) the minimum performance parameters of a given function which the subject equipment must meet in order to satisfy the test. As a minimum, subsystem tests shall be performed to demonstrate the gain, gain/system temperature ratio, gravity loss, and pointing requirements specified in Section 3 of this document.

The tests shall be performed with the equipment installed in its operating environment. All interfaces shall be established and verified for proper operation with the interfacing subsystems.

Procedures for running the test, conduct of the actual test, and preparation of a test report shall be provided by the subsystem CDE, as described in Reference Document (1), 820-20. The test data shall be evaluated for satisfactory performance by the ANT engineer in accordance with Document 820-20.

Section 6

Operational Characteristics

6.1 Maintainability

Since the antenna is a series element in the operation of each DSS and consists of mechanical devices which are subject to wear and consumption, the minimum practical down time is to be a primary goal in the design of the antenna.

6.1.1 Mechanical Components

6.1.1.1 Maintainability

Design features shall be incorporated into the antenna to permit the removal, repair, and replacement of each component subject to wear or contamination. Specifically, bearings, motors, gears, brake linings, clutches, filters, etc., that are subject to wear and contamination shall be easily accessible, with minimum removal of other components.

6.1.1.2 Redundancy

Equipment requiring frequent service shall be installed in redundant pairs so that either unit can be isolated for servicing while the other is in operation.

6.1.1.3 Operational Life

All structures and drive equipment shall have a 20-year design life requirement.

6.1.2 Electronic Modules

6.1.2.1 Design Life

Electronic modules shall have a design life of 10 years and shall be designed for replaceability on a module or assembly basis.

6.1.2.2 Maintenance Features

Where possible, replaceable units shall contain a complete function, be easily diagnosed for degraded performance, and be small enough to be easily handled by one man.

6.2 Spares

6.2.1 Provisioning Criteria

An appropriate quantity of spare components shall be provided, based on several considerations:

(1) Cost of spare components

(2) Time to procure replacements

(3) Anticipated life or mean time between failures.

6.2.2 Replacement Intervals

Consumable items, such as filters, brake linings, etc., shall be provided for each new antenna to permit six months of normal operation.

6.3 Documentation

The documentation specified by the agreement for transfer to Operations of the developed subsystem shall list all equipment of the subsystem, shall include the bill of materials, and shall describe the installation procedure, the acceptance test procedures, and all connection details (both internal and interfacing) for all operating, testing, and maintenance conditions. The documentation shall also include a technical manual, to be prepared in accordance with Reference Document (13), 810-27.

6.4 Safety

The ANT is, by the nature of its physical size, an inherently dangerous device. Adequate precautions shall be taken to protect the operating and maintenance personnel, as well as the antenna proper.

6.4.1 Access Ways

Ladders and catwalks shall have protective guardrails.

6.4.2 Moving Parts

All moving machinery shall have guards to prevent accidental entanglement.

6.4.3 Safety Manual

All antennas shall meet the applicable sections of Reference Document (14), 890-213.

6.4.4 *OSHA Standards*

All applicable Occupational Safety and Health Administration (OSHA) and California Safety Orders shall apply to all antennas built in California.

6.4.5 *Other Standards and Requirements*

Equivalent safety codes shall apply to antennas at other locations. Electrical paths to ground shall be provided for grounding of signal, power, and lightning at the antenna.

6.5 *Life-Cycle Cost*

6.5.1 *Definition*

Modifications to existing equipment and new equipment implemented into the network shall be evaluated on the basis of life-cycle cost. In the absence of other criteria, life-cycle cost shall be taken as the cost of implementation, plus the cost of maintenance and operation, for a period of 10 years.

6.5.2 *Cost Tradeoffs*

Alternate configurations, technologies, and designs shall be considered during the planning and design phases to validate that minimum life-cycle costs are achieved.

6.5.3 *Energy Consumption*

Since an important element of life-cycle cost is the consumption of energy, consideration shall be given to minimizing the direct consumption of energy during normal operation and during stand-by or non-operational periods. Reliable turn-off when not in use and rapid stabilization after turn-on are especially desirable qualities. Consideration shall also be given to minimizing the energy demands upon the environment which sustains the equipment. Minimum air conditioning and humidification demands are especially desirable.

6.6 *Functional Availability*

6.6.1 *Availability Definition*

Functional availability is defined in Reference Document (1), 820-20. Major failures (structure, drives, bearings, hydraulics, etc.) will require scheduling of extensive maintenance time which will reduce or eliminate scheduled end user hours. The antennas shall be designed such that major failures will not occur during the design life.

