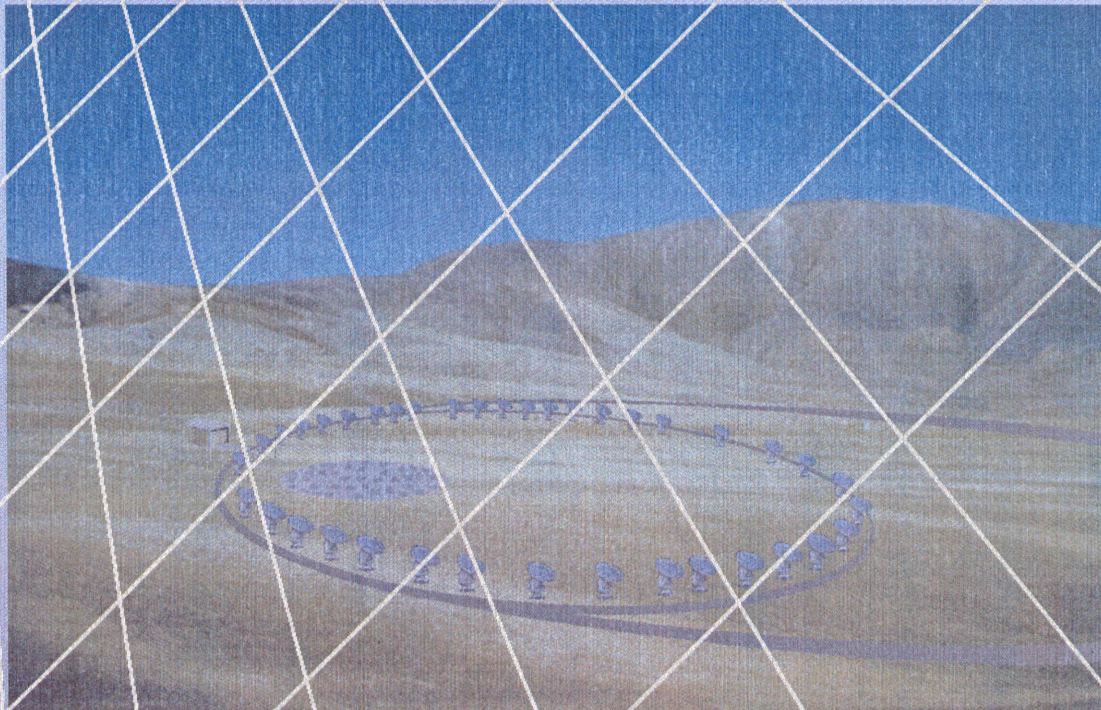


# **REQUEST FOR PROPOSAL**

## **A Prototype Antenna for The Millimeter Array/Large Southern Array Radio Telescope**

1999-March-30



**NATIONAL RADIO ASTRONOMY OBSERVATORY**

A facility of the National Science Foundation operated under  
cooperative agreement by Associated Universities, Inc.



**REQUEST FOR PROPOSAL**

**A PROTOTYPE ANTENNA FOR  
THE MILLIMETER ARRAY/LARGE SOUTHERN ARRAY RADIO TELESCOPE**

**ISSUE DATE: 1999-MARCH-30**

**REQUEST FOR PROPOSALS**  
**A PROTOTYPE ANTENNA FOR**  
**THE MILLIMETER ARRAY/LARGE SOUTHERN ARRAY RADIO TELESCOPE**

**Issued by:** Associated Universities, Inc.  
National Radio Astronomy Observatory  
520 Edgemont Road  
Charlottesville, VA 22903-2475

**For:** The Design, Fabrication, Shipping, Erection, Alignment, and Acceptance Testing of a prototype antenna for the Millimeter Array/Large Southern Array (MMA/LSA) Radio Telescope.

**For Erection at:** Plains of San Augustin, New Mexico

**RFP Date:** 1999-March-30

**Date Proposals Due:** 1999-June-30

**Pre-Proposal Conference:** To be held in Socorro, New Mexico on 1999-May-18.

**Cooperative Agreement:** NSF-AST-9223814 between Associated Universities, Inc., and the National Science Foundation

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## SECTION 1

### GENERAL INFORMATION AND INSTRUCTIONS

#### 1.1 GENERAL

Associated Universities, Inc. (AUI), a not-for-profit educational and research management corporation that operates the National Radio Astronomy Observatory (NRAO) under cooperative agreement with the National Science Foundation (NSF) an agency of the U.S. government, is soliciting proposals for the design, fabrication, shipping, erection, alignment, and acceptance testing of a prototype antenna for the Millimeter Array/Large Southern Array (MMA/LSA) Radio Telescope. The Millimeter Array (MMA) is a project of the U.S. National Science Foundation (NSF) presently in a design and development phase. The Large Southern Array (LSA) is a project of the European Coordinating Committee (ECC), a coalition of European countries and institutions for which the European Southern Observatory (ESO) is serving as administrative agency. The LSA is also presently in a design and development phase. The term "MMA/LSA" is used here as a designation for the joint, merged, project presently under negotiation by the agencies involved. The MMA/LSA currently has a goal of sixty-four (64) 12-meter diameter antennas to be built on a site in northern Chile.

Prospective proposers should be aware that AUI and ESO envision the MMA/LSA as a joint project between two equal partners. Although it is a joint project, each partner is engaged in a separate procurement to purchase a prototype antenna (a total of two prototypes). Each partner is issuing an RFP which contains identical technical specifications, but which may vary somewhat in other areas such as terms and conditions. Each partner will manage its own procurement with its own staff on its own schedule. The procurement schedules will be closely related; it is anticipated that ESO's procurement schedule will follow AUI's within four to six weeks. *In general*, it is expected that the proposals received by AUI and ESO for the two procurements will be very similar. Technical sections should be identical. Other sections of the proposals should be the same to the maximum extent possible.

Two (2) prototype antennas will be purchased; one by AUI and one by ESO, from two different contractors. The successful proposer in AUI's prototype procurement will be ineligible for an award in ESO's prototype procurement. Although there will be two separate procurements underway, it is anticipated that proposal review and evaluation will be done by AUI and ESO in cooperation with one another and the selection of the two successful proposers will be made by AUI and ESO in conjunction.

The prototype MMA/LSA antennas, both of which shall be erected at the NRAO Very Large Array site on the Plains of San Augustin, New Mexico, are 12 meter diameter alt-azimuth dishes. The basic antenna, for which proposals are solicited, will be augmented by an antenna foundation, scientific receiving equipment, computers, and metrology equipment, all of which will be supplied by AUI and ESO. The two antennas will be tested together by AUI and ESO. The prototype antenna

judged by the MMA/LSA Project to be the better will be considered for the MMA/LSA Production Project. See 1.11.

AUI intends to negotiate with the successful proposer for a firm fixed-price contract for the entire scope of work defined herein. ESO will do the same for its prototype antenna.

This Request for Proposal consists of four (4) Sections plus Appendices. The Sections include the following:

Section 1, General Information and Instructions, containing information of a general nature regarding the MMA/LSA project and the proposal process.

Section 2, Content of Proposal, containing information about the format and content of the proposal.

Section 3, Specifications and Statement of Work, containing information on the design criteria to be followed and the antenna performance requirements.

Section 4, Form of Contract, containing administrative provisions for the performance of the contract, and the terms and conditions.

The Appendices to the RFP include additional design information, back-up material and various representation, certification, acknowledgment, and signature forms.

Two (2) copies of the RFP documents will be furnished to each proposer. Additional sets may be obtained from the MMA Business Manager, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903-2475, at a non-refundable reproduction expense of \$100 per set, or may be found on the NRAO website at URL: <http://www.cv.nrao.edu/~cwhite/mma/rfp/mmalsa.finalrfp.html>.

## **1.2 FORM OF PROPOSAL AND MANNER OF SUBMISSION**

Six (6) copies of a detailed proposal shall be submitted and shall be organized in accordance with the categories outlined in Section 2, Content of Proposal. In addition to the printed copies of the proposal, a digital copy of the proposal shall be submitted on the electronic medium of the proposer's choice (diskettes, CD-ROM, etc.). The format of digital copy shall be Adobe PDF file format. Cost/pricing information shall be on a second, clearly labeled medium (diskette, CD-ROM, etc.).

Proposals shall be delivered on the date set forth on the title sheet of this RFP to:

The MMA Business Manager  
National Radio Astronomy Observatory  
520 Edgemont Road  
Charlottesville, VA 22903-2475

Any proposal received after the close of business (5:00 p.m. U.S. Eastern time) on the stated date will not be considered.

Proposals must set forth full, accurate, and complete information as required in this RFP. Proposals that are incomplete or partial in any material respect affecting the responsiveness of the proposal will not be considered.

Proposals submitted in response to this RFP shall be in the English language. Proposals received in other than English shall be rejected.

Price quotes submitted in response to this RFP shall be in terms of U.S. dollars. Offers received in other than U.S. dollars shall be rejected.

AUI reserves the right to (1) postpone the date of submission, (2) to amend this RFP as it considers necessary, and (3) to waive informalities and minor irregularities in proposals received.

### **1.3 METHOD OF PROCUREMENT**

AUI intends to negotiate a firm fixed-price contract for the entire scope of the work as defined herein with the successful proposer, and intends to award the contract to the qualified proposer whose proposal is within a competitive price range and is most advantageous to AUI and the MMA/LSA partnership, all factors considered.

AUI reserves the right to make an award based on the proposer's initially proposed price without discussion of such proposals. AUI is not obligated to award all or any part of the work solicited, and in any event will not be responsible for the cost of proposal preparation or any other cost incurred in connection with this RFP. Further, AUI reserves the right to accept other than the lowest price proposal.

### **1.4 GENERAL PRICING INSTRUCTIONS**

Cost or pricing information shall be incorporated only in Volume 4 of the proposal, "Cost and Pricing Proposal." See Section 2, Content of Proposal, for a discussion of the required proposal format.



Each proposer shall include a fixed-price proposal for the prototype MMA/LSA antenna, as set forth on the price summary form included in Appendix A. A detailed price breakdown will also be submitted in Volume 4 in accordance with Appendix B, Guidance for Presentation of Pricing Data. In addition, proposers shall include a firm-fixed price for an optional identical second prototype MMA/LSA antenna, which option may be unilaterally exercised by AUI not later than 2000-December-31. This optional AUI prototype is not the ESO prototype antenna.

Further, proposers shall include estimated pricing to provide sixty-four (64) identical 12 m diameter MMA/LSA antennas, which is the project goal, at a rate of eight (8) per year beginning in 2003 (the "Production MMA/LSA" project). The production cost estimate shall be provided in the same format as the prototype price, and shall be on a per antenna basis in 1999 dollars. Proposers are encouraged not to include the cost of production tooling in the prototype pricing. See 4.1.11.

### **1.5 DELIVERY SCHEDULE**

The Proposer shall provide in Volume 3 of the proposal a proposed schedule for all project tasks for delivering a specification-compliant antenna. In developing the schedule, proposers are requested to consider AUI's target delivery date of 2001-June-01 for the first prototype antenna. However, it is the proposers's responsibility to develop and propose a schedule which is attainable. The successful Proposer shall be responsible to provide all the necessary resources, manpower, materials, tools, etc., to meet the schedule ultimately agreed upon.

### **1.6 PRE-PROPOSAL CONFERENCE**

A pre-proposal conference to discuss the project will be held in Socorro, New Mexico, at the time indicated on the title sheet of this RFP.

Confirmation of attendance, with the names of the attendees, is requested by the MMA Business Manager in Charlottesville, Virginia, at least seven days in advance of the meeting.

### **1.7 EXPLANATION OF PROPOSAL DOCUMENTS**

Should a Proposer find any discrepancies in, or omissions from, any of the documents, or be in doubt as to the meaning of any document, he shall immediately advise the MMA Business Manager in writing or by e-mail. Explanations or clarifications will be made in writing to all recipients of the Request for Proposal and by e-mail to those recipients able to receive e-mail.

In order to be considered, questions, comments, or communications must be received by the MMA Business Manager no later than 5:00 p.m. (U.S. Eastern time) fifteen (15) working days prior to the proposal due date. No response will be made to communications received after that date.

During the procurement phase, all contact between Proposers and AUI must be made through the MMA Business Manager. Direct contact by a Proposer with any AUI employee other than

through the MMA Business Manager may result in disqualification. Neither AUI nor the U.S. Government will be bound by any oral interpretations of the RFP documents.

## **1.8 CRITERIA FOR PROPOSAL EVALUATION**

The three major categories of performance for evaluating proposals in relative order of decreasing importance are: (1) ability of proposer to complete the MMA/LSA Project and the technical concept for the prototype antenna, (2) price, and (3) schedule for completion. Some of the criteria within each category are presented below.

Ability of Proposer to Complete the MMA/LSA Project and the Technical Concept for the Prototype Antenna. Proposers will be evaluated by, among other factors, their:

- Organization and management procedures.
- Experience and record on projects similar in magnitude, and on the production project (see 1.11).
- Availability and competence of experienced management and technical personnel to be assigned to the project.
- Thoroughness of response to requests in this RFP.
- Financial stability and willingness to commit resources to the project.
- Understanding of the technical difficulty of achieving the performance specifications.
- Engineering calculations and analysis supporting the claimed performance of the antenna.
- Methods for assuring compliance with specifications.
- Manufacturing and erection plans, including division between in-house and on-site tasks.
- Quality assurance provisions.
- Plan to secure long-lead items.
- Ability to successfully perform the MMA/LSA Production project (see 1.11).

Price. Price is a significant factor in the final selection of the successful proposer. AUI will consider both the firm fixed price proposed for the prototype MMA/LSA antenna as well as the estimated pricing for the goal production project of 64 MMA/LSA antennas.

Schedule of Completion. A goal date for initial use of the first MMA/LSA prototype telescope is 2001-June-01. Proposers must provide detailed schedules for meeting this target, or explanation of their schedule which leads to an alternate delivery date, if they believe it necessary. Proposers also must submit a detailed schedule for delivery of the second (optional) prototype assuming authorization by 2000-December-31.

### **1.9 AUI ACTION UPON PROPOSALS**

In the event that no proposals are received consistent with AUI's budget, or proposals received at the desired price do not fulfill the required specifications, AUI reserves the right to:

- a. Review and/or modify its specifications and reissue a Request for Proposals to any or all of the current proposers or to any other party it feels is competent to compete.
- b. Select any proposal(s) AUI feels may be close to its desired standards and negotiate with Proposer(s) thereof to determine if an acceptable price can be obtained.

### **1.10 No-BIDS**

If a prospective Proposer elects not to submit a proposal in response to this RFP, AUI requests a written statement to that effect, and the return of any AUI-provided RFP material (documents, drawings, etc.). Also, AUI requests a brief statement of why the firm elected to no-bid the project.

### **1.11 MMA/LSA PRODUCTION PROJECT**

AUI anticipates that following this Prototype MMA/LSA Project there will be a follow-on Production MMA/LSA Project which will consist of the fabrication, shipping, and site erection of the sixty-four (64) identical 12 m diameter antennas which is currently the goal under discussion for the joint project. The final site for the Production MMA/LSA will be in the north of Chile near San Pedro de Atacama at a site named Llano de Chajnantor. While at this time there is no guaranteed connection between the MMA/LSA Prototype Project and the MMA/LSA Production Project, AUI and ESO reserve the right to award the production MMA contract to the supplier of the successful prototype antenna. Since the cost of the production project will be split between the partners, AUI and ESO reserve the right to apportion the production project, as necessary, to the successful contractor(s).



## **SECTION 2**

### **CONTENT OF PROPOSAL**

#### **2.1 PROPOSAL FORMAT**

The proposal shall include:

- General Summary
- Volume 1 - Technical Proposal (this volume should be identical for both AUI and ESO prototype antenna procurements)
- Volume 2 - Management Proposal
- Volume 3 - Master Summary Schedules
- Volume 4 - Cost and Pricing Proposal

Submittals made to AUI in response to this RFP which include proprietary information or which are not to be disclosed or used for any purpose other than the evaluation of the proposal, shall be clearly marked or labeled.

#### **2.2 GENERAL SUMMARY OF PROPOSAL**

This summary shall include on ten (10) pages or less a concise synopsis of the proposal. Exclude cost and price information.

#### **2.3 TECHNICAL PROPOSAL (VOLUME 1)**

##### **2.3.1 DESIGN**

Design concepts shall be in sufficient detail to permit evaluation of the proposed antenna and shall include the following as a minimum:

1. Technical approach. Describe the proposed structure and methods of analysis.
2. Performance estimates. Estimate the performance of the proposed antenna and indicate the degree of confidence for meeting the specifications. Include the estimated or known performance of systems and components to be used as part of the antenna. Comment in particular on the performance with respect to the reflector surface accuracy, pointing, path length errors and fast motion requirements. Include estimates of the resonant frequency performance of the antenna and the electrical power required when the drive system is accelerating the antenna at the maximum required rate about both axes simultaneously.
3. Accuracy estimates. Analyze error contributions showing their assignment into the overall error budget. Include as a minimum the following in the proposed error budget table and state the loading conditions that have been assumed in preparing these error budgets:

- a. Primary and Secondary Reflector surfaces—Manufacturing tolerance, measurement and setting tolerance, gravity deformation, wind and thermal deformation, and other error sources. Provide this information for the primary reflector and the subreflector.
  - b. Antenna pointing error (repeatable and non-repeatable) due to gravity deformation in various positions, wind and thermal deformation, servo errors, and other error sources.
  - c. Path length errors due to wind and thermal deformations of the mount and reflector.
4. Materials. Discuss effects of fatigue on materials. Discuss specific materials, components, parts, and other items included in the design. If metrology equipment is proposed for the purposes of correcting for deformations of the antenna structure, provide details of this equipment. Provide details of the CFRP materials proposed for the reflector backup structure and subreflector support legs and of the methods proposed for joining components of these structures.
5. Design for quantity production. Discuss the features of the proposed design which make it particularly suitable for an economical production run goal of 64 antennas. It is important that the production run antennas all have close to identical performance; discuss aspects of the design which will ensure that production antennas will be identical to each other.
6. Design for transportability. Discuss the design features which demonstrate that the antenna can be picked up and carried safely on a transporter vehicle from one array configuration to another.
7. Calculations and supporting data. Include these as proof of ability to meet the specifications.
8. Cost drivers. Identify specifications or technical requirements which are the cost drivers in either the prototype or production antenna projects. Make suggestions of how to reduce the specifications which might make the project more efficient and less costly. Describe and explain the correlation between specification reduction and cost savings.

### **2.3.2 TECHNOLOGY TESTING**

The Proposer may propose to use technology for the antenna that previously has not been demonstrated in a similar application. Examples of such technology could include, but are not limited to, metrology for measuring mount deformation, high precision reflector surface panels, novel methods of joining the CFRP components of the reflector backup structure, and high precision angle encoders. Provide a plan for demonstrating acceptable performance of any such previously undemonstrated technology on prototype samples before building the technology into the antenna.

### **2.3.3 CONTRACTOR'S MANUFACTURING PLAN**

The manufacturing plan section should include a discussion in detail of the following:

1. Place or source of manufacture.
2. Manufacturing processing and plant lay-out and setup.
3. List all subcontractors and describe what part of the project will be subcontracted to each.
4. Special equipment or tooling, with particular emphasis on metrology equipment, surface reflector panels and antenna carbon fiber components.
5. Method of transporting and shipping components to the construction site.
6. Estimated weight budget for the major components of antenna, plus an estimate of the total antenna weight. Consider joint weights in the FEA.
7. Control of tolerances.
8. Quality Assurance plan and procedures for the prime contractor and all subcontractors.

### **2.3.4 ON-SITE ERECTION PLAN**

The on-site erection plan section should include a discussion in detail of the following:

1. Various steps in field assembly and erection of the antennas.
2. Type of field equipment and facilities to be utilized
3. Assembly and erection techniques proposed—explain how tolerances will be achieved and maintained.
4. Utilization of subcontractors and lower tier subcontractors.
5. Protection and storage of unassembled components at the site.

### **2.3.5 TEST AND ACCEPTANCE PLAN**

The test and acceptance plan section should include a discussion in detail of how the proposer intends to provide acceptance testing of the antenna (see 3.9.4.3),

1. Mechanical
2. Structural
3. Servo
4. Electrical
5. Safety
6. Environmental
7. Reliability

### **2.3.6 EXCEPTIONS TAKEN TO AUI SPECIFICATIONS**

The exceptions section shall include a detailed explanation of any exceptions taken to the AUI specifications, reasons for the exception, and any alternate specifications proposed.

### **2.3.7 PERFORMANCE IN EXCESS OF REQUIREMENTS**

If the performance of the proposed antenna can be shown to exceed the requirements of this RFP, this shall be clearly stated and explained in the Technical Proposal.

## **2.4 MANAGEMENT PROPOSAL (VOLUME 2)**

This portion shall include data on the Proposer's experience, personnel, and resources which qualify it for the MMA/LSA project. It should include the following:

### **2.4.1 GENERAL COMPANY PLAN**

Provide information concerning past experience and work similar to the work in this proposal; contract source, price, schedule, and delivery date for projects of similar size and character designed or constructed by the Proposer over the past five years. Give names of references and points of contact for each project listed.

### **2.4.2 WORK BACKLOG**

Specify the total backlog of work under contract or subcontract and the estimated completion dates for this backlog. Be specific concerning work related to this RFP and work for the U.S. Government or its agencies, or other domestic or foreign buyers.

### **2.4.3 MANAGEMENT QUALIFICATIONS**

Describe qualifications as related to this project: scheduling, project management, subcontracting and or purchasing, field engineering organization, quality controls, etc.

### **2.4.4 COMPANY FACILITIES AND CAPABILITIES**

Describe facilities, facilities location(s), and capabilities for research, design, engineering, testing, and reliability.

### **2.4.5 KEY PERSONNEL**

List key management and technical personnel expected to be assigned to this project in all areas of the project and include their curriculum vitae. State how long each key person has been a regular, full-time employee with the company. Identify and define in the proposal the names, titles, mailing addresses, and telephone numbers of persons authorized to conduct negotiations and make contractual commitments for the company.

#### **2.4.6 ORGANIZATION CHARTS**

Provide an organization chart showing the proposed project organization and how it fits into the company organization. Include names and functions of all key personnel.

#### **2.4.7 METHOD OF MANAGEMENT**

Describe the management of both in-house and out-of-house work, including administration and supervision, manpower, plans, inspection, and liaison.

#### **2.4.8 SUBCONTRACTORS AND CONSULTANTS**

List by name all subcontractors and consultants which are proposed to be used in the performance of the work. Describe work areas, qualifications, and capabilities for subcontractors and consultants as set forth in items 2.4.1 through 2.4.7. All subcontractors and consultants are subject to AUI approval.

#### **2.4.9 COMMITMENT OF COMPANY RESOURCES**

Include a statement of the extent to which the proposer is willing to commit its resources.

#### **2.4.10 FINANCIAL CAPACITY**

Include latest certified audit and financial statements and last yearly report of the company and any parent organization.

#### **2.4.11 REPRESENTATION, CERTIFICATIONS, AND ACKNOWLEDGMENTS**

Forms for the various representations, certifications, and acknowledgments are included in Appendix C. These forms are to be completed by the proposer by checking or filling in all applicable blanks, and signing each paragraph where indicated.

The completed representations, certifications, and acknowledgments included in Appendix C are to be made part of the Business Proposal, Volume 2.

Failure to include a completed and signed copy of the representation, certification, and acknowledgment forms will result in the proposal being considered non-responsive.

### **2.5 MASTER SUMMARY SCHEDULES (VOLUME 3)**

This volume shall include a detailed master schedule showing all aspects of the work from contract award through project completion. Indicate starting and completion dates and significant milestones for accomplishing tasks, such as Preliminary Design Review, Critical Design Review,

delivery of Complete Design Documentation Package, approval of Complete Design, fabrication, shipment, erection, and test of the telescope. The schedule must show a clearly defined critical path through the project. With the schedule, the Proposer shall include a schedule risk analysis and proposed countermeasures to be undertaken in the event of schedule delays.

Also include a summary of manpower to be assigned to each portion of the work, together with estimated man hours. This schedule may be combined with the detailed schedule required in the preceding paragraph.

This volume shall also include lead times for authorization to purchase items necessary to maintain the program schedule.

## **2.6 COST AND PRICING (VOLUME 4)**

### **2.6.1 PRICING DATA**

No pricing data of any kind shall be included in the Technical, Business, or Schedule Proposal Volumes. Cost and price breakdown shall be included only in the separate Volume 4. The electronic proposal shall have pricing data on a separate and clearly labeled medium (diskette, CD-ROM, etc.).

### **2.6.2 PRICE SUMMARY**

Include the price summary form found in Appendix A as the first page of the Price Proposal. Supply price breakdown data per Appendix B.

When presenting the estimated pricing for the Production MMA/LSA project, Proposers are requested to state opinions on whether the quantity of eight (8) production antennas per year is economically advantageous to AUI. Any Proposer who believes that acquisitions in different quantities would be more advantageous is invited to recommend an economic purchase quantity/schedule for a goal of sixty-four (64) identical 12 m diameter production antennas.

### **2.6.3 TAXES**

Proposers shall prepare and present cost and pricing information without including Federal, State of New Mexico or local taxes or customs or duties. The contract price will be adjusted to include any and all applicable taxes, customs and duties and the Contractor will be reimbursed accordingly.



#### **2.6.4 AUDIT OF COST OR PRICE DATA**

List the name of your cognizant government audit agency; the name and telephone number of the auditor; and the location where cost and pricing data may be reviewed. If the firm has no cognizant government audit agency, list the name, address, and contact person of the firm's external auditor.

#### **2.6.5 DISPUTES AND LITIGATION**

List any current outstanding or ongoing disputes related to any aspect of projects performed for the U.S. Government, including labor safety and environmental disputes. Also describe any pending or ongoing legal actions in which the firm is involved. Describe any disputes/legal actions, whether resolved or ongoing, related to any projects offered as evidence of Proposer's experience and management capabilities (see Section 2.4).

## **SECTION 3**

### **SPECIFICATIONS AND STATEMENT OF WORK**

#### **3.1 STATEMENT OF WORK**

##### **3.1.1 GENERAL STATEMENT OF WORK**

The work described herein shall consist of the furnishing of labor, materials, services, drawings, data, detailed specifications, test documents, and other items required for the detailed design, manufacture, assembly on site, alignment, and testing for a prototype antenna for the MMA/LSA radiotelescope.

##### **3.1.2 OBJECTIVES OF THE PROGRAM**

The MMA/LSA radiotelescope will consist of a goal of 64 identical 12 m diameter antennas to be built on a remote, high-altitude site in Northern Chile. A prototype of this 12 m antenna will be extensively tested by AUI and ESO at a test site in the USA to ensure that it meets all requirements before the production phase of the project is initiated. The six primary objectives of this program concern the design, technology testing, fabrication, assembly, and acceptance testing of this prototype 12 m diameter antenna, including both primary and secondary reflectors, and planning for production, as follows:

#### **1. Design**

The important features of the prototype antenna design include the following:

- (a) A design that meets the operating parameters and requirements set forth in this specification. The key performance parameters are reflector surface accuracy, pointing accuracy, path length stability and fast motion performance. With respect to fast motion performance, the design should take into account ways of reducing the electrical power required to accelerate the antenna at its maximum acceleration rate so as to minimize the demand on the site power system when all antennas accelerate together.
- (b) A design that satisfies the requirement that the antenna be transportable between foundations.
- (c) A design that is optimized for production of a quantity goal of 64 units, taking advantage of economies that may be realized by maximum duplication and standardization of parts, use of tooling to minimize labor, and simplification of assembly effort. Since assembly of the future planned production run of antennas will take place at a remote location in Northern Chile, the antenna will be designed for manufacture and shipping in such modules as will minimize shipping and assembly costs to the extent possible.
- (d) A design that takes into consideration ease of maintenance and the reliability of components to minimize maintenance and for which the major components of the antenna such as the mount structure, the azimuth and elevation bearings, the drive systems, the

reflector backup structure and the reflector surface have a lifetime of 30 years in the environmental conditions expected to prevail at the Chilean site.

## **2. Technology testing**

The Contractor may elect to use technology on the 12 m diameter antenna that has not been previously demonstrated in a similar application. Prototype specimens of any critical technology which is used in the antenna and which has not been previously demonstrated in a similar application shall be fabricated and tested prior to building the technology into the prototype antenna. For example, such technology could include, but would not be limited to, high precision reflector panels, novel methods for joining CFRP elements of the reflector backup structure, metrology for measuring mount deformations or high-accuracy angle encoders.

## **3. Prototype antenna fabrication**

A prototype antenna will be fabricated according to the Contractor's Design. Since AUI plans to thoroughly test this prototype to verify that it meets all performance requirements before initiating the production phase of the project, it is important that the performance of this prototype antenna be the same as production antennas built to the same design.

## **4. Antenna assembly and alignment**

The prototype antenna will be assembled and aligned at the MMA test site in New Mexico, according to the specifications and procedures set forth during the design stage.

## **5. Acceptance testing**

The Contractor will perform acceptance tests according to the acceptance documents prepared in the design stage to establish that the antenna meets the specified performance requirements. Some aspects of the antenna performance will be accepted based on the results of calculations (see Section 3.9.4.3).

## **6. Production planning**

The Contractor shall deliver a Manufacturing Plan and On-Site Erection Plan for the production antennas and an updated production cost estimate. The production plans and cost estimate will be revised, and updated versions of the plans and cost estimate submitted, based on the experience gained in performing the prototype manufacturing and erection.

### **3.1.3 SUMMARY LIST OF CONTRACTOR DELIVERABLES**

<b>Item</b>	<b>Schedule</b>	<b>Reference</b>
Initial Project Schedule	15 business days after contract award	4.1.5.1
Project Manpower Schedule	15 business days after contract award	4.1.5.2

<b>Item</b>	<b>Schedule</b>	<b>Reference</b>
Project Breakdown for Scheduling and Payment	15 business days after contract award	4.1.7
Submit Drafting Standards for Approval	15 business days after contract award	3.9.1
Current FEA Model	1 month after contract award, updated monthly	3.9.2
Updated Project Schedule	5 <sup>th</sup> day of each month	4.1.5.3
Status Report	5 <sup>th</sup> day of each month	4.1.6
Preliminary Design Review (PDR) Information Package	2 weeks prior to PDR	3.1.4
PDR	Project schedule	3.1.4
Critical Design Review (CDR) Information Package	2 weeks prior to CDR	3.1.5
CDR	Project schedule	3.1.5
Gravitational Deformation Calculations	CDR	3.9.2
Eigenfrequency and Eigenmode Calculations	CDR	3.9.2
Structural Calculations for Wind Loading	CDR	3.9.2
Structural Calculations for Thermal Loading	CDR	3.9.2
Pointing Error Budget	CDR	3.9.2
Reflector Surface Error Budget	CDR	3.9.2
Path Length Error Calculations	CDR	3.9.2
Servo Analysis	CDR	3.9.2
Dynamic Analysis of Fast Switching	CDR	3.9.2
Dynamic Analysis of Application of Brakes at Full Velocity	CDR	3.9.2
Structural Fatigue Analysis	CDR	3.4.4
Metrology Analysis	CDR	3.9.2
HVAC System Calculations	CDR	3.9.2

Item	Schedule	Reference
CFRP Properties Definition Document	CDR	3.7.2
CFRP Process Control Definition Document	CDR	3.7.2
BUS Node Analysis	CDR	3.9.2
Antenna Stress Analysis	CDR	3.9.2
Foundation Design Analysis and Three Foundation Designs	CDR	3.5.3
Grounding Counterpoise Design and Analysis With Impedance Calculations for All Grounding Wires	CDR	3.9.2
Seismic Survival and Transporter Analysis	CDR	3.3.2.5
High Altitude Cooling Analysis of All Electrical Components	CDR	3.9.2
Compliance Analysis for All AUI Interfaces	CDR	3.6
Antenna Disassembly Plan	CDR	3.5.10
Antenna Assembly Plan	CDR	3.9.4.1
Antenna Alignment Plan	CDR	3.9.4.1
Acceptance Test Procedures	CDR	3.9.4.3
Corrosion Resistance Plan, Specification for Solar Reflecting Paint and Results of Accelerated Tests	CDR	3.7.4
Results of Technology Testing	CDR	3.1.2
List of Supplier's MTBF and Lifetime Specifications	CDR	3.5.9
Complete Design Documentation (CDD)	Project schedule	3.1.6
Operations and Maintenance Manuals	CDD	3.9.6
Quality Assurance Plan	CDD	3.9.5
Spare Parts List	CDD	3.9.7
Final Design Approval	Project schedule	3.1.6
Antenna Fabrication	Project schedule	3.1.2

Item	Schedule	Reference
Antenna Assembly and Alignment	Project schedule	3.1.2
Acceptance Testing	Project schedule	3.1.2
Updated Plan for Production Phase	1 month after antenna delivery	3.1.2
As-built Drawings	1 month after antenna delivery	3.9.1
Servo Software Documentation and Code	1 month after antenna delivery	3.5.6.5

### **3.1.4 PRELIMINARY DESIGN REVIEW (PDR)**

At the time of the PDR the Contractor should have used approximately 35% of the total manpower allocated to produce the Complete Design Documentation. Contractor should anticipate receiving direction from AUI at the PDR that will require Contractor to perform additional design work to either further demonstrate proof of concept, or to redesign areas that AUI does not believe will meet the Design Requirements. Material to be reviewed at the PDR shall include:

- (a) General Proof of Concept: The design shall be developed to the level that the feasibility, performance, manufacturability, reliability and maintainability of all structural, mechanical, electrical and control design of the antenna are proven.
- (b) Proof of Performance: Contractor shall present data and design information to demonstrate that all of the Contract performance specifications will be achieved with the design presented.
- (c) Survivability: Contractor shall present data and design information to demonstrate that the design presented will survive the survival conditions presented in Section 3.3.2.5.
- (d) Design Performance: Contractor shall develop a system level FEA model to allow the static, dynamic, and thermal design performance to be determined. The model shall include all components that influence the structural performance of the design, including the compliance of bearing, drives, non-intersecting structural joint members, stress stiffening, foundations and soil properties. Contractor shall clearly indicate the basis for selection of the stiffness values used to model mechanical components of the design such as bearings, drives, etc. The model shall be used to verify the performance of the antenna under the operating conditions defined in Section 3.3.2.2. Contractor shall clearly identify all structural components that are designed to operate with stresses that exceed the infinite lifetime fatigue limit during normal operating conditions. Contractor shall present error budgets for reflector surface accuracy, pointing performance and path length errors and shall present results of analysis to demonstrate that the error budgets are achievable. Special attention will be given to any metrology provided to allow



active correction of reflector surface, pointing or path length errors. Contractor shall present results of analysis of the control and drive system to demonstrate that fast motion performance requirements are achievable.

(e) Design Layout: Contractor shall provide a full assembly drawing and drawings of all sub assemblies to clearly indicate the design configuration of the design. The drawings shall include details of all structural connections necessary to meet the transportability requirements of the Contract. Contractor shall provide mass estimates accurate to 10% for all antenna components. Contractor shall provide preliminary wiring diagrams. Contractor shall provide performance data and engineering calculations for all selected components. Contractor shall provide catalog information for all selected major mechanical components (metrology, drive motors, brakes, encoders, bearings, HVAC etc).

(f) Material Selection: Contractor shall fully specify material properties for all major structural components. If CFRP has been selected, Contractor shall supply specifications of materials and processes required for the fabrication. If CFRP has been selected, Contractor shall construct and test a full size joint of the backup structure (BUS) and test structural integrity of the joint. Results of these tests are to be presented at the PDR.

(g) Interface Definition. Contractor shall demonstrate that all of the interfaces defined in the specifications have been incorporated, or can readily be incorporated, into the design.

(h) Maintainability: Contractor shall present procedures for preventative and corrective maintenance for all major mechanical components, including, but not limited to, bearings, drive motors, encoders, and brakes, to demonstrate that provisions have been incorporated into the design to allow these procedures to be performed efficiently and safely.

(i) Risk Management: Contractor shall identify and list all aspects of the design that represent a risk to achieving completion of the design, manufacture, and site assembly of the antenna, on schedule, and to budget, and at the same time, meeting all Performance Requirements.

(j) Manufacturability: Contractor shall demonstrate that all aspects of the design can be manufactured.

(k) Code Compliance: Contractor shall demonstrate that the design will meet all applicable codes.

(l) Production Run: Contractor shall present aspects of the design that are well suited, or may present problems, to achieving economic quality production of 64 antennas over 8 years. Contractor shall present any special requirements that will be required to achieve product assurance during the production run.

