



Atacama Large Millimeter Array

ANNEX 4

STATEMENT OF WORK

Design, Manufacturing, Transport and Integration on Site of the 32 ALMA ANTENNAS

ALMA-34.00.00.00-007-A-SOW

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Prepared by:		
Name(s) and Signature(s)	Organisation	Date
	ESO, Antenna IPT	2003-12-16
	NRAO, Antenna IPT	2003-12-16
Approved by:		
Name(s) and Signature(s)	Organisation	Date
	ESO, Project Manager	2003-12-16
	NRAO, Project Manager	2003-12-16
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Name(s) and Signature(s)	Organisation	Date
	JAO, ALMA Director	2003-12-16

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1 INTRODUCTION

The Atacama Large Millimeter Array (ALMA) is an international astronomy facility. ALMA is an equal partnership between Europe and North America, in cooperation with the Republic of Chile, and is funded by the U.S. National Science Foundation (NSF), the National Research Council of Canada (NRC), the European Southern Observatory (ESO), and the Ministries of Science and Technology and of Public Works of Spain. ALMA construction and operations are lead on behalf of Europe by ESO, and on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI).

Astronomical observation will be carried at the Array Operation Site (AOS) located at an elevation of 5000 meters above sea level on the Chajnantor plateau in the Atacama desert in northern Chile. The array will be a synthesis radio telescope of 64 antennas of 12m diameter, operating in interferometric mode at millimeter and sub-millimeter wavelengths (0.3 to 10 millimeters). The antennas will be relocated by means of a dedicated antenna transporter between a large number¹ of antenna stations spread over an area of approximately 20 km radius. An assembly and maintenance facility, the Operating Support Facility (OSF) will be constructed near San Pedro de Atacama to support the observatory during the construction and the operation phases.

This Statement of Work foresees a first phase in which the design proposed by the Contractor during the bid phase is developed up to the detail design level, and subjected to an engineering review process by ALMA to verify its ability to meet the ALMA Antenna Specification. This is followed by the antenna production phase. The antennas will be shipped, integrated and acceptance tested at the OSF in Chile.

The total number of antennas to be delivered under the Contract corresponding to this Statement of Work is 32.

¹ It is expected that more than 200 antenna stations will be constructed.



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2 APPLICABLE AND REFERENCED DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents are integral to this statement of work to the extent specified herein. In the event of conflict between the documents referenced herein and the content of this Statement of Work, the content of this Statement of Work shall be considered as a superseding requirement.

- AD 01 ALMA-34.00.00.00-006-A-SPE
Technical Specification for the Design, Manufacturing, Transport and Integration on Site of the ALMA Antennas
- AD 02 ALMA-10.00.00.00-002-A-PRO
Conditions, Rules and Regulations applicable for Contractors working at the ALMA Operations Support Facility
- AD 03 ALMA-80.09.00.00.001-B-PLA
ALMA Reviews, Definitions, Guidelines and Procedure
- AD 04 ALMA-80.11.00.00.001-B-GEN
Product Assurance Requirements
- AD 05 SAF-POL-ESO-00000-0001, issue 2, dated 01.09.97
ESO Safety Policy
- AD 06 NRAO Environment, Health and Safety Manual,
Latest edition

2.2 REFERENCED DOCUMENTS

- RD 01 ICD between ALMA Chile Infrastructure and Antenna Transporter
ALMA 20.00.00.00-37.00.00.00-A-ICD



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3 ACRONYMS AND DEFINITIONS

3.1 ACRONYMS

ACCn	Antenna Acceptance Unit #n
ACRVn	Acceptance Review Antenna Unit #n
ACU	Antenna Control Unit
ADxx	Applicable Document no. XX
AIPCn	Assembly Inspection Point Chile of antenna #n
AOS	Array Operations Site
ALMA	Atacama Large Millimeter Array
AUI	Associated Universities, Incorporated
BUS	Back-up Structure
CFRP	Carbon Fiber Reinforced Plastic
CRE	Change Request
DRL	Documentation Requirement List
DRD-XX	Document Requirement Definition of document XX
ESO	European Southern Observatory
FEM	Finite Element Model
FEA	Finite Element Analysis
FTP	File Transfer Protocol
HW	Hardware
IPT	Integrated Product Team
MTBF	Mean Time Between Failure
NCR	Non Conformance Report
NRAO	National Radio Astronomy Observatory
OSF	Operation Support Facility
PA	Product Assurance
PCU	Portable Control Unit
PPDR	Pre Production Design Review
RDXX	Referenced Document XX
RFW	Request For Waiver
SW	Software
SOW	Statement of Work
WBS	Work Breakdown Structure
WP	Work Packages



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3.2 DEFINITIONS

ALMA

The term “ALMA” means either ESO or AUI. It is the Executive Organization that has contracted with the Contractor for the Work.

ALMA Project Office

For the purposes of this Statement of Work equivalent to ALMA above.

Antenna or “serial antenna”:

Any antenna of the ALMA project manufactured according to this Statement of Work.

Antenna acceptance:

This means “Provisional Acceptance” according to the Contractual Terms of ESO, and “Final Acceptance” according to the Business Conditions of AUI/NRAO.

Proposal Design:

This is the design of the antenna as it has been submitted by the Contractor during the bid phase and been selected for the execution of the Contract.

Technical Specification

For the purpose of this SOW Technical Specification means the Technical Specification proper(AD01) and its applicable documents (ICD, Standards, drawings....)

Antenna #1

This is the first antenna to be delivered to the OSF in Chile, irrespective of the sequence of manufacturing chosen by the Contractor.

Antenna #n

This is the antenna number n to be delivered at the OSF in Chile.

Site

The Operation Support Facility (OSF) in Chile close to San Pedro de Atacama. (not to be confused with the Array Operation Site (AOS), where the antennas will be operating).

Work Area or “Contractor’s Work Area

The antenna assembly, erection and storage area assigned to the Antenna Contractor at the OSF site.



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4 TASK ORGANISATION FOR THE ALMA ANTENNAS CONTRACT

4.1 GENERAL CONSIDERATIONS

The work described herein consists of the furnishing of labor, materials, services, drawings, data, detailed specifications, test documents, hardware, software, tooling, and other items required for the design, engineering, fabrication, shipping, assembly on site and acceptance testing of a specified number of ALMA antennas as further herein specified.

The Contractor shall perform all engineering and management tasks associated with the present statement of work in accordance with the applicable documents, the state of the art and good engineering practice.

The various tasks have to be performed according to the schedule given in section 4 hereunder.

In particular the Contractor shall perform:

- The technical tasks defined under section 5.2.
- The project management tasks defined under section 6.
- The product assurance tasks defined under section 7.

4.2 TASKS OVERVIEW

The tasks associated with the design and development, manufacturing, transport, testing, integration at the OSF site, and delivery of the contracted number of antennas at the ALMA OSF site in Chile, have been globally distributed into the following phases:

4.2.1 TASKS RELATED TO THE ANTENNA #1:

4.2.1.1 Design Phase

In this phase the Contractor shall elaborate the *proposal design* up to all details and shall demonstrate at design and analysis level the compliance of the design with the Technical Specification. This phase will terminate with the Pre-Production Design Review in which the overall design will be reviewed by the ALMA Project Office.



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4.2.1.2 Manufacturing Phase

During this phase the Contractor shall manufacture the first antenna. In this phase the Contractor will perform all subsystem and system pre-assembly and verification activities as he deems necessary to assure full compliance with the Technical Specification at the time of delivery of the antenna at the site.

4.2.1.3 Transport Phase

During this phase the Contractor shall pack and transport to the Operation Support Facility (OSF) site in Chile Unit #1. A *Work Area* will be assigned to the Contractor by ALMA for all his activities including unloading and storage of the antenna parts. The Contractor will have prepared his *Work Area* in advance of this phase, (See Section 4.2.3, “Non-recurring tasks”).

4.2.1.4 Assembly Phase:

During this phase the various parts of the antenna are assembled, the antenna is erected, aligned and tested by the Contractor in his *Work Area*. Dedicated antenna stations, provided by ALMA at the Contractor’s area will be used by the Contractor for the assembly phase. This phase ends with an Assembly & Inspection Point, AIP1, which allows the start of the Acceptance Testing Phase.

4.2.1.5 Acceptance Testing Phase

During this phase all the testing activities related to the Acceptance testing of Unit #1 are performed at the OSF in Chile. The testing will be performed in accordance with the Verification requirements of the Technical Specification, with the antenna mounted on one of the antenna stations assigned to the Contractor. This Phase terminates with an Antenna Acceptance Review ACRV1.

4.2.2 TASK RELATED TO THE ANTENNA #2 TO N

4.2.2.1 General considerations

The Contractor shall have complete control on the sequence of manufacturing, transport and assembly of Antennas #2 to 32. The present SOW does not require that the manufacturing of the Antenna #2 and following ones is linked to the completion of phase related to the Antenna #1. Nevertheless, while choosing the sequence of manufacturing the Contractor shall take into account that all units must be manufactured and delivered to an identical design.

Modifications of design becoming necessary as the result of the testing of Antenna #1, must be introduced in the subsequent antennas. Similarly, modifications of design found by ALMA or the Contractor to be necessary in order to meet the Technical



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Specification of the antennas during the manufacturing of any Antenna #n must be retrofitted to the Antenna #1 to Antenna #(n-1). This includes software.

4.2.2.2 Manufacturing and Manufacturing Sequence

During this phase the Contractor shall manufacture Antennas #2 to 32. The Contractor shall organize the manufacturing activities and their sequence in order to comply with the requirements of Section 4.3 herein. Pre-assembly, inspection and testing of individual subsystems shall be performed to the extent deemed necessary to assure the final performance of the units.

4.2.2.3 Transport and Storage

The Contractor shall pack and transport antenna parts and equipment to his *Work Area* at the OSF. Storage is also possible at the *Work Area*.

4.2.2.4 Assembly on Site

Each individual antenna shall be assembled, aligned and tested by the Contractor in its *Work Area*. The alignment and testing of each antenna shall take place with the antenna mounted on an antenna station. For each individual antenna this phase ends with an Assembly & Inspection Point in Chile, AIPC_n, which allows the start of the Acceptance Testing for that antenna.

