

<u>ANTENNA</u>

Atacama Large Millimeter Array

Presented by Stefano Stanghellini

ESO-Wide Review 13 – 17 February 2003





ALMA Antenna Integrated Product Team Current Organization

Antenna IPT Leader - Jeffrey S. Kingsley (NRAO) Deputy IPT Leader - Stefano Stanghellini (ESO)

European Antenna Group (From TEC Div.)

- Maximilian Kraus (Mechanics, Transpsorter)
- Franz Koch (Structural analysis)
- Fabio Biancat Marchet (Servo & Controls)
- Birger Gustafsson (Software)
- Arno van Kesteren (EMC, electrical safety)
- Canio Dichirico (Power distribution)
- Others (ESO)
- Josef Strasser (Contract Support, Antenna & NRAO I/F)
- M. Boecker (Safety)
- Jutta Quentin (drafting)

External Support from:

- Richard Hills (Metrology) Cambridge
- Albert Greve (Metrology & Thermal) IRAM

North American Antenna Group

- Jingquan Cheng (Structural Engineer) NRAO
- Victor Gasho (Mechanical Engineer) NRAO
- Nicolas Emerson (Mechanical Engineer) NRAO

Support from:

- Simon Radford (Site & Nutator) NRAO
- Bob Freund (Servo, Control & Electrical) NRAO
- Antonio Perfetto (Electronics) NRAO
- Mick Brook (Controls & CAN bus) NRAO
- Lee King (Structural Engineer) NRAO



Phase 1: Scope Summary

- To deliver 2 prototype antennas (one European, one North American) at the VLA site in Socorro, including their foundation.
 - North American Prototype manufactured by VERTEX RSI, European prototype manufactured by ALCATEL/EIE Consortium, based on equal specification.
- To deliver 2 optical pointing telescopes and two nutating subreflectors to be mounted on the prototype antennas for testing
- To support the work of the Antenna Evaluation Group in assessing the Antenna performance.
- To evaluate the feasibility and the specification of the transporter for the ALMA antenna



Antenna Specification

ALMA Project

Configuration	12 Meter Diameter, elevation-over-azimuth mount, Cassegrain focus	
Frequency Range	30 GHz to 950 GHz	
Precision Performance Conditions	Nighttime: wind 9 m/s, Daytime: wind 6 m/s and sun from any angle	
Reflector Surface accuracy	20 μm rms goal, 25 μm rms specification0.6 arcsec (offset, 2 degrees in position and 15 minutes time)2.0 arcsec (absolute)	
Pointing Accuracy, rms		
Fast Switching (settle to 3 arcsec pointing)	Move 1.5 degrees in position in 1.5 seconds	
Phase Stability	15 μm rms	
Close Packing	1.25 dish diameters	
Solar Observing	Full solar observing allowed	
Transportability	Transportable on a rubber-tired vehicle	



Two <u>different</u> Prototypes:

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AEC Antenna

120 Replicated Nickel panels, Rh coated 5 adjusters / panel Cabin in CFRP Closed back BUS in CFRP, 16 sectors, Feed legs and Apex in CFRP Direct drives on both axes Direct connection Cabin BUS Three axes Apex mechanism 6 Points support base Total mass ~ 75 tons, $f_1 \approx 11$ Hz

VertexRSI Antenna 264 machined AL panels 8 adjusters / panel Open back CFRP BUS, 24 sectors CFRP feed legs & apex Rim pinion drives Hexapod secondary positioner Invar support cone Invar/steel Rx. Cabin Base on 3-point connection Mass ~110 tons, $f_1 \approx 7.5$ Hz



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European Antenna Prototype Status: Contractual Notes

- Contract awarded to Consortium of <u>European Industrial Engineering</u> & COSTAMASNAGA.
- Contract amended in Dec. 2001 (#3) with introduction of ALCATEL in the Consortium. New delivery date introduced (18 April 2003 in Socorro).
- Issues still to be treated at time of amendment #3:
 - Design of metrology system to guarantee antenna pointing performance,
 - Low resistance to wind due to low stiffness
 - Use of replicated reflector panels produced by electroforming technique
- In May 2002 COSTAMASNAGA files for bankruptcy under Italian legislation. This causes delays to manufacture of most mechanical structure and subsystems.
- The default of COSTAMASNAGA leads to the amendment # 4 on 1.08.02, with:
 - A reduction of the scope of pre-assembly in Europe,
 - Introduction of Preliminary Acceptance (ESO access to the antenna) on <u>18 April 2003</u>,
 - Shift of provisional Acceptance shifted to <u>17 June 2003</u> in Socorro