(m) Within 2 weeks of the completion of the PDR, AUI will provide Contractor with a list of aspects of the design that:

- (a) requires additional engineering to clearly demonstrate Proof of Concept, or
- (b) requires redesign because AUI does not believe the rejected aspects of the design will meet the requirements of the specification. For any work that AUI requires redesigning, AUI will provide detailed written explanations of why the rejected aspects of the design will not meet the specified requirements

Contractor will incorporate all of the comments made by AUI into the PDR documentation and present the modified PDR documents to AUI for approval before starting work for the CDR

### **3.1.5 CRITICAL DESIGN REVIEW (CDR)**

At the time of the CDR the Contractor should have used approximately 75% of the total manpower allocated to produce the Complete Design Documentation. The material to be reviewed at the CDR will include, but will not be limited to:

1. The final antenna design.
2. Final versions of all material presented in preliminary form at PDR.
3. Final versions of all of the analysis, error budgets and plans and procedures listed in Table 3.1.3 for delivery at the CDR.
4. Final results of any technology testing.
5. Final antenna foundation design analysis and drawings in sufficient detail to allow AUI's foundation subcontractor to construct the foundation at the US test site.

Within 2 weeks of the completion of the CDR, AUI will provide Contractor with a list of aspects of the design that require redesign because AUI does not believe the rejected aspects of the design will meet the requirements of the specification. For any work that AUI requires to be redesigned, AUI will provide detailed written explanations of why the rejected aspects of the design will not meet the specified requirements.

Contractor will incorporate all of the comments made by AUI into the CDR documentation and present the modified CDR documents to AUI for approval before starting work for the Complete Design Documentation package.

### **3.1.6 COMPLETE DESIGN DOCUMENTATION (CDD)**

The Complete Design Documentation package is the final deliverable product of the Design Phase of the antenna. It will contain sufficient drawings (including shop fabrication drawings), specifications, plans, procedures and manuals to allow the antenna to be fabricated, assembled, tested and maintained.

Within 2 weeks of the completion and delivery of the CDD, AUI will provide Contractor with a list of aspects of the package that require additional information because AUI does not believe there is sufficient information to fabricate, assemble, test or maintain the antenna so as to meet the requirements of the specification. For any area that AUI requires additional work, AUI will provide detailed written explanations of why additional information is needed.

Contractor will incorporate all of the additional information required by AUI into the CDD and present the modified CDD documents to AUI for approval before starting work on the fabrication of the antenna, except for specific long-lead items which may be approved by AUI.

### **3.2 APPLICABLE DOCUMENTS**

The following documents (current version as of issue date of RFP) are to be used as a guide in the preparation of the design. The development of the required additional configuration and detailed design drawings and specifications supplementing and extending these documents are a part of the effort required in the design stage. In the event of a conflict between this specification and any of the documents listed, this specification shall govern:

1. MMA Memo No. 240 - 10-m Antenna Design for the Millimeter Array (NRAO/BIMA)
2. MMA Memo No. 241 - A Design for a Precision 10 m Submillimeter Antenna (OVRO)
3. MMA Memo No. 253 - 12 m Submillimeter Antenna (ESO)
4. MMA Memo No. 254 - The 15m (12.8m) Telescopes for the MMA/LSA Project (IRAM)
5. MMA Memos:

No. 256 - Scattering of Solar Flux by Panel Grooves

No. 246 - Optimized Optical Layout for MMA 12-m Antennas

No. 234 - Thermal Behavior of the Leighton 10-m Antenna Backing Structure

No. 232 - A Simple Method to Improve Pointing of the MMA Antennas

No. 231 - A First Study of MMA Antenna Offset Performance

No. 203 - Forced Air Cooling at High Altitude

No. 197 - Feed Leg Blockage and Ground Radiation Pickup for Cassegrain Antennas

No. 195 - Spillover Control on Secondary Mirror Support Struts

- No. 193 - Report of the LSA/MMA Antenna Study Committee
- No. 182 - A 12-m Antenna Design for a Joint US-European Array
- No. 181 - Notes on Possible Sensors for Improving the Pointing of MMA Antennas
- No. 145 - Antennas for the Millimeter Wave Array
- No. 141 - Thermal Behavior of BIMA Antenna Dish Structure
- No. 125 - Damping and Vibration Control
- No. 105 - Rapid Position Switching in Radio Telescopes: Structural Damping using a Constrained Layer Treatment
- No. 100 - Temperature Measurements on BIMA 6-m Antennas -- Part I: Backing Structure
- No. 96 - Proposed Surface Error Budget for MMA Antennas
- No. 83 - Thermal Considerations for MMA Antennas
- No. 64 - Minimum Spacing Constraints for MMA Antennas
6. Electronic Industries Association TIA/EIA-222-F- Structural Standards for Steel Antenna Towers and Antenna Supporting Structures
  7. American Institute of Steel Construction - Manual of Steel Construction
  8. National Fire Protection Association, National Electrical Code
  9. MIL-STD-461A. - Electromagnetic Interference
  10. "Analysis Concepts for Large Telescope Structures under Earthquake Load," by F. Kock, in Proc. SPIE 2871, 117-126 (1997).
  11. Occupational Safety and Health Administration - Workplace Safety Regulations & Index
  12. ANSI Y14.5 "Dimensioning and Tolerancing"

Item (5) above is a list of MMA Memos, all available on the WWW at <http://www.mma.nrao.edu/memos/>, which documents various studies performed by MMA/LSA, which may be of use to the Contractor. Items (1),(2),(3) and (4) above describe four different

conceptual designs for antennas that MMA/LSA has developed to describe antenna concepts well suited to achieve the required performance. AUI believes, but has done no calculations to verify, that these designs can be modified to achieve the required specifications. Contractors may elect to base their design on whichever of these concepts they consider best suited to their fabrication capabilities and previous experience. Contractors will not be required to adopt any of these concepts and may choose to propose another concept provided it meets the performance parameters set forth in this specification. If the Contractor elects to use any of the MMA/LSA concepts, it will be the responsibility of the Contractor to perform the necessary analysis, to modify the design as necessary, and to develop the detailed design, drawings, and component specifications necessary to accomplish a finished antenna design which meets the performance requirements set forth in this document. Finite element models for concepts (1) and (2) are available on request.

### **3.3 DESIGN PARAMETERS**

#### **3.3.1 CONFIGURATION**

The operating frequency range of the antenna will be 30 GHz to 950 GHz. The antenna will be a symmetric paraboloidal reflector, of diameter 12 m, mounted on an elevation over azimuth mount. The overall optical layout of the antenna will be a Cassegrain geometry, as shown in Appendix E. In the event that the Contractor needs to change any of the dimensions in Appendix E to allow him to achieve, or improve on, any of the performance requirements specified below, AUI will negotiate with the Contractor to define an acceptable Cassegrain geometry. An example of a change that the Contractor could request would be a change in the focal length of the primary so that the "close packing" requirement (see Section 3.4.6) can be achieved. The subreflector support legs will be either tripod or quadripod configuration, to be selected by the Contractor.

A primary reflector surface consisting of machined aluminum panels is preferred. Reflector surfaces other than machined aluminum can be proposed if they offer advantages of cost or performance so long as they meet the survival and lifetime requirements specified below. The reflector surface will not be painted but must have a suitable surface finish to enable the solar observing requirement (see Section 3.4.7). The reflector surface will be mounted on a preferred carbon fiber reinforced plastic (CFRP) reflector backup structure (BUS). The BUS may be built completely of CFRP or may consist of CFRP struts connected by metal nodes. Precision performance of the antenna is required under direct thermal loading from the sun (Section 3.3.2.2) and the Contractor may consider the use of sunshades or insulation on the antenna structure to reduce the effects of the sun.

There is no requirement that the elevation and azimuth axis of the mount intersect, although there is a requirement regarding how closely the axis offsets must match among antennas built using the design (Section 3.4.1). The azimuth bearing can be either a sealed bearing or a wheel-on-track bearing so long as the antenna base size requirements for transportability are satisfied (see Section 3.5.2). In the event that a wheel-on-track design is used the track shall be enclosed so that

dust and grit do not cause maintenance or performance problems and the track must be built into the base of the antenna so that it moves with the antenna during transportation.

The antenna will be bolted to a reinforced concrete foundation buried in the ground. The Contractor shall design the foundation (see Section 3.5.3 below) and the interface between the foundation and the antenna and AUI will be responsible for the construction of the foundation.

The antenna shall be designed for a lifetime of 30 years in the environment expected to prevail on the Chilean site. During its lifetime the antenna will execute not less than 270,000 complete cycles of elevation motion, where a complete cycle of elevation motion is here defined to be movement of the reflector from its lower elevation limit up to its upper elevation limit and back down to its lower elevation limit. During its lifetime the antenna will execute not less than 200,000,000 degrees of total motion about each axis.

All drawings shall have metric units in general as the primary units with non-metric units, if they are required, being provided as secondary units. All fasteners will be metric; however, allowances may be made for fasteners that are on off-the-shelf units. The use of standard metric cross-sections for construction materials is preferred but will not be required if such use results in increased cost.

The antenna will be designed to operate on the standard Chilean supply voltages of 220 VAC single phase, 380 VAC three phase. The Chilean supply frequency is 50 Hz but AUI plans to test the prototype antenna in the U.S. using a supply frequency of 60 Hz. All electrical equipment on the antenna shall be designed to operate correctly using both 50 Hz and 60 Hz supply frequencies. AUI will provide the transformer required at the U.S. test site to convert from U.S. to Chilean voltages.

### **3.3.2 OPERATING PARAMETERS AND CONDITIONS**

#### **3.3.2.1 GENERAL OPERATING CONDITIONS AND PARAMETERS**

The antennas will operate on a high altitude (5000 m) volcanic plateau in Northern Chile (latitude -23d 01m S, longitude 67d 45m W). The average barometric pressure at this altitude is 55 percent of its sea level value. The site ground surface is principally volcanic soil and gravel with no vegetation of any kind to stabilize the surface, so the antenna must be designed to withstand windblown dust and grit. The annual 50<sup>th</sup>, 75<sup>th</sup> and 95<sup>th</sup> percentile winds on the site are respectively 6.5 m/s, 10.4 m/s and 17 m/s. The annual median temperature is -2.5 C.

Annual precipitation on the site is in the range 100 mm to 300 mm. Most of this falls as snow but thunderstorms do occur. The antenna must be designed to withstand brief periods of heavy rain and hail. The monthly average humidity in the summer (January) is 53 percent and in the winter (June) it is 31 percent. The annual average humidity is 39 percent. The monthly average water vapor pressure in the summer (January) is 4.0 hPa ( 4 g/cm<sup>2</sup>) and in the winter (July) it is 1.2 hPa. The annual average water vapor pressure is 2.3 hPa.

The site location on the southern tropic, the high altitude and low water vapor result in insolation rates among the highest in the world. The median midday solar flux in the wavelength range 0.3-60 micrometers for the months of December and June are  $1290 \text{ w/m}^2$  and  $840 \text{ w/m}^2$  respectively. Ultraviolet radiation will be approximately 70 percent higher than at sea level.

### **3.3.2.2 PRIMARY OPERATING CONDITIONS**

For the purpose of computing the performance of the antenna (see specifications below) the Contractor shall assume the following conditions:

Gravity: Elevation angle range 2 deg to 90 deg.

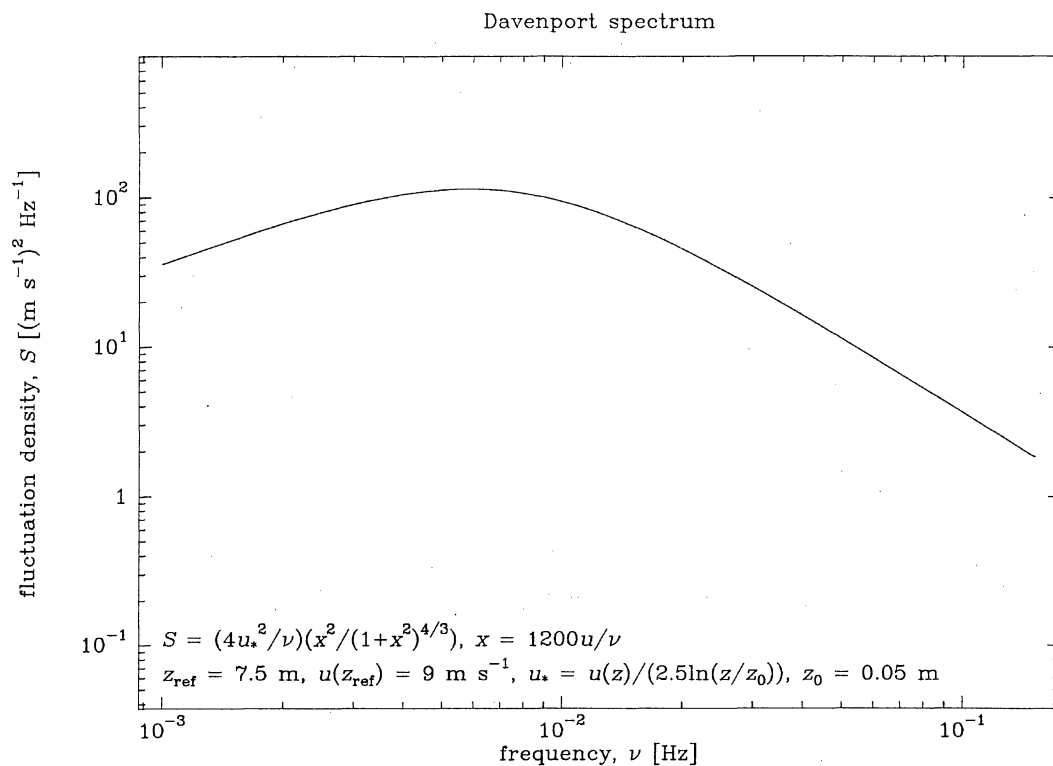
Temperature: ambient temperature -20 C to +20 C.

Wind and thermal:

Daytime: 6 m/s average wind, spectral content to be obtained by scaling the spectrum in Figure 3.3.2.2-1  
full solar heating from any direction (assume no reduction in structure temperature gradients due to wind)  
change in ambient air temperature in 10 minutes 0.6 C  
change in ambient air temperature in 30 minutes 1.8 C

Nighttime: 9 m/s average wind, spectral content as shown in figure 3.3.2.2-1  
assume that all parts of the antenna are at the same, constant temperature

Precipitation: no precipitation



**Figure 3.3.2.2-1.** Wind Spectrum for MMA Site, 9 m/s average wind speed.

### 3.3.2.3 SECONDARY OPERATING CONDITIONS

Observations with the antenna will continue to be possible under the following conditions. It is understood that performance will be degraded.

Gravity: Elevation angle range 2 deg to 125 deg  
 Temperature: ambient temperature -20 C to + 30 C  
 Wind: wind up to 20 m/s  
 Precipitation: no precipitation

### 3.3.2.4 STOW CONDITIONS

The antenna will be stowed (stow position is elevation 15 deg, azimuth 90 deg—see Section 3.4.1) under the following conditions:

Temperature: temperature below -20 C. It shall be possible to drive the antenna to stow when the temperature is in the range -25 C to 30 C.



Wind: wind greater than 20 m/s. It shall be possible to drive the antenna to stow when the wind is in the range 0 to 30 m/s with a single drive motor operating on either axis.

Precipitation: the antenna will be stowed if it is raining, snowing or if ice accumulation is occurring. It shall be possible to drive the antenna to stow in a rainfall of rate 2 cm/hr, with a snow accumulation of 50 kg/m<sup>2</sup> in the reflector or with an ice load of 1 cm radial ice on all exposed surfaces.

### **3.3.2.5 SURVIVAL CONDITIONS**

The antenna must survive without damage, and continue to meet all performance specifications after experiencing, the following conditions:

Earthquake: 0.3G horizontal or 0.3G vertical acceleration, antenna in any position. For analysis purposes the Contractor will use the Acceleration Response Spectrum for the Maximum Likely Earthquake shown in Figure 3.3.2.5-1. The definition of this spectrum is provided in Document (10) of Section 3.2. The Contractor will use the analysis method of Document (10), or an equivalent method, to analyze the seismic performance of the telescope.

Transporter Handling: 4 G vertical impact, 2 G horizontal impact acceleration, antenna in zenith position.

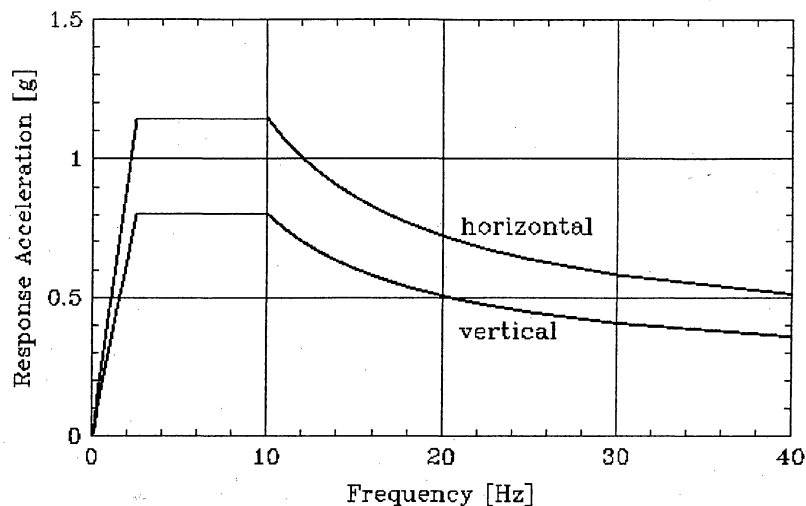
Braking: activation of the azimuth or elevation brakes when the antenna is moving at its maximum velocity (3 deg/s elevation velocity, 6 deg/s azimuth velocity—see Section 3.4.4), antenna in any position.

Wind: 65 m/s with the antenna in the stow position with elevation and azimuth stow pins in, wind from any azimuth.

Temperature: -30 C, antenna in stow position.

Precipitation: maximum rate of rainfall 50 mm/hr, hailstones 2 cm diameter with velocity 25 m/s, radial ice on all exposed surfaces 1 cm, all with the antenna in any orientation. Snow load 100 kg/m<sup>2</sup> on reflector surface, with antenna at zenith. Reflector surface heating to prevent snow and ice buildup not required. The ice loading and survival wind conditions are to be survived simultaneously.

Lightning: direct lightning strike, lightning protection required. Antenna in any orientation.



**Figure 3.3.2.5-1.** Acceleration Response Spectrum for Maximum Likely Earthquake.

### 3.4 ANTENNA PERFORMANCE

#### 3.4.1 MOUNT REQUIREMENTS

The allowable observing range of motion of the antenna in azimuth will be 270 degrees either side of due north and in elevation it will be 2 degrees to 89.8 degrees. Access to the elevation range 90.2 - 125 degrees is desired but if this requirement impacts cost or performance the upper elevation range may be limited to 89.8 degrees. The keyhole at the zenith in which tracking at sidereal rate is not possible will have a radius of less than 0.2 degrees. Prelimits and final limits will be beyond this range. As well as hardware prelimits and final limits a software prelimit will be provided. Positions of the prelimits and final limits will be chosen so as to stop the antenna before the final limit if it enters the prelimit moving at its maximum velocity. Elevation energy absorbing hard stops will be provided to protect the BUS from damage beyond the low and high elevation final limits. Stow position for Survival Conditions will be 15 degrees elevation, 90 degrees azimuth. Maintenance stow position will be 90 degrees elevation, 90 degrees azimuth. Computer commanded stow pins for both azimuth and elevation shall be provided for both survival and maintenance stow positions.

The azimuth and elevation axes do not need to intersect but the offset between the axes must be very nearly the same for all antennas built using the design, so the offset between the axes shall be set to the nominal design value to within  $\pm 3$  millimeters. The azimuth and elevation axes shall be orthogonal to within 1 arcminute. The axis of symmetry of the primary reflector shall intersect the elevation axis to within  $\pm 3$  millimeters and shall be orthogonal to the elevation axis to within

1 arcminute. The azimuth axis of the antenna shall be parallel to local gravity. The plane of the bolt circle on the base of the antenna that interfaces to the antenna foundation shall be orthogonal to the azimuth axis to within 25 arcseconds.

### **3.4.2 REFLECTOR SURFACE ACCURACY**

A total equivalent antenna surface accuracy of  $< 25$  micrometers root-sum-squared (RSS) during Primary Operating Conditions is required. A surface accuracy goal of 20 micrometers (RSS) is desired. In the event that the goal (20 micrometers) will require a higher price than the specification (25 micrometers), the Contractor is requested to provide price information for both the goal and the specification. The total error budget includes contributions from both primary reflector and the subreflector. Factors contributing to the error budget are shown in the example error budget shown in Table 3.4.2-1. AUI will take responsibility for the final precision setting of the primary reflector surface using holography. In the Contractor's error budget the Contractor will allocate 10 micrometers rms for the holographic setting accuracy, as shown in Table 3.4.2-1. The Contractor may vary all other contributions in the error budget in any way he wishes, provided that the RSS total is less than 25 micrometers.

The errors for panels shall be calculated by taking root mean square (RMS) of the component along the boresight axis of the normal-to-surface deviations between the theoretical paraboloid and the deformed panel surface without fitting. (This does not exclude fitting measured data to eliminate measurement reference errors when determining the panel manufacturing error.) In measuring the manufacturing accuracy of each panel a grid of points shall be chosen such that each measured point represents approximately  $10 \text{ cm}^2$  of surface area. The RMS error of the panel measurement method shall not exceed 25% of the panel RMS manufacturing accuracy.

Backup structure (BUS) gravity errors shall be calculated by taking the RMS of the component along the boresight axis of the normal-to-surface deviations between the deformed surface and the best fit paraboloid. For calculating gravity errors, the Contractor may select the surface tuning which provides the best overall performance. When calculating BUS thermally induced and other slowly varying errors the Contractor may assume that the antenna is refocused every 30 minutes.

The final, precision measurement of the surface will be done using holography and AUI will be responsible for this adjustment after the Contractor has released the antenna to AUI. Prior to releasing the antenna to AUI the Contractor will be responsible for adjusting the surface to an RMS setting accuracy of 100 micrometers (see Section 3.9.4.4).

The panel adjusters will be calibrated so that an adjustment point can be moved with a resolution of 5 micrometers. A full surface adjustment should require no more than 16 person-hours of work. Panel gaps shall not exceed 0.3 percent of the total area of the reflector.

Table 3.4.2-1 Example Surface Accuracy Budget

Error Source	RMS Error
<b>Panels</b>	
Manufacturing ( <i>Including measurement errors</i> )	8.5 $\mu\text{m}$
Aging	2.0 $\mu\text{m}$
Gravity	4.0 $\mu\text{m}$
Wind	4.0 $\mu\text{m}$
Absolute Temperature	4.0 $\mu\text{m}$
Temperature Gradients	4.0 $\mu\text{m}$
<b>Total Panel (RSS)</b>	<b>11.8 <math>\mu\text{m}</math></b>
<b>Backing Structure</b>	
Gravity (Ideal)	9.0 $\mu\text{m}$
Gravity (Departure From Ideal)*	3.0 $\mu\text{m}$
Wind	4.0 $\mu\text{m}$
Absolute Temperature	8.0 $\mu\text{m}$
Temperature Gradients	7.0 $\mu\text{m}$
<b>Total Backing Structure</b>	<b>14.8 <math>\mu\text{m}</math></b>
<b>Panel Mounting</b>	
Absolute Temperature	3.0 $\mu\text{m}$
Temperature Gradients	3.0 $\mu\text{m}$
Panel Location in Plane	3.0 $\mu\text{m}$
Panel Adjustment Perpendicular to Plane	3.0 $\mu\text{m}$
Gravity	5.0 $\mu\text{m}$
Wind	4.0 $\mu\text{m}$
<b>Total Panel Mounting (RSS)</b>	<b>8.8 <math>\mu\text{m}</math></b>
<b>Secondary Mirror</b>	
Manufacturing	5.5 $\mu\text{m}$
Gravity	2.0 $\mu\text{m}$
Wind	2.0 $\mu\text{m}$
Absolute Temperature	4.0 $\mu\text{m}$
Temperature Gradients	4.0 $\mu\text{m}$
Aging	3.0 $\mu\text{m}$
Alignment	3.0 $\mu\text{m}$
<b>Holography**</b>	
Measurement and Adjustment	10.0 $\mu\text{m}$
<b>Total Holography (RSS)</b>	<b>10.0 <math>\mu\text{m}</math></b>
<b>Other Errors not Included Above</b>	<b>2.0 <math>\mu\text{m}</math></b>
<b>TOTAL (RSS)</b>	<b>25.0 <math>\mu\text{m}</math></b>

\* Departures from ideal such as member true size, manufacturing, modeling accuracy, etc

\*\* AUI is responsible for the precision adjustment of the primary surface.

### 3.4.3 POINTING ACCURACY

The pointing error is defined as the difference between the commanded position of the antenna and the actual position of the main beam of the antenna. Pointing errors are classified as repeatable and nonrepeatable.

Repeatable pointing errors are caused by gravity deformation, axis alignment errors, encoder offsets, bearing runout, bearing alignment, and similar errors, which can be corrected using a computer pointing model. The repeatable pointing error for the antenna shall not exceed 2 arcminutes.

Nonrepeatable pointing errors are pointing errors that vary with time or are not repeatable as a function of antenna position. Such pointing errors are due to wind, effects of temperature differences and temperature changes, acceleration forces, encoder resolution, encoder errors, servo and drive errors, position update rate, bearing non-repeatability and other sources of nonrepeatable errors. The Contractor may include metrology equipment in the antenna design to provide active correction for some of these error sources and the contribution to the pointing error budget for such corrected error sources may be reduced accordingly. Nonrepeatable pointing errors which are “systematic” in the sense that the pointing error is likely to be the same for all antennas and approximately constant in time are much more damaging to the performance of the array than pointing errors which are random amongst antennas and time variable. In the pointing error budget the Contractor will give preference to minimizing “systematic” pointing errors in preference to sources of error which are likely to be random amongst antennas and variable in time. The pointing error is specified for two different kinds of pointing, “offset” and “absolute” pointing. For “offset” pointing the contribution to the error budget for slowly varying causes of pointing error, but not for wind induced errors, may be limited to the differential error over a solid angle of 2 degrees radius about the desired position, and then only the change in that differential error over a 15 minute period when tracking at sidereal rate. For “absolute” pointing no such limitation of slowly varying errors will be made to contributions in the error budget. The nonrepeatable pointing error under Primary Operating Conditions (3.3.2.2) for “offset” pointing shall not exceed 0.6 arcseconds RSS when tracking an astronomical source at sidereal rate. The nonrepeatable pointing error under Primary Operating Conditions for “absolute” pointing shall not exceed 2.0 arcseconds RSS when tracking any astronomical source at sidereal rate.

The nonrepeatable pointing error will be computed in the following way:

(1) For nighttime Primary Operating Conditions (9 m/s wind, see Section 3.3.2.2) calculate the pointing error for each of the sources of nonrepeatable pointing error and RSS these contributions together to obtain the RSS pointing error. Calculate this RSS pointing error for each of the eleven wind directions shown in Table 3.4.3-1. The RSS pointing error for any of the eleven wind pointing directions individually shall not exceed 1.0 arcsecond. The nighttime nonrepeatable pointing error is defined to be the weighted RMS of these eleven RSS pointing errors, where the weighting is shown in Table 3.4.3-1 and accounts for the fraction of observing time anticipated for each wind direction.

(2) For daytime Primary Operating Conditions the Contractor will use a computer thermal model of the antenna to determine the worst case nonrepeatable pointing error due to temperature differences and temperature changes in the structure. The structural temperature differences calculated using the computer thermal model must be consistent with the structural temperature differences actually measured on radiotelescopes as reported in MMA Memos No. 83, 100, 141 & 234 and references therein. The daytime thermal pointing error is defined to be 75 percent of this worst case error. Compute the daytime wind pointing error using the definition in (1) above with a wind velocity of 6 m/s. The daytime nonrepeatable pointing error is defined to be the RSS of the daytime thermal pointing error and the daytime wind pointing error.

**Table 3.4.3-1 Antenna Orientations for Wind Pointing and Path Length Error Calculations**

<b>Azimuth Angle (deg)</b>	<b>Elevation Angle (deg)</b>	<b>Weighting Factor</b>
0	0	.031
60	0	.062
120	0	.062
180	0	.031
45	45	.188
135	45	.188
0	60	.094
90	60	.188
180	60	.094
90	90	.031
0	90	.031

\*Assume that the wind is blowing in direction 180 deg. Thus the case azimuth 0, elevation 0 corresponds to the reflector being face into the wind.

An example of possible daytime and nighttime pointing error budgets is shown in Table 3.4.3-2. Wind and temperature effects may be partially corrected by incorporating information from an antenna metrology system (see Section 3.5.1).

**Table 3.4.3-2 Example pointing error budget**

<b>Non-repeatable Pointing Error (Arcsec)</b>	<b>Day</b>	<b>Night</b>
wind, steady component	.2	.45
wind, gusty component	.1	.1
structure temperature gradients	.35	0.0
ambient temperature changes	.2	0.0
inertial forces	.15	.15
encoder errors	.2	.2
servo error	.1	.1
bearing errors	.2	.2
other errors	.19	.19
Total RSS error	.60	.60

#### **3.4.4 FAST MOTION CAPABILITY**

The antenna will be used to track astronomical sources across the sky at sidereal rate. Three observing modes require the MMA/LSA antenna to have special fast motions superimposed on the slow sidereal tracking rate. These fast motion modes are fast switching phase calibration, on-the-fly total power mapping and on-the-fly interferometric mosaicking.

Fast switching phase calibration requires the antenna to move from the target source to a calibration source 1.5 degrees away on the sky and settle to within 3 arcseconds peak pointing error, all in 1.5 seconds of time. A few seconds later the antenna will switch back to the target source with the same requirements on switching time and settling accuracy. A typical time for a full cycle of target-calibrator-target observation is 10 to 20 seconds and the antenna may spend many hours cycling in this way. The antenna must be designed to survive 50 million of these cycles during a 30 year lifetime.

In the on-the-fly total power mapping mode the antenna will scan at a rate of up to 0.5 deg/s on the sky across a large target source, several or many beamwidths in size, and then turn around as rapidly as possible and scan back across the source in the opposite direction. As the antenna scans across the source, it is not necessary for the position at any time to be precisely a pre-commanded position. It is sufficient to simply know where the antenna is actually pointing.

In on-the-fly interferometric mosaicking, the antenna will scan at a rate of up to 0.05 deg/s on the sky across a large target source, several or many beamwidths in size, and then turn around and scan back across the source in the opposite direction. As the antenna scans across the source it must follow the commanded path to within 1 arcsecond pointing accuracy.

These fast motion modes place the following requirements on antenna velocity, acceleration and settling time:

#### **3.4.4.1 VELOCITY AND ACCELERATION**

Maximum angular velocity:      >3 deg/s in elevation  
   >6 deg/s in azimuth

Maximum angular acceleration:    >12 deg/s<sup>2</sup> in elevation  
   >24 deg/s<sup>2</sup> in azimuth

where both these axes must be able to achieve these rates simultaneously. Since all antennas in the array must move at the same time, the demand on the array electrical power system will be large and consideration will be given in the antenna design to reducing the power requirements during maximum acceleration.

#### **3.4.4.2 SETTLING TIME**

If a step change in position is commanded, the direction of the boresight axis shall settle to within 3 arcseconds of the new position within a time interval of

$$t_{\max} = \begin{array}{l} 1.5 \text{ s for a step of } 1.5 \text{ deg or less} \\ 1.5 \text{ s} + x/(3\text{deg/s}) \text{ for a step of } x > 1.5 \text{ deg} \end{array}$$

This applies to the motion on the sky and in any direction, except that the azimuth component of the motion need only meet this requirement if the elevation is less than 60 deg.

#### **3.4.5 PATH LENGTH ERRORS**

Path length errors must be considered since the antenna will be used in an array. Path length (also called delay) errors are defined as follows. Consider a plane wave arriving at the antenna from the direction of the boresight. Define the "excess delay" of the antenna to be the difference between the arrival time of that wave at the secondary focus (via the main reflector and subreflector) and its arrival time at an arbitrary reference point fixed with respect to the ground as if the antenna were not present. (It is convenient to choose the reference point along the azimuth axis. If the boresight axis, elevation axis and azimuth axis all intersect, then choosing that intersection as the reference results in an excess delay that is nearly constant.) The Contractor shall calculate the excess delay (expressed as a pathlength) for the nominal antenna in the absence of environmental perturbations, as a function



of boresight direction over the full range of azimuth and elevation, and he shall provide this data to AUI as the "nominal excess delay function." Now define the "residual delay" as the difference between the actual excess delay of a particular antenna under existing conditions and the nominal excess delay. The residual delay is limited by the specifications of this section. The residual delay has a repeatable and a nonrepeatable component.

The repeatable residual delay is caused by the difference in gravity deformation between an antenna and the nominal antenna (for example, this could be caused by differences in the material properties of an antenna compared to the nominal material properties), axis alignment errors, bearing runout, bearing alignment, and similar errors, which repeat as a function of antenna position and can be corrected using a computer delay model. The repeatable residual delay for an antenna shall not change by more than 20 micrometers when the antenna moves between any two points 2 degrees apart in the sky.

The nonrepeatable residual delay is the delay component that varies with time or is not repeatable as a function of antenna position. It is caused by wind, effects of temperature differences and temperature changes, acceleration forces, bearing non-repeatability and other sources of nonrepeatable errors. The Contractor may include metrology equipment in the antenna design that can be used to estimate the residual delay in real time. In that case, both the measured values and the results of a calculation estimating the residual delay shall be provided to AUI via the digital interface (see Section 3.5.6.3). If this is done, then the estimate shall be subtracted from the actual residual delay for the purpose of meeting the specifications of this section. Further, for slowly varying sources of residual delay, but not for wind induced residual delay, the contribution to the residual delay budget may be limited to the differential residual delay over a solid angle of 2 degrees radius on the sky and then only the change in that differential delay over a 3 minute period when tracking at the sidereal rate. The nonrepeatable residual delay under Primary Operating Conditions (3.3.2.2) must be less than 15 micrometers RSS when tracking an astronomical source at sidereal rate.

The non repeatable residual delay will be computed in the following way:

(1) For nighttime Primary Operating Conditions (9 m/s wind, see section 3.3.2.2) calculate the residual delay for each of the sources of nonrepeatable residual delay and RSS these contributions together to obtain the RSS residual delay. Calculate this RSS residual delay for each of the eleven wind directions shown in Table 3.4.3.1. The nighttime nonrepeatable residual delay is defined to be the weighted RMS of these eleven RSS residual delays, where the weighting is shown in Table 3.4.3.1 and accounts for the fraction of observing time anticipated for each elevation angle.

(2) For daytime Primary Operating Conditions the Contractor will use a computer thermal model of the antenna to determine the worst case nonrepeatable residual delay due to temperature differences and temperature changes in the structure. The structural temperature differences calculated using the computer thermal model must be consistent with the structural temperature differences actually measured on radiotelescopes as reported in MMA Memos No. 83, 100, 141 & 234 and references therein. The daytime thermal residual delay is defined to be 75 percent of this

worst case residual delay. Compute the daytime wind induced residual delay using definition (1) above with a wind velocity of 6 m/s. The daytime nonrepeatable residual delay is defined to be the RSS of the daytime thermal residual delay and the daytime wind residual delay.

#### **3.4.6 CLOSE PACKING**

It shall be possible to locate two antennas with their azimuth axes within 15 meters of each other without any possibility of the antennas colliding with each other, no matter what the relative orientation of the two antennas.

#### **3.4.7 SOLAR OBSERVATIONS**

Direct observations of the sun will be allowed and all specifications will be met during solar observations. The primary surface will be unpainted but will have a suitable surface treatment to prevent solar heating damage to the subreflector support legs or subreflector during solar observing or when the sun is close to boresight. When the antenna is pointed directly at the center of the Sun, the power absorbed by a black body anywhere in the secondary focal region shall not exceed 3 kW/m<sup>2</sup>.

#### **3.4.8 LOW NOISE**

Contributions to system noise from the antenna, due to resistive loss of the primary reflector surface and scattering of ground noise into the feed, will be minimized as much as possible without compromising the surface accuracy and pointing requirements (MMA Memo No. 195 & 197). Design features will include supporting the subreflector support legs close to the edge of the reflector and shaping the underside of the support legs to reduce ground pickup. The total geometric blockage shall not exceed three (3) percent. Contributions to geometric blockage shall include: subreflector, vertex hole in primary, subreflector support legs, panel gaps, front side panel adjusters, optical pointing telescope, and any other items in the design that will contribute to the geometric blockage. It shall be required that the support structure behind the subreflector be of a smaller diameter in size than the subreflector. The underside of the subreflector support legs will have a wedge shaped profile to minimize ground noise pickup. This profile will be specified by AUI, in negotiation with the Contractor, after the Contractor has designed the overall subreflector support leg geometry.