6.6.2 Normal and Critical Activities

The ANT shall be designed to provide the following functional availability:

(1) Normal Spacecraft Activities: single antenna: 99.70%

(2) Critical Spacecraft Activities: single antenna: 99.80%

6.6.3 Scheduled Availability

The antenna shall require no more than 8 hours per month to be scheduled for maintenance and testing.

6.7 Reliability

6.7.1 Mechanical and Hydraulic Parts

Each antenna including its associated mechanical/hydraulic equipment shall be designed to provide a 1000-hour MTBF, with appropriate maintenance.

6.7.2 Electronic Parts

The antenna electronic equipment shall be designed to provide a 3000-hour MTBF.

6.8 Software

6.8.1 Software Development

All software and firmware for use in this subsystem shall be developed in accordance with the requirements of Reference Document (15), D-4000.

6.8.2 Data Flow

All software and firmware shall comply with the requirements of Reference Documents (8), 890-132, and (9), 890-133.

6.9 Equipment

All equipment of this subsystem shall meet the requirements of Reference Document (16), DSN-STD-00001.

6.10 Environmental Requirements

The antenna structure within each DSCC shall operate under any combination of the environmental conditions shown in Table 6-1, including temperature control for elements of other subsystems which must be antenna mounted.

Table 6-1. Environmental Requirements

Parameter	Value
Externally Mounted Equipment	
Operating Temperature	-18° to + 46°C
Non-operating Temperature	-29° to + 57°C
Operating Wind	45 mph
Survival Wind:	
(1) Stowed	100 mph
(2) Any Position	70 mph
Ice (0.5 specific gravity), stowed	1 inch
Snow (0.1 specific gravity), stowed	30 inches
Rain, any position	2 inches/hour
Hail, any position	Up to 1-1/2 inches diameter
Humidity	0-100 percent
Altitude	0-4000 feet
Dust	Desert environment
Internally Located Equipment	
Operating Temperature	10° to 40°C
Storage Temperature	-29° to 57°C
Humidity	20 to 80 percent

Appendix A

Abbreviations

ACC	Antenna Control Console
ACG	Antenna Control Group
ACM	Antenna Control and Monitor
ACS	Antenna control Subassembly
AGC	Automatic Gain Control
ANT	Antenna Mechanical Subsystem
APA	Antenna Pointing Assembly
ASC	Antenna Servo Controller
AZ	Azimuth
BWG	Beam Waveguide
CALIB	Calibration
CDE	Cognizant Development Engineer
COE	Cognizant Operations Engineer
Dec	Declination
DMC	Monitor and Control Subsystem
DRS	Discrepancy Reporting System
DSCC	Deep Space Communications Complex
DSN	Deep Space Network
DSP	Spectrum Processing Subsystem
DSS	Deep Space Station
DTK	DSCC Tracking Subsystem
DTS	DSCC Test Support Subsystem
EL	Elevation
FAC	DSCC Technical Facilities Subsystem
FHD	Film Height Detector
FTS	Frequency and Timing Subsystem
GMT	Greenwich Mean Time
HA	Hour Angle
HEF	High Efficiency
HVAC	Heating, Ventilating, and Air Conditioning
LAN	Local Area Network
LMC	Link Monitor and Control
MEC	Master Equatorial Controller
MPA	Metric and Pointing Assembly
OCI	Operator-Controlled Input
RCV	Receiver-Exciter Subsystem
RF	Radio Frequency
RSS	DSN Radio Science System; root-sum-square value
S/R	Subreflector
SETI	Search for Extra Terrestrial Intelligence
SPC	Signal Processing Center
SRC	Subreflector Controller

STD	Standard
UBI	Ungerman-Bass Industries
TRK	DSN Tracking System
TXR	Transmitter Subsystem
UWV	Antenna Microwave Subsystem
VLBI	Very Long Baseline Interferometry
VSWR	Voltage-Standing Wave Ratio

Appendix B

DSCC Antenna Mechanical Subsystem (AMT) Requirement Priorities for the 1990-1995 Era

Table B-1. DSCC Antenna Mechanical Subsystem Functional Priorities

Functional Priority	Calendar Year				
	1993	1994	1995	1996	1997
New 34-m BWG Antennas at					
Goldstone	A	-	-	-	-
Australia	-	-	A	-	-
Spain	-	-	A	-	-
Provide ACG for DSS 24	A	-	-	-	-
Provide ACG for DSS 54	-	-	A	-	-
Provide ACG for DSS 34	-	-	A	-	-
Provide ACG for 34-m HEF Subnet	-	-	B	-	-
Provide ACG for 70-m Subnet	-	-	-	-	B
Provide Metric and Pointing Assembly for 26-m and 9-m Antennas	A	-	-	-	-

Priority Code:

A. Required for flight project support.

B. Required to improve network reliability, maintainability, and operability.

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