4.2.2.5 Acceptance Testing Phase

This phase is constituted by the activities related to the Acceptance testing of Antenna #n with the antenna mounted on one of the antenna stations assigned to the Contractor. The testing demanded by verification requirements of the Technical Specification is a subset of the test program demanded for Antenna #1. This Phase terminates with an Antenna Acceptance Review ACRV_n.

4.2.3 NON-RECURRING TASKS

The following non-recurring tasks have been identified, in addition to the antenna design activities:

- Design and procurement of antenna manufacturing tools, such as CFRP moulds, machining tools, and in general any device which may be needed to manufacture in a timely manner the antenna parts.
- Layout design of the Contractor's Work Area at the OSF and submittal to ALMA for comment and approval.
- Preparation of the Work Area according to the design approved by ALMA



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- Procurement of tools and equipment necessary for the handling, assembly, integration, alignment and testing of the antennas, and transport of them to the Work Area at the OSF.
- Restoration of the Work Area after completion of the delivery of all antennas.

The Contractor shall be responsible for the organization of all logistic tasks which may be necessary for the timely manufacturing, transport, assembly, testing and delivery of the antennas at the OSF, even if not specifically listed above.

4.3 TECHNICAL MILESTONES

The following technical milestones for the execution of the Contract are identified:

T0	Start of Contract
PPDR	Pre-Production Design Review
AIPC1	Assembly and Inspection Point in Chile of Unit #1
ACC1	Acceptance of Unit #1
AIPCn	Assembly and Inspection Point in Chile Antenna #n with n =2 to 32
ACCn	Acceptance of Unit #n with n=2 to 32

4.4 BASELINE PLANNING AND SCHEDULE REQUIREMENTS

The schedule of the top-level milestones for the execution of the Contract is the following:

- Antenna #1 accepted at the OSF 18 months after Start of Contract
- Antenna #32 accepted at the OSF in 4th Quarter 2011

Note: The detail and intermediate milestones agreed with the Contractor will be incorporated in this Statement of Work at the time of signature of the Contract.



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5 DETAILED DEFINITION OF THE TECHNICAL TASKS

The Contractor shall perform as a minimum the following technical tasks covered by this section in order to ensure the proper design and operation of the “Antenna” in compliance with the Technical Specification AD01 and all related applicable documents.

5.1 DESIGN PHASE

The purpose of this phase is to provide the detail design of the Antennas, starting from the *Proposal Design* selected for the execution of the Contract. This phase will terminate with the Pre-Production Design Review.

During this phase the Contractor shall:

- Submit for approval to the ALMA Project Office within 2 weeks from the Kick-off meeting an updated version of the Analysis Tree (DRD-20) provided in the bid package.
- Perform the analyses foreseen by the Analysis Tree. As a minimum the Contractor shall perform the engineering analyses required under Section 5.1.1. and produce the corresponding reports.
- Compute the Error Budgets related to the system performance of the antenna (Section 5 of AD01) and prepare the related Error Budget Report (DRD-21)
- Prepare the engineering design reports (DRD-22) related to the performance of the antenna not covered by the Error Budgets
- Finalize the detail design of the antenna, compliant with the requirements of AD01 and produce the manufacturing file (DRD-30, DRD-33, DRD-34). Particular attention shall be dedicated to the issue linked to the operation of the antenna at the Observation site at an altitude in excess of 5000 m (DRD-26).
- Perform, as applicable, the engineering qualification tasks of Section 5.1.3 below.
- Deliver the Pre-Production Design Review Data Package (DRD-37), 4 weeks in advance of the Pre-Production Design Review.
- Provide the documents listed under Section 5.1.5 below.

The Design Phase ends when all issues identified during the Pre-Production Design Review have been resolved and/or implemented by the Contractor.



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5.1.1 ANALYSIS TASKS

The list below identifies specific analyses which have to be performed as a minimum. Specific requirements governing these analyses are given in AD01.

- a) Finite Element Analysis (DRD-23)
 - Gravity and Wind loading analysis,
 - Stress analysis and fatigue verification
 - Dynamic analyses (eigenfrequency and seismic)
 - Survival conditions load cases (transporter shock, emergency braking)
 - Thermal modeling and thermal analyses
- b) Error Budget Computations (DRD-21):
 - Antenna surface error budget
 - Pointing error budget
 - Path length error computation
- c) Mass and Balance Budget (DRD-24)
- d) Dynamic servo simulation analysis for fast switching and other dynamical performances of the antenna. (DRD-23)
- e) HVAC system calculations (DRD-22)
- f) Lifetime, reliability and maintainability analyses (DRD-25)
- g) EMC Control Plan (DRD-32)
- h) Engineering analysis and reports not specifically mentioned here, if necessary (DRD-22)
- i) Preparation of spare parts list. The spare part list shall be the update of the spare part list provided in the Bid phase, and adapted to take into account the results of the reliability requirements and calculations (DRD-35).

5.1.2 CONTROL HARDWARE AND CONTROL SOFTWARE TASKS

The Contractor shall design the Antenna Control System according to the requirements of AD01 and of the applicable ICD between the Antenna and the ALMA computing and Control Software.

During the design phase the Contractor shall take into account, in addition to the functionality imposed by the ICD, any functionality which may become necessary as a result of the design provisions adopted and of the Hazard Analysis, and other requirements of the Technical Specification. This includes but it is not limited to Section 8, Reliability/Maintainability/Safety Requirements. In particular, the Contractor shall use the results of his Hazard Analysis and include any control



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hardware and software in order to ensure that the requirements of Section 8 and specifically section 8.3.2.4 “Requirements on Operational Hazards” of the Technical Specification are met.

At the end of the design Phase ALMA the Contractor shall deliver the Software and Hardware Design Reports and Specifications and propose an ICD upgrade (DRD-31). ALMA will update the ICD based on the proposal of the Contractor.

5.1.3 QUALIFICATION TASKS

The Contractor shall in this phase validate any technological choice likely to affect the life expectations of the Antenna, also considering the ability of the chosen antenna equipment to operate at the environmental conditions expected at the AOS site. At the PPDR the Contractor shall deliver a CFRP and CFRP Process qualification report (DRD-27) including CFRP paint protection.

5.1.4 SAFETY RELATED TASKS

The Contractor shall start from the Preliminary Hazard List provided in the Bid package, and develop it to a complete safety analysis for the antenna system. This requires the following tasks.

5.1.4.1 Hazard Analysis

The Contractor shall update the Preliminary Hazard List provided in the Bid package in order to ensure that it encompasses all possible hazards related to design, the operation and the maintenance of the Antenna, including their probability and criticality. The analysis shall furthermore discuss all the identified hazards and discuss the measures implemented to bring the hazards to an acceptable level to ALMA. Specific Requirements on the Hazard Analysis are provided in AD01, Section 8. The analysis shall be reported in the Hazard Analysis report (DRD-28)

5.1.4.2 Safety Compliance Assessment

The Contractor shall prepare the Safety Compliance Assessment report (DRD-29) documenting the compliance with specified, national, and industry codes imposed contractually or by law to ensure the safe design of a system, and to comprehensively evaluate the safety risk being assumed prior to test or operation of a system. The assessment includes information from the Hazard Analysis and other analysis and inspections to the extent necessary to assure the safe design operation and maintenance of the antenna. It includes also a Declaration of Conformity.

Specific requirements are given in Section 8 of AD01.



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5.1.5 PROJECT MANAGEMENT RELATED DOCUMENTS

At the time of the Pre-Production Design Review, the Contractor shall deliver the following project management related documents

- An updated version of the Manufacturing Plan (DRD-40) submitted during the Bid phase.
- An updated Verification Plan (DRD-51) listing all the verification activities to be performed during the manufacturing and the acceptance testing, in order to verify satisfaction of the requirements of the technical Specification AD01.
- Update the On-site Assembly Plan (DRD-42) provided in the bid package.
- Prepare a Compliance Matrix according to the requirements of DRD-54

5.2 MANUFACTURING PHASE

5.2.1 MANUFACTURING OF ANTENNA #1

During this phase the Contractor shall manufacture the Antenna #1. This includes manufacturing or production of all hardware and software.

The Contractor shall procure all parts and materials of the antenna in accordance with the manufacturing file produced during the Design Phase.

The Contractor shall perform in this phase all subsystem and system pre-assembly and verification activities as he deems necessary to ensure full compliance with the Technical Specification at the time of acceptance of the antenna by ALMA. The Contractor may choose to pre-assemble the first antenna prior to its shipment to Chile or to perform only pre-integration at the factory of major subsystems.

Prior to shipment the Contractor shall ensure that:

- all parts and assemblies are free of manufacturing defects,
- all parts and assemblies conform to the valid manufacturing file (lower level specifications, drawings, part lists),
- all Contractor internal inspection and testing records are available and conform to the Contractor's Verification Plan (DRD-51) and Quality Assurance requirements (DRD-04).

Prior to integration individual subsystems shall have been accepted by the Contractor according to the inspections and tests foreseen in the Manufacturing Plan (DRD-40).



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5.2.2 MANUFACTURING OF THE FOLLOWING ANTENNAS

The Contractor shall optimize the manufacturing sequence of the Unit #2 to 32 according to his needs and the planning requirements of Section 4.4.

The Contractor shall nevertheless follow the inspections and testing verifications demanded by his Manufacturing Plan (DRD-40) and Verification Plan (DRD-51). It is mandatory that all assemblies and parts prior to their shipment to the OSF have undergone a process of inspection and testing that assures:

- all parts and assemblies are free of manufacturing defects,
- all parts and assemblies conform to the valid manufacturing file (specifications, drawings, parts lists)
- all Contractor internal inspection and acceptance testing records are available and conform to the Verification Plan and Quality Assurance requirements

5.3 PACKING AND TRANSPORT TO THE OSF IN CHILE

The Contractor shall pack, transport and deliver all the hardware from the Contractor premises or those of his subcontractors to the OSF site in Chile.

The Contractor is responsible for all logistics, including the proper packing of the equipment. The packing shall take into account the transport method adopted and the storage conditions at the Work Area. General environmental conditions for transport and specific environmental conditions at the OSF are given in the ALMA Environmental Conditions, applicable to AD 01. Particular care shall be applied for protection against corrosion during sea transport.

For specific equipment, if needed, the Contractor shall include in the packing diagnostic tools (shock measurement devices, temperature and humidity monitors, etc.) able to identify severity of transport conditions, likely to affect integrity and performance of the antenna.