The primary reflector surface and the secondary mirror shall each have a surface resistive loss of less than 1.0 percent over the operating frequency range (Section 3.3.1) of the antenna.

### **3.5 ADDITIONAL REQUIREMENTS**

#### **3.5.1 METROLOGY**

The Contractor will make provision in the antenna design for inclusion of the following metrology equipment.

- (1) Laser system to measure the lateral displacement of the apex.
- (2) Two 2-axis tiltmeters, one above and one below the azimuth bearing.
- (3) Temperature probes to measure structure temperatures.
- (4) Metrology system to measure structural deflections of the elevation over azimuth mount.

Any of this equipment that the Contractor considers essential for meeting the antenna performance specifications shall be provided by the Contractor who will also provide the required real-time correction software in the Antenna Control Unit (ACU). All data measured by this metrology equipment will also be provided as digital monitor data out of the ACU.

Any of this equipment that is not required by the Contractor to meet the antenna performance specifications will not be provided by the Contractor. For this equipment, AUI will negotiate an interface with the Contractor and will provide and install the equipment.

##### **3.5.1.1 OPTICAL TELESCOPE FOR POINTING TEST**

An optical telescope will be mounted on the antenna for pointing tests that will be used to characterize the mount of the telescope. This telescope will be mounted in a representative position on the antenna BUS and protrude through the reflector surface. AUI will provide the optical telescope and install the unit. The Contractor will provide a stable mount on the BUS for the optical telescope and a cut-out through the reflector surface for the telescope to protrude. The drawings and specifications of the optical telescope are in Appendix F.

#### **3.5.2 TRANSPORTABILITY**

The antenna will be designed to be transportable. The antenna will be transported on a transporter vehicle, which will be designed and provided by AUI. The Contractor will provide an interface above the azimuth bearing that will enable the antenna transporter to pick up the antenna and move it between antenna foundations. This interface shall be several points on the antenna that will enable secure and stable attachment to transporter while being transported. AUI will negotiate the details of this interface with the Contractor when the Contractor has defined the overall layout of the antenna. The pickup points are located above the azimuth bearing so that the azimuth bearing and drive can be used to rotate the base of the antenna for bolt hole alignment as the transporter places the antenna on the foundation. The antenna base must be able to be rotated +/- 30 degrees in azimuth while on the transporter. The maximum diameter of the antenna base must be less than

7.0 meters to a height of 3.0 meters above ground level. For the information of the Contractor, information on AUI's transporter concepts is provided in MMA Memo No 240 and Memo No. 241.

The antenna must be designed to minimize the amount of time that it takes to make and break the connections between the antenna and the foundation and the antenna and the transporter. All connections and interfaces to the transporter and foundation must be removable in less than 15 minutes and installable in less than 15 minutes. This shall include all setting and calibrating of metrology instruments.

### **3.5.3 FOUNDATION**

The Contractor is responsible for the design of the antenna foundation to ensure that it provides the support and stiffness necessary to achieve the deformation allowed by the Contractor's error budgets for the various antenna performance specifications. The construction and installation of the foundation will be the responsibility of AUI. The Contractor will design a foundation suitable for the installation of the antenna at the MMA U.S. test site in New Mexico. Since the soil conditions on the MMA/LSA site in Chile are quite variable over the 10 km extent of the array, the Contractor will design two additional foundations, one representative of the best soil conditions on the MMA/LSA Chilean site and the other representative of the worst soil conditions. These two Chilean foundations will be used by AUI as a proof of design existence and for planning and costing purposes. The design of the actual foundations to be built on the Chilean site is not part of this contract. Soil reports for the three foundation designs will be provided at or before the bidders meeting.

The Contractor must ensure that the design of the foundation provides the performance required by his error budget. The design will include all connections between the foundation and antenna. The design shall be optimized to minimize the cost of the foundation, because the MMA/LSA will require foundations in five different locations for each antenna. The compliance of the combined soil and foundation shall be included in the dynamic analysis of the antenna. Foundation connections to the antenna must provide azimuth axis repeatability of  $\pm 2$  millimeters for translation and  $\pm 25$  arcseconds for angular repeatability for multiple installations of the antenna on the foundation. The azimuth axis of the antenna shall be parallel to local gravity.

The foundation design will include a center vault with a french drain that is large enough for a person to work on cables in the vault. This vault will include a sealed cover plate. Conduits must be provided through the foundation for cables of various kinds. The foundation design must also accommodate a loaded antenna transporter crossing over the foundation.

### **3.5.4 RECEIVER CABIN**

A receiver cabin with dimensions, approximately as shown in Appendix E, will be provided at the Cassegrain focus. The minimum receiver cabin door size shall be 1 meter wide by 1.6 meters in height in order to move receiver equipment in and out. Cabin service access will be with the antenna

positioned at the zenith. The mass of AUI installed equipment in the cabin will not be greater than 1,600 kg. Adequate work lighting shall be provided in the receiver cabin. A total of 12 electrical receptacles shall be located in the receiver cabin with locations approved by AUI.

Temperature in the cabin shall be maintained by an antenna mounted HVAC system at a temperature which can be selected in the range of 16-22 C. Air temperature will be regulated to an accuracy of +/- 1C in the output plenum of the HVAC system. This system shall be capacity modulated with proportional control. The air distribution system shall utilize continuous air flow through the receiver cabin to avoid sudden changes in temperature. The air distribution system shall take into account the fact that the receiver cabin is continuously changing position relative to gravity. The system shall use high-grade air filters. The outputs of the plenum will be to 3 equipment racks, 2 room vents and 3 auxiliary use vents. Each plenum output shall have an adjustable damper. AUI will furnish and install equipment in the receiver cabin with electrical power consumption of not greater than 10 kW. The receiver cabin walls, floor and ceiling shall be insulated. All refrigeration piping shall be insulated. All exposed insulation shall be mechanically protected with a metal cover and weatherproof in exterior applications.

A built-in mechanism shall be provided so that a receiver can be lifted from the ground, through the cabin door and into its observing location, all without significant man-handling of the receiver. The maximum weight of the receiver is 550 kg. The equipment interface is an important issue for the antenna structure. Two racks of equipment will be required in the cabin along with access to these racks and receiver package. AUI will negotiate the detailed mounting interface for the equipment and receiver in the cabin with the Contractor during cabin design.

The cabin will be watertight and a thin RF-transparent membrane will cover the aperture through which the RF beam enters the cabin at the vertex hole. AUI will provide the material for this membrane. The Contractor shall provide a computer actuated shutter which will be deployable to protect the membrane under survival condition (3.3.2.5) when necessary. This system shall have status sensors with a manual override and will perform about 400 cycles per year.

AUI may wish to add oxygen to the air in the receiver cabin when workers are inside on the high altitude site. For this reason, the cabin must not have any large air leaks and a flange will be provided on an HVAC air duct external to the cabin into which the oxygen can be injected. Any such oxygen enhancement equipment will be provided by AUI.

Antenna mounted ladder and/or platforms will allow access to the receiver cabin while in maintenance stow position.

### **3.5.5 APEX EQUIPMENT**

The Contractor shall design and provide a subreflector with three translation stages at the apex of the antenna. Two stages will be orthogonal to the optical axis with automated translation stages having 20 millimeters of travel with a positional repeatability and accuracy required by pointing

specification. All three stages shall travel at a speed of 2 mm/sec with a closed loop servo, limit switches, readouts and shall be monitored. The third stage is parallel to the optical axis and will be automated with +/- 15 millimeters of travel from secondary focus with a positional repeatability of +/-10 micrometers. These systems will be integrated into the Contractor's antenna servo and control system.

The subreflector support legs shall also be designed to support a cable weight of 2 kg/m that can be divided among the subreflector support legs and meet all specifications herein. The apex structure shall be designed so that specifications regarding clearance, mounting and mass as shown in Appendix G are met. The spacer block and mounting flange will provide for an AUI supplied reactionless nutator and subreflector in the future if necessary. The configuration shall be such that a clear opening of approximately 40 millimeter diameter exists on the centerline of symmetry. The support structure behind the subreflector shall be of a smaller diameter in size than the subreflector and not protrude outside the subreflector diameter in any translation position.

### **3.5.6 SERVO AND CONTROLS**

#### **3.5.6.1 GENERAL DESCRIPTION**

The Contractor shall provide an antenna control system that includes a closed-loop servo for driving the antenna to follow a commanded trajectory. It shall also include reasonable protection equipment and circuitry, such as limit switches. Additional details of the requirements are given in this section.

The control system shall provide all the necessary controls for the azimuth and elevation axis drives and shall monitor the angular position of the antenna in both axes. Cabling to interconnect all components of the system shall be supplied and installed by the Contractor. No components of this system may be located in the receiver cabin except perhaps some low-power sensors, and then only with AUI's approval.

#### **3.5.6.2 LOCAL CONTROL AND MONITORING**

The front panel of the Antenna Control Unit (ACU) shall provide for local control and monitoring of the antenna. It shall include at least (1) an Emergency Stop switch (see also 3.5.6.7), (2) selection of Remote or Local access (see 3.5.6.3), (3) mode selection (see 3.5.6.3) and (3) rate loop driving of the antenna. It shall display at least the following information:

1. Binary encoder position
2. Binary commanded position
3. Motor status (each)
4. Field status (each)
5. Motor over temperature (each)
6. Emergency Stop

7. Stow Pins
8. Limit Switch Status (each)
9. Computer Mode Status (each)
10. Each Motor Current
11. Each Tachometer (Pin Jacks)
12. Circuit Breakers (each)
13. Contractor Metrology System Status

An auxiliary control panel shall also be provided for the use of maintenance personnel who may be servicing the antenna. This shall provide at least rate loop driving of the antenna in both azimuth and elevation, effective only during Local Access. This auxiliary control shall also provide emergency stop control. This unit should connect to the base of the antenna with a dis-connectable 30 meter cable and be water tight and protected from the weather.

### 3.5.6.3 MODES OF OPERATION

At any time, the controller may be in one and only one of several operating modes, as listed in Table 3.5.6.3-1. Simultaneously, it may be in either of two access modes, Local or Remote. When Remote access is selected, the controller responds to a defined set of commands via the digital interface (3.5.6.4). When Local access is selected, commands received from the digital interface are ignored (but status requests are still accepted and processed) and the antenna may be driven using the controls described in 3.5.6.2. Switching between Local and Remote access may be done only from the ACU front panel. Upon changing access mode and at power-up, the controller automatically enters the Shutdown operating mode. Not all operating modes may be entered from either access mode; see Table 3.5.6.3-1. In addition, Stow mode or Shutdown mode may be entered automatically when the controller detects certain fault conditions, regardless of the selected access mode.

The following rules govern changes of mode: From Shutdown mode, the only change permitted is to Standby mode, and then only if no fault conditions are true. An Active mode may only be entered from Standby mode. From Stow mode, Standby mode is automatically entered upon reaching the stow position.

**Table 3.5.6.3-1 Modes of Operation**

Operating Mode	Local	Remote	Auto	Description
Shutdown	Yes	Yes	Yes	Brakes set, no power to motors
Standby	Yes	Yes	No	Ready to drive
Active:				Brakes off, servo loop closed
Velocity	Yes	No	No	

Operating Mode	Local	Remote	Auto	Description
Position				
Encoder	No	Yes	Yes	Drive so encoders equal commanded position.
Autonomous	No	Yes	No	Drive so boresight equals commanded position.
Stow	Yes	Yes	Yes	Drive to stow position.

### **3.5.6.4 MONITOR AND CONTROL DIGITAL INTERFACES**

#### **3.5.6.4.1 GENERAL**

The antenna shall be controlled via commands from an AUI-supplied computer and shall provide status information to the same computer. The connection will be via a serial data bus whose details will be specified prior to award of contract (3.5.6.4.2). The bus may be shared with other devices mounted in the antenna. There are strict timing requirements with respect to the execution of some commands and the sampling of some status data (3.5.6.4.3).

The primary commands consist of the azimuth and elevation to which the antenna shall be pointed. Other commands may be generally described as changing the mode of operation of the antenna. The detailed design of the command set is at the discretion of the Contractor, subject to guidelines given in Section 3.5.6.4.4.

The primary status information consists of the actual azimuth and elevation to which the antenna was pointed at an accurately known time. Additional status information for monitoring the health and safety of the antenna is also required, such as motor currents, temperatures at critical locations, and any detected fault conditions.

#### **3.5.6.4.2 PHYSICAL LAYER AND LOW-LEVEL PROTOCOL**

The serial data bus by which the Antenna Control Unit will communicate with AUI's computer has not yet been decided. The low-level protocol for messaging on this bus depends on the bus characteristics, so it is also not yet known. This information will be supplied within six months of contract award, but it is not expected to have an appreciable effect on cost.

For planning purposes, it should be assumed that commands will consist of an 8-bit code specifying which command should be executed, followed by one or more numerical parameters in the form of fixed-point binary numbers. Each parameter may be an 8-bit, 16-bit, or 32-bit number.



For planning purposes, it should be assumed that status information will be solicited by polling and that the antenna controller will not send any messages nor generate any interrupts autonomously. A request for status information will consist of a 1-byte code specifying which information is desired. The antenna controller shall respond with one or more binary numbers in the forms given above.

#### **3.5.6.4.3 TIMING**

In addition to a connection to the serial bus, the antenna controller will receive a precise timing reference signal. This will be a periodic pulse, supplied by differential signaling conforming to RS485. The pulse period shall be negotiated, but it is expected to be near 50 ms and the final value will be selected before proposals are due. The pulse duration will be no less than 1 microsecond. The leading edge of each pulse marks a timing event.

For certain commands, in particular the antenna position command, the antenna controller shall consider the effective time of the command to be that of the \*second\* timing event after the command is received. The controller must then ensure that the condition specified by the command becomes true within 10 microseconds of the effective time whenever this is not prevented by a mechanical or structural limit. For other commands, such as mode changes, there is no requirement for precise timing.

The controller shall also measure the actual position of the antenna twice per timing event, with one measurement made within 10 microseconds of a timing event and the other within 1 ms of the midpoint between timing events. Each such measurement shall include the readings of all appropriate sensors (although sensors whose values are known to change slowly may have their readings interpolated from measurements made less frequently). The controller shall store these measurements in a circular buffer sufficient to hold data from at least the last 10 seconds. Status request codes shall be included to solicit (a) the most recent measurement at the last timing event; (b) a subset of the measurements in the buffer (size shall be negotiated); and (c) all measurements in the buffer. There may be other status request codes that require delivery of a measurement made at the last timing event.

The number of commands and status requests that might be transmitted in a given time interval is limited only by the speed of the bus and its low-level protocol. However, the total number of commands and status requests requiring precise timing will be limited to a maximum of 4 per timing event. The controller shall be capable of processing all of these. Other commands and status requests shall be buffered and executed at lower priority in the order that they were received. The buffer should be capable of storing at least 256 commands and status requests.

#### **3.5.6.4.4 HIGH LEVEL COMMAND PROTOCOL**

Each antenna position command will have 4 parameters, consisting of elevation, azimuth, elevation rate, and azimuth rate. The elevation and azimuth will be 32 bit numbers, interpreted as

signed, twos-complement, fixed-point binary numbers representing angles from -1 turn through +1-2-31 turn (i.e., the binary point comes just after the sign bit). The elevation rate and azimuth rate will be in the same fixed-point format in units of turns per second.

For the elevation parameter, zero represents the horizon and the valid range is from the lower mechanical limit (2 degrees) to the upper mechanical limit (89.8 or 125 degrees (see 3.4.1)). For the azimuth parameter, a value of zero represents the center of the range of rotation (3.4.1) and the valid range is from one mechanical limit to the other (540 degrees). If out-of-range commands are received, the antenna should be driven to the nearest mechanical limit and an error status bit should be set.

The commanded position and rate apply at the second timing event after the command is received. The AUI computer will guarantee that the command is available no later than 10 ms in advance of the next timing event. If no position command is received between two timing events, the position and rate applicable at the next timing event shall be derived by constant-velocity extrapolation of the most recently received command. In this way, there is a commanded position and rate that applies at each timing event. At any time between timing events, the commanded trajectory shall be determined by a fixed interpolation rule chosen by the Contractor to produce smooth motion, taking into account the response of the servo. (AUI believes that a cubic polynomial matching the position and rate at each timing event is adequate.)

The servo shall attempt to make the actual trajectory of the antenna follow the commanded trajectory. If the latter contains first or second derivatives exceeding the maximum angular velocity or acceleration (see 3.4.4), the servo shall drive the antenna so as to converge to the commanded trajectory as quickly as possible while meeting the settling time requirements (3.4.4).

The antenna may have several sub-modes of active operation determined by the Contractor, but at least the following two modes shall be included.

**Autonomous pointing mode:** In this mode, position commands are interpreted to mean the actual orientation of the axis of symmetry of the main reflector (boresight axis) with respect to established local coordinates (zenith direction and nominal azimuth zero). The controller shall determine this automatically by using all available sensors and, if necessary, calibration information specific to this antenna that has been previously determined and stored. Accuracy specifications given earlier in (3.4.3) are expected to be met.

**Encoder positioning mode:** In this mode, position commands are interpreted to mean the readings of the azimuth and elevation shaft rotation sensors (encoders). The readings of other sensors shall be ignored in executing the position command, but they shall still be measured and recorded for reporting in response to status requests.

### **3.5.6.5 COMPUTING AND SOFTWARE**

It is assumed that the control unit will contain one or more embedded microprocessors. The source code for programming all such processors shall be delivered to AUI.

It is desired that (a) all application programming for processors in the control unit be written in a widely-used high level language such as C or C++; (b) executable code be stored in non-volatile electronic memory, avoiding mechanically driven peripherals such as disk drives; and (c) if a general-purpose computer requiring an operating system is included, then the operating system should be commercially available at the time of contract award (not proprietary). Although the specifications of this paragraph are desired and not required, any intention to deviate from them should be stated and justified in the proposal.

### **3.5.6.6 LIMIT SWITCHES**

There shall be two limit switches near each extreme of motion of each axis, at slightly different positions. The two switches of each pair shall use independent wiring and independent circuit components as much as possible; the likelihood of a component failure affecting both circuits shall be minimized.

#### **3.5.6.6.1 FIRST LIMIT (PRELIMIT)**

When the first limit switch of a pair is actuated, the controller shall inhibit driving further in the same direction (into the limit), but should permit driving in the opposite direction (out of the limit) in all modes. Receipt of a second command (Remote or Local) that would cause motion into the limit shall cause the controller to enter Shutdown Mode, and thus to remove motor power and engage the brakes. An override switch shall be provided to disable these features of the first limit. This switch shall be accessible only locally (not via remote control), and it shall not be on the control unit's front panel.

#### **3.5.6.6.2 SECOND LIMIT (FINAL LIMIT)**

When the second limit switch of a pair is actuated, all motion of the antenna shall be stopped by causing the controller to enter Shutdown Mode immediately. In addition, each second limit switch shall include a set of normally closed contacts through which current to at least one brake of its axis must flow. There shall be no provision in the ACU for overriding the second limits. The Contractor shall make provisions for manual override of brakes and axis drives.

### **3.5.6.7 EMERGENCY STOPS AND FAULT DETECTION**

The Contractor shall supply, wire and install emergency stop switches that can be padlocked in stop position for Lock-out/Tag-out. The setting of an emergency stop switch shall completely remove power from the motor drive circuits and cause the brakes to be engaged. It shall

cause the control system to enter the Shutdown mode, but the removal of motor power and engaging of brakes shall be independent of any other control circuits; it shall be effective even if the main electronics chassis is powered down. These switches are to be located in at least the following locations:

1. In the receiver cabin
2. Two on the pedestal
3. On the elevation drive platform
4. At each azimuth drive motor
5. On the local control front panel
6. On the auxiliary control panel

The control system shall continuously monitor fault conditions that may affect the safety of equipment or personnel, and shall automatically enter Shutdown mode if a sufficiently serious fault is detected. Serious faults include, but are not limited to:

1. Excessive motor current
2. Motor overheating
3. Servo oscillation
4. Limit switch actuated (but see 3.5.6.6)
5. Critical sensor fault (especially an encoder) or power failure
6. No commands received for 60 seconds when in Remote access
7. Overspeed of the azimuth or elevation axis.

#### **3.5.6.8 AUTOMATIC STOW CONDITIONS**

The antenna will automatically enter stow mode under the following conditions:

1. ACU Commanded
2. No commands received for 60 seconds when in remote access.

#### **3.5.6.9 PRIME POWER**

The drive system prime power shall be 380 VAC +/- 10 %, 3 phase, 5 wire, 50 Hz or 60 Hz, connected to a 3 phase circuit breaker located on the antenna pedestal. The connections from this circuit breaker to the motor amplifiers shall be by wire and conduit.

Electronic components of the system shall be connected to 220 VAC, 1 phase 50 Hz or 60 Hz and have varistor surge protection. The encoder prime power shall be connected to the same source and have varistor surge protection. This prime power shall be connected to a disconnecting device (supplied under this contract) that will allow resetting all servo and encoder power supplies, motor faults and other faults. The disconnecting device will be actuated by an AUI remote 28 Volt DC signal.

### **3.5.7 RFI AND EMI**

The control circuit, drive motors amplifiers, and switching devices shall be designed and constructed in accordance with Mil-STD-461A, paragraphs 4.2.1.2., 4.2.1.4., and 4.2.1.5. concerning radiated and conducted electromagnetic energy. In particular, all motor leads, power and control should be filtered. The motor leads may be shielded instead of filtered provided the shielding provides suppression equal to or better than the filters. All relay contacts and actuators should be properly bypassed, shielded and/or filtered. All amplifiers and oscillators shall be mounted in shielded enclosures that will provide effective shielding of radio frequency energy. Silicon-controlled rectifiers switching devices shall not be used unless phase controlled and zero current crossing switching techniques are used. No gaseous discharge devices, except noise sources for test shall be employed. Means shall be employed to reduce static electricity and the consequent R.F. noise generated in any rotating machinery. All displays (LCD, plasma, LED, CRT) shall have a transparent RFI shield in front of the display to avoid radiated RFI. In addition, all digital equipment, whether a simple logic circuit, embedded CPU, or rack mounted PC shall be shielded and have its AC power line and modem/LAN line(s) filtered at the chassis.

The frequency range of interest for RFI suppression extends from 50 MHz to 12 GHz. No verification measurements by the Contractor will be required. All wires and cables provided by the Contractor that enter the receiver cabin shall have RFI suppression. The receiver cabin will be an effective continuous metal surface for shielding and will require RFI shielding on the cabin door. AUI will be responsible for shielding of the receiver cabin vertex hole.

### **3.5.8 ELECTRICAL**

#### **3.5.8.1 POWER DISTRIBUTION**

The Contractor shall supply a 75 kVA electrical service entrance at the base of the antenna for connection to supply power from two sources that are switchable. This switch shall have the two power inputs from removable connectors and be provided by the Contractor. The supply voltages of 220 VAC single phase, 380 VAC three phase at a frequency of 50 Hz or 60 Hz will be provided. The Contractor shall be responsible for all his antenna electrical wiring from this point. All connector and receptacle types shall be approved by AUI. All cabling and wiring shall be in metal conduit unless specifically approved by AUI.

The antenna Contractor shall supply a three bus system. One bus is the "Critical Electronics Bus" for receiver cabin electronics, encoding systems, ACU and safety systems with a sub-panel in the receiver cabin. The power for this bus shall be supplied by a 20 kVA UPS system. This UPS system shall be not be located in the receiver cabin but at a location chosen by the Contractor. The second bus is the "Critical Cryogenic Bus " that powers the cryogenic compressor, and cryogenic refrigerator. The other bus is the "Non-Critical Bus" for lighting, HVAC, with sub-panels in the receiver cabin and base of telescope. The bus system is also listed in the Table 3.5.8.1-1. Size and type of the circuit breakers are to be determined later by AUI. Fuses shall not be used for equipment

protection unless specifically authorized by AUI. All three buses shall have single phase and reverse phase protection interlocked with smoke detectors specified in Additional Electrical Requirements (3.5.8.4).

**Table 3.5.8.1-1 Bus Power Distribution**

<b>Bus</b>	<b>Systems on Bus</b>	<b>UPS</b>
(1) Critical Electronics Bus	Receiver cabin electronics, encoding systems, ACU, safety systems	UPS System (20 kVA) for a minimum of 10 minutes, 220 VAC, single phase
(2) Critical Cryogenic Bus	Cryogenic compressor & cryogenic refrigerator	No UPS
(3) Non-Critical Bus	All other system, including prime drives & HVAC systems	No UPS

### **3.5.8.2 JUNCTION BOXES**

Junction boxes shall be provided to accommodate all electrical connections to be supplied by the Contractor. Separation in junction boxes shall be provided for power and signal wiring; junction boxes shall meet National Electrical Code specifications for NEMA Type IV.

### **3.5.8.3 GROUNDING**

The antenna requires safety and equipment grounds. A station ground shall be provided for the antenna structure. The Contractor will design the grounding counterpoise as part of the antenna foundation design (Section 3.5.3) in accordance with National Electric Code Specifications. Soil resistivity data for this design will be included with the soils report prior to award of contract. AUI will provide the counterpoise as part of the foundation construction. The apex, elevation bearings and azimuth bearing shall have a by-pass grounding connection. The antenna grounding system shall be specifically designed to prevent or minimize ground loops.

Lightning rods shall be provided as required to protect all parts of the antenna.

### **3.5.8.4 ADDITIONAL ELECTRICAL REQUIREMENTS**

Smoke detectors are required in any equipment compartment in the base of the antenna and in the receiver cabin and shall be interlocked to shunt trip all electrical power in the antenna. When smoke is detected the detector will immediately close a contact which will be used by AUI for a remote fire alarm and will energize a local audible alarm. The shunt trip of all power will occur 5 seconds after smoke detection. Emergency power for the smoke detectors and local alarm shall utilize "Gel-cells" with a minimal reserve of 6 hours.

Single phase and reverse phase protection is required and will be interlocked to remove all electrical power on the antenna. When a single phase or reverse phase problem is detected the detector will immediately close a contact which will be used by AUI for a remote alarm. The shunt trip of all power will occur 5 seconds after detection of the problem. This shunt trip shall automatically reset after proper conditions are restored. Emergency power for the single phase and reverse phase detectors shall utilize "Gel-cells" with a minimal reserve of 6 hours. All electrical and electronic wires shall be in metal conduits unless specifically approved by AUI.

### **3.5.9 MAINTENANCE AND RELIABILITY**

The antennas shall be designed so that, with normal preventive maintenance, they will operate for 30 years, with 24 hours per day of continuous operation, without requiring the replacement of the elevation bearings, azimuth bearing, reflector surface, antenna structure, or drive surfaces. In order to deal with the possibility of a premature failure a straightforward elevation and azimuth bearing replacement procedure must be included in the antenna design. For all purchased mechanical and electrical components the Contractor shall provide the supplier's lifetime and MTBF specifications for the component.

To the maximum extent feasible, all equipment shall be designed to be repaired by replacement of spare plug-in modules or assemblies so as to minimize any need to repair a failed component in place. Design features shall be incorporated in the antennas to permit the removal, repair, and replacement of components subject to wear or contamination. Bearings (excluding the azimuth and elevation bearings), drive motors, gearboxes, HVAC equipment, etc., that are subject to wear and contamination shall be easily accessible with minimal removal of other components. All mechanical and electrical components (excluding the azimuth and elevation bearings) that are integral parts of the antenna structure shall be designed to be removed and replaced by a two-person crew in a period of no more than 4 hours. All parts shall be interchangeable with like parts.

### **3.5.10 DISASSEMBLY**

The prototype antenna will be tested initially at a site in the U.S. and later disassembled and shipped to the MMA site in Chile. The ability to disassemble the antenna into pieces for economic overseas shipping is required. AUI will be responsible for this future disassembly, shipping and reassembly of the antenna. The Contractor will deliver this disassembly/reassembly procedure at the end of the design phase of the contract. Disassembly of the antenna shall be sufficient to allow the pieces to fit in an industry standard overseas freight container, the dimensions of which are approximately 12 meters in length, 2.3 meters in width, and 2.6 meters in height. There may be exceptions made to this requirement if the Contractor can show that this requirement will significantly increase the cost of the antenna compared to the cost of shipping an oversize piece. The disassembly/reassembly procedure must be approved by AUI.

It is likely that the production antennas will be assembled, outfitted and tested at a low (2400 m) altitude site 50 km from the high altitude MMA site. The antenna would then be split into two pieces, the mount and the reflector, for transport to the high altitude site. For this purpose the antenna shall be designed for ease of disassembly and reassembly at the elevation axis. The Contractor will provide connectors on all cables to allow them to be disconnected at the elevation axis. Pickup points will be provided on both the mount and reflector so that they can be lifted as entire units.

### **3.5.11 SAFETY**

The antenna shall meet all applicable requirements of National Electrical Code, Occupational Safety and Health Administration Standards, Underwriters Laboratory Requirements 1950 and the contract. This is particularly important when designing for preventive maintenance during antenna operation.

All machinery shall be covered or protected in such a way that working personnel are not subject to hazards. All axis drives will have Castell lockout systems. All brake system shall be of a fail-safe type.

## **3.6 SUMMARY OF AUI AND CONTRACTOR INTERFACES**

### **3.6.1 MONITOR AND CONTROL DIGITAL INTERFACES**

AUI will provide specifications and guidelines for the Monitor and Control Digital Interface in Sections (3.5.6).

Contractor will provide a monitor and control interface that will meet AUI's requirements.

### **3.6.2 INTERFACE TO CABLE WRAPS**

A cable wrap or loop shall be provided in azimuth and elevation which will accommodate all Contractor-provided cables and AUI cables and be of the bending type only. Appendix H lists all AUI cables and hoses for elevation and azimuth wraps. The cable wrap shall permit full angular rotation of the antenna as specified in 3.4.1. The cable wrap arrangements shall be such that cables are neither excessively stressed by twisting or bending, nor damaged by pulling over edges of fixed structure.

AUI will provide and install all its own cables and hoses.

The Contractor shall provide cable wraps. Contractor shall provide pass throughs for all cables from the entrance at the base of the telescope to the inside of the receiver cabin. Two cable/hose feed-through plates will be provided by the Contractor of size 30 cm x 60 cm. The base plate will bolt to the base of the antenna from inside. The second plate is at the receiver cabin and will bolt to the outside of the receiver cabin.



### **3.6.3 INTERFACE TO ON-AXIS CABLE WRAPS**

Provisions will be made for a separate, special, stable fiber optic cable wrap that will pass through the two axes of the telescope. These on-axis cable wraps will hold a fiber optic cable fixed between axes. AUI will be responsible for providing this cable wrap.

The Contractor shall provide accesses in the azimuth and one in the elevation axis for this on-axis special cable wrap. A minimum diameter hole of 28 millimeters through the center of each axis will be required. This shall include a hole of this size through the azimuth encoder.

### **3.6.4 RECEIVER PACKAGE INTERFACE**

AUI provides receiver specifications in Appendix I as a guide and details will be negotiated. AUI will provide the receiver and installation of the unit.

Contractor will design and provide a receiver mount that meets all antenna specifications.

### **3.6.5 RECEIVER CABIN EQUIPMENT RACK INTERFACE**

AUI provides receiver cabin equipment rack specifications in Appendix J, and will provide the receiver cabin equipment racks and installation of the unit.

Contractor will design and provide a receiver cabin equipment rack mounting that meets all antenna specifications and provides cooling for the equipment racks (see Section 3.5.4).

### **3.6.6 RECEIVER PACKAGE INSTALLATION INTERFACE**

AUI provides receiver package specifications in Appendix I and installation guidelines in Section 3.5.4.

Contractor designs and installs the receiver package installation system.

### **3.6.7 CRYOGENIC COMPRESSOR INTERFACE**

AUI provides the cryogenic compressor specifications such as power, air flow, size, hose size, cable sizes, and mass. AUI will install cryogenic compressor, including hoses and cables. See Appendix K for specifications.

Contractor designs location for cryogenic compressor and provides power receptacle, ventilation, hose, and cable pass-throughs. This design will include a simple method for installing and removing the compressor from the antenna structure.

### **3.6.8 TRANSPORTER INTERFACE**

AUI shall provide guidelines for transporter interface (3.5.2). AUI shall approve Contractors design.

Contractor designs antenna transporter interface that is approved by AUI.

### **3.6.9 FOUNDATION INTERFACE**

AUI provides site soil report and provides foundation.

Contractor designs and documents three foundations based on soils report. Contractor provides all interface mechanical and electrical connection hardware for one foundation.

### **3.6.10 OPTICAL TELESCOPE INTERFACE**

AUI provides weight, size, location and mounting information for the optical telescope in Appendix F. AUI provides and installs the optical telescope.

Contractor designs, documents, and provides the interface between the optical telescope and the antenna system.

### **3.6.11 MOLECULAR SIEVE INTERFACE**

AUI provides manufacturer's specifications for a molecular sieve for oxygen enrichment of the receiver cabin (see Appendix L). AUI will purchase this item and install it on the antenna.

Contractor will design a mounting flange on the receiver cabin for the molecular sieve that is in accordance with manufacturer's specifications. The Contractor will also provide and install a cover plate on this flange.

### **3.6.12 ELECTRICAL POWER INTERFACE**

AUI provides entrance power specification in (3.5.8.1).

Contractor shall design antenna to meet entrance power specification.

### **3.6.13 RF- TRANSPARENT MEMBRANE INTERFACE**

AUI provides material for membrane and location (3.5.4).

Contractor shall design and install membrane at vertex hole.

### **3.6.14 COMPUTER ACTUATED SHUTTER INTERFACE**

AUI provides specification in (3.5.4).

Contractor shall design computer actuated shutter to specifications.

## **3.7 MATERIALS AND FABRICATION**

### **3.7.1 GENERAL**

Materials shall be in agreement with the general requirements as set down in these specifications. It shall be the responsibility of the Contractor to prepare specific material specifications for the various components of the antenna. These specifications may be either on the drawings or in a separate document and shall be subject to AUI review and approval. Fabrication shall be in accordance with best shop practices and shall be fabricated to proper size and tolerance as shown on the approved drawings.

### **3.7.2 MATERIALS**

The elevation-over-azimuth mount is to be of carbon or low alloy steel using the most economical shapes available from both a weight and fabrication cost standpoint. The type of steel selected for the mount structure shall be such that the low temperature embrittlement characteristics shall be acceptable. The nil-ductility transition temperature of the selected material shall not exceed -45 C. Nil-ductility transition temperature is defined as a temperature below which a specimen will exhibit cleavage fracture with very little or no evidence of notch ductility. It is the intent of these specifications to secure a metal which at the lowest operating temperature will not be brittle enough for flaws or defects in joints or welds to be subject to brittle propagation.

All components which are designed for welded connections shall be weldable grade material. Bull gears and pinions, if used, shall be of a material having a minimum hardness of 255 BHN and shall be surface hardened as required by life of the system (Section 3.1.2 #1).

The Contractor shall consider annealing steel structures to removed locked in stresses and long term creep, important for reducing non-repeatable structural deformations and achieving pointing specifications.

For those parts of the antenna fabricated from CFRP the Contractor will provide AUI, for approval, specifications for all materials and processes required for the fabrication. For the bonding methods selected for CFRP to CFRP joints or for CFRP to metal joints the Contractor will perform tests on sample joints to verify that the required strength and lifetime are achieved. Special attention will be given to the problem of degradation of CFRP by solar radiation. All CFRP structure will be protected from solar radiation either by a sun shade or by a suitable coating. The Contractor shall

make considerations for the Chile site being of low humidity in the selection and design of items made out of CFRP.

### **3.7.3 MANUFACTURE**

All structural components shall be manufactured to proper size and tolerance and in the manner shown on the approved drawings. Methods of manufacture shall be of the best shop practice. Mis-manufactured members shall be discarded and not repaired unless prior written approval is obtained from AUI. Shop connections for metal structure may be either welding or bolting (as stated in the design drawings), but components to be field assembled shall be high strength bolted. All holes shall be drilled or sub-punched and reamed according to good practice so that connection clearances may be held to a minimum. Manufacture and assembly of all components will be such that uniform dimensions of the components and sub-assemblies of the antenna may be maintained and maximum commonality of both components and antennas built using the design may be maintained.

### **3.7.4 PROTECTIVE COATINGS**

The reflector surface of the antenna will be unpainted but will have a suitable surface treatment to enable direct observations of the sun without causing heat damage to structure and components in the vicinity of the antenna apex (see Section 3.4.7).

