

ALMA Proto-Memo

ALMA Prototype Antenna Tests

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Abstract

This memo describes the ALMA prototype antenna tests. In formulating this plan, our basic assumptions are:

1. The primary goal of the ALMA prototype antenna tests are to evaluate the prototype antenna to determine if it meets the manufacturer specifications set forth in the antenna fabrication contract.
2. A secondary goal of these tests is to evaluate the ALMA electronics systems, such as LO, IF, etc.
3. Testing of the electronics and monitor and control software should not interfere with evaluation of the prototype antenna.

Our approach to this plan is purposely conservative, emphasizing single antenna tests of the prototype antenna, which are followed by interferometric tests once interferometric capabilities can be established.

1 System Installation

It will be necessary to install a number of ancillary devices on the prototype antenna in order to complete the tests listed in §2. Most of these devices will be used to test the mechanical integrity of the telescope structure. Before installing any of these devices, the following tasks must be completed:

1. Cable outfitting for NRAO equipment
2. Installation of additional safety equipment
 - Personnel and antenna safety equipment

1.1 Install Measurement Devices

1. Thermistors
2. Tiltmeters
3. Accelerometers
4. Strain Gauges
5. On-Axis Cable Wrap
6. RF Transparent Membrane
7. Instrument Racks
8. Cryogenic Compressor
9. Telephone and Intercoms
10. Prepare Control Room and Connection Cables
11. Quadrant Detector
12. Solar Filter
13. Molecular Sieve
 - (a) For oxygenation of receiver cabin
14. Nutator
15. Alignment of Receiver Optical Systems
16. Control interfaces
 - (a) NRAO computer hardware/software interfaces
17. Optical pointing system
18. Calibration Systems

- (a) 22/183 GHz phase calibration system
 - (b) Hot load vane
 - (c) Berkeley apex calibration system
 - (d) Photonic LO injection at apex
19. Evaluation Receiver
 20. Prime Focus Holography Receiver

2 System Tests

1. General Mechanical Inspection
 - (a) Wiring, Power, and UPS
 - (b) Brakes
 - (c) Interface Integrity
 - (d) Slew Rate Check
 - (e) Tracking Check
 - i. Sidereal, fast-switching, OTF
 - (f) Weather Proofing Check
 - (g) AUI Equipment Installation and Removal Checks
 - (h) Grounding Checks
 - i. Antenna-to-ground and antenna grounding measurements
 - (i) Antenna Hard-Stop Motion Tests
 - i. Antenna at full velocity brake test and check
 - (j) Optics Check
 - i. Aperture diameter
 - ii. Optics locations, alignments, travel, stability, blockage
 - (k) Cable Wrap Tests
 - i. Range and operation
 - (l) Transporter Interface
 - (m) Safety Inspection
 - i. Stow, power failure, smoke detection, power faults, wind, lockouts, servo oscillation, etc.

(n) Surface Setting

2. Dynamical/Mechanical Tests

(a) Tiltmeter Checks of AZ Rotational Stability

(b) Resonant Frequency Measurements

(c) Acceleration Measurements

i. Check for AZ/EL/apex oscillations

(d) Movement Tests

i. Motor current, power consumption, bearing friction measurements during slewing and tracking

(e) Apex Translations

i. Accelerations, velocity, travel, range, stability, natural frequency, and dampening

(f) Optical Telescope Operation and Stability

(g) Panel Mounting Stability

i. Stability, adjustment, and gap check

(h) Transporter Testing of Antenna

i. Moving, stability, repeatability

(i) Nutator Testing

i. Switching, throw, and duty-cycle performance

(j) Vertex Shutter

i. Transparency characteristics and mechanical stability

(k) Receiver Cabin Temperature Stability and Capacity

(l) Calibration Systems Testing

(m) Test Antenna Transporter Survival Conditions

(n) Verify Code Compliance of Antenna

(o) Test Antenna RFI/EMI Characteristics

i. To be completed in collaboration with VLA staff

(p) Verify Antenna Alignment

(q) Evaluate Antenna Electrical Cooling at Altitude

(r) Check Auto Stow, Emergency Stops, and Range Limits

(s) Evaluation of Antenna Manuals

- (t) Inspect Corrosion Resistance Compliance
3. Monitoring (requires fast sampling)
 - (a) Temperatures
 - (b) Tiltmeters
 - (c) Motor Currents and Temperatures
 - (d) Weather
 - i. T_{amb} , P_{amb} , V_{wind} , D_{wind} , *etc.*
 - (e) Acceleration
 - i. Check for flutter in the telescope servo
 - (f) Strain
 - (g) Quadrant Motion
 - (h) General Correlations
 - i. Use archived weather data to look for correlated effects on antenna.
 - ii. Start this work after measurement systems have been installed.
 - (i) Receiver, Rack Equipment, Cryogenics, and Safety Items
 4. Optical Tracking and Pointing
 - (a) Optical Pointing Model
 - i. First astronomical pointing model
 - ii. Study time stability of pointing model
 - (b) Optical guide star tracking
 5. Holography
 - (a) Remove Subreflector
 - (b) Pointing and Tracking System
 - (c) Control System Interface
 - (d) Holography Frontend/Backend
 - (e) Reference Feed Measurement (should have been done in lab)
 - (f) Holographic Data Acquisition