The Contractor shall perform an Incoming Inspection upon arrival on site of the major antenna parts, and keep proper inspection records. The use of parts having suffered damage, and having being repaired, shall be subjected to the submittal by the Contractor of an NCR (DRD-16) to be approved by ALMA.

5.4 ASSEMBLY ON SITE

The Contractor shall in this phase assemble, align and test the antennas at the OSF in Chile prior to Acceptance Testing. To this purpose the Contractor will use his *Work Area* at the OSF, as described in Section 5.8.1.



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During this phase the Contractor shall also install in the Antenna cabling and equipment (electronic cabinets, Optical Pointing Telescope, Goretex membrane.....) provided by ALMA as defined in Section 9 of this Statement of Work.

For each antenna, this phase ends when the Antenna (#1 to #N) is fully erected, tested and operational, and ready for acceptance testing. The readiness is checked by means of an Assembly and Inspection Point.

5.5 ASSEMBLY INSPECTION POINT IN CHILE

An Assembly Inspection Point in Chile (AIPCn) shall be jointly performed by the Contractor and ALMA in order to record the status and configuration of the antenna, possible workmanship issues, and in general its readiness to undergo Acceptance Testing. It shall therefore be verified that:

- The assembly and integration tasks are completed
- The antenna is fully operational
- Deviations from the design and manufacturing file are known and properly documented (example CREs, RFWs, NCRs,).
- All Test and Inspection Procedures (DRD-52) are available and agreed by ALMA.

In addition for AIPC1:

- The Operations and Maintenance Manuals have been issued.

5.6 ACCEPTANCE

Acceptance Testing of each contracted antenna and the associated deliverables for that antenna shall take place on site after successful completion of the corresponding Assembly Inspection Point Chile (AIPCn).

Acceptance testing will take place while the antenna is installed on one of the antenna stations reserved for the Contractor at the OSF.

The purpose of the Acceptance is to check that the antenna (hardware and software):

- meets all functional and performance requirements of AD01
- is free from any material and workmanship defects
- meets the safety requirements applicable to the Contract.
- is built in accordance with the prescribed manufacturing file
- the complete documentation is available, correct and in compliance with the Contract requirements.



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5.6.1 REQUIREMENTS FOR ALL ANTENNAS

The scope and extent of the acceptance testing of each antenna shall be in accordance with what prescribed by the Verification Plan (DRD-51), provided by the Contractor in accordance with the Verification Requirements of Section 11 of AD 01.

The Contractor shall perform all inspections and tests foreseen by the Verification Plan for the acceptance phase, according to the Inspection and Tests Procedures (DRD-52) previously approved by ALMA. Results and findings shall be reported in the filled-in test procedures.

Each acceptance testing shall include a pointing and tracking test with the Optical Pointing Telescope.

5.6.1.1 Pointing Tests with the Optical Pointing Telescope

The verification of the pointing and tracking performance of the antenna shall be done with the optical pointing telescope provided by ALMA as foreseen in Section 9. This test shall consist in the verification of certain elements of the pointing error budget provided by the Contractor as well as the verification of the sidereal tracking performance of the antenna. During the testing a software pointing model will be generated as foreseen by the ICD06 of AD 01. The Contractor shall assume for his planning a duration of 2 weeks for these activities in the case of the antenna #1 and 1 week of activity for the following antennas.

These activities will be performed during night-time.

5.6.2 SPECIFIC TESTS FOR ANTENNA #1

The scope and extent of the testing of the Antenna #1 shall be defined by the Verification Plan, in accordance with the Performance Verification Matrix of Section 11.2 of AD 01. Specific tests are foreseen with Antenna #1 in addition to the tests foreseen on all antennas.

5.6.2.1 Holography Setting of Main Reflector

In the framework of the acceptance testing of Antenna #1 the panels of the main reflector will be set to the final specified level, after the setting and measurement performed by the Contractor. The measurement of the surface accuracy and the setting of the panels will be performed by means of holography testing. The setting to the final surface specification will be performed by the Contractor based on the holography maps obtained by ALMA. The holography receiver and its handling tool will be provided by ALMA at the time specified in Section 9. The installation will be performed by the Contractor according to the requirements of the relevant ICD of AD 01 during acceptance testing.



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The Contractor shall assume for his planning purpose 2 weeks of work for this activity. The setting will be performed to the specified level of accuracy corrected to take into account the error budget of the Contractor. The test will allow verification of both surface accuracy requirement and the panel surface setting time.

5.6.2.2 Transporter Interface Testing

At the time of Acceptance ALMA will provide the Antenna Transporter for verification of the relevant interface. A test shall be foreseen in which the Antenna is attached and powered by the Transporter, lifted, put down onto the station and connected to the station. The test shall follow the complete procedure defined in the Antenna Transport Procedure (DRD-47).

5.6.2.3 Maintainability Testing

At the time of acceptance of Unit #1 the Contractor shall demonstrate the maintainability of the antenna in accordance with the Maintenance Manual (DRD-48) and demonstrate compliance with the requirements set in Section 8.2 of the Technical Specification. As a minimum the test shall demonstrate:

- Fault detection by software and other diagnostic methods.
- The procedures, the tooling and the time necessary to exchange all Line Replaceable Units (LRUs)
- The major activities of corrective maintenance not involving LRU exchange
- The checking of alignment requirements

It shall also illustrate the major steps necessary to perform any planned overhaul.

5.6.3 REQUIREMENT FOR THE UNIT #2 TO #N

In accordance with the Verification requirements of AD01 both the extent of the testing phase and the test principles used for Units #1 differ from those of Units #2 to #N, for which a reduced test programs is foreseen. This shall be reflected in the Verification Plan (DRD-51). The Verification Plan shall be updated to ensure full testing whenever a design change is introduced during the production of the units #2 to N.

For the unit #2 to N holography measurement and setting of the primary reflector panel will be performed by ALMA after Acceptance of the antennas. Should ALMA determine during this activity that the primary surface measurement and setting method used by the Contractor does not provide the accuracy specified for delivery, ALMA reserves his right to demand holography measurement prior acceptance.



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5.6.4 TEST BOARD

In order to perform the tests, the Contractor shall set-up a Test Board . As a minimum, this board shall consist of the following members:

- the Test Conductor who is responsible for the complete test
- the Product Assurance Representative
- other specialists who may be called in to contribute.
- ALMA Project Office representative(s).

The Test Board has to:

- approve the start of any test after proper assessment of the readiness of the items to be tested and the readiness of the testing facilities.
- review the test data and results and decide either to proceed to the next test or to repeat it (in case of errors or failures).

5.6.5 CONTRACTOR'S TASKS

The Contractor shall:

- prepare the Inspection and Tests Procedures (DRD-52) and submit them to the ALMA Project Office for approval.
- inform the ALMA Project office about the test schedule 3 weeks in advance.
- perform all verification activities, under its own responsibilities and witnessing by the ALMA Project Office representative(s).
- evaluate the results of the tests and perform the necessary analyses or assessments.
- prepare a test report according to DRD-53.
- Prepare the Acceptance Data Package according to DRD-56, for the corresponding antenna #n.
- organise the Acceptance Review (ACRVn) at the OSF premises..

5.6.6 OTHER REQUIREMENTS

Spare parts and other deliverables, if foreseen by the Contract, shall be accepted on the basis of their inspections and testing records.

5.7 GUARANTEE PHASE

Provisions related to the guarantee are set forth in the Contract. For each antenna the Guarantee period shall start at the time at which Antenna Acceptance is granted.



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5.8 NON RECURRING TASKS

5.8.1 WORK AREA

The Contractor shall be responsible for preparing and constructing the *Work Area* assigned to him at the OSF site.

The Contractor shall update, not later than 4 weeks after the kick-off meeting, the design of the *Work Area* submitted in the bid phase and submit it to ALMA for approval. In preparing the design the Contractor shall take into consideration the requirements of AD02 and shall assume a maximum contiguous *Work Area* of 30.000 m². Specifically related to the provisions of Section 18. of AD02, the Contractor shall fence his assigned *work area*. ALMA will approve or comment the design within 3 weeks from submission of the updated design.

The design of the *work area* shall include the location of two (2) antenna stations or any number set forth in the Contract. It is assumed here that 2 stations will be needed to comply with the schedule requirement of Section 4.4 for every 32 antennas (4 in case of N=64). Access roads suitable for antenna transporter operation shall also be included in the layout of the *work area*. The characteristics of the road are given in RD01, Sections 4.1 and 4.2.

The antenna stations as well as the roads will be constructed by ALMA at the locations indicated by the Contractor and made available to the Contractor at the time foreseen in Section 9 of this statement of work. The stations will be compliant with the requirement of the relevant Interface Control Document of AD01. The Contractor shall accept the antenna stations on the basis of their compliance with the relevant ICD.

Upon approval by ALMA of the design of the work area, the Contractor shall have access to the work area for preparation, grading, consolidation and paving, erection of temporary shelters and facilities, storage of equipment and tools, including workshop and offices, parking and in general any activity necessary to prepare the *work area* for the efficient and timely execution of the Antenna assembly and testing activities.

The preparation and construction and use of the Work Area shall be in accordance with the requirements of AD02.

At the completion of the delivery of the Unit #N the Contractor shall remove temporary facilities and restore the Work Area to pristine or quasi-pristine conditions.



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5.8.2 TOOLING & TEST EQUIPMENT

The Contractor shall design and procure and transport all tooling necessary for the manufacturing, the transport, the erection on site, and the testing of the antennas.

5.8.3 SERVICE EQUIPMENT

The contractor shall define and design the complete set of deliverable tools, handling tools and in general service jigs and equipment to be used by ALMA for performing servicing, diagnostics and maintenance of the antenna after acceptance, during the lifetime of the observatory. This equipment is specified in Section 7 of AD01.

In defining the detail list of the deliverable the Contractor shall take into account the design of the antenna, the preventive maintenance and corrective operation, and the overhaul operations according to his Maintenance Manual.

The list of deliverable tools shall be in a preliminary form at the time of the PPDR, and be updated if necessary at the AIPC1.

This equipment shall be manufactured and tested by the Contractor, prior to undergoing formal acceptance with ALMA. The acceptance of this equipment shall be planned together with the maintainability testing of the Antenna #1.