To limit the effect of solar heating and associated differential expansion of structural members and to protect the structure against atmospheric corrosion, the antenna structure, with exception of the reflector surface, shall be painted with white solar reflecting paint. The paint will be chosen to last at least 10 years before repainting is necessary. Special attention will be given to the severe solar radiation environment on the high-altitude site. The Contractor will provide a specification for material, preparation, application and quality control testing for the paint system for approval by AUI. Prior to submitting the paint specification for approval, the Contractor will provide AUI with the results of accelerated testing of samples which demonstrates the adequacy of the paint system.

## **3.8 FIELD ASSEMBLY**

### **3.8.1 GENERAL**

The Contractor will assemble and test this prototype antenna at the site of the MMA Test Interferometer which will be located at the Very Large Array (VLA) Radio telescope site. The VLA is located 80 km west of Socorro, New Mexico on U.S. Rt 60 at an elevation of 2100 m. At the VLA the following facilities can be made available to the Contractor at no cost provided that an agreement concerning the liability assignment, scheduling and operation of the facilities is negotiated between the Contractor and AUI.

VLA facilities:

- (1) Floor space in the VLA Antenna Assembly Building (AAB) and use of the AAB 5 tons (short) overhead crane.
- (2) Mobile cranes: 30 tons (short), 30 tons (short), 5 tons (short).
- (3) Man lifts and fork lifts.
- (4) Fully equipped machine shop for making field modifications.
- (5) Sleeping, bathroom and cooking accommodations.

The antenna will be assembled and tested on an antenna foundation designed by the Contractor and provided by AUI (Section 3.5.3). The foundation is approximately 800 m from the AAB. An MMA antenna transporter will NOT be available at the time of the assembly of the antenna.

The Contractor shall furnish all materials, plant and equipment, tools (except such materials, plant and equipment, and tools as may be furnished by AUI as provided elsewhere in this document) and all labor, services and supervision necessary to complete the assembly, alignment and testing of the antennas.

### **3.8.2 WORK AT THE SITE**

Special and other conditions applying to work at the site are contained in Section 4.

## **3.9 DRAWINGS, SPECIFICATIONS AND OTHER DATA**

### **3.9.1 DESIGN AND MANUFACTURING DRAWINGS**

Design and manufacturing drawings shall be produced on standard size drawing forms whose size and format have been approved by AUI. Drawings shall conform to good commercial practice and use symbols, conventions, and notations endorsed by manufacturing and standards associations such as the Drawing Requirements Manual by Jerome H. Lieblein (ISBN 1-57053-034-3), DIN or ISO codes. At the start of the design phase, the Contractor shall submit a copy of his drafting standards and submittal format of editable electronic documents to AUI for its review and approval. Three printed copies and one editable electronic version of all design and manufacturing drawings shall be submitted to AUI for its review and approval at the time of completion of the drawings. On board reviews may be substituted. One reproducible and three printed copies shall be furnished to AUI after approval of drawings. One reproducible copy and an editable electronic copy of all drawings generated by the Contractor or any sub-contractor will be supplied as part of this contract. The final drawing sets will be the as-built fabrication drawings, schematics, assembly drawings, alignment procedures, procurement specifications, and parts list required to duplicate the antenna system. As-built drawings shall be final and reproducible. "Red-lined" drawings are not considered as final. Lower tier Contractors will furnish sufficient drawings so that their equipment can be fabricated, operated and maintained by AUI.

### **3.9.2 DESIGN CALCULATIONS AND DATA**

Three printed copies and one editable electronic copy of all design calculations, design data, studies, or other information prepared or utilized by the Contractor in the performance of the work shall be delivered to AUI. One copy of all computer programs, calculation runs, and printouts shall be furnished for AUI's review. When a computer program is not owned by the Contractor, input and output data will be provided along with the identification of the computer program. All structural input data will be provided on modern archiving media, such as DAT tapes, CD-ROMs or DVD-ROM. Calculations and data to be provided will include, but will not be limited to:

1. Gravitational Deformation Calculations
2. Eigenfrequencies and Eigenmodes
3. Wind Loading Conditions
4. Wind Pointing Calculations
5. Thermal Loading Conditions
6. Thermal Pointing Calculations
7. Survival Wind Calculations
8. Path Length Error Calculations
9. Servo Analysis
10. Dynamic Analysis of Fast Switching
11. Dynamic Analysis of Application of Brakes at Full Velocity
12. Surface Error Budget
13. Pointing Error Budget
14. Path Length Error Budget
15. Metrology Analysis
16. HVAC System Calculations
17. CFRP Properties
18. CFRP Processes
19. BUS Node Analysis
20. Antenna Stress Analysis
21. Foundation Design Analysis
22. Dynamic Seismic Analysis
23. Structural Fatigue Analysis
24. Grounding Counterpoise Design and Analysis with Impedance Calculation for all Grounding Wires
25. High Altitude Cooling Analysis of all Electrical Components
26. Dynamic Seismic Analysis and Antenna Transporter Shock Analysis
27. Documentation on Suppliers' MTBF and Lifetime specifications for all Electrical and Mechanical Components

Current FEA models shall be provided to AUI on a monthly basis with the first FEA model due one month after the contract is awarded. These models shall include descriptions of changes made

since the previous version. Contractor shall state accuracy of the FEA models describing all relevant assumptions and loadings.

### **3.9.3 MANUFACTURING AND PROCUREMENT SPECIFICATIONS**

Three (3) printed copies and one (1) editable electronic copy of all manufacturing and procurement specifications, referenced on any drawing or prepared for procurement of purchased items, are to be submitted for AUI approval.

### **3.9.4 TESTS, ASSEMBLY, ALIGNMENTS, AND ACCEPTANCE**

#### **3.9.4.1 ASSEMBLY AND ALIGNMENT PLANS**

The Contractor shall, at the completion of the detailed design, prepare and submit to AUI for its approval the following items:

(a) An assembly plan which shall specify each step in the assembly, equipment to be used, the facilities to be used, and a schedule for the completion of the work.

(b) An alignment plan which shall demonstrate to AUI the methods to be used to ensure that the alignment tolerances specified in this document and specified in the antenna Contractor's design effort shall be accomplished. Performance parameters and error budgets set forth in the specifications shall be satisfied.

(c) A plan for the disassembly of the antenna, shipping to Chile and reassembly. Execution of this plan is not part of this contract.

#### **3.9.4.2 TESTS AND INSTRUMENTATION**

The Contractor shall provide all special instrumentation and equipment required to align and test the antenna structure accurately. The term special instrumentation and equipment is defined to be equipment which is specially designed for alignment or testing of the antennas. Procedures and reference points, required for the initial alignment of the antennas and periodic checking thereafter, shall be furnished by the Contractor. Consideration shall be given to preserving the reference marks made on the antennas in the process of initial alignment and adjustment for operational use. The alignment tolerance shall be consistent with and reflected in the system accuracy analyses required in this document.

#### **3.9.4.3 TESTING AND ACCEPTANCE**

The Contractor shall prepare a test plan to be approved by AUI that will qualify the mechanical, electrical, and electronic system performance in accordance to this specification after assembly and alignment are completed.

Because of the precision required and the range of environmental conditions specified, AUI does not consider it feasible for the Contractor to demonstrate by test full compliance with the reflector surface accuracy (3.4.2), pointing accuracy (3.4.3) and path length error (3.4.5) specifications. The full performance of the antenna with respect to these specifications will be determined by AUI using extended radioastronomical tests after AUI has accepted the antenna from the Contractor. For these specifications AUI will accept the gravity, wind and thermal performance of the antenna on the basis of the Contractor's calculations, approved by AUI, that demonstrate that the allocations for gravity, wind and thermally induced errors in the specification error budget have been achieved. The acceptance of the antenna on the basis of these calculations shall not be deemed a waiver of the Contractor's responsibility to meet the specification. The Contractor will provide tests to demonstrate that other entries in the specification error budget have been achieved. If the Contractor provides any metrology equipment, tests will be provided to demonstrate the correct operation of this equipment. For the pointing specification the Contractor will provide tests which use the optical telescope supplied by AUI (see Section 3.6.10) to confirm the correct operation of the antenna drive system and the pointing performance of the antenna mount. The Contractor should assume that the optical telescope will provide pointing information accurate to 0.2 arcsecond in 1 second of time. Further details concerning acceptance of the surface accuracy specification are given in Section 3.9.4.4 below.

Three (3) printed copies and one (1) editable electronic copy of the test plan shall be submitted to AUI for its approval prior to commencement of acceptance testing of the antenna. Approval of a test plan shall not preclude AUI from requiring additional testing. In addition, it shall not be deemed a waiver of the requirement to demonstrate the performance of the antenna in accordance with any or all of the performance specifications. The tests and alignments shall be conducted by Contractor personnel in the presence of an AUI representative unless written authority is obtained to do otherwise. During this testing program, the Contractor shall demonstrate to AUI that the performance specifications set forth in this document have been met.

#### **3.9.4.4 REFLECTOR SURFACE ACCURACY TESTS**

Since the final precision adjustment of the primary reflector surface panels is the responsibility of AUI (see Section 3.4.2), it will not be possible for the Contractor to demonstrate that the specified primary reflector surface accuracy has been achieved prior to handing the antenna to AUI. Instead the Contractor will prepare and execute a plan that demonstrates, either by calculation or test, that all components of the primary reflector surface accuracy error budget under Primary Operating Conditions, except reflector panel setting, have been achieved.

The Contractor shall conduct a survey of the primary reflector surface after adjustment using his instrumentation and personnel to demonstrate that the reflector as installed meets the coarse adjustment setting accuracy of 100 micrometers rms with the antenna positioned at the zenith. The Contractor will propose a measurement method of suitable accuracy to achieve this coarse setting. AUI shall approve the Contractor's instrumentation and method of survey before this survey is conducted. Surveys shall be conducted at times of minimum wind and thermal loading (i.e., on



windless nights) with the reflector positioned at the zenith. Measurements shall be made to reference points on reflector panels and adjacent to the panel adjustment points. These measurements shall then be reduced to a RMS error from a best-fit paraboloid. The acceptance of the paraboloid will be based on the acceptable results of these surveys.

### **3.9.5 QUALITY ASSURANCE INSPECTION PROCEDURES**

The Contractor shall submit three (3) printed copies and one (1) editable electronic copy each of quality assurance and inspection procedures to AUI for review and approval prior to the start of procurement and manufacturing.

Quality assurance tests will be performed on materials, components, and assemblies as specified in the quality assurance procedure. AUI will be notified prior to these tests and may be a witness to such tests. All quality assurance test results recorded by either the Contractor or its Contractors shall be signed and submitted to AUI in an approved documented form. AUI may perform such inspections or tests it considers necessary on any component or assembly during or after fabrication at the site of fabrication or the site of assembly. Copies of test results normally performed by suppliers, such as certificates of conformance for steel, bearings, etc., shall be supplied in duplicate to AUI.

### **3.9.6 OPERATION AND MAINTENANCE MANUALS**

The Contractor shall deliver at the start of assembling the antenna three (3) printed copies and one (1) editable electronic copy of an Operation and Maintenance Manual. This Operation and Maintenance Manual shall contain the following information:

(a) Manufacturers' drawings, exploded view assembly drawings, parts list and recommended lubrication procedures for all mechanical components. Manufacturers' drawings, parts lists, specifications, wiring diagrams, and testing procedures for all electronic components. A lubrication schedule showing lubrication points, types of lubrication, recommended lubricant, and frequency of lubrication.

(b) A maintenance section that describes the method for removal of mechanical components, methods and control to be used to reassemble and realign components that might be reasonably expected to be replaced because of wear characteristics. Assembly and subassembly drawings, which include mechanical setting dimensions such as bearing preload, gear runouts, gear backlash settings, torque bias settings, drive train alignment requirements, and the weight of components.

(c) An operations section, which describes the function of the various mechanical and electrical components of the antennas. A narrative section shall be provided which describes the various controls and modes of operation which also includes illustrations of the control circuitry.

### **3.9.7 SPARE PARTS**

Within sixty days of the approval of the detailed design, the Contractor shall submit a recommended spare parts list. Three (3) printed copies and one (1) editable electronic copy of the list shall be furnished to AUI. Each item listed shall be detailed as to the identity, OEM part number, drawing reference, original manufacturer, model number, etc.

AUI shall have the right by change order to its contract to order such spare parts as it has selected and/or such parts, whether so selected or not, which were originally manufactured by the Contractor. The Contractor agrees to negotiate in good faith to arrive at a firm fixed price for such spare parts.

The Contractor shall maintain the capability to furnish AUI the agreed spare parts for a period of ten years from the acceptance of the final antenna.

AUI may purchase such spare parts from any supplier or have such parts manufactured by others as it appears in its best interest to do so, without limitation or liability to the Contractor and/or its lower tier Subcontractor(s).

## **SECTION 4**

### **FORM OF CONTRACT**

#### **4.1 SPECIAL CONDITIONS OF THE CONTRACT**

##### **4.1.1 ORDER OF PRECEDENCE**

Any inconsistency in this Request for Proposal shall be resolved by giving precedence in the following order: (a) Written Instruction; (b) Special Conditions; (c) Representations, Certifications, and Acknowledgments; (d) General Terms and Conditions; (e) Other provisions, documents, exhibits, and attachments whether incorporated by reference or otherwise; (f) Specifications; and (g) Drawings.

##### **4.1.2 CHANGE ORDER AUTHORITY**

No change in contract performance, specifications, terms and conditions or other matters affecting the work or contract price shall be authorized unless in writing signed by the Director of NRAO, or his authorized representative, designated in writing and acting within the scope of his authority. Any changes made or work performed outside of the scope of the contract prior to the receipt of a written Change Order shall be solely at the Contractor's risk and expense.

##### **4.1.3 SUPERVISION OF THE WORK**

Supervision of the work in accordance with the terms of this contract will be under the direction of the MMA Project Manager, who will have authority to act on behalf of AUI in all matters.

##### **4.1.4 LIAISON DURING DESIGN AND FABRICATION PROGRAM**

Periodic technical and progress review meetings are to be held between the Contractor and AUI during the design program. The place and time of such meetings will be determined by the MMA Project Manager. At least two of these meetings will be formal review meetings, a preliminary design review (PDR) and a critical design review (CDR). In addition to these face-to-face meetings a weekly teleconference will be held between Contractor and AUI personnel to discuss progress and problems.

It is expected that AUI technical representatives will spend considerable time, up to and including full time, at the Contractor's home plant or at plants of any Subcontractor during design and fabrication. The Contractor shall provide, at no cost to AUI, acceptable office space for the AUI representative, with private telephone connection, and shall ensure that its subcontractors, at any level, also provide the same.

#### **4.1.5 SCHEDULES AND WORK PROGRESS**

##### **4.1.5.1 SCHEDULE**

The Contractor shall, within fifteen (15) working days after notice of award of the contract, prepare and submit to the MMA Project Manager for approval three (3) copies of a practicable detailed schedule, both in hard-copy and electronic (digital) form, showing the Work Breakdown Structure (WBS) of the project, the working order in which the Contractor proposes to carry on the work, the date on which he will start each phase, subdivision, and task (including the procurement of materials, plant, and equipment). The work breakdown shall be of adequate scale so that all information required can be entered legibly. Dates for the PDR and CDR, delivery of Complete Design Documentation Package, approval of Complete Design, fabrication, shipment, erection, and test of the telescope shall be shown. The project critical path shall be clearly shown.

Fabrication of the antenna shall not begin until the Complete Design Documentation Package has been approved by AUI, except for specific long-lead items approved by AUI.

##### **4.1.5.2 MANPOWER SCHEDULE**

The Contractor shall also furnish a curve or graph depicting the anticipated design, fabrication, and assembly manpower requirements of the contract.

##### **4.1.5.3 UPDATING SCHEDULES**

The Contractor shall enter on the approved schedule the actual progress at the end of each month and deliver to the Project Manager three (3) copies by the fifth working day of the month following.

The Contractor shall keep the approved progress schedule and manpower chart in accord with the job conditions, making internal changes as necessary and incorporating any AUI-required changes to the schedule. The Contractor shall not, however, make changes of any kind that will affect price or the completion date of the project without a written change order or supplemental agreement to the contract. If extensions of time are granted by AUI, the Contractor shall within five (5) working days revise the schedule and manpower chart accordingly and submit three (3) copies of each.

##### **4.1.5.4 WORK PROGRESS**

The Contractor shall furnish sufficient forces, construction plant and equipment, and shall work such hours including night shifts, overtime operations, and holiday work as may be necessary to ensure the prosecution of the work in accordance with the approved progress schedule. When, in the opinion of the MMA Project Manager, it appears the Contractor is falling behind on the approved schedule, the Project Manager will so notify the Contractor in writing. The Contractor shall confirm the schedule slippage and submit for approval the necessary plan to accomplish a schedule recovery

and shall initiate such plan within five (5) working days. The plan may include a manpower increase, increase in number of shifts worked, additional days of work, overtime operations, and/or increase in construction plant; all without additional costs to AUI.

#### **4.1.5.5 OTHER DATA**

In addition to the requirement set forth in this section, if the Contractor uses other techniques to schedule and manage the work, three (3) copies of all such documents will be submitted for information to the MMA Project Manager.

#### **4.1.6 STATUS REPORT**

In conjunction with the updated schedule required in paragraph 4.1. 5.3, the Contractor shall submit a monthly status report setting forth the status of the work under the contract. The report shall contain, but not be limited, to the following:

- Work completed during the month
- Progress to date
- Problems encountered and solutions
- Explanation and detail for any schedule delays and recovery schedule plans or schedule advances
- Planned activity for ensuing month
- Number of assigned employees by classification, and manhours spent, during the previous month
- Planned personnel and manhour loading for ensuing month

Reports will be signed by the Contractor's authorized representative and transmitted to the MMA Project Manager by the fifth day of the following month.

#### **4.1.7 PROJECT BREAKDOWN FOR SCHEDULING AND PAYMENT**

The Contractor shall within fifteen (15) working days after award of the contract, and prior to any progress payment request, prepare and submit to the MMA Project Manager for approval a comprehensive price breakdown of the project for use in scheduling the work and for payment. This breakdown shall be in a form adequate for control of progress payments by AUI. Sub-items shall total to the price breakdown submitted in the proposal or as negotiated prior to the award of the contract.

#### **4.1.8 PROGRESS PAYMENTS**

Progress payments shall be made to the Contractor based on the percentage of acceptable work completed, and the Contractor shall permit AUI personnel to physically identify materials delivered.

The Contractor shall file a monthly statement (with its invoice) detailing the percentage of completion in accordance with the project breakdown provided under paragraph 4.1. 5 above.

No monthly progress payment shall be made until the progress schedule has been updated and submitted.

Payments shall be in accordance with the terms of the Progress Payments article in Section 4.2. All request for payment shall be made in United States dollars. All payments will be made in United States dollars.

#### **4.1.9 RELEASE OF CLAIMS**

The Contractor shall submit to AUI a Release of Claims in the form set forth in Appendix D hereof, as a condition precedent to final payment by AUI. Any balance due to the Contractor under the progress payments provisions of this contract as a result of final acceptance of the antenna will be held by AUI until a Release of Claims has been received by AUI.

#### **4.1.10 U.S. GOVERNMENT PROPERTY**

No materials, property, or facilities will be furnished by AUI or the U.S. Government unless otherwise provided herein or agreed to in writing during the course of the project.

#### **4.1.11 TOOLING AND TEST EQUIPMENT**

Temporary tooling should be used wherever practical. Proposers are encouraged not to use permanent tooling in the prototype project.

Any permanent tooling, special tooling, or special test equipment which has been fabricated, purchased, or otherwise procured, such as assembly fixtures, measuring devices, jigs, etc., that are used to fabricate or assemble any components, to locate, measure, or adjust any components or assemblies, or to perform any special operation during the scope of the work shall become the property of the U.S. Government. All permanent tooling, special tooling, and special test equipment shall be delivered to AUI or disposed of at AUI's direction. Optical tools, inclinometers, levels, theodolites, and similar tooling which are not purchased specifically for this job and whose purchase price is not included in the cost of the work herein are excepted from this requirement.

The design and accuracy of all tooling is the responsibility of the Contractor.

#### **4.1.12 CONTROL OF THE ERECTION SITE**

The MMA Project Manager, or his designee, will have authority to control the erection site. His authority shall include but not be limited to the following:

- Assignment of work areas
- Assignment of storage space
- Access and other roads
- Utilities
- Vehicle traffic and parking
- Conduct of personnel
- Safety and fire protection
- Security

#### **4.1.13 ON-SITE WORK AREAS**

The MMA Project Manager will assign to the Contractor an adequate assembly, storage, and test area for the execution of its on-site work. The Contractor's equipment will have direct access to the installation site. Provision of all-weather access within the construction area is the Contractor's responsibility.

#### **4.1.14 SHIPMENT, UNLOADING, AND PROTECTION**

All components shall be properly prepared, packaged, and marked for shipment. Gear boxes, open gears, bearings, couplings, and other mechanical components shall be given a rust preventive coating and shall be packaged such that outside storage or exposure to the elements would not damage the component. Shipment, and protection during shipment, shall be the responsibility of the Contractor.

All unloading, receiving, storing, and protecting the Contractor's material and equipment shall be the Contractor's responsibility.

#### **4.1.15 UTILITIES**

##### **4.1.15.1 ELECTRIC**

The Very Large Array (VLA) site electricity is supplied by a 25kV line administered by the Socorro Electric Cooperative (SEC). AUI will run electric services to the prototype antenna construction site as a part of the foundation construction project. The Contractor's foundation design shall designate clearly the power design, point of service pickup, and the required type of interface.

Electricity in quantities sufficient for the Contractor's normal requirements for performing the work and for warehousing and office use will be furnished by AUI without charge. AUI is not responsible for interruptions in commercial power.

#### **4.1.15.2 WATER AND SANITARY FACILITIES**

Potable (chlorinated) water will be available at a hydrant on the site within one (1) mile of the prototype antenna construction site. The Contractor may use the water, in reasonable quantities, free of charge. The Contractor must provide his own hauling and storage facilities. Water use shall be coordinated with the MMA Project Manager, or his designee.

The Contractor shall furnish all his own necessary sanitary facilities. Water will not be provided for these.

#### **4.1.15.3 TELEPHONE AND MAIL**

AUI will supply necessary telephone (voice and data) lines to the construction site for the Contractor's use. There is no charge for line installation; however the Contractor will be billed for usage. The Contractor must supply his own telephone equipment.

The Contractor shall be responsible for handling his own mail and shipping/receiving needs.

#### **4.1.16 HEALTH, FIRST AID, AND RESCUE FACILITIES**

The Contractor shall provide his own health, first aid, and rescue facilities.

#### **4.1.17 SECURITY**

The Contractor shall provide his own security for materials, supplies, and equipment on site. The Contractor shall take such measures as he deems necessary to protect his material, plant, and equipment and be solely liable for any losses. The Contractor shall comply with all physical security rules and regulations set forth by the MMA Project Manager.

#### **4.1.18 FIRES**

The Contractor shall keep adequate fire fighting equipment on site to quickly extinguish accidental fires. Open fires will not be allowed.

#### **4.1.19 TRAFFIC CONTROL**

Construction site access will be through the main VLA entrance and near the VLA Visitor Center. The Contractor's vehicular traffic shall be controlled and scheduled so as not to interfere with VLA operations or present a hazard to AUI employees or visitors. Flagmen shall be provided as necessary during busy periods, and when required by the MMA Project Manager, or his designee.

Site access by the Contractor's employees is limited to the construction site and public areas. The Contractor's employees are required to stay clear of all operations areas, shops, assembly areas,



etc., not part of the MMA prototype construction project, unless invited and accompanied by an authorized AUI representative.

#### **4.1.20 EROSION AND SEDIMENT CONTROL**

AUI shall provide and install all necessary erosion and sediment control devices required by Federal, State, and/or local ordinance.

#### **4.1.21 DISPOSAL OF DEBRIS**

The construction site shall be kept free of litter at all times and litter shall not be allowed on adjacent areas. The Contractor may dispose of reasonable amounts of construction debris in the VLA construction waste dump. Such disposal shall be coordinated with the MMA Project Manager, or his designee. If in the judgment of AUI, the waste stream is excessive, the Contractor shall haul excess litter and debris off-site to an approved, licensed disposal site at no additional cost to AUI.

In no case may the Contractor dump material in the VLA disposal area which may harm the water quality of the underlying aquifer. No disposal of any toxic or hazardous waste is allowed on site.

No burning is allowed.

#### **4.1.22 SENSITIVITY TO RADIO FREQUENCY INTERFERENCE**

The prototype construction site is located in an area sensitive to radio frequency interference (RFI). The Contractor is encouraged to make maximum use of diesel and RFI-protected equipment (gasoline motor driven equipment, mobile telephones, CB radios, computers, etc., are significant sources of RFI which are detrimental to radio astronomy observations at certain frequencies).

The Contractor on rare occasions may be asked to limit or cease his RFI-producing operations for limited periods. Any shutdowns to eliminate RFI will be coordinated with the Contractor by the MMA Project Manager, or his designee.

This concern about RFI will not apply to the MMA production project.

### **4.2 GENERAL TERMS AND CONDITIONS**

#### **ARTICLE 1. INDEPENDENT CONTRACTOR**

(a) In the conduct of the work hereunder the Contractor is acting in the capacity of an independent Contractor and is not an agent or employee of AUI in the performance of the work. AUI, however, shall have general direction of the work and the right to control the final result sought to be obtained.

(b) The Contractor will hold harmless and indemnify the U.S. Government, the National Science Foundation and AUI and their respective officers, agents and employees from and against any and all liability, including all losses and damages or negligence of the Contractor, arising out of or connected with the work.

## **ARTICLE 2. NOTICES**

All notices or communications shall be in writing and mailed or delivered to MMA Business Manager, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, Virginia 22903-2475, and to the Contractor at the address set forth on his proposal letterhead, or to such other place or places as AUI or the Contractor, as the case may be, shall designate in writing.

## **ARTICLE 3. PERMITS AND RESPONSIBILITY FOR WORK**

The Contractor shall, without additional expense to AUI, obtain all necessary licenses and permits required for completion of the work. He shall be responsible for all damages to persons or property that occur as a result of his fault or negligence in connection with the prosecution of the work. He shall also be responsible for all materials delivered and work performed until completion and final acceptance, except for any completed unit thereof which theretofore may have been finally accepted. He shall take proper safety and health precautions to protect the work, the workers, the public, and the property of others.

## **ARTICLE 4. COMPLIANCE WITH LAWS AND REGULATIONS**

1. The Contractor agrees to comply with the latest revision or modification of all applicable Federal, State, and local laws, codes, and regulations in connection with the prosecution of the work, including those applicable by reason of the fact that this contract is issued under a cooperative agreement with the U.S. Government.

2. The Contractor shall ensure that activities under this award carried on outside the United States are coordinated as necessary with appropriate Government authorities and that appropriate licenses, permits or approvals are obtained prior to undertaking proposed activities. AUI and the National Science Foundation do not assume responsibility for Contractor compliance with the laws and regulations of the country in which the work is to be conducted.

## **ARTICLE 5. DESIGN—REVIEW AND OWNERSHIP**

All drawings, sketches, designs, design data, specifications, notebooks, technical and scientific information, and all photographs, negatives, reports, findings, recommendations and memoranda of every description, as well as all copies of the foregoing, relating to the work or any part thereof, shall be subject to review by AUI and the National Science Foundation at all reasonable times. All such material (whether or not specifically identified above) originated in the course of the work shall be the property of AUI and may be used by AUI for any purpose whatsoever, without any claim on the

part of the Contractor for additional compensation. Such material shall be delivered to AUI, or otherwise disposed of by the Contractor as AUI may direct during the progress of the work, or in any event as AUI shall direct upon completion or termination of this contract. The Contractor and his subcontractors shall afford AUI and the National Science Foundation proper facilities for any inspection pursuant to this article.

#### **ARTICLE 6. CHANGES**

(a) AUI may, at any time, without notice to the sureties, by written order designated or indicated to be a change order, make any change in the work within the general scope of the contract, including but not limited to changes: (i) in the specifications (including drawings and designs); (ii) in the method or manner of performance of the work, or place of delivery; (iii) in the AUI-furnished or U.S. Government-furnished facilities, equipment, materials, services, or site; (iv) time of performance of the work, or delivery schedule; or (v) plans and specifications and instructions incorporated in the contract.

(b) Any other written order, including direction, instruction, interpretation, or determination which is regarded as a change by the Contractor will be considered, provided AUI receives written notice within thirty (30) days stating the date, circumstances, and source of the order and that the Contractor regards the order as a change order.

(c) Except as herein provided, no order, statement, or conduct of AUI or its representatives shall be treated as a change under this article or entitle the Contractor to an equitable adjustment hereunder.

(d) If any change under this article causes an increase or decrease in the Contractor's cost of, or the time required for, the performance of any part of the work under this contract, whether or not changed by an order, an equitable adjustment will be made and the contract modified in writing accordingly. Except for claims based on defective specifications, no claim for any change under (b) above shall be allowed for any costs incurred more than 20 days before the Contractor gives written notice as therein required. Furthermore, in the case of defective specifications for which AUI is responsible, the equitable adjustment shall include any increased cost reasonably incurred by the Contractor in attempting to comply with such defective specifications.

(e) If the Contractor intends to assert a claim for an equitable adjustment under this article, he must, within 30 days after receipt of a written change order under (a) above, submit to AUI a written statement setting forth the general nature and monetary extent of such claim, unless this period is extended by AUI. The statement of claim hereunder may be included in the notice under (b) above. Failure to agree to any adjustment shall be a dispute concerning a question of fact within the meaning of the "Disputes" article of this contract; however, nothing in this article shall excuse the Contractor from proceeding with the contract as changed.

(f) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

#### **ARTICLE 7. INSPECTION AND INSPECTION SYSTEM**

(a) Except as otherwise provided in this contract, all material and workmanship shall be subject to inspection, examination and test by AUI at any and all times during the manufacture and/or construction and at any and all places where such manufacture and/or construction are carried on. AUI shall have the right to reject defective material and workmanship or require their correction. Rejected workmanship shall be satisfactorily corrected, and rejected material shall be replaced with proper material without charge therefor and the Contractor shall promptly segregate and remove the rejected material from the premises. If the Contractor fails to proceed at once with the replacement of the rejected material and/or the correction of defective workmanship, AUI may, by contract or otherwise, replace such material and/or correct such workmanship and charge the cost thereof to the Contractor, or may terminate the right of the Contractor to proceed as provided in the Termination for Default article.

(b) The Contractor shall furnish promptly, without additional charge, all reasonable facilities, labor, and materials necessary for the safe and convenient inspection and tests that may be required by AUI. All inspection and tests by AUI shall be performed in such manner as not unnecessarily to delay the work. The Contractor may be charged with any additional cost of inspection when material and workmanship are not ready at the scheduled time of inspection as agreed between the Contractor and AUI.

(c) Should it be considered necessary or advisable by AUI at any time before final acceptance of the entire work to reexamine work already completed, the Contractor, on request, shall promptly furnish all necessary facilities, labor and materials. If such work is found to be defective or nonconforming in any material respect, due to fault of the Contractor or its subcontractors, it shall defray all the expenses of such examination and of satisfactory reconstruction. If, however, such work is found to meet the requirements of this contract, an equitable adjustment shall be made in the amount due under this contract to compensate the Contractor for the additional services rendered in such examination and reconstruction. If completion of the work has been delayed, the Contractor shall be granted a suitable extension of time on account of the additional work involved.

(d) Inspection of material and finished articles to be incorporated in the work at the site shall be made at the place of production, manufacture or shipment, whenever the quantity justifies it, unless otherwise agreed in writing between the Contractor and AUI. Such inspection and acceptance shall be final, except as to latent defects, departures from specific requirements of this contract and the Specifications and drawings made a part thereof, damage or loss in transit, fraud, or such gross mistakes as amount to fraud. Subject to the requirements contained in the preceding sentence, the inspection of material and workmanship for final acceptance as a whole or in part shall be made at the site. Nothing contained in this article shall in any way restrict AUI's right under any warranty or guarantee.

(e) The Contractor shall (1) maintain an adequate inspection system and perform such inspections as will ensure that the work performed under the contract conforms to the contract requirements, and; (2) maintain and make available to AUI adequate records of such inspections.

#### **ARTICLE 8. MATERIALS AND WORKMANSHIP WARRANTY**

(a) All equipment, material, and articles incorporated into the work covered by this contract shall be new and of the most suitable grade for the purpose intended, unless otherwise specifically provided in this contract. References in the specifications to equipment, material, articles, or patented processes by trade name, make, or catalog number, shall be regarded as establishing a standard of quality and shall not be construed as limiting competition. The Contractor may, at its option, use any equipment, material, article, or process that, in the judgment of AUI, is equal to that named in the specifications, unless otherwise specifically provided in this contract. This paragraph does not apply to the paint specifications.

(b) The Contractor shall obtain AUI's approval of the machinery and mechanical and other equipment to be incorporated into the work. When requesting approval, the Contractor shall furnish to AUI the name of the manufacturer, the model number, and other information concerning the performance, capacity, nature, and rating of the machinery and mechanical and other equipment. When required by this contract or by AUI, the Contractor shall also obtain AUI's approval of the material or articles which the Contractor contemplates incorporating into the work. When requesting approval, the Contractor shall provide full information concerning the material or articles. When directed to do so, the Contractor shall submit samples for approval at the Contractor's expense, with all shipping charges prepaid. Machinery, equipment, material, and articles that do not have the required approval shall be installed or used at the risk of subsequent rejection.

(c) All work under this contract shall be performed in a skillful and workmanlike manner. AUI may require, in writing, that the Contractor remove from the work any employee AUI deems incompetent, careless, or otherwise objectionable.

#### **ARTICLE 9. WARRANTY**

Unless otherwise expressly provided herein, the Contractor warrants to AUI that the goods to be delivered hereunder shall be free from defects in design, material, workmanship, and title, shall fully conform to the specifications and shall meet all the requirements of this contract. If it appears at any time or times within one (1) year from the date of final acceptance by AUI that the goods delivered hereunder do not meet the warranty specified above, and AUI notifies the Contractor promptly to this effect, the Contractor shall thereupon correct any defect, including non-conformity with the specifications, at its own expense, in a manner satisfactory to AUI, or, at the option of and at no cost to AUI, replace the goods F.O.B. AUI's premises with goods conforming to the requirements. If installation and/or final testing is required as a condition of this Contract, the Contractor warrants that the material, equipment, and apparatus, after such installation and/or final testing, shall give proper and continuous service under all conditions and services required and

specified, or which may be reasonably inferred from the specification. This warranty shall be applicable to any and all corrected or replaced parts, material, or workmanship until one (1) year after the delivery, or, as the case may be, the installation, final testing and acceptance of the same. The rights and remedies specified in this Article shall be without prejudices to any other rights or remedies that AUI may have for breach of warranty.

#### **ARTICLE 10. PREFERENCE FOR UNITED STATES-FLAG AIR CARRIERS**

1. "International air transportation," as used in this article, means transportation by air between a place in the United States and a place outside the United States, or between two places both of which are outside the United States.

"United States," as used in this article, means the 50 States, the District of Columbia, the Commonwealth of Puerto Rico, and possessions of the United States.

"United States-flag air carrier," as used in this article, means an air carrier holding a certificate under Section 401 of the Federal Aviation Act of 1958 (49 USC 1371).

2. Section 5 of the International Air Transportation Fair Competitive Practices Act of 1974 (49 USC 1517 (Fly America Act)) requires that all Federal agencies and U.S. Government Contractors and subcontractors use U.S. flag air carriers for U.S. Government financed international air transportation of personnel (and their personal effects) or property, to the extent that service by those carriers is available. It requires the Comptroller General of the United States, in the absence of satisfactory proof of the necessity for foreign-flag air transportation, to disallow expenditures from funds, appropriated or otherwise established for the account of the United States, for international air transportation secured aboard a foreign-flag air carrier if a U.S.-flag air carrier is available to provide such services.

3. The Contractor agrees, in performing work under this contract, to use U.S.-flag air carriers for international air transportation of personnel (and their personal effects) or property to the extent that service by those carriers is available.

4. In the event that the Contractor selects a carrier other than a U.S.-flag air carrier for international air transportation, the Contractor shall include a certification on vouchers involving such transportation essentially as follows:

## CERTIFICATION OF UNAVAILABILITY OF U.S.-FLAG AIR CARRIERS

I hereby certify that international air transportation of persons (and their personal effects) or property by U.S.-flag air carrier was not available or it was necessary to use foreign-flag air carrier service for the following reasons (see Section 47.403 of the Federal Acquisition Regulation).  
[STATE REASONS]:

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(end of certification)

5. The Contractor shall include the substance of this article, including this paragraph 5., in each subaward or purchase under this agreement that may involve international air transportation.