- (g) Raster Scanning
- (h) Holography Data Analysis System
- (i) Mountain-Top Beacon (92 GHz)
- (j) Mast-Top Near-Field Measurement
- (k) First Holographic Maps
 - i. 129×129
 - ii. 10 cm spatial resolution
 - iii. Day/night repeatability
 - iv. Elevation dependencies
- (l) Reinstall Subreflector

6. Millimeter Receiver Tests

- (a) Apex Focus, Translation, and Receiver Alignment
- (b) Radio Pointing (90/230 GHz)
- (c) Radio/Optical Pointing Comparison
- (d) Radio Tracking Tests (Moon, Jupiter etc.)
- (e) Efficiency Tests
 - i. Best done at highest frequency possible
- (f) Beam Studies (Moon, planet scans)
- (g) Forward/Rear Spillover Efficiency Studies (sky tips *etc.*)
- (h) Fast Switching Tests
 - i. Best done at 230 GHz
 - ii. Check settling time
- (i) OTF Turn-Around Performance
- (j) Solar observation test
 - i. Heating of subreflector, feedlegs, cabin, solar filter, Rx, and RF window
- (k) Nutation/Total Power Tests
 - i. Pointing stability
 - ii. Check beam throw on sky
- (l) Spectral Baseline Stability Tests (requires correlator)
- (m) Testing of Calibration Systems
- (n) Stability With Transportation
- (o) Verify Surface Accuracy Budget

3 Interferometer Tests

1. Check Close Packing Limitations
 - (a) Only need be done if two similar antennae are tested
2. Phase Stability and Electronics Tests
 - (a) Lateral displacements, wind, bearing slop, differential temperature
 - (b) Stability while fast switching
 - (c) Includes round-trip phase correction system installation and testing
 - (d) Includes path length error evaluation
3. More Extensive Radio Pointing Tests
4. Interferometric Holography:
 - (a) Using 86 GHz SiO maser (needs spectral correlator) and/or planets.
 - (b) Needs complete interferometric, phase stable, fringe tracking, delay tracking electronics.
 - (c) Measure surface (e.g. 48×48) deformations as a function of elevation.
 - (d) Might tweak surface setting with these measurements

ALMA Task Scheduling
Antenna Testing selected

ID	WBS (f)	Task	Start	Finish	Duration	2002												J	F	M			
						F	M	A	M	J	J	A	S	O	N	D							
9	9	<u>System Engineering & Integration</u>	<u>2/1/2002</u>	<u>4/1/2003</u>	<u>425d</u>	[Gantt bar spanning from Feb 2002 to Apr 2003]																	
16	9.7	<u>Joint evaluation of prototype antennas</u>	<u>2/1/2002</u>	<u>4/1/2003</u>	<u>425d</u>	[Gantt bar spanning from Feb 2002 to Apr 2003]																	
17	9.7.1	<u>System Installation</u>	<u>2/1/2002</u>	<u>3/12/2002</u>	<u>40d</u>	[Gantt bar from Feb 1 to Mar 12, 2002]																	
41	9.7.2	<u>System Tests</u>	<u>3/13/2002</u>	<u>11/24/2002</u>	<u>257d</u>	[Gantt bar from Mar 13 to Nov 24, 2002]																	
42	9.7.2.1	<u>General Mechanical Inspection</u>	<u>3/13/2002</u>	<u>4/16/2002</u>	<u>35d</u>	[Gantt bar from Mar 13 to Apr 16, 2002]																	
57	9.7.2.2	<u>Dynamical/Mechanical Tests</u>	<u>4/17/2002</u>	<u>5/2/2002</u>	<u>15.5d</u>	[Gantt bar from Apr 17 to May 2, 2002]																	
78	9.7.2.3	<u>Monitoring</u>	<u>5/2/2002</u>	<u>5/28/2002</u>	<u>26d</u>	[Gantt bar from May 2 to May 28, 2002]																	
88	9.7.2.4	<u>Optical Tracking and Pointing</u>	<u>5/28/2002</u>	<u>6/18/2002</u>	<u>21d</u>	[Gantt bar from May 28 to Jun 18, 2002]																	
91	9.7.2.5	<u>Holography</u>	<u>6/18/2002</u>	<u>8/14/2002</u>	<u>57.5d</u>	[Gantt bar from Jun 18 to Aug 14, 2002]																	
104	9.7.2.6	<u>Millimeter Receiver Tests</u>	<u>8/15/2002</u>	<u>11/24/2002</u>	<u>102d</u>	[Gantt bar from Aug 15 to Nov 24, 2002]																	
120	9.7.3	<u>Interferometer Tests</u>	<u>11/24/2002</u>	<u>1/26/2003</u>	<u>63d</u>	[Gantt bar from Nov 24, 2002 to Jan 26, 2003]																	
125	9.7.4	Selection of production antenna design	4/1/2003	4/1/2003	0d	[Gantt bar from Apr 1, 2003 to Apr 1, 2003]																	

Milestones: **bold type**
Summary Tasks: underline

Joint Task		Summary (Joint)		Progress		Summ. Progress	
Eur Task		Summary (Eur)		Milestone		Split	
US Task		Summary (US)		Completed Mlstr			

ALMA Task Scheduling
Antenna Testing selected

2003										2004																
A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
▲ 4/1/2003																										

Milestones: **bold type**
Summary Tasks: underline

Joint Task 	Summary (Joint) 	Progress 	Summ. Progress 
Eur Task 	Summary (Eur) 	Milestone ▲	Split 
US Task 	Summary (US) 	Completed Mlstn ▲	