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6 PROJECT ORGANIZATION AND CONTROL

6.1 PROJECT ORGANIZATION REQUIREMENTS

The Contractor shall establish and maintain an effective project management organization to accomplish the objectives of this contract. This management organization shall be separated from other projects and operations to the extent necessary to prevent interference with the effective and timely completion of this contract. This organization shall have effective control and support from appropriate senior company management.

The Contractor's project management office shall coordinate and control all technical and commercial activities, project resources and manage all disciplines required to successfully complete the Contract. Project organization and the project rules shall ensure on all levels of the project: implementation, enforcement and control of the methods and procedures covering the schedule control, configuration control, product assurance, including implementation of reliability and safety design aspects.

The key personnel of the project shall consist of experienced personnel. Exchange of the key personnel during the execution of the Contract shall be with notification and agreement by ALMA in due time.

The Contractor shall assign a Project Manager with full authority over all personnel and resources of the project organization as well as those of other members of his industrial team. He shall be assigned full authority to negotiate and conclude with ALMA and his subcontractors/suppliers all issues related to the Contract. He shall be the single point of contact to ALMA for all formal matters.

If events occur that may cause an impact on the critical schedule, for example technical problems or changes requested by ALMA or initiated by the Contractor, the Contractor shall evaluate every possible management measure to avoid a schedule impact, including utilization of additional manpower and facilities, and the application of a double shift at ALMA's request and after agreement with ALMA.

If required by ALMA the Contractor, within 4 weeks from the Kick-off meeting, shall submit an updated Management Plan (DRD-01) for approval by the ALMA Project Office.

6.1.1 SITE ACTIVITIES REQUIREMENTS

Conditions set forth in AD 02, with the exception of Section 4.1, shall be fully applicable.

The Contractor shall nominate an experienced On-site representative (Site Manager)



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with full authority over all personnel and resources of the project on site. The Contractor shall demonstrate that for the execution of the Contract his on-site representative has relevant, adequate and practical on-site experience, has the capability to operate a work site in Chile and at the described location, and is fluent in English (written and oral communications).

The on-site representative shall have full authority to interact with ALMA on matters pertaining to the execution of the work, occupational safety, health and security, and in general on all issue related to the execution of the work on site. He shall follow ALMA rules and regulations on site and execute orders of ALMA in this respect. He shall have a deputy during his absence.

The On-site representative shall be the sole responsible for the work performed in the Contractor's work area.

6.1.2 SITE SAFETY

The Contractor shall designate a Site Safety Officer with the responsibility (as a minimum) to:

- Prepare a Site Safety Manual (DRD-43)
- Review and supervise all safety relevant procedures and operations on site and to ensure full compliance with the relevant ALMA safety requirements.
- Authorize or forbid specific delicate operation
- Perform regular safety training to Contractor's personnel.
- Stop the work in case of lack of non compliance with safety measures and procedures.
- Ensure that the special conditions in terms of environmental and archeological protection set in AD 02 are applied.

The on-site representative (Site Manager) and the Site Safety Officer shall be two separate persons.

6.2 PROJECT PLAN

The Contractor shall submit the final version of the Project Plan (DRD-02) not later than 4 weeks after Contract award. Modifications and updates of the Plan shall be approved by the ALMA Project Office and serve as a Project Control document for the ALMA Project Office.

The ALMA Project Office may ask for additional detailed plans for critical areas at any time of the antenna project.



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6.3 REPORTING

6.3.1 PROGRESS REPORT

The Contractor shall submit to the ALMA Project Office monthly Progress Reports as defined in DRD-05.

Independently and in addition to the regular Progress Reports, the Contractor shall report any event with potential implications on the schedule of delivery of the antennas or their performance.

6.3.2 RED FLAG REPORT

A "Red Flag Report" (DRD-07) shall be issued by the Contractor within one day of occurrence of major problems jeopardizing the timely delivery of the antennas, the achievement of the contract milestones, or the achievement of the technical performance and requiring the immediate attention of the ALMA Project Office. This reporting shall apply to major problems at all levels.

6.4 REVIEWS, INSPECTIONS AND MEETINGS

6.4.1 REVIEWS

The Contractor shall plan and prepare project reviews in consultation with ALMA, particularly with regard to the agenda, participants and contents of the reviews. The following major reviews shall be held:

The **Pre-Production Design Review (PPDR)** is a review to verify the complete design of the antenna as prepared during the Design Phase. The review will follow the general requirements and objectives set in AD 03, particularly with respect to Sections 4 and 6.

The review will cover all aspects of the analyses and design of the antenna. A Design Data Package shall be produced according to the requirements of DRD-37. The Data package shall be delivered to the ALMA Project Office not later than 4 weeks in advance of the scheduled PPDR. ALMA will need three weeks to study the Data Package, and to make written comments. The PPDR is closed when all issues and comments raised by ALMA have been taken into account in the design of the antenna.

The PPDR will take place at Contractor premises.

The **Antenna Acceptance Review (ACRVn)** takes place in Chile at the OSF Contractor's site after completion of Acceptance tests on the Antenna # n. These tests are performed in the work area of the Contractor. The Contractor shall complete the Acceptance Data Package to include the results of all tests performed during the



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acceptance phase as well as those related to the sub-assembly testing. After closure of all the actions identified, Acceptance will be granted.

As a general rule:

- Completion of reviews is defined as resolution of all action items as per the minutes of the review meeting.
- The Contractor shall prepare the various data packages and submit them for comments to the ALMA Project Office. ALMA will need three weeks to study the data packages and prepare comments and requests for clarification that will be submitted to the Contractor one week prior to the review meeting.
- ALMA will need two weeks to review and transmit the comments to the verification/test procedures after their reception.
- When test reports are submitted, ALMA requires a 3 week period to approve the report.

6.4.2 INSPECTIONS

The following inspections shall be held.

The **Incoming Inspection in Chile** takes place, at the arrival of each antenna shipment at the ALMA OSF site in Chile. An Inspection Report will describe the status after transport, and report any anomalies. ALMA may decide to witness this inspection. Irrespective of ALMA witnessing or not the inspection, the Contractor shall keep proper inspection records able to identify and trace back possible damages incurred by the antenna during transport.

Incoming Inspection shall be performed also in case of batch transport.

The **Assembly Inspection Point in Chile** (AIPCn,) takes place, at the OSF *Work Area*, at the end of each antenna assembly. The Contractor shall plan and prepare this inspection in consultation with ALMA, particularly with regard to the agenda, participants and content of it.

The aim of this inspection is to verify that all integration activities have been completed and that the antenna is ready to undergo acceptance testing. It also checks that all testing material needed in the acceptance testing is available, including the approved Inspection and Test Procedures (DRD-52). An Inspection and Test Report (DRD-53) shall be issued by the Contractor.

6.4.3 MEETINGS

The Contractor shall plan and prepare project meetings in consultation with ALMA, particularly with regard to the agenda, participants and contents of the meeting.



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Unless otherwise requested by ALMA, the Contractor shall write the minutes for all formal meetings. The minutes shall be signed by both parties. The signature of such minutes indicates solely that the wording is correct and properly reflects the outcome. The signature shall not be construed as a formal, contractual agreement. Any matter having contractual implications shall be handled in accordance with the regulations of the Contract. The minutes will include the recording and reviewing of the Action Item List (DRD-06).

Any decisions affecting performance, cost, or schedule require formal contractual coverage in order to become binding.

The following major project meetings are foreseen.

6.4.3.1 Kick-off Meeting

At the beginning of the Contract, a Kick-off meeting will be held at Contractor's premises. The aim is to clarify with the Contractor all technical and managerial aspects required to proceed during the Design Phase, and in general to set specific procedures and rules between the Contractor and ALMA to be followed during the execution of the Contract (example communication, documentation, etc.).

6.4.3.2 Progress Meetings

During the Design Phase progress meetings shall be held at the Contractor's premises on a monthly base (*in conjunction with the Contractor's submission of monthly progress reports*). The purpose of a progress meeting is to review the progress of work and to highlight and discuss problems or issues needing special consideration and to determine, as appropriate, the corrective measures to be taken. The progress meeting will cover the entire scope of the Contract, including programmatic, contractual, and technical aspects.

During the manufacturing phase the progress meetings will be held every 6 weeks at a minimum, but more frequently, if mutually agreed.

6.4.3.3 Special Meetings

Special meetings may be requested by ALMA to discuss urgent technical issues, or to review important programmatic aspects. ALMA may request special meetings, one week in advance.

6.4.3.4 ALMA Rights

The presence of major subcontractors during progress meetings and special meetings may be requested by ALMA.

ALMA may request participation in progress meetings held between the Contractor and his subcontractors.



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Meetings may, at the discretion of ALMA, involve other participants upon agreement by the Contractor.

6.5 CONFIGURATION CONTROL

No later than 4 weeks after contract award, the Contractor shall submit the final version of the Configuration Control Plan. (DRD-03) This plan shall include a Software configuration control plan. This Configuration Control Plan shall ensure that:

- The manufacturing file is in line with the design documentation
- The product is in line with the manufacturing documentation
- The activities performed in verifying the product (*analyses, tests*) have been performed against the configuration of the delivered product
- The design as presented to ALMA in the design review(s) by the Contractor is not changed without prior notice to ALMA
- All deviations from the requirements of the specifications are properly documented and submitted to ALMA for approval by means of Requests for Waiver (DRD-15)
- Effective change control is established and maintained
- All affected participants in the program are cognizant of the impact of changes and participate in their evaluation

To satisfy these objectives the Contractor shall, as a minimum:

- Identify, release and manage all the technical documentation that defines the configuration of the end product.
- Control, coordinate, approve or reject, and implement changes to the configuration of the end product whose configuration has been formally approved by the Contractor and ALMA.
- Account and report all documentation that describes the status of an end product at any point in time.
- Produce a Configuration Item Data List (CIDL, DRD-11) that describes the status of the product configuration by means of listing the relevant requirements, design/development, manufacturing, and operational documentation.
- Produce a Configuration Item marking plan which uniquely identifies each configuration item according to the requirements of Section 9 of AD 01 (Product Marking).

All applicable technical documents, which define the end product, shall be put under configuration control at PPDR. For the changes of all documents under configuration control, change procedures as per Section 6.6 shall apply.



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6.6 CHANGE PROCEDURES

Each participant (ALMA and Contractor) of the Project may initiate at any time a change to be introduced into the contracted scope of work that may affect:

- Contractual conditions
- Technical and baseline documentations
- Interfaces
- Performance
- Schedules, etc.