### ARTICLE 11. ASSIGNMENT

Neither this contract nor any interest therein, or claim thereunder, shall be assigned or transferred by the Contractor except with the prior written approval of AUI. AUI may assign this contract in whole or in part to the U.S. Government and in the event of such assignment this contract shall continue in full force and effect, notwithstanding the termination of the Cooperative Agreement between the U.S. Government and AUI. The Contractor agrees to look solely to the U.S. Government for payment of the part so assigned; subject to such assignment and acceptance by the U.S. Government this contract does not bind or purport to bind the National Science Foundation or the U.S. Government.

### ARTICLE 12. AUDIT

(a) Examination of costs. The Contractor shall maintain—and AUI and NSF or representatives of either shall have the right to examine and audit—books, records, documents, and other evidence and accounting procedures and practices, sufficient to reflect properly all costs claimed to have been incurred or anticipated to be incurred in performing this contract. This right of examination shall include inspection at all reasonable times of the Contractor's plants, or parts of them, engaged in performing the contract.

(b) Cost or pricing data. If, pursuant to law, the Contractor has been required to submit cost or pricing data in connection with pricing this contract or any modification to this contract, representatives of AUI or the National Science Foundation shall have the right to examine and audit all books, records, documents, and other data of the Contractor (including computations and projections) related to negotiating, pricing, or performing the contract or modification, in order to evaluate the accuracy, completeness, and currency of the cost or pricing data. The right of examination shall extend to all documents necessary to permit adequate evaluation of the cost or pricing data submitted, along with the computations and projections used.

(c) Reports. If the Contractor is required to furnish cost, funding, or performance reports, representatives of AUI or the National Science Foundation shall have the right to examine and audit books, records, other documents, and supporting materials, for the purpose of evaluating (1) the effectiveness of the Contractor's policies and procedures to produce data compatible with the objective of these reports and (2) the data reported.

(d) Availability. The Contractor shall make available at its office at all reasonable times the materials described above, for examination, audit, or payment under this contract, or for any shorter period specified in Subpart 4.7. Contractor Records Retention, of the Federal Acquisition Regulation, or for any longer period required by statute or by other articles of this contract. In addition:

- (1) If this contract is completely or partially terminated, the records relating to the work terminated shall be made available for 3 years after any resulting final termination settlement.
- (2) Records relating to appeals under the Disputes article or to litigation or the settlement of claims arising under or relating to this contract shall be made available until such appeals, litigation, or claims are disposed of.

(e) The Contractor shall insert an article containing all the terms of this article, including this paragraph (e), in all subcontracts over \$10,000 under this contract, altering the article only as necessary to identify properly the National Science Foundation and AUI.

### **ARTICLE 13. EXAMINATION OF RECORDS**

(a) The Contractor agrees that the Comptroller General of the United States or any of his duly authorized representatives shall, until the expiration of three years after final payment under this contract or such lesser time specified in the Federal Acquisition Regulations (Subpart 4.7, Contractor Records Retention) have access to and the right to examine any directly pertinent books, documents, papers, and records of the Contractor involving transactions related to this contract.

(b) The Contractor further agrees to include in all his subcontracts hereunder a provision to the effect that the Subcontractor agrees that the Comptroller General of the United States or any of his duly authorized representatives shall, until the expiration of three years after final payment under the subcontract or such lesser time specified in the Federal Acquisition Regulation Subpart 4.7 have access to and the right to examine any directly pertinent books, documents, papers, and records of such Subcontractor, involving transactions related to the subcontract. The term "subcontract" as used in this article excludes subcontracts or purchase orders for public utility services at rates established for uniform applicability to the general public, plus any applicable reasonable connection charge.



(c) The periods of access and examination described in (a) and (b), above, for records which relate to (1) appeals under the "Disputes" article of this contract, (2) litigation or the settlement of claims arising out of the performance of this contract, or (3) costs and expenses of this contract to which exception has been taken by the Comptroller General or any of his duly authorized representatives, shall continue until such appeals, litigations, claims, or exceptions are disposed of.

#### **ARTICLE 14. U.S. GOVERNMENT PROPERTY**

The Contractor assumes the risk of, and shall be responsible for any loss of or damage to U.S. Government property or AUI property in its possession, except for reasonable wear and tear, and except to the extent that such property is consumed in the performance of this contract. The term "U.S. Government property" shall be taken to mean property, title to which is vested in the U.S. Government. The term "AUI property" shall be taken to mean property, title to which is vested in AUI.

#### **ARTICLE 15. INSURANCE**

Where the Contractor is required to work on a site or sites owned or operated by AUI or the U.S. Government:

(a) The Contractor will maintain policies providing the following insurance protection for the Contractor, which insurance shall apply to all operations of the Contractor under this contract and employees of the Contractor engaged therein. The Contractor shall also provide an endorsement to its liability policies naming AUI as additional insured.

- (1) **WORKER'S COMPENSATION**—Coverage, as provided in the Worker's Compensation Law, including occupational disease coverage, by the law of the State where the work is performed. Where all or any portion of this contract is performed in more than one State, Worker's Compensation coverage shall not be less than that of the State requiring the highest limits.
- (2) **GENERAL LIABILITY**—Insurance with limits of \$500,000/\$1,000,000 for bodily injury liability and \$100,000 property damage in the comprehensive policy form.
- (3) **VEHICLE PUBLIC LIABILITY AND PROPERTY DAMAGE**—Insurance with limits of \$500,000/\$1,000,000 for bodily injury liability and \$100,000 for property damage liability on the comprehensive policy form covering all owned, non-owned, and hired vehicles which will be used in connection with the work to be done under this contract.

(b) The Contractor may purchase at its own expense such additional or other insurance protection as it may deem necessary. AUI may allow or restrict access to the site of the work to such personnel of any insurance carrier providing additional or other insurance coverage to that referred

to in the foregoing paragraph (a) as AUI may deem necessary for the proper servicing of such insurance.

(c) The Contractor shall furnish three copies of a certificate of insurance naming Associated Universities, Inc., as an additional insured, to show compliance with subparagraph (a) above. The Contractor shall furnish AUI with renewal notices of all applicable insurance policies.

(d) The Contractor shall require that its subcontractors, any tier, working on the site shall maintain as a minimum the insurance coverage set out in paragraph (a) above, and shall provide that such subcontractors provide AUI with certificates of insurance as provided in paragraph (c) above.

#### **ARTICLE 16. TERMINATION FOR DEFAULT**

(a) If the Contractor refuses or fails to prosecute the work, or any separable part thereof, with such diligence as will ensure its completion within the time specified in this contract, or any extension thereof, or fails to complete said work within such time, AUI may, by written notice to the Contractor, terminate his right to proceed with the work or such part of the work as to which there has been delay. In such event, AUI may take over the work, and prosecute the work to completion, by contract or otherwise, and may take possession of and utilize in completing the work such materials, appliances, and plant as may be on the site of the work and necessary thereof. Whether or not the Contractor's right to proceed with the work is terminated, he and his sureties shall be liable for any damage to AUI resulting from his refusal or failure to complete the work within the specified time.

(b) If fixed and agreed liquidated damages are provided in the contract and if AUI so terminates the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until such reasonable time as may be required for final completion of the work together with any increased costs occasioned AUI in completing the work.

(c) If fixed and agreed liquidated damages are provided in the contract and if AUI does not so terminate the Contractor's right to proceed, the resulting damage will consist of such liquidated damages until the work is completed or accepted.

(d) The Contractor's right to proceed shall not be so terminated nor the Contractor charged with resulting damage if:

- (1) The delay in the completion of the work arises from unforeseeable causes beyond the control and without the fault or negligence of the Contractor, including but not restricted to acts of God, acts of the public enemy, acts of AUI in its contractual capacity, acts of another contractor in performance of a contract with AUI, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather, or delays of subcontractors or suppliers at any tier arising from unforeseeable causes beyond the control

and without the fault or negligence of both the Contractor and such subcontractors or suppliers; and

- (2) The Contractor within ten (10) days from the beginning of such delay (unless AUI grants a further period of time before the date of the final payment under the contract), notifies AUI in writing of the causes of delay.

AUI shall ascertain the facts and the extent of the delay and extend the time for completing the work when, in its judgment, the findings of fact justify such an extension, and its findings of fact shall be final and conclusive on the parties subject only to appeal as provided in the article of this contract entitled "Disputes."

(e) If, after notice of termination of the Contractor's right to proceed under the provisions of this article, it is determined for any reason that the Contractor was not in default under the provisions of this article, or that the delay was excusable under the provisions of this article, the rights and obligations of the parties shall, if the contract contains an article providing for termination for convenience of AUI, be the same as if the notice of termination has been issued pursuant to such article. If, in the foregoing circumstances, this contract does not contain an article providing for termination for convenience by AUI, the contract shall be equitably adjusted to compensate for such termination and the contract modified accordingly; failure to agree to any such adjustment shall be a dispute concerning a question of fact within the meaning of the article of this contract entitled "Disputes."

(f) The rights and remedies of AUI provided in this article are in addition to any other rights and remedies provided by law or under this contract.

#### **ARTICLE 17. TERMINATION FOR CONVENIENCE**

(a) The performance of work under this contract may be terminated by AUI in accordance with this article in whole, or from time to time in part, whenever AUI or the U.S. Government shall determine that such termination is in the best interest of AUI or the U.S. Government. Any such termination shall be effected by delivery to the Contractor of a Notice of Termination specifying the extent to which performance of work under the contract is terminated, and the date upon which such termination becomes effective.

(b) After receipt of a Notice of Termination, and except as otherwise directed by AUI, the Contractor shall:

- (1) Stop work under the contract on the date and to the extent specified in the Notice of Termination;
- (2) Place no further orders or subcontracts for materials, services, or facilities except as may be necessary for completion of such portion of the work under contract as is not terminated;

- (3) Terminate all orders and subcontracts to the extent that they relate to the performance of work terminated by the Notice of Termination;
  - (4) Assign to AUI, in the manner, at the time, and to the extent directed by AUI, all of the right, title, and interest of the Contractor under the orders and subcontracts so terminated, in which case AUI shall have the right, in its discretion, to settle or pay any or all claims arising out of termination of such orders and subcontracts;
  - (5) Settle all outstanding liabilities and all claims arising out of such termination of orders and subcontracts, with the approval or ratification of AUI to the extent it may require, which approval or ratification shall be final for all the purposes of this article;
  - (6) Transfer title to the U.S. Government and deliver in the manner, at the times, and to the extent, if any, as directed by AUI:
    - (i) The fabricated or unfabricated parts, work in progress, completed work, supplies, and other material produced as part of, or acquired in connection with the performance of, the work terminated by the Notice of Termination, and
    - (ii) The completed or partially completed plans, drawings, information, and other property which, if the contract has been completed, would have been required to be furnished to AUI.
  - (7) Use its best efforts to sell, in the manner, at the times, to the extent, and at the price or prices directed or authorized by AUI, any property of the types referred to in (6) above. The Contractor may acquire any such property under the conditions prescribed and at a price or prices approved by AUI. The proceeds of any such transfer or disposition shall be credited to the price or cost of the work covered by this contract or paid as AUI may direct;
  - (8) Complete performance of such part of the work as shall not have been terminated by the Notice of Termination; and
  - (9) Take such action as may be necessary, or as AUI may direct, for the protection and preservation of the property related to this contract.
- (c) After receipt of a Notice of Termination, the Contractor shall submit to AUI its termination claim, in the form and with the certification prescribed by AUI. Such claim shall be submitted promptly but in no event later than six (6) months from the effective date of termination, unless one or more extensions in writing are granted by AUI upon written request of the Contractor within such six month period or authorized extension thereof.
- (d) Subject to the provisions of paragraph (c), the Contractor and AUI may agree upon the whole or any part of the amount or amounts to be paid to the Contractor by reason of the total or

partial termination of work pursuant to this article, which amount or amounts may include a reasonable allowance for profit on work done. Such agreed amount or amounts, exclusive of settlement costs, shall not exceed the total contract price as reduced by the amount of payments otherwise made and as further reduced by the contract price of work not terminated. The contract shall be amended accordingly, and the Contractor shall be paid the agreed amount.

(e) In arriving at the amount due the Contractor under this article, there shall be deducted:

- (1) All unliquidated advance or other payments on account made to the Contractor, applicable to the terminated portion of this contract,
- (2) Any claim which AUI may have against the Contractor in connection with this contract, and
- (3) The agreed price for, or the proceeds of sale of, any materials, supplies, or other things kept by the Contractor or sold, pursuant to the provisions of this claim, and not otherwise recovered by or credited to AUI.

(f) If the termination hereunder is partial, prior to the settlement of the terminated portion of this contract, the Contractor may file with AUI a request in writing for an equitable adjustment of the price or prices specified in the contract relating to the continued portion of the contract (the portion not terminated by the Notice of Termination), and such equitable adjustment as may be agreed upon shall be made in such price or prices.

#### **ARTICLE 18. DISPUTES**

Any controversy or claim arising out of or relating to this contract, or the breach thereof, shall be settled by arbitration in accordance with the rules of the American Arbitration Association. Hearings shall be held in the City of Charlottesville, Commonwealth of Virginia, unless an alternate site is designated by mutual agreement. Judgment upon the award rendered by the arbitrators may be entered in any court having jurisdiction thereof. Pending the final decision of any dispute under or in connection with this contract that may arise prior to the completion of performance hereunder, the Contractor shall diligently proceed with the performance of its undertakings.

#### **ARTICLE 19. COPYRIGHTABLE MATERIAL**

1. "Subject writing" means any material that:

- (a) is or may be copyrightable under Title 17 of the United States Code, and
- (b) is produced by the Contractor or its employees in the performance of work under this contract.

"Subject writings" includes such items as reports, books, journal articles, software, sound recordings, video tapes, and video discs. "Subject writings" do not include adaptations of, modifications to, and improvements on material produced in the performance of work under this contract so long as the adaptation, modification, or improvement is not performed under this contract.

2. Copyright Ownership, U.S. Government License. The Contractor may own or permit others to own the subject writings and copyrights therein. The Contractor agrees that if it or anyone else does own copyright in a subject writing, the U.S. Government will have a nonexclusive, nontransferable, irrevocable, royalty-free license to exercise or have exercised for or on behalf of the United States throughout the world all exclusive rights provided by copyright. Such license, however, will not include the right to sell copies or phonorecords of the copyrighted work to the public.

3. Delivery of Subject Writings. The Contractor agrees to deliver to the National Science Foundation (NSF), on written request from the Grants and Agreements Officer, two copies of any subject writing. The Contractor may identify portions of any subject writing that it believes to be exempt from disclosure under the Freedom of Information Act and request that NSF not disclose those portions outside the U.S. Government.

4. Publications. The Contractor may transfer or permit its employees to transfer rights to a subject writing submitted for publication in a scientific journal, another periodical, a book, or a collection. Any transfer of rights to a subject writing for publication will include a requirement that an acknowledgment of NSF support and, if appropriate, a disclaimer be published with the subject writing.

5. Approval of Commercialization Plans. The Contractor will obtain the written approval of the NSF Grants and Agreements Officer before transferring to any party exclusive or nonexclusive rights for commercial development, use, or sale of subject writings. The Contractor may request such permission for a particular transaction, all transactions planned for a particular subject writing, a class of transactions, or a class of subject writings.

6. Income. Unless otherwise specifically approved by the NSF Grants and Agreements Officer, all income earned by the Contractor from subject writings, after payment of expenses incidental to the preparation and dissemination of subject writings, including costs associated with commercial development, will be used to support scientific research or education consistent with the mission and objectives of AUI and the National Radio Astronomy Observatory.

7. Contractor Action to Protect U.S. Government's Interest. The Contractor agrees to acquire, through written agreement or an employment relationship, the ability to comply with the requirements of the preceding paragraphs. The Contractor further agrees that any transfer of copyright or any other rights to a subject writing, by it or anyone whom it has allowed to own such rights, will be subject to the requirements of this article. Finally, the Contractor agrees that it will

not deliver to NSF any copyrighted material other than subject writings unless it has obtained for the U.S. Government a license for such material identical to that reserved in subject writings by paragraph 2 of this article.

8. NSF Response to Requests, Appeal. NSF will respond to a request that portions of a subject writing be withheld from disclosure before disclosing the material and to a request for approval of a commercialization plan within thirty days. The Contractor may appeal a complete or partial denial of its request to the NSF Director of the Division of Grants and Agreements.

## **ARTICLE 20. PATENT RIGHTS**

### **1. Definitions**

(a) "Invention" means any invention or discovery which is or may be patentable or otherwise protectable under Title 25 of the United States Code (USC), or any novel variety of plant which is or may be protected under the Plant Variety Protection Act (USC 2321 et. seq.).

(b) "Subject invention" means any invention of the Contractor conceived or first actually reduced to practice in the performance of work under this contract, provided that in the case of a variety of plant, the date of determination (as defined in Section 41(d) of the Plant Variety Protection Act, 7 USC 2401(d) must also occur during the period of contract performance.

(c) "Practical application" means to manufacture in the case of a composition or product, to practice in the case of a process or method, or to operate in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is being utilized and that its benefits are, to the extent permitted by law or U.S. Government regulations, available to the public on reasonable terms.

(d) "Made" when used in relation to any invention means the conception or first actual reduction to practice of such invention.

(e) "Small business firm" means a domestic small business concern as defined at Section 2 of Public Law 85-536 (15 USC 632) and implementing regulations of the Administrator of the Small Business Administration. For the purpose of this article, the size standards for small business concerns involved in U.S. Government procurement and subcontracting/subawarding at 13 CFR 121.3-8 and 13 CFR 121.3-12, respectively, will be used.

(f) "Nonprofit organization" means a university or other institution of higher education or an organization of the type described in Section 501(c)(3) of the Internal Revenue Code of 1954 (26 USC 501(c)) and exempt from taxation under Section 501(a) of the Internal Revenue Code of (25 USC 501(a)) or any nonprofit scientific or educational organization qualified under a state nonprofit organization statute.

## 2. Allocation of Principal Rights

The Contractor may retain the entire right, title, and interest throughout the world to each subject invention subject to the provisions of this article and 35 USC 203. With respect to any subject invention in which the Contractor retains title, the U.S. Government shall have a non-exclusive, non-transferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States the subject invention throughout the world.

## 3. Invention Disclosure, Election of Title and Filing of Patent Application by Contractor

(a) The Contractor will disclose each subject invention to the National Science Foundation (NSF) within two months after the inventor discloses it in writing to Contractor personnel responsible for patent matters. The disclosure to NSF shall be in the form of a written report and shall identify the agreement under which the invention was made and the inventor(s). It shall be sufficiently complete in technical detail to convey a clear understanding to the extent known at the time of the disclosure, of the nature, purpose, operation, and the physical, chemical, biological, or electrical characteristics of the invention. The disclosure shall also identify any publication, on sale or in public use of the invention and whether a manuscript describing the invention has been accepted for publication at the time of disclosure. In addition, after disclosure to NSF, the Contractor will promptly notify NSF of the acceptance of any manuscript describing the invention for publication or of any on sale or public use planned by the Contractor.

(b) The Contractor will elect in writing whether or not to retain title to any such invention by notifying NSF within two years of disclosure to NSF. However, in any case where publication, on sale, or public use has initiated the one-year statutory period wherein valid patent protection can still be obtained in the United States, the period for election of title may be shortened by NSF to a date that is no more than 60 days prior to the end of the statutory period.

(c) The Contractor will file its initial patent application on a subject invention to which it elects to retain title within one year after election of title or, if earlier, prior to the end of any statutory period wherein valid patent protection can be obtained in the United States after a publication, on sale, or public use. The Contractor will file patent applications in additional countries or international patent offices within either ten months of the corresponding initial patent application or six months from the date permission is granted by the Commissioner of Patents and Trademarks to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

(d) Requests for extension of the time for disclosure election, and filing under subparagraphs (a), (b), and (c) may, at the discretion of NSF be granted.

## 4. Conditions When the U.S. Government May Obtain Title

The Contractor will convey to NSF, upon written request, title to any such invention:



(a) If the Contractor fails to disclose or elect title to the subject invention within the times specified in 3., above, or elects not to retain title; provided that NSF may only request title within 60 days after learning of the failure of the Contractor to disclose or elect within the specified times.

(b) In those countries in which the Contractor fails to file patent applications within the times specified in 3., above; provided, however, that if the Contractor has filed a patent application in a country after the times specified in 3., above, but prior to its receipt of the written request of NSF, the Contractor shall continue to retain title in that country.

(c) In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceeding on, a patent on a subject invention.

#### 5. Minimum Rights to Contractor and Protection of the Contractor Right to File

(a) The Contractor will retain a non-exclusive, royalty-free, license throughout the world in each subject invention to which the U.S. Government obtains title, except if the Contractor fails to disclose the invention within the times specified in 3., above. The Contractor's license extends to its domestic subsidiary and affiliates, if any, within the corporate structure of which the Contractor is a party and includes the right to grant sublicenses of the same scope to the extent the Contractor was legally obligated to do so at the time the contract was awarded. The license is transferable only with the approval of NSF except when transferred to the successor of that party of the Contractor's business to which the invention pertains.

(b) The Contractor's domestic license may be revoked or modified by NSF to the extent necessary to achieve expeditious practical application of the subject invention pursuant to an application for an exclusive license submitted in accordance with applicable provisions at 37 CFR Part 404 and NSF licensing regulations (if any). This license will not be revoked in that field of use or the geographical areas in which the Contractor has achieved practical application and continues to make the benefits of the invention reasonably accessible to the public. The license in any foreign country may be revoked or modified at the discretion of NSF to the extent the Contractor, its licensees, or the domestic subsidiaries or affiliates have failed to achieve practical application in that foreign country.

(c) Before revocation or modification of the license, NSF will furnish the Contractor a written notice of its intention to revoke or modify the license, and the Contractor will be allowed 30 days (or such other time as may be authorized by NSF for good cause shown by the Contractor) after the notice to show cause why the license should not be revoked or modified. The Contractor has the right to appeal, in accordance with applicable regulations in 37 CFR Part 404 and NSF regulations (if any) concerning the licensing of U.S. Government-owned inventions, any decision concerning the revocation or modification of its license.

#### 6. Contractor Action to Protect the U.S. Government's Interest

(a) The Contractor agrees to execute or to have executed and promptly deliver to NSF all instruments necessary to: (1) establish or confirm the rights the U.S. Government has throughout the world in those subject inventions to which the Contractor elects to retain title, and (2) convey title to NSF when requested under paragraph 4., above, and to enable the U.S. Government to obtain patent protection throughout the world in that subject invention.

(b) The Contractor agrees to require, by written agreement, its employees, other than clerical and non-technical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in a format suggested by the Contractor each subject invention made under contract in order that the Contractor can comply with disclosure provisions of paragraph 3., above, and to execute all papers necessary to file patent applications on subject inventions and to establish the U.S. Government's right in the subject inventions. The disclosure format should require, as a minimum, the information required by 3(a), above. The Contractor shall instruct such employees through employee agreements or other suitable educational programs on the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to United States or foreign statutory bars.

(c) The Contractor will notify NSF of any decision not to continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than 30 days before the expiration of the response period required by the relevant patent office.

(d) The Contractor agrees to include, within the specification of any United States patent applications and any patent issuing thereon covering a subject invention, the following statement:

“This invention was made with U.S. Government support under (identify the agreement) awarded by the National Science Foundation. The U.S. Government has certain rights in this invention.”

## 7. Subcontracts

The Contractor will include this article, suitably modified to identify the parties, in all subcontracts, regardless of tier, for experimental, developmental, or research work. The Subcontractor will retain all rights provided for the Contractor in this article, and the Contractor will not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractors subject inventions.

## 8. Reporting on Utilization of Subject Inventions

The Contractor agrees to submit on request periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining such utilization that are being made by the Contractor or its licensees or assignees. Such reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the

Contractor, and such other data and information as NSF may reasonably specify. The Contractor also agrees to provide additional reports as may be requested by NSF in connection with any march-in proceeding undertaken by NSF in accordance with paragraph 10. of this article. As required by 35 USC 202(c)(5), NSF agrees it will not disclose such information outside the U.S. Government without permission of the Contractor.

#### 9. Preference for United States Industry

Notwithstanding any other provision of this article, the Contractor agrees that neither it nor any assignee will grant to any person the exclusive right to use or sell any subject invention in the United States unless such person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for such an agreement may be waived by NSF upon a showing by the Contractor or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that under the circumstances domestic manufacture is not commercially feasible.

#### 10. March-in Rights

The Contractor agrees that with respect to any subject invention in which it has acquired title, NSF has the right in accordance with procedures in 37 CFR 401.6 and NSF regulations at 45 CFR 650.13 to require the Contractor, an assignee, or exclusive licensee of a subject invention to grant a nonexclusive, partially exclusive, or exclusive license in any field of use to a responsible applicant or applicants, upon terms that are reasonable under the circumstances, and if the Contractor, assignee, or exclusive licensee refuses such a request, NSF has the right to grant such a license itself if NSF determines that:

(a) Such action is necessary because the Contractor or assignee has not taken, or is not expected to take within a reasonable time, effective steps to achieve practical application of the subject invention in such field of use;

(b) Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the Contractor, assignee, or their licensees;

(c) Such action is necessary to meet requirements for public use specified by Federal regulations and such requirements are not reasonably satisfied by the Contractor, assignee, or licensee; or

(d) Such action is necessary because the agreement required by paragraph 9. of this article has not been obtained or waived or because a licensee of the exclusive right to use or sell any subject invention in the United States is in breach of such agreement.

## 11. Special Provisions for Awards With Nonprofit Organizations

If the Contractor is a nonprofit organization, it agrees that:

(a) Rights to a subject invention in the United States may not be assigned without the approval of NSF, except where such assignment is made to an organization which has as one of its primary functions the management of inventions, provided that such assignee will be subject to the same provisions as the Contractor;

(b) The Contractor will share royalties collected on a subject invention with the inventor, including Federal employee co-inventors (when the agency deems it appropriate) when the subject invention is assigned in accordance with 35 USC 202(e) and 37 CFR 401.10;

(c) The balance of any royalties or income earned by the Contractor with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration of subject inventions, will be utilized for the support of scientific research or education; and

(d) It will make efforts that are reasonable under the circumstances to attract licensees of subject invention that are small business firms and that it will give a preference to a small business firm when licensing a subject invention if the Contractor determines that the small business firm has a plan or proposal for marketing the invention which, if executed, is equally as likely to bring the invention to practical application as any plans or proposals from applicants that are not small business firms; provided that the Contractor is also satisfied that the small business firm has the capability and resources to carry out its plan or proposal. The decision whether to give a preference in any specific case will be at the discretion of the Contractor. However, the Contractor agrees that the NSF may review the Contractor licensing program and decisions regarding small business applicants, and the Contractor will negotiate changes to its licensing policies, procedures, or practices with the NSF when the NSF's review discloses that the Contractor could take reasonable steps to implement more effectively the requirements of this paragraph 11(d).

## 12. Communications

All disclosures, elections, confirmations of the U.S. Government license, copies of patents, and other routine communications should be sent to the NSF Patent Paralegal, Office of the General Counsel, National Science Foundation, Arlington, VA 22230. Requests for waivers and other exceptional communications with the Foundation regarding this clause should be addressed to the NSF Intellectual Property Attorney, Office of the General Counsel, National Science Foundation, Arlington, VA 22230.

## **ARTICLE 21. AUTHORIZATION AND CONSENT**

The U.S. Government hereby gives its authorization and consent for all use and manufacture of any invention described in and covered by a patent of the United States in performance of the contract or any part hereof or any amendment hereto or any subcontract hereunder (including any lower-tier subcontract).

## **ARTICLE 22. NOTICE AND ASSISTANCE REGARDING PATENT AND COPYRIGHT INFRINGEMENT**

1. The Contractor shall report to the NSF Grants and Agreements Officer, promptly and in reasonable written detail, each notice or claim of patent or copyright infringement based on the performance of this contract of which the Contractor has knowledge.

2. In the event of any claim or suit against the U.S. Government on account of any alleged patent or copyright infringement arising out of the performance of this contract or out of the use of any supplies furnished or work or services performed hereunder, the Contractor shall furnish to the U.S. Government, when requested by the NSF Grants and Agreements Officer, all evidence and information in possession of the Contractor pertaining to such suit or claim. Such evidence and information shall be furnished at the expense of the U.S. Government except where the Contractor has agreed to indemnify the U.S. Government.

## **ARTICLE 23. CLEAN AIR AND WATER**

1. "Air Act," as used in this article, means the Clean Air Act (42 USC 7401 et. seq.).

"Clean air standard," as used in this article, means:

(a) Any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions, work practices, or other requirements contained in, issued under, or otherwise adopted under the Air Act or Executive Order 11738;

(b) An applicable implementation plan as described in Section 110(d) of the Air Act (42 USC 7410 (d));

(c) An approved implementation procedure or plan under Section 111(c) or Section 111(d) of the Air Act (42 USC 7411 (c) or (d)); or

(d) An approved implementation procedure under Section 111(d) of the Air Act (42 USC 7412(d)).

"Clean water standard," as used in this article, means any enforceable limitation, control, condition, prohibition, standard, or other requirement promulgated under the Water Act or contained

in a permit issued to a discharger by the Environmental Protection Agency or by a State under an approved program, as authorized by Section 402 of the Water Act (33 USC 1342), or by local government to ensure compliance with pretreatment regulations as required by Section 307 of the Water Act (33 USC 1317).

“Compliance,” as used in this article, means complied with:

- (a) Clean air or water standards; or
- (b) A schedule or plan ordered or approved by a court of competent jurisdiction, the Environmental Protection Agency, or an air or water pollution control agency under the requirements of the Air Act or Water Act and related regulations.

“Facility,” as used in this article, means any building, plant, installation, structure, mine, vessel, or other floating craft, location, or site of operations, owned, leased, or supervised by a Contractor or Subcontractor used in the performance of a contract or subcontract. When a location or site of operations includes more than one building, plant, installation, or structure, the entire location or site shall be deemed a facility except when the Administrator, or a designee, of the Environmental Protection Agency, determines that independent facilities are colocated in one geographical area.

“Water Act,” as used in this article, means Clean Water Act (33 USC 1251 et. seq.).

2. The Contractor agrees:

- (a) To comply with all the requirements of Section 114 of the Clean Air Act (42 USC 7414) and Section 308 of the Clean Water Act (33 USC 1318) relating to inspection, monitoring, entry, reports, and information, as well as other requirements specified in Section 114 and Section 308 of the Air Act and the Water Act, and all regulations and guidelines issued to implement those acts before the award of this contract;
- (b) That no portion of the work required by this contract will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this contract was awarded unless and until the EPA eliminates the name of the facility from the listing;
- (c) To use best efforts to comply with clean air standards and clean water standards at the facility in which the contract work is being performed; and
- (d) To insert the substance of this article into any non-exempt subcontract, including this subparagraph 2(d).

## **ARTICLE 24. NATIONAL SECURITY: CLASSIFIABLE RESULTS ORIGINATING UNDER THIS AGREEMENT**

1. The National Science Foundation does not have original classification authority and does not normally support classified projects. It therefore does not expect that results of NSF-supported research projects will be classifiable, except in very rare instances.

2. Executive Order 12356 (47 Federal Register 14874-1982) states that basic scientific research information not clearly related to the national security may not be classified (Section 1.6(b)). Nevertheless, some information concerning, among other things, scientific, technological, or economical matters relating to the national security or cryptology may require classification (Section 1.3(a)).

3. There may therefore be cases when a Contractor originates information during the course of an NSF-supported project that AUI and/or the Contractor believes requires classification under Executive Order 12356 (Section 1.2(e)).

4. In such a case, the Contractor has the responsibility promptly to :

1. submit the information directly to the U.S. Government agency with appropriate subject matter interest and classification authority, or, if uncertain which agency should receive the information, to the Director of the Information Security Oversight Office, General Services Administration;
2. protect the information as though it were classified until it is informed that the information does not require classification, but no longer than thirty (30) days after receipt by the agency with subject matter interest or by the General Services Administration; and
3. notify AUI and the cognizant NSF Program Officer.

5. The Executive Order requires the agency with appropriate subject matter interest and classification authority to decide within thirty (30) days whether to classify the material. If it determines the information to require classification, the Contractor shall cooperate with that agency, the NSF, or other appropriate agencies in securing all related project notes and papers.

## **ARTICLE 25. HEALTH AND SAFETY**

1. The Contractor shall take all reasonable precautions in the performance of the work under this contract to protect the health and safety of employees and of the public and to minimize danger from all hazards to life and property and shall comply with all health, safety, and fire protection regulations and requirements (including reporting requirements) required by Federal, State, and local

authorities, including but not limited to, OSHA 29CFR1910, OSHA29CFR1926, and EPA 40CFR260-299.

2. The Contractor shall maintain an accurate record of all cases of death, occupational disease, or injury arising out of, or in the course of, employment incident to performance of the work under this contract. In addition, the Contractor shall promptly furnish AUI and the NSF Grants and Agreements Officer details of any deaths, serious occupational diseases, injuries resulting in permanent handicaps, and major accidents occurring in connection with this contract.

3. The Contractor further agrees to indemnify and hold harmless the U.S. Government, the National Science Foundation, and AUI and their respective officers, agents and employees from any loss, damage, fine, penalty or any expense whatsoever as a result of Contractor's or its Subcontractor(s) failure to comply with OSHA and any standards or regulations issued thereunder.

4. The Contractor shall comply with any requirements established by AUI for operations on site including, but not limited to, those listed in paragraph 5 below. In the event that the Contractor fails to comply with any such safety regulations or requirements, AUI may without prejudice to any other legal or contractual rights, issue an order stopping all or any part of the work. Thereafter a start order for resumption of the work may be issued at the discretion of AUI.

#### 5. Rules

- (a) [Reserved.]
- (b) The Contractor shall meet with AUI's safety and contracting representatives prior to starting the site work to review safety matters. The Contractor is responsible for informing its employees of AUI site specific safety rules. AUI's Safety Manual will be available to the Contractor. The Contractor shall provide AUI with a copy of its safety policy manual appropriate to the work being performed.
- (c) The Contractor shall ensure that its employees wear required PPE (hard hats, safety shoes, eye and ear protections, etc.). The Contractor is responsible for the training of its employees in the work practices necessary to perform their job safety.
- (d) The Contractor shall promptly report all accidents, fires or medical problems resulting from the performance of work to AUI's Safety representative. The Contractor is responsible for providing its employees with medical care and first aid treatment.
- (e) The Contractor will not enter any AUI facility without prior authorization and unless required in the performance of the work. The Contractor shall abide by all posted safety signs, including "No Smoking" and "Do Not Enter" signs.
- (f) The Contractor will maintain at all times clean work areas free from exposure to physical or environmental hazards and will dispose of any discarded materials in a proper and legal manner.
- (g) Contractors bringing chemicals on AUI property must provide the AUI Safety representative with the appropriate MSDSs and comply with State and Federal Hazard Communication requirements.



- (h) The Contractor is required to vacate buildings immediately when fire alarm sounds.
- (i) AUI expressly prohibits illegal drugs or alcoholic beverages on AUI premises.
- (j) AUI expressly prohibits possession or use of firearms on AUI premises.

**ARTICLE 26. CONTRACT WORK HOURS AND SAFETY STANDARDS ACT—OVERTIME COMPENSATION (JULY 1995)**

This contract is subject to the Contract Work Hours and Safety Standards Act and to the applicable rules, regulations and interpretations of the Secretary of Labor.

1. Overtime Requirements—No Contractor or Subcontractor contracting for any part of the work which may require or involve the employment of laborers or mechanics (see Federal Acquisition Regulation (FAR) 22.300) shall require or permit any such laborers or mechanics in any workweek in which the individual is employed on such work to work in excess of 40 hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than 1½ times the basic rate of pay for all hours worked in excess of 40 hours in such workweek.

2. Violation, liability for unpaid wages, and liquidated damages—In the event of any violation of the provisions set forth in paragraph (a) of this article, the Contractor and any Subcontractor responsible therefor shall be liable for the unpaid wages. In addition, such Contractor and Subcontractor shall be liable to the United States (in the case of work done under agreement for the District of Columbia or territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic employed in violation of the provisions set forth in paragraph (a) of this article in the sum of \$10 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of 40 hours without payment of the overtime wages required by provisions set forth in paragraph (1) of this article.