Major Design Update: Status

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- Status of planned design update foreseen at time of amendment #3:
 - <u>Improved wind resistance</u>: Structure reinforced with associated changes of drives, brakes etc. Completed and reviewed (July 02)
 - <u>Use of Replicated Panels</u> (Media Lario) in existing BUS: Design Review on panels and panel adjusters performed in July 2002. Rhodium Coating selected to guarantee thermal and optical performances.
 - <u>Metrology system</u>: Suffered delays. PDR occurred on 7.10.02. FDR performed successfully on 11.02.03. System based on System based on 5D laser sensors, thermal sensors, inclinometers and reconstruction algorithm to evaluate wind deflection of structure. Serious effort needed for calibration
- Other changes introduced :
 - Quadrupod legs and apex reinforced (finished)
 - Modification of foundation and base for safer mounting procedure
 - Minor improvements in detail areas (motor cooling, feed shutter...)

Antenna now fully compliant with specification!

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Manufacturing Status: Antenna Structure Pre-assembly

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- Antenna structure assembled at Galbiati as per mid November. A number of subsystem integrated (azimuth motor, cable wrap,brake..)
- Azimuth bearing stiffness tested. Bearing manufacturer intervened to exchange rollers on 3.12.02. (Issue still open).
- Antenna structure dismounted, painted and transported to Genoa. Left on 21.12.02



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Manufacturing Status: CFRP Receiver Cabin (Plyform, Galbiati)

- CFRP delayed. Two halves and roof joined on 4.12.02. Cabin finished with lateral panels and mounting of elevation motor support and thermal curing on 21.12.02.
- Beg. of January 2003 a handling accident occurred causing (minor) damage to the cabin. This demanded repair and new curing before restarting machining of interfaces (receiver, BUS, elevation axis)





Manufacturing Status: Receiver Cabin (cont.d)

- Cabin now in machining process. Machining performed at low speed to reduce risk. Expected to be finished within 2 weeks. Afterwards adjustment I/F to BUS
- Afterwards painting and flame spray, installation of metal floor and furnishing. Cabin expected to be ready for shipment 15 March 2003. (*Transport issue still tbd*)



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Manufacturing Status: Back Up Structure (ATR)

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- Delayed due to late start of manufacturer (ATR). Sloppy control by AEC. Fabrication of two moulds took longer than anticipated and demanded corrections. <u>BUS always on critical path</u>.
- All slices manufactured at end of December 2002.



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Manufacturing Status: BUS Pre-assembly

- On 27.11.02 the assembly of BUS started with special jigs to glue radial ribs and for mounting the paraboloid. The last 2 slices arrived damaged at Galbiati factory due to road accident. A third slice (No.11) damaged during handling accident with cabin. (Now in manufacturing)
- Various jigs needed for assembly of BUS, for gluing radial ribs and joining the slices.
- Assembly performed under dimensional control (laser tracker).



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Manufacturing Status: Status at 10.02.03

- 8 slices glued, 9th and 10th in preparation for mounting. Three new slices (no. 11, 14, and 15) in manufacturing, expected before end of February. (No. 11th will be needed in a matter of days.)
- After full assembly, axis is determined with laser tracker, and used for positioning the flanges to the cabin (same jig used for cabin) and for positioning the interfaces to the panels.
- BUS manufacturing extending to end of March. 2003.



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Manufacturing Status: Panel (Media Lario) & adjusters (RIC)

- All (120) replicated Nickel panels manufactured. Process of sealing close to completion
- Rhodium coating selected given poor Aluminium performance on quality and durability. All toolings and bath procured. Rhodium solution procured and coating started successfully.
- Panel adjusters gone trough prototyping, testing and design update. Now in serial production
- Panels undergoing a final measurement on real adjusters in order to generate reference surface to be used later during panel adjustment in Socorro.
- Panel final batch delivery during 2nd half of April 2003.