The Contractor shall deliver to ALMA a cost, and schedule-wise, reasonable and justified change proposal to any change initiated by the Contractor or by ALMA and perform the work upon agreement of the change. He may involve third parties as is deemed necessary. The Contractor shall respond to any Change Request within 4 weeks.

ALMA reserves the right to involve any third party for the implementation of a change if no satisfactory agreement can be achieved by change negotiations.

Before preparing a change proposal the Contractor shall carry out an investigation of the initiated change and provide ALMA with all information necessary for a decision, as a minimum:

- The reason for the change
- Assessment of technical feasibility
- Assessment of the technical and performance impacts on the total system/other subsystems.
- Affected work package, documents, drawings.
- Schedule impact on the item/key milestones (*including detailed schedule of the change.*)
- Total cost impact (*giving detailed information on the manpower, material, etc. costs and reflecting the differential cost for changes in baseline work packages.*)
- Other related factors (reliability, safety, maintenance etc.).
- Any additional documents needed to justify the change.

Each proposed change must be identified by an individual and unique number, which shall be used in all subsequent correspondence.

Implementation of the proposed changes shall not commence prior to written authorization or approval in accordance with contract requirements.

The Contractor shall keep a change log that shall list all initiated changes with their status (*approved, rejected, pending, closed*) and provide an update together with the regular Progress Report (DRD-05).



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6.7 ACTION ITEM CONTROL

The aim of action item control is to provide a simple system to ensure that actions are raised and resolved effectively. Actions will normally originate from meetings and reviews or may be raised at ALMA's request.

Actions raised at meetings will be recorded with the minutes. Once initiated, the Action Items will be uniquely identified and recorded in the Action Item List (DRD-06). The record will contain as a minimum:

- The action identifier,
- A brief title,
- A brief description,
- An anticipated closing date,
- The actionee,
- The initiator.

Actions should proceed immediately on the basis of their acceptance. This acceptance can be reached during the meeting, or, if requested by the actionee, after confirmation by his management. Actions that may have an impact on the scope of the contracted work, shall be communicated promptly and change procedures shall apply. Only participants may be initially nominated as actionees. Any subsequent disagreement with the acceptance of an action or change of actionee must be promptly communicated to ALMA, who shall also be informed of the closing, i.e. results of an action or reason for delay.

The Contractor shall keep an Action Item List and provide ALMA with an update of the list regularly together with the Progress Reports or upon request, The list shall include:

- All open actions
- All late actions
- All actions closed in reporting period.

6.8 DOCUMENTATION

The Contractor shall operate a centralized documentation system to fulfill the information requirements of the project. This system shall be capable of providing up-to-date information on all aspects of the project at all times, including the subcontractors.

The documentation system shall exist in electronic format. A copy of the valid documentation shall be kept on an electronic database accessible to ALMA (FTP



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server or similar method to be agreed with ALMA). The Contractor shall inform ALMA when the documentation on the server is updated.

The Contractor shall maintain documentation lists of all documents generated or received. He shall supply ALMA with an updated document list as part of his progress reports.

6.9 TRAINING

The Contractor shall provide training to ALMA operations and maintenance personnel. The training program shall be agreed with ALMA. Baseline training shall include as a minimum:

- antenna startup and shutdown procedures
- alignment of the axes of the antenna
- alignment of the reflector surface
- removal, installation and alignment of subreflector and apex equipment
- antenna maintenance procedures, including LRU replacement
- antenna software downloading, upgrade and maintenance
- safety procedures and programs
- inspections, fault detection
- documentation and manuals, including electrical schematics
- panel mounting and setting
- planned overhaul activities

In proposing a training plan the Contractor shall take into account the need for ALMA to be able to operate and adjust the antenna immediately or shortly after delivery. The training topics may be organized in more than one session. As a general rule the full training program shall be completed not later than 12 months after acceptance of the antenna #1.

6.10 ACCOMMODATION FOR ALMA PERSONNEL AT CONTRACTOR'S PREMISES

The Contractor shall provide, at no extra cost, adequate office space, furniture and communication facilities as may be required for ALMA personnel (*maximum 3 persons*) who visit the Contractor's premises to survey critical project phases such as integration and testing.



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7 PRODUCT ASSURANCE TASK

The Contractor shall implement for the complete execution of the project a product assurance program that follows the guidelines of ISO 9001.

In particular the Contractor shall deliver, not later than 4 weeks in the execution of the project the final update of the Product Assurance Plan provided in the bid phase and specifically dedicated to the antenna project.

This plan shall be in accordance with DRD-04, and follows the general requirements of AD-04.



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8 SUMMARY LIST OF CONTRACTOR DELIVERABLES

The Contractor for the Antenna shall deliver to ALMA all items necessary for the fulfillment of the technical specification AD 01 and the present Statement of Work, including the following:

#	Item	Number	Schedule
1	Antennas	32	As per Contract
2	Control Software	Versions as needed	ACC1 + updates as needed
3	Portable Control Units	4+4*	1+1 at ACC1, 3+3 at ACC2 to ACC3
4	Counterweights for balancing	32 sets	ACC1 to ACC 32
5	Service equipment		
5.1	LRU exchange tools	1 set	
5.2	Subreflector handling tool	1 set	
5.3	Manual panel setting tools	10 sets	
5.4	Automated panel setting tool	3 sets	
5.4	Diagnostic tools	1 set	
5.5	Calibration tools	2 sets	
5.6	Servicing tools and generic tools (see notes)	3 sets ** 2 sets*** 1 set****	1 full set at AIPC1 rest before AIPC I
6	Documentation	2 paper copies + electronic	As per DRL
7	Spare parts and consumables	As foreseen by Contract	

Notes:

- * These are delivered with different cable length as per AD 01
- ** Tools for maintenance occurring with periodicity of less than 6 months
- *** Tools for maintenance occurring with periodicity of less than 1 year
- **** Tools for maintenance occurring with periodicity of more than 1 year



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9 ALMA PROJECT OFFICE TASKS

ALMA will provide the following items according to the schedule below:

#	Item	Number	Schedule
1	FEM of the antenna foundation	n/a	T0
2	Access to the OSF (<i>Work area</i>)	n/a	<i>At Work Area</i> design approval
3	Antenna Stations	(2)	AIPC1- 6 months
4	ALMA Cables and pipes	N units	3 months before AIPCn
5	Goretex membrane	As needed	1 month before AIPC 1
6	Cabin electronic cabinets*	1+ 1	3 month before AIPC-1
7	ALMA Cryo compressor equipment and lines*	1	1 months before AIPC-1
8	Optical Pointing Telescope	1	ACCn -1 month
9	Holography Receiver	1	ACC1 - 1 month

Note*: These equipment will be provided only for the first antenna in order to check or define in detail the interface with the antenna, the cabling and the routing.



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10 APPENDIX 1: DRL LIST

**DOCUMENT REQUIREMENTS LIST (DRL) APPLICABLE TO THE
ANTENNA CONTRACT**

DRD No	Title	Category*	Delivery Date/Weeks	Remarks
1	Project Management Plan	A	T0 + 4 w	Update from submittal of bid package
2	Project Plan	A	T0 + 4 w	(Schedule to be updated monthly)
3	Configuration Control Plan	A	T0 + 4 w	
4	Product Assurance Plan	A	T0 + 4w	Update of the bid package
5	Progress Reports	R		To be delivered monthly
6	Action Item List	R		To be updated monthly
7	Red Flag Report	R	As needed	Not later than 24 hours from event
11	Configuration Item Data List	R/A	TO + 4 w	To be updated monthly, and at ACCn
14	Change Request	A	As needed	
15	Request for Waiver	A	As needed	
16	Non-Conformance Report	A	As needed	
20	Analysis Tree	A	T0 +2 weeks	Update from submittal of bid package
21	Error Budget Report	R/A	PPDR	Update from submittal of bid package
22	Design Report	R/A	PPDR	
23	Analysis Report	R/A	PPDR	
24	Mass and Balance Budget	R/A	PPDR	Update from submittal of bid package, updated as needed
25	Reliability Availability Analysis	R/A	PPDR	
26	High Altitude Analysis	R/A	PPDR	
27	Qualification Summary Report	R/A	PPDR	
28	Hazards analysis	A	PPDR	Update from submittal of bid package, updated as needed
29	Safety Compliance Assessment	A	PPDR	Final Version at ACCn
30	Lower Level Specification	R	PPDR	
31	Software Design Specification/ ICD	A	PPDR	
32	EMC Control Plan	R/A	PPDR	
33	Drawing set	R/A	PPDR	As built at ACCn
34	Parts Lists	R/A	PPDR	Final version at ACCn
35	Spare Parts List	R	PPDR	Update from submittal of bid package
36	Finite Element Model	R	T0+4 w	Update as needed
37	Pre-Production Design Review Data Package	R	PPDR-4 w	
40	Manufacturing Plan	R	PPDR	Update from submittal of bid package
41	Work Area Design	A	T0+4w	Update from submittal of bid package



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42	On Site Assembly Plan	R	PPDR	Update from submittal of bid package
43	Site Safety manual	R/A	Start of Site activities -1 M	
44	Assembly –Disassembly Alignment Proced.	R	PPDR	Final version at AIPC1
45	Operations Manual	A	PPDR	Final version at AIPC1
46	Software User Manual	A	AIPC1	Update as needed
47	Antenna Transport Procedure	A	PPDR	Final version at AIPC1
48	Maintenance Manuals	A	PPDR	Final version at AIPC1
49	Software Maintenance Manuals	A	AIPC1	Update as needed
45	Software release Summary	A	PPR	Update as needed
50	Product Assurance Plan	A	TO + 4 w	Update from submittal of bid package
51	Verification Plan	A	PPDR	Update from submittal of bid package To be updated at AIPC1-4 w
52	Inspection and Test Procedure	A	AIPC1-4w	
53	Inspection and Test Report	A	ACC1	(2 weeks after testing)
54	Compliance Matrix	A	PPDR	ACRVn-
56	Acceptance Data Package	A	ACRVn	

Notes* A: Approval by ALMA
 R: Review by ALMA



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11 APPENDIX 2: DOCUMENT REQUIREMENT DEFINITIONS (DRD'S)

PROJECT MANAGEMENT PLAN (DRD-01)

The Project Management Plan shall describe the management approach implemented by the Contractor to control the project. It shall contain an Organizational Chart which summarizes the organization and the lines of authority including subcontractors.