3. Withholding for unpaid wages and liquidated damages—AUI shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by the Contractor or Subcontractor under any such agreement or any other Federal agreement with AUI, or any other Federally assisted agreement subject to the Contract Work Hours and Safety Standards Act which is held by AUI, such sums as may be determined to be necessary to satisfy any liabilities of such Contractor or Subcontractor for unpaid wages and liquidated damages as provided in the provisions set forth in paragraph (2) of this article.

4. Payrolls and basic records

(a) The Contractor or Subcontractor shall maintain payrolls and basic payroll records during the course of contract work and shall preserve them for a period of three years from the completion of the contract for all laborers and mechanics working on the contract. Such records shall contain the name and address of each such employee, social security number, correct classifications, hourly

rates of wages paid, daily and weekly number of hours worked, deductions made, and actual wages paid. Nothing in this paragraph shall require the duplication of records required to be maintained for construction work by Department of Labor regulations at 29 CFR 5.5(a)(3) implementing the Davis-Bacon Act.

(b) The records to be maintained under paragraph (4)(a) of this article shall be made available by the Contractor or Subcontractor for inspection, copying, or transcription by authorized representatives of AUI, the Grants and Agreements Officer or the Department of Labor. The Contractor or Subcontractor shall permit such representatives to interview employees during working hours on the job.

5. Subcontracts—The Contractor or Subcontractor shall insert in any subcontracts exceeding \$100,000 the provisions set forth in paragraphs (1) through (5) of this article and also an article requiring the subcontractors to include these provisions in any lower tier subcontract. The Contractor shall be responsible for compliance by any Subcontractor or lower tier Subcontractor with the provisions set forth in paragraphs (1) through (5) of this article.

## **ARTICLE 27. APPRENTICES AND TRAINEES**

1. Apprentices shall be permitted to work at less than predetermined rate for the work they perform (1) when they are employed and individually register in a bona fide apprenticeship program registered with the U.S. Department of Labor, Manpower Administration, Bureau of Apprenticeship and Training, or with a State Apprenticeship Agency recognized by the Bureau, or (2) if a person is employed in her or his first 90 days of probationary employment as an apprentice in such an apprenticeship program, who is not individually registered in the program, but who has been certified by the Bureau of Apprenticeship and Training or a State Apprenticeship Agency (where appropriate) to be eligible for probationary employment as an apprentice. The allowable ratio of apprentices to journeymen in any craft classification shall not be greater than the ratio permitted to the Contractor as to its entire work force under the registered program. Any employee listed on a payroll at an apprentice wage rate, who is not a trainee as defined in paragraph 2. of this article and who is not registered or otherwise employed as stated above, shall be paid the wage rate determined by the Secretary of Labor for the classification of work he or she actually performed. The Contractor shall furnish to AUI written evidence of the registration of its program and apprentices as well as the appropriate ratios allowed and wage rates (expressed in percentages of the journeymen hourly rates) for the area of construction, prior to using any apprentices on the contract work. The wage rate paid apprentices shall be not less than the appropriate percentage of the journeyman's rate contained in the applicable wage determination.

2. Except as provided in 29 CFR 5.15, trainees shall not be permitted to work at less than the predetermined rate for the work performed unless they are employed pursuant to and individually registered in a program which has received prior approval, evidenced by formal certification, by the U.S. Department of Labor, Manpower Administration, Bureau of Apprenticeship and Training. The term "trainee" means a person registered and receiving on-the-job training in a construction

occupation under a program which has been approved in advance by the U.S. Department of Labor, Manpower Administration, Bureau of Apprenticeship and Training, as meeting its standards for on-the-job training programs and which has been so certified by the Bureau. The ratio of trainees to journeymen shall not be greater than the ratio permitted under the plan approved by the Bureau of Apprenticeship and Training. Every trainee must be paid at not less than the rate specified in the approved program for his or her level of progress. Any employee listed on the payroll at a trainee rate who is not registered and participating in a training plan approved by the Bureau of Apprenticeship and Training shall be paid not less than the wage rate determined by the Secretary of Labor for the classification of work she or he actually performed. The Contractor shall furnish AUI written evidence of the certification of its program, the registration of the trainees, and the ratios and wage rates prescribed in the program. In the event the Bureau of Apprenticeship and Training withdraws approval of a training program, the Contractor shall no longer utilize trainees at less than the applicable predetermined rate for the work performed until an acceptable program is approved.

3. The utilization of apprentices, trainees, and journeymen under this article shall be in conformity with the equal employment opportunity requirements of Executive Order 11246, as amended, and 29 CFR Part 30.

4. If at any time the Bureau of Apprenticeship and Training determines, after opportunity for a hearing, that the standards of a training program have not been complied with, or that such a program fails to provide adequate training for participants, the Contractor shall not utilize trainees at less than the predetermined rate for the classification of work actually performed until an acceptable program is approved. If the Contractor brings an appeal pursuant to 29 CFR 5.17 within 30 days of his or her receipt of a certified letter withdrawing the Bureau of Apprenticeship and Training's approval, the effect of the withdrawal of approval of the program will be delayed until a decision is rendered on the appeal pursuant to 29 CFR 5.17.

## **ARTICLE 28. PAYROLLS AND BASIC RECORDS**

1. The Contractor shall maintain payrolls and basic records relating thereto during the course of the work and shall preserve them for a period of three years thereafter for all laborers and mechanics, including apprentices, trainees, watchmen, and guards, working at the site of the work. Such records shall contain the name and address of each employee, his or her correct classification, rate of pay (including rates of contributions for, or costs assumed to provide, fringe benefits), daily and weekly number of hours worked, deductions made and actual wages paid.

2. The Contractor shall submit weekly a copy of all payrolls to the cognizant AUI Business Manager. The Contractor shall be responsible for the submission of copies of payrolls of all subcontractors. The copy shall be accompanied by a statement signed by the Contractor indicating that the payrolls are correct and complete, that the wage rates contained therein are not less than those determined by the Secretary of Labor, and the classifications set forth for each laborer or mechanic, including apprentices, trainees, watchmen, and guards, conform with the work he or she performed. Submission of the "Weekly Statement of Compliance" required under this agreement

and the Copeland Regulations of the Secretary of Labor (29 CFR Part 3) shall satisfy the requirement for submission of the above statement.

3. The Contractor shall make the records required under this article available for inspection at any time by authorized representatives of AUI, the NSF Grants and Agreements Officer, and the Department of Labor and shall permit such representatives to interview employees during working hours on the job.

#### **ARTICLE 29. COMPLIANCE WITH COPELAND REGULATIONS**

The Contractor shall comply with the Copeland Regulations of the Secretary of Labor (29 CFR Part 3) which are incorporated herein by reference.

#### **ARTICLE 30. WITHHOLDING OF FUNDS**

1. There may be withheld from the Contractor so much of the accrued payments or advances as may be considered necessary (1) to pay laborers and mechanics, including apprentices, trainees, watchmen, and guards, employed by the Contractor or any Subcontractor on the work the full amount of wages required by this contract, and (2) to satisfy any liability for liquidated damages under paragraph 2. of the article entitled "Contract Work Hours and Safety Standards Act—Overtime Compensation."

2. If the Contractor or Subcontractor fails to pay any laborer, mechanic, apprentice, trainee, watchman, or guard, employed or working on the site of the work, all or part of the wages required by this contract, AUI or the National Science Foundation, may take such action as may be necessary to cause suspension of any further payments or advances until such violations have ceased.

#### **ARTICLE 31. SUBCONTRACTS**

All subcontractors and lower-tier subcontractors are subject to approval by AUI. The Contractor agrees to insert the articles hereof entitled "Contract Work Hours and Safety Standards Act—Overtime Compensation," "Apprentices and Trainees," "Payrolls and Basic Records," "Compliance with Copeland Regulations," "Withholding of Funds," "Subcontracts," "Contract Termination—Debarment," and "Equal Opportunity" in all subcontracts. The term "Contractor" as used in such article in any subcontract shall be deemed to refer to the Subcontractor.

#### **ARTICLE 32. CONTRACT TERMINATION—DEBARMENT**

A breach of the articles hereof entitled "Contract Work Hours and Safety Standards Act—Overtime Compensation," "Apprentices and Trainees," "Payrolls and Basic Records," "Compliance with Copeland Regulations," "Withholding of Funds," and "Subcontracts," may be grounds for termination of this contract and for debarment as provided in 29 CFR 5.12.

### **ARTICLE 33. DISPUTES CONCERNING LABOR STANDARDS**

The United States Department of Labor has set forth in 29 CFR Parts, 5, 6, and 7 procedures for resolving disputes concerning labor standards requirements. Such disputes shall be resolved in accordance with those procedures and not the Disputes clause of this agreement. Disputes within the meaning of this clause include disputes between the Contractor (or any of its subcontractors) and AUI, the National Science Foundation, or the employees or their representatives.

### **ARTICLE 34. EQUAL OPPORTUNITY**

1. If, during any 12-month period (including the 12 months preceding the award of this contract), the Contractor has been or is awarded nonexempt Federal contracts/awards and/or subcontracts/subawards that have an aggregate value in excess of \$10,000, the Contractor shall comply with subparagraphs 2.a. through 2.k. below. Upon request, the Contractor shall provide information necessary to determine the applicability of this article.

2. During performing of this contract, the Contractor agrees as follows:

(a) The Contractor shall not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

(b) The Contractor shall take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. This shall include, but not be limited to, (1) employment, (2) upgrading, (3) demotion, (4) transfer, (5) recruitment or recruitment advertising, (6) layoff or termination, (7) rates of pay or other forms of compensation, and (8) selection for training, including apprenticeship.

(c) The Contractor shall post in conspicuous places available to employees and applicants for employment the notices that explain this article.

(d) The Contractor shall state, in all solicitations or advertisement for employees placed by or on behalf of the Contractor, that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(e) The Contractor shall send, to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding, the notice advising the labor union or worker's representative of the Contractor's commitments under this article, and post copies of the notice in conspicuous places available to employees and applicants for employment.

(f) The Contractor shall comply with Executive Order 11246, as amended, and the rules, regulations, and orders of the Secretary of Labor.

(g) The Contractor shall furnish to AUI and the National Science Foundation all information required by Executive Order 11246, as amended, and by the rules, regulations, and orders of the Secretary of Labor. Standard Form 100 (EEO-1), or any successor form, is the prescribed form to be filed within 30 days following the award, unless filed within 12 months preceding the date of the award.

(h) The Contractor shall permit access to its books, records, and accounts by the awarding agency or the Office of Federal Contract Compliance Programs (OFCCP) for the purpose of investigation to ascertain the Contractor's compliance with the applicable rules, regulations, and orders.

(i) If the OFCCP determines that the Contractor is not in compliance with this article or any rule, regulation, or order of the Secretary of Labor, this agreement may be canceled, terminated, or suspended in whole or in part and the Contractor may be declared ineligible for further U.S. Government awards under the procedures authorized in Executive Order 11246, as amended. In addition, sanctions may be imposed and remedies invoked against the Contractor as provided in Executive Order 11246, as amended, the rules, regulations, and orders of the Secretary of Labor, or as otherwise provided by law.

(j) The Contractor shall include the terms and conditions of subparagraph 2.a. through 2.k. of this article in every subcontract or purchase order that is not exempted by the rules, regulations, or orders of the Secretary of Labor issued under Executive Order 11246, as amended, so that these terms and conditions will be binding upon each subcontract or vendor.

(k) The Contractor shall take such action with respect to any subcontract or purchase order as the National Science Foundation may direct as a means of enforcing these terms and conditions, including sanctions for noncompliance provided that, if the Contractor becomes involved in, or is threatened with, litigation with a subcontract or vendor as a result of any direction, the Contractor may request the United States to enter into the litigation process to protect the interests of the United States.

3. Notwithstanding any other article in this contract, disputes relative to this article will be governed by the procedures in 41 CFR 60-1.1.

### **ARTICLE 35. NONDISCRIMINATION**

1. The Contractor and its subcontractors are subject to the provisions of Title VI of the Civil Rights Act of 1964 (PL 88-352) and the regulations issued pursuant thereto by the Foundation (45 CFR 611). No person on the basis of race, color, sex, national origin, or handicap shall be excluded from participation in, be denied benefits of, or otherwise be subjected to discrimination under the contract. In addition, if the project involves an education activity or program, as defined by Title IX of the Education Amendments of 1972 (PL-3181 20 USC 1681-1686), no person on the basis of sex shall be excluded from participation in the project. Further, by acceptance of the contract, the

Contractor ensures AUI and the Foundation that it will comply with Section 504 of the Rehabilitation Act of 1973 (29 USC 794) and the Foundation's implementing regulations (45 CFR 605) effective March 1, 1982.

2. The Contractor shall provide to AUI within thirty (30) days of award an Assurance of Compliance with Title VI of the Civil Rights Act of 1964. Civil Rights Act assurances may be filed with AUI in one of two ways: (1) by written notification that the appropriate Assurance of Compliance form has been executed and filed either with the Foundation or the U.S. Department of Health and Human Services; or (2) by executing and filing with AUI an NSF Assurance of Compliance Form.

3. The Contractor agrees to comply with the Age Discrimination Act of 1975 as implemented by the Department of Health and Human Service regulations at 45 CFR 90 and the regulations of the Foundation at 45 CFR 617.

4. The Contractor, by virtue of its acceptance of this contract, ensures AUI, the National Science Foundation, and the U.S. Department of Labor that it is compliant pursuant to Section 504 of the Rehabilitation Act of 1973.

#### **ARTICLE 36. NOTICE OF LABOR DISPUTES**

Whenever an actual or potential labor dispute is delaying or threatens to delay the performance of the work, the Contractor shall immediately notify AUI in writing. Such notice shall include all relevant information concerning the dispute and its background.

#### **ARTICLE 37. CONTINGENT FEES**

The Contractor warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide established commercial or selling agencies maintained by the Contractor for the purpose of securing business. For breach or violation of this warranty, AUI shall have the right to annul this contract without liability, or in its discretion to deduct from the contract price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

#### **ARTICLE 38. OFFICIALS NOT TO BENEFIT**

No member of or delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

## **ARTICLE 39. PRICING OF ADJUSTMENTS**

When costs are a factor in any determination of a contract price adjustment pursuant to the "Changes" article or any other provision of this contract, such costs shall be in accordance with the contract cost principles and procedures in Part 31 of the Federal Acquisition Regulations in effect on the date of this contract.

## **ARTICLE 40. COST ACCOUNTING STANDARDS**

1. The Contractor in connection with this contract, shall:

(a) (National Defense Contracts Only) By submission of a Disclosure Statement, disclose in writing the Contractor's cost accounting practices as required by FAR 30.202-1 through 30.202-5. The practices disclosed for this contract shall be the same as the practice currently disclosed and applied on all other contracts and subcontracts being performed by the Contractor and which contain a Cost Accounting Standards (CAS) article. If the Contractor has notified the Contracting Officer that the Disclosure Statement contains trade secrets and commercial or financial information which is privileged and confidential, the Disclosure Statement shall be protected and shall not be released outside of the U.S. Government.

(b) Follow consistently the Contractor's cost accounting practices in accumulating and reporting contract performance cost data concerning this contract. If any change in cost accounting practices is made for the purposes of any contract or subcontract subject to CAS requirements, the change must be applied prospectively to this contract and the Disclosure Statement must be amended accordingly. If the contract price or cost allowance of this contract is affected by such changes, adjustment shall be made in accordance with subparagraph 1.(c) or 1.(e) nor this article as appropriate.

(c) Comply with all CAS, including any modifications and interpretations indicated thereto contained in FAR Subpart 304., in effect on the date of award of this contract or, if the Contractor has submitted cost or pricing data, on the date of final agreement on price as shown on the Contractor's signed certificate of current cost or pricing data. The Contractor shall also comply with any CAS (or modifications to CAS) which hereafter become applicable to a contract or subcontract of the Contractor. Such compliance shall be required prospectively from the date of applicability to such contract or subcontract.

(i) Agree to an equitable adjustment as provided in the Changes article of this contract if the contract cost is affected by a change which, pursuant to subparagraph 1.(c) of this article, the Contractor is required to make to the Contractor's established cost accounting practices.

(ii) Negotiate to determine the terms and conditions under which a change may be made to a cost accounting practice, other than a change made under other provisions



of subparagraph 1.(3) of the article provided that no agreement may be made under this provision that will increase costs paid by the United States.

(iii) When the parties agree to a change to a cost accounting practice, other than a change under subparagraph 1.(c)(ii) of the article, negotiate an equitable adjustment as provided in the Changes article of this contract.

(d) Agree to an adjustment of the contract price or cost allowance, as appropriate, if the Contractor or a Subcontractor fails to comply with an applicable Cost Accounting Standard, or to follow any cost accounting practice consistently and such failure results in any increased costs paid by the United States. Such adjustment shall provide for recovery of the increased costs to the United States, together with interest thereon computed at the rate determined by the Secretary of the Treasury pursuant to Pub. L.92-41, 85 Stat. 97, from the time the payment by the United States was made to the time the adjustment is effected.

(i) If the parties fail to agree whether the Contractor or a Subcontractor has complied with an applicable CAS in FAR Subpart 30.4 or a CAS rule or regulation in FAR Subpart 30.3 and as to any cost adjustment demanded by the United States, such failure to agree shall be a dispute concerning a question of fact within the meaning of the Disputes article of this contract.

(ii) The Contractor shall permit any authorized representatives of the U.S. Government to examine and make copies of any documents, papers, or records relating to compliance with the requirements of this article.

(iii) The Contractor shall include in all negotiated subcontracts which the Contractor enters into, the substance of this article, except paragraph 2., and shall require such including in all other subcontracts, of any tier, including the obligation to comply with all CAS in effect on the subcontract's award date or if the Subcontractor has submitted cost or pricing data, on the date of final agreement on price as shown on the Subcontractor's signed Certificate of Current Cost or Pricing Data. This requirement shall apply only to negotiated subcontracts in excess of \$100,000 where the price negotiated is not based on:

(1) Established catalog or market prices of commercial items sold in substantial quantities to the general public.

(2) Prices set by law or regulation, and except that the requirement shall not apply to negotiated subcontracts otherwise exempt from the requirement to include a CAS article as specified in FAR 30.201-1.

Note (1): New or modified CAS shall be applicable to both national defense and nondefense CAS covered contracts upon award of a new national defense CAS-covered contract

containing the new or modified Standard. The award of a new nondefense CAS-covered contract shall not trigger application of new CAS or modification to CAS.

- Note (2): Subcontractors shall be required to submit their Disclosure Statements to the Contractor. However, if a Subcontractor has previously submitted its Disclosure Statement to a U.S. Government Administrative Contracting Officer (ACO), it may satisfy that requirement by certifying to the Contractor the date of the Statement and the address of the ACO.
- Note (3): In any case where a Subcontractor determines that the Disclosure Statement information is privileged and confidential and declines to provide it to the Contractor or higher tier Subcontractor, the Contractor may authorize direct submission of that Subcontractor's Disclosure Statement to the same U.S. Government offices to which the Contractor was required to make submission of its Disclosure Statement. Such authorization shall in no way relieve the Contractor of liability as provided in paragraph (a)(5) of this article. In view of the foregoing and since the contract may be subject to adjustment under this article by reason of any failure to comply with rules, regulations, and Standards as specified in FAR Subparts 30.3 and 30.4 in connection with covered subcontracts, it is expected that the Contractor may wish to include an article in each such subcontract requiring the Subcontractor to appropriately indemnify the Contractor. However, the inclusion of such an article and the terms thereof are matters for negotiation and agreement between the Contractor and the Subcontractor, provided that they do not conflict with the duties of the Contractor under its contract with the U.S. Government. It is also expected that any Subcontractor subject to such indemnification will generally require substantially similar indemnification to be submitted by its subcontractors.
- Note (4): If the Subcontractor is a business unit which, pursuant to FAR 30.201-2(b) is entitled to elect modified contract coverage to follow 30.401 and 30.402, the article at 52.230-5, "Disclosure Consistency of Cost Accounting Practices," of the Federal Acquisition Regulation shall be inserted in lieu of this article.
- Note (5): The terms defined in FAR 30.301 and 31.001 shall have the same meanings herein. As there defined, "negotiated subcontract" means any subcontract except a firm-fixed-price subcontract made by a Contractor or Subcontractor after receiving offers from at least two person not associated with each other or with such Contractor or Subcontractor, providing (1) the solicitation to all competitors is identical, (2) price is the only consideration in selecting the Subcontractor from among the competitors solicited, and (3) the lowest offer received in compliance with the solicitation from among those solicited is accepted.

## ARTICLE 41. ADMINISTRATION OF COST ACCOUNTING STANDARDS

For the purpose of administering the Cost Accounting Standards (CAS) requirements under this contract, the Contractor shall take the steps outlined in 1. through 6., below:

1. Submit to the NSF Grants and Agreements Officer a description of any accounting change, the potential impact of the change on contracts containing a CAS article, and if not obviously immaterial, a general dollar magnitude cost impact analysis of the change which displays the potential shift of costs between CAS-covered contracts by contract type (i.e., firm-fixed-price, incentive, cost-plus-fixed-fee, etc.) and other Contractor business activity. As related to CAS-covered contracts, the analysis should display the potential impact of funds of the various Agencies/Departments (i.e., Department of Energy, National Aeronautics and Space Administration, Army, Navy, Air Force, other Department of Defense, other U.S. Government) as follows:

(a) For any change in cost accounting practices required to comply with a new CAS in accordance with paragraphs (a)(3) and (a)(4)(i) of the CAS article, within 60 days (or such other date as may be mutually agreed to ) after award of a contract requiring this change.

(b) For any change in cost accounting practices proposed in accordance with paragraph 1.(d)(ii) or 1.(d)(iii) of the CAS article or with paragraph (a)(3) or 1.(e) of the Disclosure and Consistency of Cost Accounting Practices article, not less than 60 days (or such other date as may be mutually agreed to) before the effective date of the proposed change.

(c) For any failure to comply with an applicable CAS or to follow a disclosed practice as contemplated by paragraph 1.(e) of the CAS article or by paragraph 1.(d) of the Disclosure and Consistency of Cost Accounting Practices article, within 60 days (or such other date as may be mutually agreed to) after the date of agreement of noncompliance by the Contractor.

2. Submit a cost impact proposal in the form and manner specified by the NSF Grants and Agreements Officer within 60 days (or such other date as may be mutually agreed to) after the date of determination of the adequacy and compliance of a change submitted pursuant to 1. above. If the above proposal is not submitted within the specified time, or any extension granted by the NSF Grants and Agreements Officer, an amount not to exceed 10 percent of each payment made after that date may be withheld until such time as a proposal has been provided in the form and manner specified by the NSF Grants and Agreements Officer.

3. Agree to appropriate contract and subcontract amendments to reflect adjustments established in accordance with paragraphs 1.(d) and 1.(e) of the CAS article.

4. For all subcontracts subject to the CAS article:

(a) So state in the body of the subcontract, in the letter of award, or in both (self-deleting articles shall not be used), and

(b) Include the substance of this article in all negotiated subcontracts. In addition, within 30 days after award of the subcontract, submit the following information to the Contractor's cognizant contract administration office for transmittal to the contract administration office cognizant of the Subcontractor's facility:

(i) Subcontractor's name and subcontract number.

(ii) Dollar amount and date of award.

(iii) Name of Contractor making the award.

(iv) Any changes the Subcontractor has made or proposed to make to accounting practices that affect prime contracts or subcontracts containing the CAS article, unless these changes have already been reported. If award of the subcontract results in making one or more CAS effective for the first time, this fact shall also be reported.

5. Notify the NSF Grants and Agreements Officer in writing of any adjustments required to subcontracts under this contract and agree to an adjustment, based on them, to this contract's price or estimated cost and fee. This notice is due within 30 days after proposed subcontract adjustments are received and shall include a proposal for adjusting the higher tier subcontract or the prime contract appropriately.

6. For subcontracts containing the CAS article, require the Subcontractor to comply with all Standards in effect on the date of award or of final agreement on price, as shown on the Subcontractor's signed Certificate of Current Cost or Pricing Data, whichever is earlier.

#### **ARTICLE 42. PROGRESS PAYMENTS**

Progress payments shall be made to the Contractor when requested as work progresses, but not more frequently than monthly in amounts approved by AUI, under the following conditions:

(a) Computation of amounts: (1) Unless the Contractor requests a smaller amount, each progress payment shall be computed as (i) 90 percent of the Contractor cumulative total costs under this contract, as shown by records maintained by the Contractor for the purpose of obtaining payment under U.S. Government contracts, plus (ii) progress payments to subcontracts (see paragraph (j), below), all less the sum of all previous progress payments made by AUI under this contract. All progress payment requests and all payments shall be in United States dollars.

2. The following conditions apply to the timing of including costs in progress payment requests:

(i) The costs of supplies and services purchased by the Contractor directly for this contract may be included only after payment by cash, check, or other form of actual payment.

(ii) Costs of the following may be included when incurred, even if before payment, when the Contractor is not delinquent in payment of the costs of contract performance in the ordinary course of business:

(A) Materials issued from the Contractor's stores inventory and placed in the production process for use on this contract.

(B) Direct labor, direct travel, and other direct in-house costs.

(C) Properly allocable and allowable indirect costs.

(iii) Accrued costs of Contractor contributions under employee pension, profit sharing, and stock ownership plans shall be excluded until actually paid unless:

(A) The Contractor's practice is to contribute to the plans quarterly or more frequently; and

(B) The contribution does not remain unpaid 30 days after the end of the applicable quarter or shorter payment period (any contributions remaining unpaid shall be excluded from the Contractor's total costs for progress until paid).

(iv) If the contract is subject to the special transition method authorized in Cost Accounting Standard (CAS) 410, Allocation of Business Unit General and Administrative Expense to Final Cost Objective, General and Administrative expenses (G&A) shall not be included in progress payment requests until the suspense account prescribed in CAS 410 is less than:

(A) Five million dollars; or

(B) The value of the work-in-process inventories under contracts entered into after the suspense account was established (only a pro rata share of the G&A allocable to the excess of the inventory over the suspense account value is including in progress payment requests under this contract).

3. The Contractor shall not include the following in total costs for progress payment purposes in subparagraph (a)1.(i), above:

(i) Costs that are not reasonable, allocable to this contract, and consistent with sound and generally accepted accounting principles and practices.

(ii) Costs incurred by subcontractors or suppliers.

(iii) Costs ordinarily capitalized and subject to depreciation or amortization except for the properly depreciated or amortized portion of such costs.

(iv) Payments made or amounts payable to subcontractors or suppliers, except for:

(A) Completed work, including partial deliveries, to which the Contractor has acquired title; and

(B) Work under cost-reimbursement or time-and-material subcontracts to which the Contractor has acquired title.

4. The amount of unliquidated progress payments may exceed neither: (i) the progress payments made against incomplete work (including allowable unliquidated progress payments to subcontractors) nor (ii) the value, for progress payment purposes, of the incomplete work. Incomplete work shall be considered to be the supplies and services required by this contract, for which delivery and invoicing by the Contractor and acceptance by AUI are incomplete.

5. The total amount of progress payments shall not exceed 90 percent of the total contract price.

6. If a progress payment or the unliquidated progress payments exceed the amounts permitted by subparagraphs (a)4. and (a)5. above, the Contractor shall repay the amount of such excess to AUI on demand.

(b) Liquidation. Except as provided in the Termination for Convenience article, all progress payments shall be liquidated by deducting from any payment under this contract, other than advance or progress payments, the unliquidated progress payments, or 90 percent of the amount invoiced, whichever is less. The Contractor shall repay AUI any amounts required by a retroactive price reduction, after computing liquidations and payments on past invoices at the reduced prices and adjusting the unliquidated progress payments accordingly. AUI reserves the right to unilaterally change from the ordinary liquidating rate to an alternate rate when deemed appropriate for proper contract financing.

(c) Reduction or suspension. AUI may reduce or suspend progress payments, increase the rate of liquidation, or take a combination of these actions, after finding on substantial evidence any of the following conditions:

1. The Contractor failed to comply with any material requirement of this contract (which includes paragraphs (f) and (g) below).

2. Performance of this contract is endangered by the Contractor's (i) failure to make progress or (ii) unsatisfactory financial condition.

3. Inventory allocated to this contract substantially exceeds reasonable requirements.
4. The Contractor is delinquent in payment of the costs of performing this contract in the ordinary course of business.
5. The unliquidated progress payments exceed the fair value of the work accomplished on the undelivered portion of this contract.
6. The Contractor is realizing less profit than that reflected in the establishment of any alternate liquidation rate in paragraph (b) above, and that rate is less than the progress payment rate stated in subparagraph (a)1. above.

(d) Title.

1. Title to the property described in this paragraph (d) shall vest in the U.S. Government. Vestiture shall commence immediately upon the date of this contract, for property acquired or produced before that date. Otherwise, vestiture shall occur when the property is or should have been allocable or property chargeable to this contract.

2. "Property," as used in this article, includes all of the below-described items acquired or produced by the Contractor that are or should be allocable or properly chargeable to this contract under sound and generally accepted accounting principles and practices.

(i) Parts, materials, inventories, and work in progress;

(ii) Special tooling and special test equipment to which the U.S. Government is to acquire title under any other article of this contract;

(iii) Nondurable (i.e., noncapital) tools, jigs, dies, fixtures, molds, patterns, taps, gauges, test equipment, and other similar manufacturing aids, title to which would not be obtained as special tooling under subparagraph (ii) above; and

(iv) Drawings and technical data, to the extent the Contractor or subcontractors are required to deliver them to AUI by other articles of this contract.

3. Although title to property is in the U.S. Government under this article, other applicable articles of this contract, e.g., the termination of special tooling articles, shall determine the handling and disposition of the property.

4. The Contractor may sell any scrap resulting from production under this contract without requesting AUI's approval, but the proceeds shall be credited against the costs of performance.

5. To acquire for its own use or dispose of property to which title is vested in the U.S. Government under this article, the Contractor must obtain AUI's advance approval of the action and the terms. The Contractor shall: (i) exclude the allocable costs of the property from the costs of contract performance, and (ii) repay to AUI any amount of unliquidated progress payments allocable to the property. Repayment may be by cash or credit memorandum.

6. When the Contractor completes all of the obligations under this contract, including liquidation of all progress payments, title shall vest in the Contractor for all property (or the proceeds thereof) not:

(i) Delivered to, and accepted by, AUI under this contract; or

(ii) Incorporated in supplies delivered to, and accepted by, AUI under this contract and to which title is vested in the U.S. Government under this article.

7. The terms of this contract concerning liability for U.S. Government-furnished property shall not apply to property to which the U.S. Government acquired title solely under this article.

(e) Risk of loss. Before delivery to and acceptance by AUI, the Contractor shall bear the risk of loss for property, the title to which vests in the U.S. Government under this article, except to the extent AUI expressly assumes the risk. The Contractor shall repay an amount equal to the unliquidated progress payments that are based on costs allocable to property that is damaged, lost, stolen, or destroyed.

(f) Control of costs and property. The Contractor shall maintain an accounting system and controls adequate for the proper administration of this article.

(g) Reports and access to records. The Contractor shall promptly furnish reports, certificates, financial statements, and other pertinent information reasonably requested by AUI for the administration of this article. Also, the Contractor shall give AUI reasonable opportunity to examine and verify the Contractor's books, records, and accounts.

(h) Special terms regarding default. If this contract is terminated under the Default article, (i) the Contractor shall, on demand, repay to AUI the amount of unliquidated progress payments, and (ii) title shall vest in the Contractor, on full liquidation of progress payments, for all property for which AUI elects not to require delivery under the Default article. AUI shall be liable for no payment except as provided by the Default article.

(i) Reservations of rights.

1. No payment or vesting of title under this article shall: (i) excuse the Contractor from performance of obligations under this contract or (ii) constitute a waiver of any of the rights or remedies of the parties under the contract.



2. AUI's rights and remedies under this article (i) shall not be exclusive but rather shall be in addition to any other rights and remedies provided by law or this contract, and (ii) shall not be affected by delayed, partial, or omitted exercise of any right, remedy, power, or privilege, nor shall such exercise or any single exercise preclude or impair any further exercise under this article or the exercise of any other right, power, or privilege of AUI.

(j) Progress payments to subcontractors. The amounts mentioned in (a)1.(ii) above shall be all progress payments to subcontractors or divisions, if the following conditions are met:

1. The amounts included are limited to: (i) the unliquidated remainder of progress payments made plus (ii) for small business concerns any unpaid Subcontractor requests for progress payments that the Contractor has approved for current payment in the ordinary course of business.

2. The Subcontractor or interdivisional order is expected to involve a minimum of approximately six months between the beginning of work and the first delivery, or if the Subcontractor is a small business concern, four months.

3. The terms of the subcontract or interdivisional order concerning progress payments are:

(i) Are substantially similar to the terms of this article, Progress Payments, for any Subcontractor that is a large business concern, or that article with its Alternate I for any Subcontractor that is a small business concern;

(ii) Are at least as favorable to AUI as the terms of this article;

(iii) Are not more favorable to the Subcontractor or division than the terms of this article are to the Contractor;

(iv) Are in conformance with the requirements of paragraph 32.504(e) of the Federal Acquisition Regulation; and

(v) Subordinate all Subcontractor rights concerning property to which AUI or the Government has title under the subcontract to AUI's right to require delivery of the property to the U.S. Government if (A) the Contractor defaults or (B) the Subcontractor becomes bankrupt or insolvent.

4. The progress payment rate in the subcontract is the customary rate used by AUI, depending on whether the Subcontractor is or is not a small business concern.

5. The parties agree concerning any proceeds received by AUI for property to which title has vested in the U.S. Government under the subcontract terms, that the proceeds shall be applied to reducing any unliquidated progress payments by AUI to the Contractor under this contract.

6. If no liquidated progress payments to the Contractor remain, but there are unliquidated progress payments that the Contractor has made to any Subcontractor, the Contractor shall be subrogated to all the rights AUI obtained through the terms required by this article to be in any subcontract, as if all such rights had been assigned and transferred to the Contractor.

7. The Contractor shall pay the Subcontractor's progress payment request under subdivision (j)1.(ii) above, within a reasonable time after receiving AUI progress payment covering those amounts.

8. To facilitate small business participation in subcontracting under this contract, the Contractor agrees to provide progress payments to small business concerns, in conformity with the standards for customary progress payments stated in Subpart 32.5 of the Federal Acquisition Regulation. The Contractor further agrees that the need for such progress payments shall not be considered as a handicap or adverse factor in the award of subcontracts.

(k) Limitations on Unfinalized Contract Actions. Notwithstanding any other progress payment provisions in this contract, progress payments may not exceed 90 percent of costs incurred on work accomplished under unfinalized contract actions. A "contract action" is any action resulting in a contract, as defined in Subpart 2.1, including contract modifications for additional supplies or services, but not including contract modifications that are within the scope and under the terms of the contract, such as contract modifications issued pursuant to the Changes article, or funding and other administrative changes. This limitation shall apply to the costs incurred, as computed in accordance with paragraph (a) of this article, and shall remain in effect until the contract action is finalized. Costs incurred which are subject to this limitation shall be segregated on Contractor progress payment requests and invoices from those eligible for higher progress payment rates. For purposes of progress payment liquidation, as described in paragraph (b) of this article, progress payments for unfinalized contract actions shall be liquidated at 90 percent of the amount invoiced for work performed under the unfinalized contract action as long as the contract action remains unfinalized. The amount of unliquidated progress payments for unfinalized contract actions shall not exceed 90 percent of the maximum liability of AUI under the unfinalized contract action or such lower limit specified elsewhere in the contract. Separate limits may be specified for separate actions.

Alternate I. If the contract is with a small business concern, change each mention of the progress payment and liquidation rates excepting paragraph (k) to the customary rate of 95 percent for small business concerns, delete subparagraphs (a)1. and (a)2. from the basic article, and substitute the following subparagraphs (a)1. and (a)2.:

(a) Computation of amounts.

1. Unless the Contractor requests a smaller amount, each progress payment shall be computed as: (i) 95 percent of the Contractor's total costs incurred under this contract whether or not actually

paid, plus (ii) progress payments to subcontractors (see paragraph (j) below), all less the sum of all previous progress payments made by AUI under this contract.

2. Accrued costs of Contractor contributions under employee pension plans shall be excluded until actually paid unless:

(i) The Contractor's practice is to make contributions to the retirement fund quarterly or more frequently; and

(ii) The contribution does not remain unpaid 30 days after the end of the applicable quarter or shorter payment period (any contribution remaining unpaid shall be excluded from the Contractor's total costs for progress payments until paid).