Pre-Assembly Europe

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- Full pre-assembly of antenna never possible given the schedule. Scope of preassembly in Europe limited due to delays in manufacturing of CFRP parts. Scope further reduced after COSTAMASNAGA default:
 - Antenna mount: assembly of legs, base, AZ bearing, yoke, and AZ bearing test.
 - Mounting and testing of cable wrap and other parts
 - BUS to cabin interface generated by common tool and template.
 - ACU tested for communication and loop closed with test motor & encoder
 - BUS to be fully assembled and dimensionally controlled in Europe.
 - Panels adjusters interfaces to BUS will be mounted in Europe
- Critical activities shifted to site:
 - Cabin and yoke elevation axis adjustment
 - Complete cabling of antenna
 - First mounting and alignment of motors and encoders
 - First mounting of equipment and of receiver cabin equipment
 - Testing of antenna driven by the ACU



Next Milestones

before 26 02 03

30.03.03

16 04 03

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- Manufacturing, Europe
 - Delivery of three new BUS sectors
 - Cabin completed (ready for shipment) 15.03.03
 - BUS fully assembled with panel I/F
 - Last batch of Panel Rhodium coated

• Socorro ATF site

- Antenna Base Yoke and base erected on site 1
- Cabin mounted on Structure
- BUS on site
- Antenna assembled

18.03.03 20.04.03 (TBC, pending on transport) 30.04.03 31.05.03 (TBC)

- Contractual Milestones
 - Preliminary acceptance (ESO/AUI access)
 - Provisional Acceptance

18.04.03 17.06.03 (Delayed to July 03))



Next Milestones: Issues

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- Manufacturing, Europe
 - Still uncertainties on BUS completion, pending delivery of replacement sectors.
 - Cabin shipment to be decided (together with BUS by air? Dedicated sea transport?).
- Socorro ATF site:
 - Consortium not yet geared for fast start.
 - Strategy of panel and BUS mounting to be decided after trial mount in Europe
 - Some critical activities done for the first time
 - Little time for metrology calibration & testing, after antenna functional.

Generally:

- Schedule still success oriented in some areas and likely to suffer from minor problems (transport, minor H/W changes, late delivery of parts.....)
- Heavy load on documentation ahead (manuf. drawings, plans & procedures, manuals.....)
- Antenna pointing achieved through testing and calibration. Monitoring & support by ESO to Contractor anticipated, after antenna achieves functionality.



Site Activities and Logistics

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- Antenna foundation with embedded beam completed and accepted (ESO/NRAO)
- Antenna structure boxes unloaded on site on 12.02.03
- 5 major shipments foreseen including BUS (by air) and cabin (by air or sea, TBD)
- Sloppy start of AEC site activities: Temporary shelter and trailer shifted to week 8/9. Key personnel still (very) busy with BUS in Italy.





Antenna Transporter Studies

- ALMA Project
- Development of concept based on existing industrial vehicle.
- Advantages of this concept:
 - •Relatively low mass
 - •Modularity based on existing subassemblies (tractor)
 - •Acceptable road width
 - •Not necessary to drive on foundation





North American Antenna Status

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- Antenna erected and functional. In the process of acceptance testing
- ESO team members involved in the acceptance process. Some problems need further testing fixing (Servo's).

• Antenna close to be handed over to the Antenna Evaluation Group.





ALMA Phase 2: Work Plan and Milestones

•	Issue Call For Tender for Production Antennas (63+1) (Sufficient performance data need to be obtained by AEG group	3/4 Q 2003
•	First Production Antenna at the OSF in Chile (first production antenna or upgraded prototype)	4Q 2005
•	First 8 antennas ready for science operation <i>(antennas to be ready in advance typically 2Q)</i>	3Q 2007
•	Transporter CFT for two transporters	1Q 2004
•	1st transporter operational on site	3Q 2005



Antenna IPT: Major tasks

- Conclude Provisional Acceptance of NA Antenna (NRAO + ESO support)
- Harmonise foundation and issue ICD / Antenna foundation (in progress)
- Ensure timely delivery of European Antenna Prototype (ESO + NRAO support)
- Provide to the JAO Call for Tender documents (Updated Spec. & ICD's, SOW, drawing sets...) for the Antenna production
- Finalise studies and specification on Antenna Transporter, submit it to a CDR review
- Support enquiries from the project (example site / logistics....)
- Participate into the Antenna Tendering process as demanded by the project.
- ISSUE:
 - Manpower is a concern if the schedule is as anticipated as per today. Considerable ESO resources will be needed in the coming months to follow activities, testing and supporting the European Prototype in Soccorro. (TOTAL 2003 FTE's = 1.9)

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