The Project Management Plan shall:

- Present the Project Organization implemented by the Contractor
- Describe the Job and Responsibilities of each function in the Organizational Chart
- Describe the lines of authority within the Contractor's organization
- Describe the interrelation among the different functions in the organization
- Present the Key Personnel assigned to the project and their relevant experience.
- Describe where and how the control of lower tier Contractors is established in the project organization.

PROJECT PLAN (DRD-02)

The Project Plan is the major project control document for ALMA and the Contractor. The Project Plan shall include at a minimum:

- a) A Top-level summary of the Plan
- b) A Work Breakdown Structure (WBS) matrix of the project activities organized according to the division of the work within the Contractor and/or to the Product tree.
- c) A Work Packages description derived from the WBS and including at least:
 - A reference number
 - The title of the WP
 - The organization and responsible for the WP
 - The input(s) necessary to complete the WP tasks
 - The description of the tasks to be performed
 - The output(s) and/or deliverable(s) of the WP



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- The location of the tasks (e.g. Factory, OSF Chile)
 - The duration of the tasks
- d) Network Planning and Scheduling Data containing as a minimum:
- A master network displaying logic and time characteristics of the Project's major activities and a master bar chart directly based on it (*Single size A4 sheet*).
 - Detailed networks schedule
 - Detailed bar charts

The planning shall be structured according to the WBS and constructed on the basis of a detailed tasks analysis and a proper logic and sequence of activities. The description of each task shall be clear and concise. The planning shall take into account resource planning:

- To provide adequate resources and facilities to each activity
- To identify potential resource shortages and conflicts
- To identify and monitor the activities on the **Critical Path**
- To resolve or improve technical/schedule criticality

The planning shall take into account all interfaces with other project participants and outside restraints, including inputs and outputs from ALMA.

The planning shall include, as appropriate, the following items:

- Design and development activities (non-recurring)
- Significant procurement activities
- Assembly and integration of product
- Production or construction of the individual units, assemblies, etc.
- Testing, acceptance and delivery of major products
- Software items, including documentation
- Higher level test activities (*Chile*)
- Support equipment and tools
- Packing, logistics and transport
- Reviews including preparation, meeting and follow-up tasks
- Key inspection points
- Payment milestones (*as appropriate as a separate list*)
- Any other major event
- All project milestones

The following instructions are emphasized:

- The Critical path must be highlighted.
- The Percentage of the Completion of the tasks must be indicated.



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- The calculated Buffer Time must be indicated with an appropriate symbol.
- The duration of activities shall reflect the expected elapsed time from start to finish under normal working conditions taking into account a project calendar which defines working and non-working periods.

ALMA may ask for detail plans for critical areas at any time of the Project.

CONFIGURATION CONTROL PLAN (DRD-03)

The Configuration Control Plan shall describe the project configuration control organization, methods, tools and procedures the Contractor intends to implement for the work under Contract. The Configuration Control Plan shall be compliant with the requirements set out in the Product Assurance requirement (AD05).

The Configuration Control Plan shall define:

- The handling of contractual changes;
- The handling of the interfaces internal to the project;
- The handling of the interfaces external to the project;
- The handling of technical changes.

The Configuration Control System to be implemented on the basis of the approved Configuration Control Plan shall ensure that:

- The manufacturing documentation is in line with the design documentation;
- The product is in line with the manufacturing documentation;
- Changes are not implemented without due analysis and approval;
- Required design, item or component and/or manufacturing changes are properly documented in Change Requests to be established by the Contractor;
- Requests for Waivers/Deviations are properly handled.

The Configuration Control Plan and System shall be imposed on all sub-contractors and third parties participating in the execution of the Contract.

The Configuration Control implies the establishment of a Configuration Item Data List, which includes lists of valid specifications, drawings and in general all documentation items properly dated and numbered for each configuration item.

PRODUCT ASSURANCE PLAN (DRD-04)

The Product Assurance Plan shall describe the Contractor's general Quality Assurance (QA) and Safety Engineering (SE) philosophy and define in detail all project-specific



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QA and SE related tasks, procedures, tools, etc. as well as the organizational structure which will be implemented to ensure that all quality and safety requirements are met throughout the complete project cycle.

In the preparation of the Product Assurance Plan the requirements of AD 04 shall be used as guidelines (Requirements applicable to the Antenna IPT in this document shall be interpreted as requirements applicable to the Antenna Contractor).

1. Scope
2. Applicable Documents
3. General QA and Safety Approach
4. Organization and Responsibilities
5. Applicable Procedures, Tools, Facilities
6. Task Definitions
 - PA Management
 - QA Engineering
 - Safety Engineering
 - Quality Control

The Chapter 6 "Task Definitions" shall also provide the following information:

- a) Task description
- b) Task reference document (i.e. specification, any norm, standard)
- c) Organization responsible for the task execution
- d) Procedure to be applied during the task execution
- e) Output/result, i.e. report
- f) Under the headline "remarks" any additional information, i.e. required input data, manpower or resources, etc.

PROGRESS REPORT (DRD-05)

The Progress Report summarizes on periodic base the progress of the project.

The Progress Report shall summarize the results achieved in the period and planned for the next period at all levels of the project, and show them against the planned date contained in the Project Schedule (DRD-02) putting in evidence any deviations. It shall also describe the critical issues detected at any level (i.e. technical, programmatic) of the project during the reporting period and identify the corrective actions

The progress report shall also contain the Action Item List (AIL) and the status of all Action Items which shall also be reviewed at each progress meeting. The Progress Reports covers a full calendar month and shall be issued not later than three working



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days after the end of the reporting period. In the course of critical phases, ALMA reserves the right to ask the Contractor for additional reports.

Progress reports are delivered on a monthly basis and shall be duly approved and signed by the Project Manager. Furthermore the progress report shall include:

- Schedule update showing the current planning versus the baseline planning,
- Document lists,
- Action item list and status (DRD 06),
- Change status list (e.g. Change Request, Request for Waiver, etc),

ACTION ITEM LIST (DRD-06)

It shall list all the actions agreed between the Contractor and ALMA. It shall list:

- The subject of the action;
- The originator;
- The actionee (s);
- The due date and the closure date;
- The reference to the document(s) containing the basis for the closure of the action.

The action item list shall be reviewed at each progress meeting.

RED FLAG REPORT (DRD-07)

A “Red Flag Report” is a formal written notification to ALMA in which the Contractor informs ALMA of the occurrence of a major problem which has the potential to seriously affect the performance of the Contract and demanding immediate knowledge by ALMA and attention by the Contractor.

The report shall be issued within 24 hours from the occurrence or the discovery of the major problem.

CONFIGURATION ITEM DATA LIST (DRD-11)

The Configuration Item Data List (CIDL) presents the status of the product configuration for each configuration item at all levels of the project, by means of listing the relevant requirements, design/development, manufacturing and operational documentation which is relevant for a configuration item:

It shall contain:

- List of the valid version of the specifications;



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- List of valid drawings, drawing tree;
- List of parts;
- List of valid plans and procedure;
- List of valid software.

All documents shall be recorded in the CIDL with their

- Document title;
- Identification number;
- Issue/revision number;
- Date of status;
- Approval status (Contractor, ALMA if required).

The CIDL will be updated at each review, as a minimum, and on demand.

CHANGE REQUEST (DRD-14)

The Change Request shall describe the proposed change and contain all information necessary for ALMA to approve or reject the change, as a minimum:

It shall be duly dated and signed by the Project Manager and shall contain:

- Identification of contract;
- The description and justification of the change requested;
- The list of specifications, requirements or performances affected by the change;
- The list of documents, drawings, deliverable items affected by the change;
- The cost impact, with detailed information on the manpower, material, etc. costs and reflecting the deviation with respect to the baseline work package costing elements;
- An updated schedule showing the impact on the tasks and key milestones;
- An assessment of the impact of the change on functional and performance requirements of the project at **any level**;

REQUEST FOR WAIVER (DRD-15)

A Request for Waiver is usually issued during the manufacturing test and integration to obtain from ALMA for one* deliverable item

- a) A relief from the relevant specification, test procedure, integration requirements and/or

* If more than one antenna are concerned a Change Request has to be issued.



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- b) To grant acceptance from ALMA to use different hardware items or materials due to the inability to procure the specified ones in due time to meet the time schedule.

A granted waiver does not lead to changes of any approved and released document!

The Request for Waiver shall include:

- Definition of the item affected
- Identification of documents, software and hardware affected
- Description of the waiver
- Description of the need for the waiver
- Effects on costs and schedule.

It shall be accompanied by all documentation required by ALMA to judge the acceptability of the waiver.

If any change in planned costs, schedule, performance are expected, these points shall be clearly addressed.

(Note: It is recalled that ALMA has no obligation to accept a request for waiver; ALMA will however provide a reply to this request within 4 weeks).

NON-CONFORMANCE REPORT - NCR (DRD-16)

It shall report non-conformities which occurred during the manufacture, assembly, testing at all levels of the project and which are authorized by ALMA. The NCR forms are part of the "as built" drawing set.

It shall:

- Identify the item at which the non-conformity occurs;
- Identify the originator;
- Describe the non-conformity in detail;
- List the documents, the software and the hardware affected;
- Describe the impact at any level of the project;
- Recommendation for further procedure.

The NCR is usually initiated by a Failure Report which is forwarded to a Material Review Board (MRB) which, in many cases, requires the ALMA participation. The MRB decides on the further use of the faulty item (re-work, use as is, or scrap) and issues in accordance with this decision the NCR for ALMA approval.



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ANALYSIS TREE (DRD-20)

The analysis tree describes the hierarchical order and the logic of the various analysis to be performed during the design phase.

It shall show in a form of flow chart all the analysis and assessments foreseen.

ANTENNA ERROR BUDGET REPORT (DRD-21)

The error budget report is the technical report providing the performance budgets of the antenna. It shall contain:

- Surface error budget
- Pointing and Tracking error budget
- Path length error .

It shall clearly state what are the assumption taken into the computation of the error budgets, indicate the antenna configuration used for the computation of the error budget and reference the Finite Element Model and analysis at the basis of the error budget, including postprocessors used in the conversion of the FE results data.