#### **ARTICLE 43. SCHEDULE OF DAMAGES**

(a) The Contractor shall promptly pay damages to AUI for failure by the Contractor to complete certain portions of the Work as follows:

(1) In the event that the Contractor does not deliver all required items for the PDR by the date specified in the approved project schedule, the agreed amount of damages shall be as follows:

<b>Weeks Late</b>	<b>Amount of Damages</b>
1 Week	U.S. \$ 5,000
2 Weeks	U.S. \$10,000
3 Weeks	U.S. \$15,000
4 Weeks	U.S. \$20,000
5 Weeks	U.S. \$25,000
6 Weeks	U.S. \$30,000
7 Weeks	U.S. \$35,000
8 Weeks	U.S. \$40,000
Each Week After 8 Weeks	U.S. \$40,000

(2) In the event that the Contractor does not deliver all required items for the CDR by the date specified in the approved project schedule, the agreed amount of damages shall be as follows:

<b>Weeks Late</b>	<b>Amount of Damages</b>
1 Week	U.S. \$ 5,000
2 Weeks	U.S. \$10,000
3 Weeks	U.S. \$15,000
4 Weeks	U.S. \$20,000
5 Weeks	U.S. \$25,000
6 Weeks	U.S. \$30,000
7 Weeks	U.S. \$35,000
8 Weeks	U.S. \$40,000
Each Week After 8 Weeks	U.S. \$40,000

- (3) In the event that the Contractor does not deliver the complete design documentation package by the date specified in the approved project schedule, the agreed amount of damages shall be as follows:

<b>Weeks Late</b>	<b>Amount of Damages</b>
1 Week	U.S. \$ 5,000
2 Weeks	U.S. \$10,000
3 Weeks	U.S. \$15,000
4 Weeks	U.S. \$20,000
5 Weeks	U.S. \$25,000
6 Weeks	U.S. \$30,000
7 Weeks	U.S. \$35,000
8 Weeks	U.S. \$40,000
Each Week After 8 Weeks	U.S. \$40,000

- (4) In the event the Contractor does not deliver the completed factory fabrication of the prototype MMA antenna by the date specified in the approved project schedule, the agreed amount of damages shall be as follows:

<b>Weeks Late</b>	<b>Amount of Damages</b>
1 Week	U.S. \$ 5,000

<b>Weeks Late</b>	<b>Amount of Damages</b>
2 Weeks	U.S. \$10,000
3 Weeks	U.S. \$15,000
4 Weeks	U.S. \$20,000
5 Weeks	U.S. \$25,000
6 Weeks	U.S. \$30,000
7 Weeks	U.S. \$35,000
8 Weeks	U.S. \$40,000
Each Week After 8 Weeks	U.S. \$40,000

- (5) In the event the Contractor does not deliver the completed MMA prototype antenna, assembled on site and ready for acceptance by the date specified in the approved project schedule, the agreed amount of damages shall be as follows:

<b>Weeks Late</b>	<b>Amount of Damages</b>
1 Week	U.S. \$ 5,000
2 Weeks	U.S. \$10,000
3 Weeks	U.S. \$15,000
4 Weeks	U.S. \$20,000
5 Weeks	U.S. \$25,000
6 Weeks	U.S. \$30,000
7 Weeks	U.S. \$35,000
8 Weeks	U.S. \$40,000
Each Week After 8 Weeks	U.S. \$40,000

(b) In the event that actual delivery occurs at a time other than at the end of a complete week of delay, the damages shall be prorated in the proportion to the amount of time that has elapse as a part of such week.

(c) AUI and the Contractor acknowledge and agree that the sum agreed upon as damages is substantially less than the actual losses that are expected to be incurred by AUI as a result of delay in completion of the work, so that the damages, if sought by AUI, are reasonable and do not constitute a penalty.

#### **ARTICLE 44. TITLE TO MATERIALS AND SUPPLIES**

Unless otherwise provided in this contract, title to the materials and supplies purchased hereunder shall pass directly from Seller to Government at the point of delivery shown herein, subject to the right of AUI to inspect and reject, in accordance with specifications and terms and conditions hereof.

#### **ARTICLE 45. RESPONSIBILITY FOR SUPPLIES**

Except as otherwise provided in this contract, (i) the Contractor shall be responsible for the supplies covered by this contract until they are delivered at the designated delivery point, regardless of the point of inspection, (ii) after delivery to AUI at the designated point and prior to acceptance or rejection by AUI and giving notice thereof by AUI, AUI shall be responsible for the loss or destruction of or damage to the supplies only if such loss, destruction, or damage results from the negligence of officers, agents or employees of AUI acting within the scope of their employment; and (iii) the Contractor shall bear all risks as to rejected supplies after notice of rejection, except that AUI shall be responsible for the loss, or destruction of, or damage to the supplies only if such loss, destruction or damage to the supplies results from the gross negligence of officers, agents, or employees of AUI acting within the scope of their employment.

#### **ARTICLE 46. MATERIALS AND PROPERTY FURNISHED**

(a) When AUI furnishes parts, tooling, equipment or other property, title to which is in the U.S. Government, the Contractor's packing sheet and final invoice must contain this statement: "All parts, tooling, or other property furnished or acquired for this contract (except that which became normal industrial waste or was replaced at the Contractor's expense) have been returned in the form of parts, equipment, and tooling." Title to all such equipment and tooling furnished by AUI shall remain in the U.S. Government, and AUI shall at all times have the right to immediate repossession thereof.

(b) If AUI furnishes any material, title to which is in the U.S. Government, for fabrication hereunder, the Contractor agrees not to use any other material in such fabrication without AUI's written consent. AUI reserves the right to retain 10 percent of the total amount of the Contractor's invoice until all requirements of this article have been fulfilled.

(c) Except as otherwise provided in this contract, the Contractor shall return to AUI the U.S. Government property furnished or acquired under this contract in as good condition as when received except for reasonable wear and tear or for utilization of the property in accordance with the requirements of this contract.

## **ARTICLE 47. CONSTRUCTION DRAWINGS AND SHOP DRAWINGS**

(a) The Contractor shall keep on the work site a copy of the drawings and specifications and shall at all times give AUI access thereto. Anything mentioned in the specifications and not shown on the drawings, or shown on the drawings and not mentioned in the specifications, shall be of like effect as is shown or mentioned in both. In case of a difference between drawings and specifications, the matter shall be promptly submitted to AUI, who shall promptly make a determination in writing. Any adjustment by the Contractor without such a determination shall be at its own risk and expense. AUI shall furnish from time to time such detailed drawings and other information as considered necessary, unless otherwise provided. "Drawings and specifications" shall be understood to mean all drawings and specifications produced under this contract, including those prepared by Contractor as part of the engineering effort under this contract after review and approval by AUI.

(b) Wherever in the specifications or upon the drawings the word "directed," "required," "ordered," "designated," "prescribed," or words of like import are used, it shall be understood that the "direction," "requirement," "order," "designation," or "prescription" of AUI is intended and similarly the words "approved," "acceptable," "satisfactory," or words of like import shall be "approved by," "acceptable to," or "satisfactory to" AUI unless expressly stated.

(c) Where "as shown," "as indicated," "as detailed," or words of similar import are used, it shall be understood that the reference is made to the drawings accompanying this contract unless stated otherwise. The word "provided" as used herein shall be understood to mean "provide complete in place," that is "furnished and installed."

(d) "Shop drawings" means drawings submitted to AUI by the Contractor or any Subcontractor pursuant to a construction contract, showing in detail:

- (1) the proposed fabrication and assembly of structural elements, and
- (2) the installation (i.e., form, fit, and attachment detail) of materials or equipment. It includes drawings, diagrams, layouts, schematics, descriptive literature, illustrations, schedules, performance and test data, and similar materials furnished by the Contractor to explain in detail specific portions of the work required by the contract. AUI may duplicate, use, and disclose in any manner and for any purpose shop drawings delivered under this contract.

(e) If this contract requires shop drawings, the Contractor shall coordinate all such drawings and review them for accuracy, completeness, and compliance with contract requirements and shall indicate its approval thereon as evidence of such coordination and review. Shop drawings submitted to AUI without evidence of the Contractor's approval may be returned for resubmission. AUI will indicate an approval or disapproval of the shop drawings and if not approved as submitted shall indicate AUI's reason therefor. Any work done before such approval shall be at the Contractor's risk. Approval by AUI shall not relieve the Contractor from responsibility for any errors or omissions in

such drawings, nor from responsibility for complying with the requirements of this contract, except with respect to variations described and approved in accordance with (f) below.

(f) If shop drawings show variations from the contract requirements, the Contractor shall describe such variations in writing, separate from the drawings, at the time of submission. If AUI approves any such variation, AUI shall issue an appropriate contract modification, except that, if the variation is minor or does not involve a change in price or in time of performance, a modification need not be issued.

(g) The Contractor shall submit for approval three (3) printed copies and one (1) editable electronic copy of all shop drawings as called for under the various headings of these specifications. If agreed between AUI and the Contractor, shop drawing submittals and approvals may be conducted at the Contractor's facility. Three sets (unless otherwise indicated) of all shop drawings will be retained by AUI and one set will be returned to the Contractor. Upon completing the work under this contract, the Contractor shall furnish a complete set of all shop drawings as finally approved. These drawings shall show all changes and revisions made up to the time the equipment is completed and accepted.

#### **ARTICLE 48. SUPERINTENDENCE BY CONTRACTOR**

The Contractor shall establish an office at the assembly site during the progress of the work and shall have a competent superintendent, satisfactory to AUI, on the site at all times, with authority to act for it.

AUI may require the Contractor to remove from the work any employee who AUI deems incompetent, careless, insubordinate or otherwise objectionable or whose continued employment on the work is deemed by AUI to be contrary to the public interest.

#### **ARTICLE 49. OTHER CONTRACTS**

AUI may undertake or award other contracts for additional work and the Contractor shall fully cooperate with such other contractors and AUI employees and carefully fit his own work to such additional work as may be directed by AUI. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other contractor or by AUI employees. In the case of a conflict, the necessary coordination shall be directed by AUI.

#### **ARTICLE 50. SUSPENSION OF WORK**

(a) AUI may order the Contractor, in writing, to suspend, delay, or interrupt all or any part of the work of the contract for the period of time that AUI determines appropriate for the convenience of AUI.



(b) If the performance of all or any part of the work is, for an unreasonable period of time, suspended, delayed, or interrupted (1) by an act of AUI in administration of this contract, or (2) by AUI's failure to act within the time specified in the contract (or within a reasonable time not specified), an adjustment shall be made for any increase in the cost of performance of this contract (excluding profit) necessarily caused by the unreasonable suspension, delay, or interruption, and the contract modified in writing accordingly. However, no adjustment shall be made under this article for any suspension, delay, or interruption to the extent that performance would have been so suspended, delayed, or interrupted by another cause, including the fault or negligence of the Contractor, or for which an equitable adjustment is provided for or excluded under any other term or condition of this contract.

(c) A claim under this article shall not be allowed (1) for any costs incurred more than 20 days before the Contractor shall have notified AUI in writing of the act, or failure to act, involved (but this requirement shall not apply as to a claim resulting from a suspension order), and (2) unless the claim, in an amount stated, is asserted in writing as soon as practicable after the termination of the suspension, delay, or interruption, but not later than the date of final payment under the contract.

#### **ARTICLE 51. DIFFERING SITE CONDITIONS**

(a) The Contractor shall within twenty-four (24) hours, and before conditions are disturbed, notify AUI in writing of: (1) subsurface or latent physical conditions at the site differing materially from those indicated in this contract, or (2) unknown physical conditions at the site, of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in this contract. AUI shall promptly investigate the conditions, and if they find that such conditions do materially so differ and cause an increase or decrease in the Contractor's cost of, or the time required for, performance of any part of the work under this contract, whether or not changed as a result of such conditions, an equitable adjustment shall be made and the contract modified in writing accordingly.

(b) No claim of the Contractor under this article shall be allowed unless the Contractor has given the notice required in (a) above; provided, however, the time prescribed therefor may be extended by AUI.

(c) No claim by the Contractor for an equitable adjustment hereunder shall be allowed if asserted after final payment under this contract.

#### **ARTICLE 52. SITE INVESTIGATION AND CONDITIONS AFFECTING THE WORK**

(a) The Contractor acknowledges that it has taken steps reasonably necessary to ascertain the nature and location of the work, and that it has investigated and satisfied itself as to the general and local conditions which can affect the work or its cost, including but not limited to (1) conditions bearing upon transportation, disposal, handling, and storage of materials; (2) the availability of labor, water, electric power, and roads; (3) uncertainties of weather, river stages, tides, or similar physical

conditions at the site; (4) the conformation and conditions of the ground; and (5) the character of equipment and facilities needed prior to and during the work performance. The Contractor also acknowledges that it has satisfied itself as to the character, quality, and quantity of surface and subsurface materials or obstacles to be encountered insofar as this information is reasonably ascertainable from an inspection of the site, including all exploratory work done by AUI, as well as from any drawings and specifications made a part of this contract. Any failure of the Contractor to take the actions described and acknowledged in this paragraph will not relieve the Contractor from responsibility for estimating properly the difficulty and cost of successfully performing the work, or for proceeding to successfully perform the work without additional expense to AUI.

(b) AUI assumes no responsibility for any conclusions or interpretations made by the Contractor based on the information made available by AUI. Nor does AUI assume responsibility for any understanding reached or representation made concerning conditions which can affect the work by any of its officers or agents before the execution of this contract, unless that understanding or representation is expressly stated in this contract.

#### **ARTICLE 53. PROTECTION OF EXISTING VEGETATION, STRUCTURES, EQUIPMENT, UTILITIES, AND IMPROVEMENTS**

(a) The Contractor shall preserve and protect all structures, equipment, and vegetation (such as trees, shrubs, and grass) on or adjacent to the work site, which are not to be removed and which do not unreasonably interfere with the work required under this contract. The Contractor shall avoid damaging vegetation that will remain in place. If any limbs or branches of trees are broken during contract performance, or by the careless operation of equipment, or by workmen, the Contractor shall trim those limbs or branches with a clean cut and paint the cut with a tree-pruning compound as directed by AUI.

(b) The Contractor shall protect from damage all existing improvements and utilities (1) at or near the work site and (2) on adjacent property of a third party, the locations of which are made known to or should be known by the Contractor. The Contractor shall repair any damage to those facilities, including those that are the property of a third party, resulting from failure to comply with the requirements of this contract or failure to exercise reasonable care in performing the work. If the Contractor fails or refuses to repair the damage promptly, AUI may have the necessary work performed and charge the cost to the Contractor.

#### **ARTICLE 54. OPERATIONS AND STORAGE AREAS**

(a) The Contractor shall confine all operations (including storage of materials) on AUI or U.S. Government premises to areas authorized or approved by AUI. The Contractor shall hold and save AUI and the U.S. Government, its officers and agents, free and harmless from liability of any nature occasioned by the Contractor's performance.

(b) Temporary buildings (e.g., storage sheds, shops, offices) and utilities may be erected by the Contractor only with the approval of AUI and shall be built with labor and materials furnished by the Contractor without expense to AUI. The temporary buildings and utilities shall remain the property of the Contractor and shall be removed by the Contractor at its expense upon completion of the work unless an alternate agreement is made between the Contractor and AUI. With the written consent of AUI, the buildings and utilities may be abandoned and need not be removed.

(c) The Contractor shall, under regulations prescribed by AUI, use only established roadways, or use temporary roadways constructed by the Contractor when and as authorized by AUI. When materials are transported in prosecuting the work, vehicles shall not be loaded beyond the loading capacity recommended by the manufacturer of the vehicle or prescribed by any Federal, State, or local law or regulation. When it is necessary to cross curbs or sidewalks, the Contractor shall protect them from damage. The Contractor shall repair or pay for the repair of any damaged curbs, sidewalks, or roads.

#### **ARTICLE 55. CLEANING UP**

The Contractor shall at all times keep the construction area, including storage areas used by him, free from accumulations of waste material or rubbish and prior to completion of the work shall remove any rubbish from the premises and all tools, scaffolding, equipment, and materials not the property of the U.S. Government or AUI. Upon completion of the construction, the Contractor shall leave the work and premises in a clean, neat, and workmanlike condition satisfactory to AUI.

#### **ARTICLE 56. SUBCONTRACTORS**

Within seven days after award of any construction subcontract by the Contractor, he shall deliver to AUI a statement setting forth the name and address of the Subcontractor(s) and a summary description of the work to be subcontracted. The Contractor shall at the same time furnish a statement signed by its Subcontractor(s) acknowledging the inclusion in its subcontract of the articles of this contract entitled "Contract Work Hours and Safety Standards Act—Overtime Compensation," "Apprentices and Trainees," "Payrolls and Basic Records," "Compliance With Copeland Regulations," "Withholding of Funds," "Subawards (Labor Standards)," "Agreement Termination—Debarment," "Equal Opportunity," and "Disputes Concerning Labor Standards." Nothing contained in this contract shall create any contractual relation between any such Subcontractor and AUI.

#### **ARTICLE 57. USE AND POSSESSION PRIOR TO COMPLETION**

(a) AUI shall have the right to take possession of or jointly use any completed or partially completed part of the work. Before taking possession of or using any work, AUI shall furnish the Contractor a list of items of work remaining to be performed or corrected on those portions of the work that AUI intends to take possession of or use. However, failure of AUI to list any item of work

shall not relieve the Contractor of responsibility for complying with the terms of the contract. AUI's possession or joint use shall not be deemed an acceptance of any work under the contract.

(b) While AUI has such possession or use, the Contractor shall be relieved of the responsibility for the loss of or damage to the work resulting from AUI's possession or joint use, notwithstanding the terms of the article in this contract entitled "Permits and Responsibility for Work." If prior possession or use by AUI delays the progress of the work or causes additional expense to the Contractor, an equitable adjustment shall be made in the contract price or the time of completion, and the contract shall be modified in writing accordingly.

#### **ARTICLE 58. CANCELLATIONS OF ITEMS**

(a) As used herein, the term "cancellation" means that AUI is canceling, pursuant to this article, its quantity requirements for items for all quantities other than that quantity currently authorized. Such cancellation shall occur only if, by the date or within the time period specified in the schedule, or such further time as may be agreed to, AUI (i) notifies the Contractor that funds will not be available for contract performance for any subsequent quantity; or (ii) fails to notify the Contractor that funds have been made available for additional quantity in accordance with schedule requirements.

(b) Except for cancellation pursuant to this article or for termination pursuant to the "Default" article, any reduction by AUI in the quantities called for under this contract shall be considered a termination in accordance with the "Termination for Convenience" article of this contract.

(c) In the event of cancellation pursuant to this article the Contractor will be paid, as consideration therefor, a cancellation charge not to exceed the cancellation ceiling described and separately set forth in the Schedule as being applicable at the time of cancellation.

(d) The cancellation charge is intended to cover (i) only costs reasonably necessary for production which would have been equitably amortized in the unit prices for the entire contract period, but which, because of the cancellation, are not so amortized and (ii) a reasonable profit on such costs. The cancellation charge shall be computed and claim therefor made as would be applicable under the "Termination for Convenience" article of this contract. The Contractor shall submit the claim promptly, but in no event later than one year (i) from the date of notification of the nonavailability of funds, if issued pursuant to paragraph (a)(i), or (ii) from the date specified in the schedule by which notification of the availability of additional funds for the next succeeding program period or quantity is required to be issued, whichever is earlier, unless one or more extensions in writing are granted by AUI, upon request of the Contractor made in writing within such one year period or authorized extension thereof. The claim may include reasonable reproduction and other nonrecurring costs, incurred by the Contractor or its Subcontractor(s), applicable to and which normally would be amortized in all items to be furnished under the requirements, such as plant rearrangement, special tooling, reproduction engineering, initial rework, initial spoilage and pilot runs, as well as costs not amortized by the level contract unit price solely because the cancellation

had precluded anticipated benefits of Contractor or Subcontractor learning. The claim shall not include any amount for:

- (i) labor, materials, or other expenses incurred by the Contractor or its subcontractors for production of canceled items;
- (ii) any item or cost for which payment has already been made to the Contractor; or
- (iii) anticipated profit on the canceled items.

## APPENDIX A

### PRICE SUMMARY

A price summary in the form set out below shall be included as the first pages of the Cost and Price proposal, Volume 4.

Date\_\_\_\_\_

TO: MMA Business Manager  
National Radio Astronomy Observatory  
520 Edgemont Road  
Charlottesville, VA 22903-2475

\_\_\_\_\_ will complete all of the work set  
(Name of Company)  
forth in the Prototype Millimeter Array Radio Telescope Request for Proposals and addenda thereto,  
receipt of which is acknowledged below, for a total price as shown on the following pages.

The proposer shall list all addenda numbers in the blank below. Failure to include all addenda may result in the proposal being considered non-responsive.

Addenda Numbers \_\_\_\_\_

The price proposal and all other provisions of the proposal shall remain in full force and subject to acceptance by AUI for a period of 150 days after the date for Proposal Submission.

By\_\_\_\_\_

Title\_\_\_\_\_

Witness\_\_\_\_\_

## PRICE SUMMARY

### PROTOTYPE MILLIMETER ARRAY/LARGE SOUTHERN ARRAY TELESCOPE

Enter N/A for any items not needed.

Design ..... \_\_\_\_\_

Technology test and demonstration ..... \_\_\_\_\_

#### **Reflector**

Reflector Backup Structure ..... \_\_\_\_\_

Reflector Backup Structure Sunshades or Insulation ..... \_\_\_\_\_

Panel Adjusters ..... \_\_\_\_\_

Elevation Wheel Structure ..... \_\_\_\_\_

Counterweight ..... \_\_\_\_\_

Subreflector Support Legs ..... \_\_\_\_\_

Reflector Panels ..... \_\_\_\_\_

Receiver Cabin ..... \_\_\_\_\_

Receiver Cabin HVAC ..... \_\_\_\_\_

Reflector Items Not Included Above (List) ..... \_\_\_\_\_

**Subtotal Reflector** ..... \_\_\_\_\_

#### **Elevation Over Azimuth Mount**

Yoke or Alidade ..... \_\_\_\_\_

Azimuth Bearing or Azimuth Ring ..... \_\_\_\_\_

Azimuth Drives and Cabling ..... \_\_\_\_\_

Pintle Bearing ..... \_\_\_\_\_

Elevation Drives and Cabling ..... \_\_\_\_\_

Elevation Bearings ..... \_\_\_\_\_

Drive Servo .....	_____
Az and El Encoders .....	_____
Metrology Equipment .....	_____
Metrology Software .....	_____
Cable Wraps .....	_____
Limit Switches .....	_____
Personnel and Equipment Access to Receiver Cabin .....	_____
Power Distribution and Lighting .....	_____
Lightning Protection and Grounding .....	_____
Mount items not included above (list) .....	_____
<b>Subtotal Mount</b> .....	_____
Painting .....	_____
Tooling and Instrumentation .....	_____
Erection (Structure) .....	_____
Erection (Electrical Support Equipment) .....	_____
Erection (Mechanical Support Equipment) .....	_____
Shipping .....	_____
Overhead and G&A Expenses .....	_____
Profit .....	_____
<b>TOTAL PROTOTYPE</b> .....	_____
(Firm Fixed Bid)	
<b>TOTAL SECOND (OPTIONAL) COPY OF PROTOTYPE*</b> .....	_____
(Firm Fixed Bid)	

\*This option may be exercised unilaterally by AUI and shall be available through 2000-December-31.



## PRICE SUMMARY

### PRODUCTION MILLIMETER ARRAY/LARGE SOUTHERN ARRAY ANTENNA

(Estimated per unit cost in 1999 \$ for a goal of sixty-four (64) identical 12 m diameter antennas produced at 8 units per year. Assume shipping to, and assembly in, San Pedro de Atacama (elevation 2400 m), Chile.)

Enter N/A for any items not needed.

#### Reflector

Reflector Backup Structure .....	_____
Reflector Backup Structure Sunshades or Insulation .....	_____
Panel Adjusters .....	_____
Elevation Wheel Structure .....	_____
Counterweight .....	_____
Subreflector Support Legs .....	_____
Reflector Panels .....	_____
Receiver Cabin .....	_____
Receiver Cabin HVAC .....	_____
Reflector Items Not Included Above (List) .....	_____
<b>Subtotal Reflector</b> .....	_____

#### Elevation Over Azimuth Mount

Yoke or Alidade .....	_____
Azimuth Bearing or Azimuth Ring .....	_____
Azimuth Drives and Cabling .....	_____
Pintle Bearing .....	_____
Elevation Drives and Cabling .....	_____
Elevation Bearings .....	_____
Drive Servo .....	_____

Az and El Encoders .....	_____
Metrology Equipment .....	_____
Metrology Software .....	_____
Cable Wraps .....	_____
Limit Switches .....	_____
Personnel and Equipment Access to Receiver Cabin .....	_____
Power Distribution and Lighting .....	_____
Lightning Protection and Grounding .....	_____
Mount items not included above (list) .....	_____
<b>Subtotal Mount</b> .....	_____
Painting .....	_____
Tooling and Instrumentation .....	_____
Erection (Structure) .....	_____
Erection (Electrical Support Equipment) .....	_____
Erection (Mechanical Support Equipment) .....	_____
Shipping .....	_____
Overhead and G&A Expenses .....	_____
Profit .....	_____
<b>TOTAL Per Unit Production Cost</b> .....	_____
(Estimated Cost)	
Non-recurring Price for Permanent Tooling for Production Run .....	_____

## **APPENDIX B**

### **GUIDANCE FOR PRESENTATION OF PRICING DATA**

#### **GENERAL**

Complete price breakdowns are required. As a minimum, in support of prices contained in Appendix A, the proposer shall submit:

- (1) Labor rates by category of labor
- (2) Direct labor by category  
i.e., Engineers, Technicians, etc.
- (3) Materials
  - Raw Materials
  - Purchased Parts
- (4) Subcontracts
- (5) Other Direct Costs
- (6) Overhead, General and Administrative Expense where applicable
- (7) Profit

Recurring and non-recurring costs shall be plainly identified. Special tooling and special test equipment will be clearly set out.

Support data shall be supplied in sufficient detail to facilitate analysis with cross references as necessary to support labor, materials, overhead, etc.

#### **PRICING DATA**

Explain the method, ground rules, assumptions, cost factors or formulas on which pricing is based. Identify the index, projection, or other base used and provide calculations of the progression (escalation) and regression (learning curve and production efficiencies) of the various elements of cost (material, labor and overhead).

#### **PROTOTYPE PRICING**

Pricing for the Prototype MMA/LSA antenna and the optional 2<sup>nd</sup> prototype is a binding, firm-fixed price bid.

#### **PRODUCTION ESTIMATE**

The pricing provided for the Production MMA/LSA antenna is an estimate only and is non-binding.

## APPENDIX C

## REPRESENTATIONS, CERTIFICATIONS, AND ACKNOWLEDGMENTS

Unless this document is returned with your proposal, your proposal will be judged non-responsive to the request.

The offeror shall complete all paragraphs. In addition to the final signature, each certification must be individually executed if the requirement for a signature is indicated.

*The offeror represents, certifies and acknowledges that the following statements are true and correct and are made part of its offer and shall be conditions precedent to the award of a contract:*

## 1. Type of Business Organization

It operates as ☐ an individual, ☐ a partnership, ☐ a nonprofit organization, ☐ a corporation, incorporated under the laws of the State of . It ☐ is, ☐ is not, owned or controlled by a parent company (enter in the blank below the name and main office address of the parent company).

/Federal ID#

## 2. Certification of Independent Price Determination

- (a) By submission of this offer, the offeror certifies and, in the case of a joint offer, each party thereto certifies as to its own organization, that in connection with this procurement:
- (1) The prices in this offer have been arrived at independently, without consultation, communication, or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other offeror or with any competitor;
  - (2) Unless otherwise required by law, prices which have been quoted in this offer have not been knowingly disclosed by the offeror and will not be knowingly disclosed by the offeror prior to opening in the case of an advertised procurement or prior to award in the case of negotiated procurement directly or indirectly to any other offeror or to any competitor; and
  - (3) No attempt has been made by the offeror to induce any other person or firm to submit or not to submit an offer for the purpose of restricting competition.

(b) Each person signing this offer certifies that:

- (1) He is the person in the offeror's organization responsible within that organization for the decision as to prices being offered herein and that he has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above; or
- (2) (i) He is not the person in the offeror's organization responsible within that organization for the decision as to the prices being offered herein but that he has been authorized in writing to act as agent for the persons responsible for such decision in certifying that such persons have not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above, and as their agent does hereby so certify; and  
  
(ii) he has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above.
- (c) An offer will not be considered for award where (a)(1), (a)(3) or (b) of the certification has been deleted or modified. Where (a)(2) of the certification has been deleted or modified, the offer will not be considered for award unless the offeror furnishes with the offer a signed statement which sets forth in detail the circumstances of the disclosure and AUI, or its designee, determines that such disclosure was not made for the purpose of restricting competition.

### **3. Contingent Fee**

- (a) He    has,    has not, employed or retained any company or person (other than a full-time, bona fide employee working solely for the offeror) to solicit or secure this contract, and
- (b) He    has,    has not, paid or agreed to pay any company or person (other than a full-time, bona fide employee working solely for the offeror) any fee, commission, percentage, brokerage fee contingent upon or resulting from the award of this contract, and
- (c) Agrees to furnish information relating to (a) and (b) above, as requested by AUI or the NSF Grants and Agreements Officer. (For interpretation of the representation, including the term "bona fide employee," see Code of Federal Regulations, Title 41, Subpart 1-1.5).

### **4. Small Business, Small Disadvantaged Business, and Women-Owned Small Business Concerns**

If you qualify as a small business, small disadvantaged business, or women-owned business concern (check)    and complete the form below entitled, "Small Business Representation." (Definitions are contained in Section 211, Public Law 95-507, Oct. 24, 1978, and Executive Order 12138, May 18, 1979. Questions concerning these definitions or the classification of your concern may be referred to the Federal or State Small Business Administration Representative covering your area.)

**5. Labor Surplus Area**

It \_\_ will, \_\_ will not, perform work in an area classified by the Secretary of Labor as (1) \_\_ section of concentrated unemployment or underemployment; (2) \_\_ persistent labor surplus area; or (3) \_\_ substantial labor surplus area.

**6. (a) Equal Opportunity**

It \_\_ has, \_\_ has not, participated in a previous contract or subcontract subject either to the Equal Opportunity clause herein or the clause originally contained in Section 301 of Executive Order 10925, or the clause contained in Section 201 of Executive Order 11114; that it \_\_ has, \_\_ has not, filed all required compliance reports; and that representation, indicating submission of required compliance reports, signed by proposed subcontractors, will be obtained prior to subcontract awards. (The above representation need not be submitted in connection with contracts or subcontracts which are exempt from this clause.)

**(b) The Following Certification Shall be Completed by Each Offeror Whose Offer is \$50,000 or More and Who Has 50 Employees or More:**

The offeror certifies that

- (1) it \_\_ has, \_\_ has not, developed and maintained at each of his establishments Equal Opportunity Affirmative Action Programs, pursuant to 41 CFR 60-1,-2, or
- (2) it \_\_ has, \_\_ has not, previously had contracts subject to written affirmative action program requirement of the rules and regulations of the Secretary of Labor.

**7. Notice of Requirement for Affirmative Action to Ensure Equal Employment Opportunity:**

- (a) The offeror's attention is called to the Equal Opportunity article of this solicitation.
- (b) [Reserved]
- (c) The Contractor's compliance with Executive Order 11246, as amended, and the regulations of 41 CFR 60-4 shall be based on (1) its implementation of the Equal Opportunity clause, (2) specific affirmative actions, and (3) its efforts to meet the goals. The hours of minority and female employment and training must remain substantially uniform throughout the length of the contract, and in each trade. The Contractor shall make a good faith effort to employ minorities and women evenly on each of its projects. The transfer of minority or female employees or trainees from Subcontractor to Contractor, or from project to project, for the sole purpose of meeting the Contractor's goals shall be a violation of the contract, Executive Order 11246, as amended, and the regulations in 41 CFR 60-4. Compliance with the goals will be measured against the total work hours performed.
- (d) The Contractor shall provide written notification to the Director, Office of Federal Contract Compliance Programs, within 10 working days following award of any

construction subcontract in excess of \$10,000 at any tier for construction work under the contract resulting from this solicitation. The notification shall list the following:

- (1) Name, address, and telephone number of the Subcontractor;
    - (i) Employer identification number of the Subcontractor;
  - (2) Estimated dollar amount of the subcontract;
  - (3) Estimated starting and completion dates of the subcontract; and
  - (4) Geographical area in which the subcontract is to be performed.
- (e) As used in this Notice, and in any contract resulting from this solicitation, the “covered area” is United States of America.

#### **8. Preaward On-Site Equal Opportunity Compliance Review**

An award in the amount of \$1 million or more may not be made under this solicitation unless the offeror and each of its known first-tier subcontractors (to whom it intends to award a subcontract of \$1 million or more) are found, on the basis of a compliance review, to be able to comply with the provisions of the Equal Opportunity clause of this solicitation.

#### **9. Notice to Prospective Subcontractors or Requirement for Certifications of Nonsegregated Facilities**

A certification of Nonsegregated Facilities must be submitted prior to the award of a subcontract exceeding \$10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each subcontract or for all subcontracts during a period (i.e., quarterly, semi-annually, or annually).

“Certification of Nonsegregated Facilities”: (Applicable to contracts, subcontracts, and to agreements with applicants who are themselves performing Federally assisted construction contracts, exceeding \$10,000 which are not exempt from the provisions of the Equal Opportunity clause.)

By the submission of this bid, the bidder, offeror, applicant, or Subcontractor certifies that he does not maintain or provide for his employees any segregated facilities at any of his establishments, and that he will not permit his employees any segregated facilities at any of his establishments, and that he will not permit his employees to perform their services at any location, under his control, where segregated facilities are maintained. The bidder, offeror, applicant, or Subcontractor agrees that a breach of this certification is a violation of the Equal Opportunity clause in this contract. As used in this certification, the term “segregated facilities” means any waiting rooms, work areas, rest rooms and wash rooms, restaurants, and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for

employees which are segregated by explicit directive or are in fact segregated on the basis of race, color, religion, or national origin, because of habit, local customs, or otherwise. He further agrees that (except where he has obtained identical certifications from proposed subcontractors for specific time periods) he will obtain identical certification from proposed subcontractors prior to the award of subcontracts exceeding \$10,000 which are not exempt from the provisions of the Equal Opportunity clause; that he will retain such certifications in his files; and that he will forward the above notice to such proposed subcontractors (except where the proposed subcontractors have submitted identical certifications for specific time periods).

#### **10. Listing of Employment Openings**

Offerors should note that this solicitation includes a provision which will be included in the contract requiring the listing of employment openings with the local office of the State employment service system if the award is for \$2,500 or more.

#### **11. Clean Air and Water Certification**

(Applicable if the bid or offer exceeds \$100,000, or AUI has determined that orders under an indefinite quantity subcontract in any year will exceed \$100,000, or a facility to be used has been the subject of a conviction under the Clean Air Act (452 U.S.C. 1857c-8(c)(1)) or the Federal Water Pollution Control Act (33 U.S.C. 1319(c)) and is listed by EPA, or is not otherwise exempt.)

The offeror certifies as follows:

- (a) Any facility to be utilized in the performance of this proposed subcontract \_\_ has, \_\_ has not, been listed on the Environmental Protection Agency List of Violated Facilities.
- (b) It will promptly notify AUI, prior to award, of the receipt of any communication from the Director, Office of Federal Activities, Environmental Protection Agency, indicating that any facility which he proposes to use for the performance of the subcontract is under consideration to be listed on the EPA List of Violating Facilities.
- (c) It will include substantially this certification, including this paragraph (c), in every non-exempt subcontract.

#### **12. [Reserved]**

#### **13. PLACE OF PERFORMANCE**

The proposer shall list below the address and name of the owner of plants or facilities, other than those located at the proposer address, where he intends to perform work under a subcontract resulting from this solicitation.



PLACE OF PERFORMANCE

OWNER IF OTHER THAN OFFEROR

\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

**14. Cost Accounting Standard Notices and Certifications  
(Not Applicable to Small Business)**

(a) Any contract over \$100,000 resulting from this solicitation shall be subject to Cost Accounting Standard (CAS) if it is awarded to a business unit that is currently performing a national defense CAS-covered contract or subcontract, except when

- (1) The award is based on adequate price competition;
- (2) The award is set by law or regulation;
- (3) The price is based on established catalog or market prices of commercial items sold in substantial quantities to the general public; or
- (4) One of the exemptions in 4 CFR 331.30(b) applies (also see Federal Acquisition Regulation (FAR) 30.301 (b)).