The error budget shall be provided for the following cases:

- a) “raw” or uncorrected by any metrology
- b) “final” or corrected by the metrology system implemented by the Contractor.

DESIGN REPORT (DRD-22)

The Design Report summarizes all the design features of all contract items subject of this contract. The Design Report shall address every requirement specified in the technical specifications and as applicable to the item subject of the Design Report. In particular the Design Report shall contain the following information:

1. Scope of the design
In this section a general description of the contents of the Design Report shall be given.
2. Applicable documents
In this section all the documents referred to in the Design Report shall be listed.
3. Assumptions
All the assumptions used in the design shall be listed. In particular:



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- design constraints
- environmental conditions others than specified in technical specifications
- all calculations methods (if applicable)
- maintenance constraints (if applicable)
- access constraints (if applicable)

(All figures used in the assumptions shall be referenced).

4. Materials

All the materials used in the design and their physical and mechanical properties as well as their chemical behavior shall be given. All applicable treatments and their purposes shall be described.

5. Design description

In this section a complete description of the design shall be given. Every requirement specified in the technical specifications shall be addressed. Figures and sketches shall have a caption and shall be referenced and described in the text. For every design solution supported by calculations shall be made reference to section 6 or to an Analysis Report.

6. Calculations

In this section all the calculations supporting the design, others than those included in the Analyses Report, shall be given in detail, including a discussion of the results.

7. Conclusions

In this section a statement concerning the compliance of the design with the requirements shall be given. Non-conformities shall be discussed.

ANALYSIS REPORT (DRD-23)

The Analysis Report summarizes all the calculations which support the design (for example F.E. calculations, dynamic simulations and control, thermal exchange analysis, etc.).

The Analysis Report shall identify against which issue of the specification and against which design/manufacturing configuration the analysis has been performed.

An Analysis Report shall be produced every time a verification by analysis is required in the verification matrix.

The Analysis Report shall contain the following information:

1. Scope of the analysis

In this section the purpose of the analysis shall be given as well as a general description of the contents of the Analysis Report.



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2. Applicable documents

In this section all the documents referred to in the Analysis Report shall be listed.

3. Assumptions

In this section all the assumptions used in the analysis shall be listed and discussed. In particular:

- assumptions used in the definition of the model
- assumptions used in defining the boundary conditions (if applicable)
- assumptions used in defining the material properties (if applicable)
- assumptions used in defining loads and loading cases (if applicable)
- assumptions used in processing the results (if applicable)
- assumptions used in the definition of masses and inertia (if applicable)
- assumptions used in the thermal exchange coefficients (if applicable)
- any other assumption.
- analysis methods

4. Model

In this section the model used in the analysis shall be described in detail.

In particular:

- the geometry
- the sectional properties (if applicable)
- boundary conditions
- loads topology
- type of elements used (if applicable)
- type of components used (if applicable)
- correspondence between the model and the actual modeled component

Plots and sketches illustrating the model shall be included and shall be readable in all details.

The detail of the description shall allow to reproduce the model.

5. Loading cases

In this section the loading cases shall be identified.

The loading applied to the model shall be given and illustrated in plots and/or sketches.

A list of the loaded nodes shall be given (if applicable).

6. Results

In this section the results shall be summarized and discussed.

The results coming out from the analysis shall be processed in such a way that they are directly comparable with the verification items verified.

Results of control simulations shall be provided (Bode plots, phase and stability margins etc) If applicable

A comparison table shall summarize the calculated values with the values of the verification items.



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7. Conclusions

In this section a statement concerning the compliance of the results with the performance requirements shall be given. Non conformities shall be discussed.

MASS AND BALANCE BUDGET (DRD-24)

The mass and balance budget shall be a report providing in an Excel format the up to date values of:

- mass of the antenna
- center of gravity location
- balancing around the elevation axis.

The mass budget shall be kept updated as long as the design progresses, and updated when the results of the mass testing becomes available.

RELIABILITY AVAILABILITY ANALYSIS (DRD-25)

The reliability analysis report shall contain as a minimum

Description of the system under examination

- Assumptions used in the analysis
- Methodology used (example Parts Count method as per MIL-HDBK-217F)
- Reliability data sources (example NPRD-95, Non electronic Parts reliability data)
- Prediction of Reliability and Availability based on failure rates
- Optimum preventive replacement time for components in a repairable system.
- Spare parts requirements and production rate, spare parts inventory
- MTBF computation
- Down time of the system and availability taking into account the MTBF, the mean time to repair (MTTR) and the Time for Preventive Maintenance (TPM)

HIGH ALTITUDE ANALYSIS (DRD-26)

The high altitude analysis shall document all measures taken at the level of the design (example: cooling provisions, insulation capacity), specification (example: equipment derating), analysis (example: lifetime of parts) in order to ensure that the reliability of the antenna when operated at 5000 m altitude is according to the specification.

It shall furthermore:



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- Contain any relevant supplier qualification data of the equipment selected by the Contractor.
- Contractor's conclusive statement of adequacy of the design.

It shall also document the measures taken at design level to support the operation and maintenance at the AOS, under consideration of the reduced capacities of employee working at high altitude.

QUALIFICATION SUMMARY (DRD-27)

The report shall contain all the data needed to validate the Carbon Fiber Reinforced Plastic (CFRP) and the CFRP processes (bonding, gluing, protective coatings) used in the design of the antenna.

HAZARDS ANALYSIS (DRD-28)

The hazards analysis report shall follow the requirements of AD01 and contain as a minimum:

- Description of the system
- Preliminary Hazard List, including the hazards depending on the adopted design and the operational hazards
- List of all the environmental and accidental hazards, including high altitude considerations
- Evaluation of their probability and severity
- Explanation of the risk reduction measures adopted.
- Any input to operation and maintenance procedures
- Demonstration of the acceptability of the residual risks
- Conclusions

Updates of the analysis may be necessary as result of design modification or experience with the assembly and testing on site.

SAFETY COMPLIANCE ASSESSEMENT (DRD-29)

The Safety Compliance Assessment report shall collect all safety related information of the project as demanded by AD01.

It shall also provide a conclusive statement of compliance with the specified, national and industry codes safety standards imposed contractually or by law to ensure the safe



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design of the antenna system prior to delivery and operation (Declaration of Conformity).

LOWER LEVEL SPECIFICATIONS (DRD-30)

They are the specifications, at **all levels of the project**, which define the subassemblies and major parts which shall be prepared by the Contractor or/and by the subcontractors.

The lower level specifications shall contain at a minimum:

- Applicable documents;
- Item description;
- Interface definitions, requirements;
- Performance characteristics, requirements;
- Physical characteristics;
- Reliability, maintainability requirements;
- Environmental conditions including EMC;
- Design and construction requirements (parts, materials, processes, workmanship etc.);
- Assembly requirements;
- Transport requirements;
- Safety requirements;
- Documentation requirements;
- Personnel and training;
- Quality assurance provisions (verification requirements - test, design analysis, etc.).

SOFTWARE DESIGN SPECIFICATION / ICD (DRD-31)

- The software design to be delivered by the Contractor shall be derived from the ALMA ICD and the Technical Specification
- It should elaborate on functional and performance requirements, normal and abnormal conditions and should include also test and maintenance requirements.

The documents to be delivered are:

- Software Design Specification
- Proposed updated ICD.



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EMC CONTROL PLAN (DRD-32)

The EMC Control Plan shall comprise the following documents:

- EMC System Analysis
 - Interaction matrices
 - Frequency diagrams
 - Level diagrams
 - Coupling matrices
- Lightning and LEMP Analysis
 - Functional analysis
 - Fixed structural and constructional features
 - Identification and establishment of protective zones
 - Identification and establishment of all interfaces
 - Coupling analysis
- EMC Prediction
- EMC Program Plan (including, but not limitedly to)
 - Definition of technical measures related to system/equipment design
- EMC Test Plan (*if applicable, it does not include ALMA tests*)
- EMC Test Reports (*if applicable, after completion of tests*)

DRAWING SET (DRD-33)

They shall define at **all levels** of the project the as-designed and as-built product.

Drawing sets shall be prepared in accordance with DIN standards or equivalent approved by ALMA, and shall contain all information necessary to manufacture, assembly, and test the item and the necessary support equipment.

The valid drawing list shall be part of the CIDL drawing set.

For mechanical parts all drawings necessary for manufacturing of the part shall be provided, including drawings for welding, casting and machining, with heat and surface treatments indicated.

For assemblies assembly drawings shall be provided. Item numbering referring to the parts list shall be included.

For purchased parts datasheets with information function, dimensions, interfaces, etc., shall be provided. A document number shall be assigned to each data sheet.

For fluidic system P&I diagrams shall be provided. The item numbering shall refer to the parts list as described above.



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For the electric control system overview drawings showing the installation location on the antenna of all equipment shall be provided including correct item numbering.

For the electric control system, functional block diagrams and wiring diagrams shall be provided.

All documentation shall be delivered in their native electronic format and in Adobe pdf format.

The validity and applicability of drawings for individual antennas shall be managed by the electronic parts database system (see DRD-34). Drawing Lists listing all applicable drawings shall be produced for reviews, for AIPCn and on request by ALMA.

PART LISTS (DRD-34)

All items comprising an antenna including the tools delivered to ALMA shall be managed by a Product Data Management (PDM) system. The data set for a part shall contain as minimum ID number, part number, description, supplier, version identifier, weight and the document reference for all documents defining the part. Also assemblies, subassemblies and purchased components shall be considered as items and shall be managed by the parts database system.

The product tree for of each antenna shall be established by linking the data sets. The parts database system shall manage these links.

Parts Lists for assemblies and subassemblies at all levels shall be established by this system automatically. In the parts list the correct version of drawings and other technical documents shall be given.

Drawing lists listing all valid drawings and other technical documents defining an individual antenna shall be established automatically.

The format for the parts database system shall be delivered to ALMA so that ALMA can set up its own parts database system and include the contractor information for each antenna subsequently.

With every antenna a complete set of parts lists defining the product tree and an update parts database shall be delivered.