(b) Contracts not exempted from CAS shall be subject to full or modified coverage as follows:

- (1) If the business unit receiving the award is currently performing a national defense contract or subcontract subject to full CAS coverage (4 CFR 331), this contract will have full CAS coverage and will contain the clauses from the FAR entitled Cost Accounting Standards (52.230-3) and Administration of Cost Accounting Standards (52.230-4).
- (2) If the business unit receiving the award is currently performing a national defense contract or subcontract subject to modified CAS coverage (4 CFR 332), this contract will have modified coverage and will contain the clauses entitled Disclosures and Consistency of Cost Accounting Standards (52.230-4).

**A. Certificate of CAS Applicability**

The offeror hereby certifies that:

\_\_\_\_\_The offeror is not performing any CAS-covered national defense contract. The offeror further certifies that it will immediately notify AUI and NSF in writing if it is awarded any national defense CAS-covered contract or subcontract subsequent to the date of this certificate but before the date of the award of a contract resulting from this solicitation. (If this statement applies, no further certification is required.)

\_\_\_\_\_The offeror is currently performing a negotiated national defense contract or subcontract that contains the Cost Accounting Standards Clause.

\_\_\_\_\_The offeror is currently performing a negotiated national defense contract or subcontract that contains the Disclosure and Consistency of Cost Accounting Practices clause.

B. Additional Certification - CAS-Applicable Proposers

\_\_\_\_\_The offeror subject to Cost Accounting Standards further certifies that practices used in estimating costs in pricing this proposal are consistent with the practices disclosed in the Disclosure Statement where it has been submitted pursuant to CAS Board regulations (4 CFR 351).

C. Data Required - CAS-Covered Offerors

The offeror certifies that it is currently performing a national defense contract containing either CAS clause (see A above) is required to furnish the name, address (including agency or department component), and telephone number of the cognizant Contracting Officer administering the offeror's CAS-covered contracts.

Name of Contracting Officer: \_\_\_\_\_

Address: \_\_\_\_\_

Telephone Number: \_\_\_\_\_

The undersigned represents and certifies that he/she is authorized to sign this document on behalf of:

\_\_\_\_\_  
(Company)

\_\_\_\_\_  
(Date)

BY: \_\_\_\_\_

(Signature)

\_\_\_\_\_  
(Title)

## SMALL BUSINESS REPRESENTATION

PLEASE RETURN WITH YOUR PROPOSAL.

Contractor's Proposal Number \_\_\_\_\_ Date \_\_\_\_\_

I hereby represent that I am authorized to and do hereby certify that

\_\_\_\_\_  
(Company Name)

\_\_\_\_\_  
(Address)

___ is	___ is not	___	a small business concern
		___	a small business concern owned and controlled by socially and economically disadvantaged individuals
		___	a small business concern owned and controlled by women
___ is	___ is not	___	a large business concern
		___	a large business concern owned and controlled by socially and economically disadvantaged individuals
		___	a large business concern owned and controlled by women

(Definition per Section 211, Public Law 95-507, October 24, 1987.)

\_\_\_\_\_  
(Company)

BY:

\_\_\_\_\_  
(Signature)

\_\_\_\_\_  
(Title)

**APPENDIX D**

**RELEASE OF CLAIMS**

Contractor \_\_\_\_\_

Contract \_\_\_\_\_

I hereby certify that the following work under Contract No. \_\_\_\_\_ (hereinafter referred to as the "Contract") between the above named Contractor and Associated Universities, Inc., (hereinafter referred to as AUI) which is a contract under Cooperative Agreement No. NSF AST-9223814 between AUI and the U.S. Government, has been completed.

In consideration of the total payment on account of the Contract in the sum of \$ \_\_\_\_\_ made by AUI, the undersigned Contractor hereby releases AUI, its officers, agents and employees and the Government of the United States, its agents and employees, from any and all claims arising under the Contract or in connection with the work, described above, required to be performed thereunder, and hereby agrees to indemnify AUI and the U.S. Government against, and to save each of them harmless from, any claims by any person arising out of or in any way connected with the Contract or the work thereunder. The following are excepted from the foregoing release and agreement:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Witness:

\_\_\_\_\_  
(Contractor)

By \_\_\_\_\_

\_\_\_\_\_  
(Address)

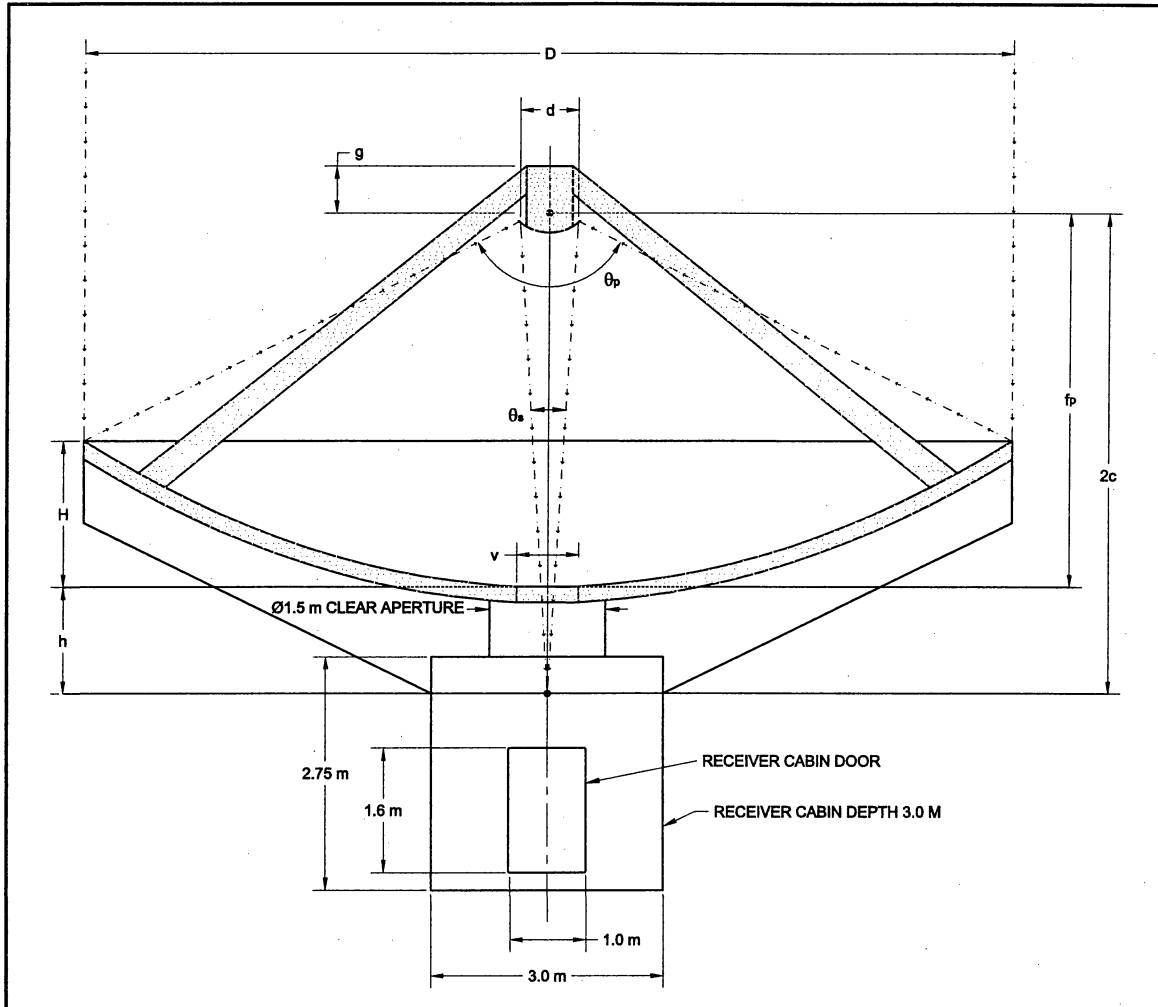
\_\_\_\_\_  
(Title)

## APPENDIX E

### ANTENNA OPTICAL CONFIGURATION

#### MMA OPTICAL CONFIGURATION

JANUARY 1999

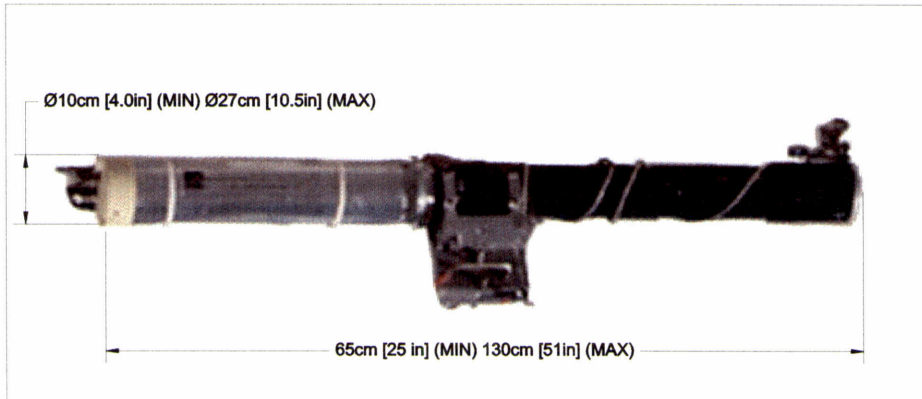


OPTICAL CONFIGURATION

D	Primary Aperture	12.0 m	472 in
$f_p$	Focal Length of Primary	4.8 m	189 in
$f_p / D$ of Primary		0.40	0.40
d	Secondary Aperture	0.75m	29.5in
	Final $f / D$	8.00	8.00
	Magnification Factor	20.0	20.0
$\theta_p$	Primary Angle of Illumination	128.02°	128.02°
$\theta_s$	Secondary Angle of Illumination	7.16°	7.16°
2c	Distance Between Primary and Secondary Foci	6.177 m	243.2in
H	Depth of Primary	1.97 m	77.7 in
h	Distance from Vertex to Secondary Focus	1.38m	54.3in
a	Distance from Elevation Axis to Focus	0.45 m	17.7 in
g	Distance from Primary Focus to Top of Quadrupod	0.60 m	23.6 in
v	Primary Vertex Hole Clear Aperture	0.75 m	29.5 in

## APPENDIX F

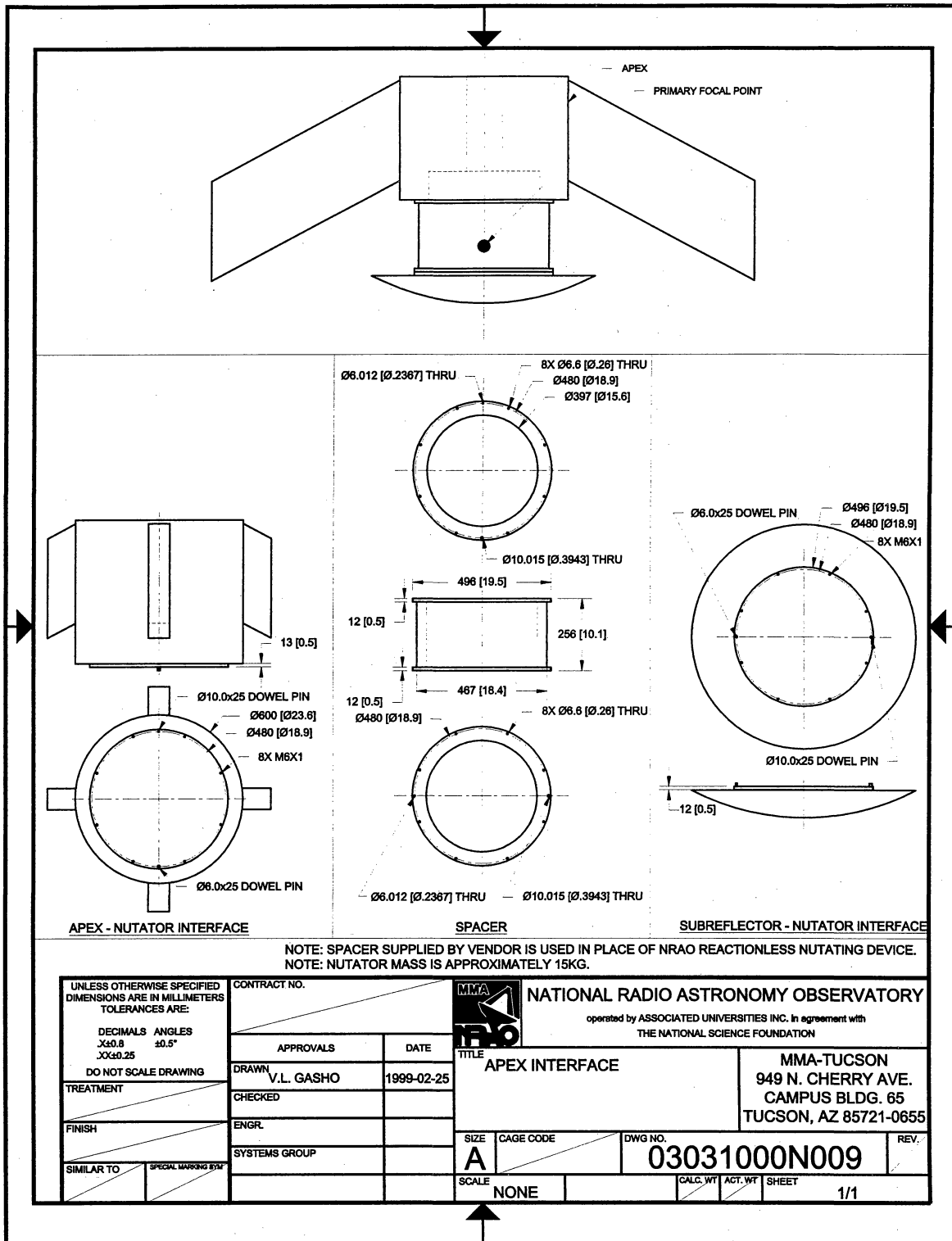
### OPTICAL TELESCOPE DRAWING AND SPECIFICATIONS



<b>METRIC</b>									
THIRD ANGLE PROJECTION									
		MASS ~ 12kg							
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS TOLERANCES ARE: DECIMALS ANGLES .X $\pm$ 0.8 $\pm$ 0.5° .XX $\pm$ 0.25 DO NOT SCALE DRAWING		CONTRACT NO.				<b>NATIONAL RADIO ASTRONOMY OBSERVATORY</b> operated by ASSOCIATED UNIVERSITIES INC. in agreement with THE NATIONAL SCIENCE FOUNDATION			
TREATMENT		APPROVALS		DATE		TITLE		MMA - TUCSON 949 N. CHERRY AVE. CAMPUS BLDG. 65 TUCSON, AZ 85721-0655	
FINISH		DRAWN		1999-01-07		TELESCOPE OPTICAL POINTING			
SIMILAR TO		CHECKED				SIZE		REV.	
SPECIAL MARKING BY		ENGR.				CAGE CODE		DWG NO.	
		SYSTEMS GROUP				A		03031000N008	
						SCALE		SHEET	
						NONE		1/1	

# APPENDIX G

## APEX INTERFACE



## APPENDIX H

### CABLE AND HOSE SIZES

AUI Additional Cables Required in Azimuth & Elevation Cable Wraps.

Quantity	Cable	Cable Diameter	Connector Dia.
6	High Pressure Gas Lines *	20 mm	40 mm
4	Fiber Optic Cable	10 mm	20 mm
4	15 Twisted Pair	25 mm	75 mm
4	RG-9 Coaxial	20 mm	35 mm

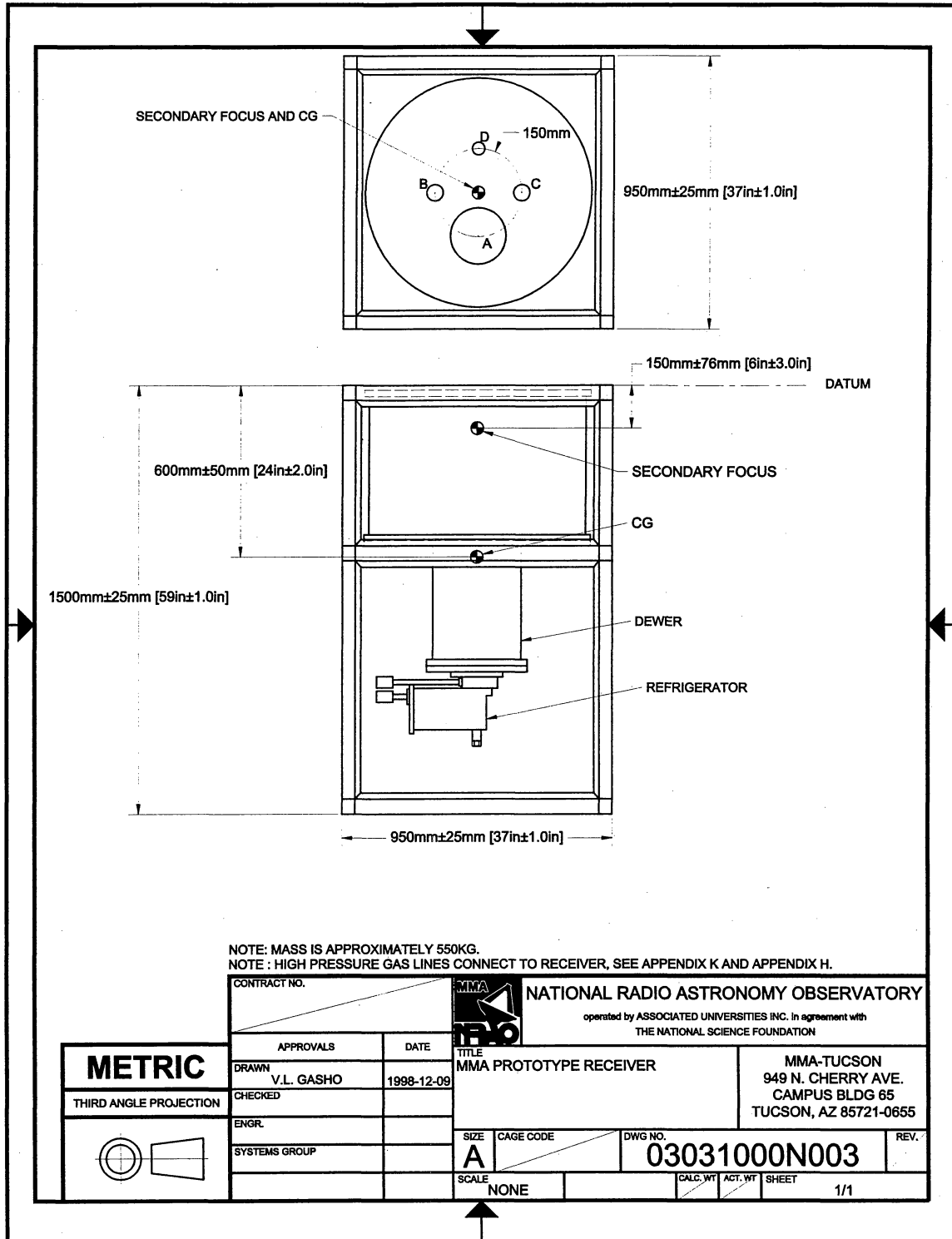
AUI will provide and install above cables in Contractor provided cable wraps.

\* See Appendix I, "Receiver Package Interface Drawing", and Appendix K, "Cryogenic Compressor Interface", for more information on high pressure gas lines.



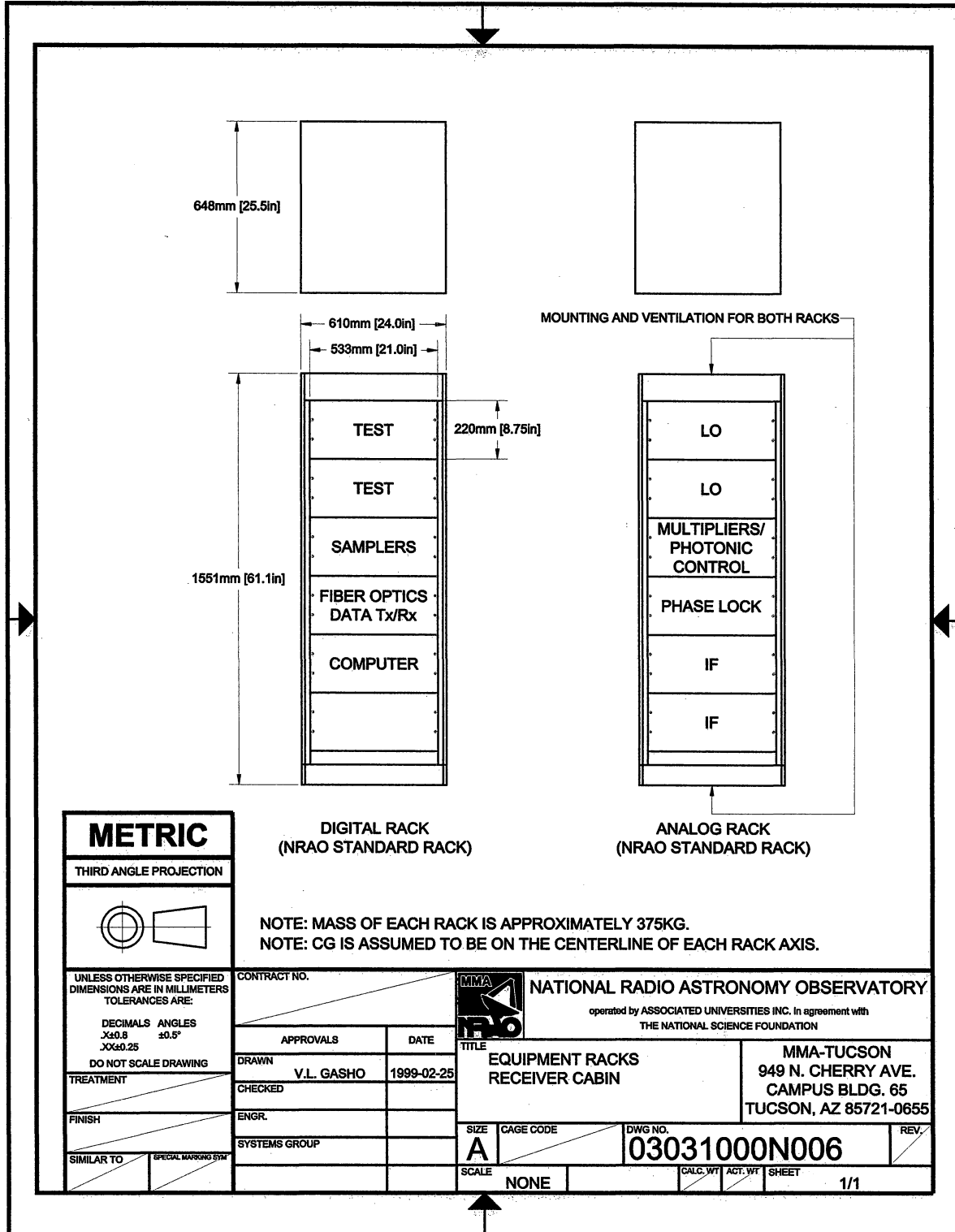
# APPENDIX I

## RECEIVER PACKAGE INTERFACE DRAWING

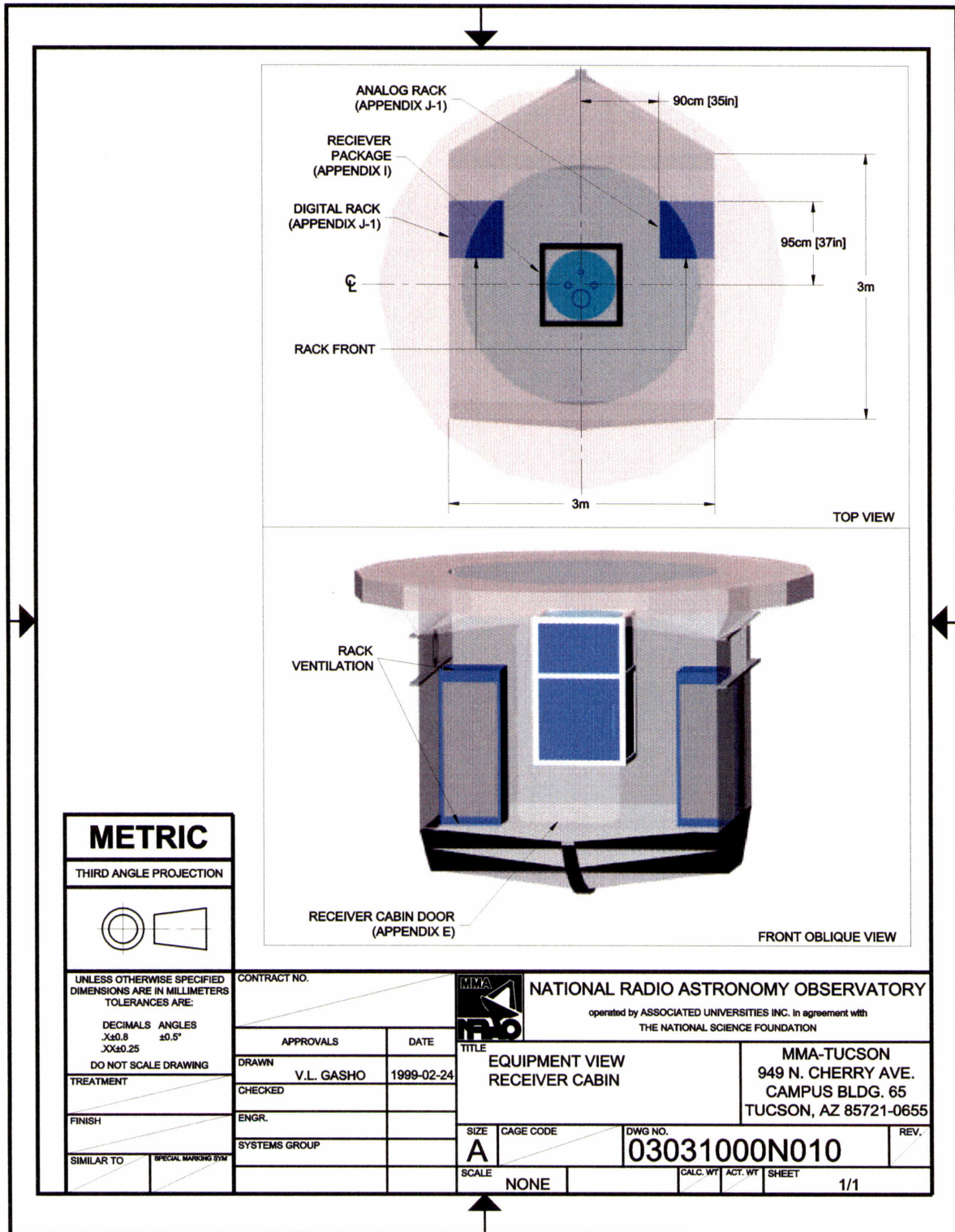


# APPENDIX J

## RECEIVER CABIN EQUIPMENT

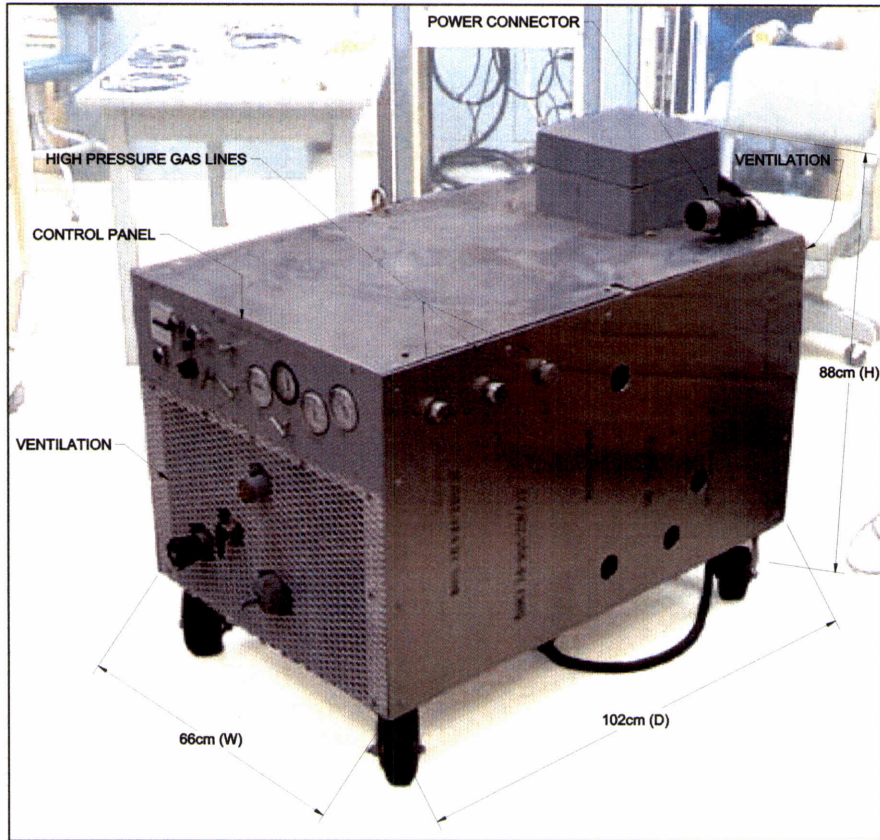


## RECEIVER CABIN EQUIPMENT VIEW



## APPENDIX K

### CRYOGENIC COMPRESSOR INTERFACE



#### METRIC

THIRD ANGLE PROJECTION



UNLESS OTHERWISE SPECIFIED  
DIMENSIONS ARE IN MILLIMETERS  
TOLERANCES ARE:

DECIMALS ANGLES  
X±0.8 ±0.5°  
XX±0.25

DO NOT SCALE DRAWING

TREATMENT

FINISH

SIMILAR TO

SPECIAL MARKING SYM

NOTES: 1. MASS ~ 136KG

2. PROVIDE MOUNTING FOR ONE COMPRESSOR.

3. PROVIDE SPACE 150cm x 120cm x 180cm (H x W x D) FOR COMPRESSOR.

4. MOUNTING WILL BE ABOVE THE AZIMUTH BEARING AND BELOW THE ELEVATION BEARING.

5. THE COMPRESSOR SHALL NOT ROTATE WITH THE ELEVATION AXIS.

6. COMPRESSOR MUST BE ACCESSIBLE FOR SERVICING AND EASILY REMOVED AND REPLACED.

7. PROVIDE 380 VAC, 3φ, 50 AMP POWER CONNECTION FOR COMPRESSOR.

8. PROVIDE ROUTING OF HIGH PRESSURE GAS LINES FROM COMPRESSOR TO THE RECEIVER CABIN.

9. VENTILATION SHOWN MUST PROVIDE HEAT DISSIPATION TO AMBIENT AIR.

CONTRACT NO.

APPROVALS

DATE

DRAWN

V.L. GASHO

1998-12-11

CHECKED

ENGR.

SYSTEMS GROUP



NATIONAL RADIO ASTRONOMY OBSERVATORY

operated by ASSOCIATED UNIVERSITIES INC. in agreement with  
THE NATIONAL SCIENCE FOUNDATION

TITLE

COMPRESSOR  
MMA CRYOGENICS

MMA-TUCSON

949 N. CHERRY AVE.  
CAMPUS BLDG. 65  
TUCSON, AZ 85721-0655

SIZE

CAGE CODE

DWG NO.

REV.

SCALE

NONE

CALC. W/T

ACT. W/T

SHEET

1/1

## APPENDIX L

### MOLECULAR SIEVE INTERFACE

For additional information call  
Toll-Free U.S./Canada:  
800-874-0202

## AS-12 Specifications



AirSep Corporation  
290 Creekside Drive  
Buffalo, NY 14228-2070 USA  
Tel: (716) 691-0202 24 Hr. Fax: (716) 691-0707  
TELEX: 8102500585 AIRSEP

**Dewpoint:** -100° F (-73° C)

**Feed Air Requirements:** None if equipped with compressor.  
150.0 SCF/hr @ 30 psig  
3.9 Nm<sup>3</sup>/hr @ 207 kPa

**Sound Level:** 55 dba @ 1 meter, open field conditions (with enclosure)

**Dimensions:** 17.25 x 10 x 26.75 inch (WxDxH)  
44 x 25.5 x 68 cm (WxDxH)

**Weight:** 55 lb. (25 kg.)  
46 lb. (21 kg.) less enclosure  
25 lb. (11.5 kg.) less compressor

**Power Requirements:** 120 VAC, 60 Hz, Single Phase,  
4.0 ampere (with compressor)  
220 VAC, 50 Hz, Single Phase,  
2.0 ampere (with compressor)  
Other voltages available.

**Power Consumption:** 350 watts (with compressor)  
25 watts (less compressor)

**Oxygen Outlet:** "B" size oxygen adaptor

#### Operating Conditions:

The generator must be located in a well ventilated area which remains above 40° F/5° C and below 100° F/38° C.

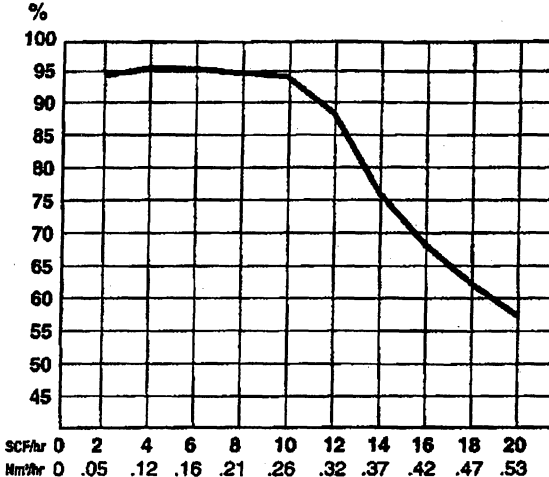
Operating the generator in an area below 40° F/5° C, or above 100° F/38° C will cause damage not covered under the manufacturer's warranty. AirSep Oxygen Generators are sold for use in industrial applications only. The generator must not be used for any "respiratory" medical application.

#### Standard Accessory Kit Included With Unit Contains:

- 1 ea. Instruction Manual
- 1 ea. Gross Particle Filter
- 1 ea. Barbed Hose Connector

### Generator Output

Oxygen Purity (+/- 5%)



Flow @ 0-9 psig (62 kPa) Maximum

Note: Contact Factory for operation at higher pressures and/or flows.

#### Ordering Information:

Description	Part Number
AS-12 Oxygen Generator (120 VAC)	AS-88-012
AS-12 Oxygen Generator (220 VAC)	AS-88-012E
Options:	
Description	Part Number
Deduct Enclosure	SB-IN-802
Deduct Compressor Assembly	SB-IN-803

AirSep Corporation is continuously striving to improve its products, and reserves the right to change specifications or equipment without incurring obligations to units previously or subsequently sold.

## APPENDIX M

### GLOSSARY

AAB - Antenna Assembly Building	MIL-STD - Military Standard
ACU - Antenna Control Unit	MHz - Megahertz
AUI - Associated Universities Incorporated	MTBF - Mean Time Before Failure
BIMA - Berkeley Illinois Maryland Association	ms - milliseconds
BUS - Back-up Structure	NEC - National Electric Code
CAS - Cost Accounting Standards	NEMA - National Electrical Manufacturers Association
CDR - Critical Design Review	NRAO - National Radio Astronomy Observatory
CFR - Code of Federal Regulations	NSF - National Science Foundation
CFRP - Carbon Fiber Reinforced Plastic	OEM - Original Equipment Manufacture
CPU - Central Processing Unit	OFCCP - Office of Federal Contract Compliance Programs
DC - Direct Current	OVRO - Owens Valley Radio Observatory
EEO - Equal Employment Opportunity	PDR - Preliminary Design Review
EPA - Environmental Protection Agency	PPE - Personal Protective Equipment
ESO - European Southern Observatory	RFI - Radio Frequency Interference
FAR - Federal Acquisition Regulation	RFP - Request For Proposal
FEA - Finite Element Analysis	RMS - Root-Mean-Squared
FOB - Free-On-Board	RSS - Root-Sum-Squared
G - Gravity	SEC - Socorro Electric Cooperative
G&A - General and Administrative	TBD - To Be Determined
GHz - Gigahertz	µm - Micrometers (microns)
Hz - Hertz	tons - (short) - (2,000 pounds or 907.2 kilograms)
IRAM - Institut de Radio Astronomie Millimétrique	U.S. - United States
kVA - kilo-volts-amps	USC - United States Code
kW - kilowatts	WBS - Work Breakdown Schedule
LO - Local oscillator	WWW - World Wide Web
LSA - Large Submillimeter Array	VA - Volts-Amps
HVAC - Heating Ventilation and Air conditioning	VAC - Volts Alternating Current
m - meter	VLA - Very Large Array
mm - millimeter	