SPARE PARTS LIST (DRD-35)

The Spare part list shall contain all the information related to the spare parts necessary to operate and maintain the antennas for 15 years. This includes as a minimum:

- Recommended number / quantity



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- Manufacturer/supplier with address
- Name
- Type designation
- Dimensions
- Specification
- Delivery times
- Expected lifetime on the shelf
- Special storage provisions (power up, high altitude influence, etc.)
- Storage conditions

In the Spare Part List a subdivision shall be made with the following categories:

- Consumables
- Fragile and/or critical parts
- Components or parts with very long delivery time or which are custom-made
- Off-the-shelf / custom-made products

FINITE ELEMENT MODELS (DRD-36)

Finite element models of the antenna developed by the Contractor are part of the deliverables. The models shall follow the requirements of AD 01.

The delivery shall be updated as long as the design progress and in case of updates.

PRE-PRODUCTION DESIGN REVIEW DATA PACKAGE (DRD-37)

The design review data package is a collection of all documentation which allows to scrutinize the compatibility of the design with the specified requirements.

The documents contained in the data package are defined in the DRL list of Section 10. The level of detail information contained shall follow the guidelines of AD 03 Section 4.2.2.

MANUFACTURING PLAN (DRD-40)

The manufacturing plan shall list all actions which are planned for the manufacture, inspection, testing and transport of the units to Chile. It shall contain sufficient information at major subsystem level.

The plan shall include a PERT diagram of all activities with the foreseen duration and shall reference all relevant documents (drawings, procedures, etc...). It shall identify



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on the PERT diagram all the Quality assurance inspections (tests, inspection, auto certification, subsystem acceptance etc.)

Constraints on procurement or deliveries shall be identified.

WORK AREA DESIGN (DRD 41)

The *Work area* design shall define the arrangement of the work area assigned to the Contractor. It shall indicate the locations of the antenna stations, and the transporter roads leading to the stations. It shall take into account the requirements of Section 5.8.1 herein, including the restoration of the area to the pristine conditions after completion of the work.

ON-SITE ASSEMBLY PLAN (DRD-42)

The On-Site Assembly Plan shall describe the sequence of the assembly and integration procedures for the on-site activities.

The plan shall clearly indicate all the inspections, checks and tests as well as all critical operations performed during the assembly process.

This plan shall furthermore identify and specify the requirements for the On-Site Assembly:

- Handling equipment;
- Special assembly tools;
- Machine and hand tools;
- Measuring and alignment equipment;
- Electric power requirements;
- Manpower (number, qualifications and categories);
- Office and workshop space.

A detailed schedule of the on-site assembly work shall be provided including the staffing plan.

SITE SAFETY MANUAL (DRD-43)

The Site Safety Manual shall clearly identify and describe all measures, procedures and safety programs that the Contractor shall implement on site in order to ensure safety during the full life of the assembly site at the OSF.



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This includes (but it is not limited to):

- Scope and methods
- Responsibilities identification
- Required applicable documents, procedures and enforced manuals,
- Preparation of the site,
- Implementation of preventive measures,
- Monitoring, auditing and periodic reviewing,
- Personnel training,
- Devices and equipment:
 - Lifting devices,
 - Machines, grinders,
 - etc.
- Reeling, walkways and guards
- Personal protective equipment
- Dangerous materials
- Fire hazards and extinguishers
- Electrical safety
- Accidents investigation and reporting;
- etc.

ASSEMBLY –DISASSEMBLY ALIGNMENT PROCEDURE (DRD-44)

It shall list and describe the major steps necessary to disassemble the antenna in its major parts (base, yoke, cabin, BUS and panels, apex and legs) to assemble it and to verify the alignment.

It shall describe the features necessary to perform these operations, (flanges, handling fixtures and points, disconnection points, special tools).

It shall also indicate methods for the checking of the proper alignment of the antenna and the reflector.

It shall also clearly identify all the checks which will be performed during the integration to ensure that:



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OPERATIONS MANUALS (DRD-45)

The Operations Manuals describe in detail all the procedures needed to operate correctly and safely the antenna.

It shall at least:

- Describe the start-up procedures;
- Describe the shut-down procedures;
- Describe all the procedures to operate the subsystems;
- Describe all the operational errors messages for the ACU and the resulting remedial action
- Describe all the safety procedures to operate the antenna and the subsystems,
- List all the operational limits
- List the emergency cases which can occur during operations;
- Describe emergency procedures;
- Make reference to any other procedure needed for safe and correct operation;
- Trouble-shooting and actions to be performed by the operator upon error conditions, fault identification
- Includes the operations manuals of the Control System

SOFTWARE USER MANUAL (DRD-46)

The SW User manual describes as a minimum:

- SW design overview, and architecture
- SW installation and downloading procedures
- Operating modes
- User Interface
- List of commands and parameters
- List of messages from the ACU.

ANTENNA TRANSPORT PROCEDURE (DRD-47)

This may be a stand-alone document or be a subset of the Operations Manual (DRD-45)

This shall contain the procedure for transport of the antenna, mounting on the antenna station, and lifting from the antenna station, connecting and disconnecting.



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It shall follow the step by step procedure provided in ICD 03 of AD 01 and describe all the actions, related to the antenna, necessary to perform safely each individual step.

It shall also include the checking of the antenna after connection to the station.

(Calibration procedures may be contained in the Operations Manual DRD-45)

MAINTENANCE MANUALS (DRD-48)

The maintenance manuals shall contain the detailed maintenance procedures with drawings. It shall contain the maintenance requirements and scheduling for all items included in the supplies of this contract.

It shall identify all maintenance actions, and provide them in a tabular form (Preventive Corrective Intervention List), with as a minimum:

- Type of maintenance, inspection, LRU exchange, overhaul etc;
- Dates (intervals) of maintenance;
- Duration of maintenance action
- Procedure identification and number

For each intervention there shall be a specific procedure with the following information as a minimum:

- Item to be maintained
- Number and qualification of maintenance personnel
- Tools and equipment, including access
- Step by step procedure, including preparation
- Required parts, consumables
- Safety measure
- Check after action and start up
- etc.

The maintenance manual and the PCIL shall also be delivered in a computer readable form for later introduction by ALMA in the overall of maintenance scheme at Observatory level.

SOFTWARE MAINTENANCE MANUAL (DRD-49)

The Control Software Maintenance manual shall cover:

- Programming language, the operating system and development system used;
- The internal organization of the software; and files description



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- The installation procedure including the environment set-up (operating system, etc);
- The preventative maintenance operations (file clean-up, etc.).
- Document the test procedures.
- Contain the design documentation
- Describe the detailed procedure to install new releases and to check the installed versions.

If, in addition to ACU software, any other "off-the shelf" software is used, the Contractor shall provide the original documentation (English version only).

SOFTWARE RELEASE SUMMARY (DRD-50)

The Software Release Summary shall state the release of a software package for the use in the project.

This is a PA document which:

- Identifies the software package, including the version number
- Lists the results of the tests performed to qualify the package.
- Provide any other relevant information (known bugs, patches, etc.)

VERIFICATION PLAN (DRD-51)

The Verification Plan shall identify all requirements of the Technical Specification (and ICDs) of the antenna and provide for each requirement the method of verification used (Design, Analysis, Test) in accordance with the Verification Requirements of AD 01.

It shall therefore identify:

- The phase of the project (manufacturing plan) in which the item verification is performed,
- The type of verification in case of test (subassembly level or Antenna level)
- The Design Report or the Analysis report covering the item verification (if applicable)
- The Test Procedure (DRD-52) applied for the verification of the item by test (if applicable)
- The Test Report containing the results of the verification (if applicable)



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The Verification Plan may be updated for the antenna 2 to N if a change of the verification method is proposed by the Contractor in accordance with the Verification Requirements of AD 01.

INSPECTION AND TEST PROCEDURE (DRD-52)

The Test Procedure describes in detail all the necessary operations to perform a verification by inspection or by test.

A test procedure shall be produced for every verification by test required in the verification matrix. Verification by inspection may require also a procedure.

The test Procedure shall contain the following information:

1. Scope of the test or inspection
In this section the scope of the test shall be described and the verification item shall be identified. It shall also define if the verification is inspection or test
2. Applicable documents
In this section all the documents referred to in the Procedure shall be listed.
3. Test or inspection conditions
In this section all applicable requirements needed to perform correctly the test shall be listed
(for instance: special environmental conditions, dedicated tools, test rigs, special requirements on the tested items, etc.), calibration requirements
4. Test or inspection procedure
In this section all the operations required to perform the verification shall be described in deep detail.
5. Test or inspection results presentation
In this section the procedures to process the raw data for the final presentation of the results shall be described.

The Test Procedure shall be submitted to ALMA at least 4 weeks prior to the test.

INSPECTION AND TEST REPORT (DRD-53)

The Test Report shall summarize the findings of the tests. The Test Report shall contain the following information:

1. Scope of the test
In this section scope of the test and the verification item shall be identified.
2. Applicable documents



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In this section all the documents referred to in the Test Report shall be listed.

3. Test Procedure

In this section reference shall be made to the applicable Test Procedure.

4. Test results

In this section the findings of the test shall be given. The results shall be processed in such a way that they are directly comparable with the verification items verified. A comparative table shall summarize the actual findings compared with the verification item.

5. Conclusions

In this section a statement concerning the conformance of the test results with the requirements specified shall be given. Non-conformities and changes shall be discussed as far as applicable.

The report shall be submitted to ALMA not later than 2 weeks after the test.

COMPLIANCE MATRIX (DRD-54)

The Compliance Matrix shall identify in a tabular form all requirements of the Technical Specification (and ICDs) of the antenna and provide for each requirement the method of verification used (Design, Analysis, Test), the reference to the design document or test report where the compliance is demonstrated or shown, the compliance (Y or N) and possible remarks.

It shall be the top level to evaluate the compliance of the antenna with the Technical Specification. It shall also clearly point to requests for waiver and Change requests.

ACCEPTANCE DATA PACKAGE (DRD-56)

The Acceptance Data Package is the collection of documentation and drawings which shall be the base for the acceptance of the as-built product at all levels of the project.

It shall include as a minimum:

- The list of data package documents (as for as not already delivered);
- The drawing set and parts list identifying the as-built product configuration;
- Material certificates, and Quality assurance certificates.
- All certificates documenting the proper application of the critical manufacturing, assembly, test, inspection procedures;
- Specific inspection/test reports fro the antenna;
- All non-conformances / waivers and changes;



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- Safety Compliance Assessment
- Analysis/design reports; (if not already delivered with previous antennas)
- The Compliance Matrix