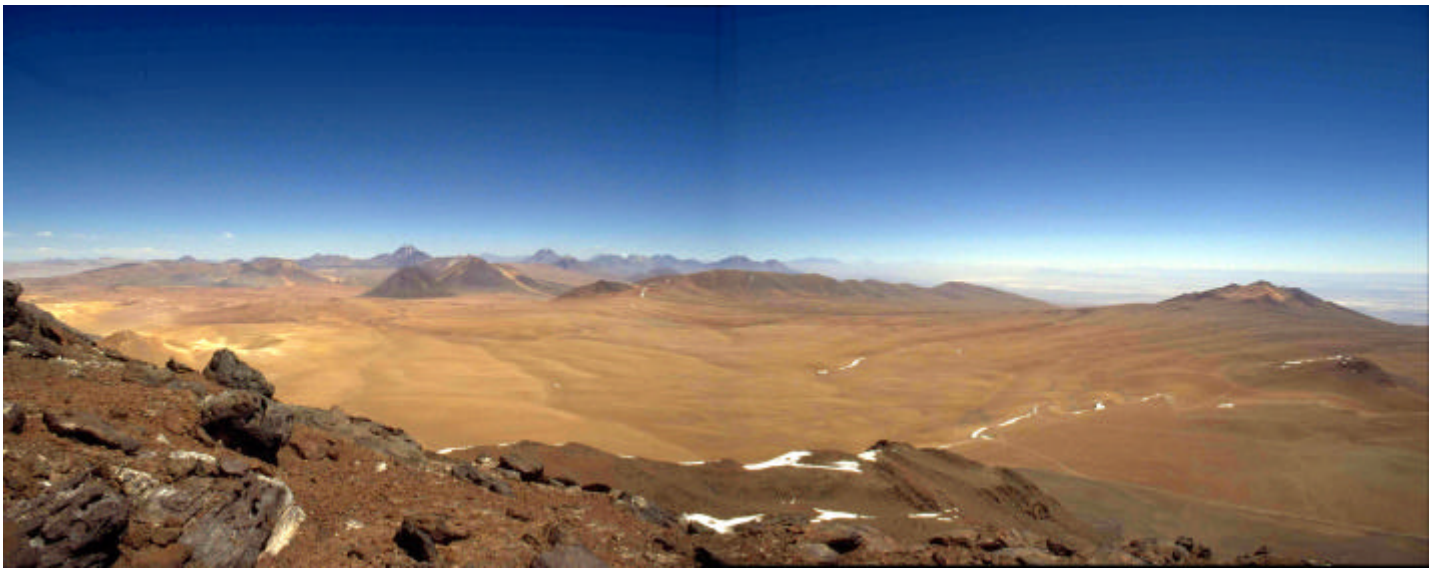
Atacama Large Millimeter Array

Quarterly Report
For the Period Ending
30 September 2003

Submitted to the ALMA Board
For the Joint ALMA Office
By M. Tarenghi, Director



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1. Activities of the Joint ALMA Office (JAO)

1.1 Project Management and Organization

1.1.1 Management IPT

The Management IPT continued to hold weekly teleconferences during this quarter, with all IPT Leads and Deputy Leads joining the Management IPT in a separate teleconference every other week. Biweekly reports are prepared by each IPT and are submitted prior to the meeting. During the meeting minutes are recorded with decisions and actions.

1.1.2 Mini ALMA Week

A Mini ALMA Week took place in Richmond, Virginia from 17.09.2003 to 20.09.2003. This meeting was attended by about 30 key personnel including all the IPT Leaders and Deputies from the entire Project. General discussions on the ALMA progress as well as specialized topics such as planning, operations and interfaces between IPTs were organized. This meeting was very important in that it contributed to further improvement of the team spirit. All presentations can be seen on the ALMAEDM page ‘Meetings’.

1.1.3 Access to the Site and Start of Site Development

On 25 July 2003 the Government of Chile officially granted 17.700 hectars of land in the Chajnantor region of the Atacama Desert in Chile for the construction and operation of ALMA. This represents a significant milestone by providing a site capable of meeting all the stringent scientific demands of the project. Now we have the approval necessary to begin construction of the infrastructure and facilities needed by ALMA. Work on the access road to the OSF has now begun.

1.1.4 Interaction with the National Astronomy Observatory of Japan (NAOJ)

Additional discussions with representatives of the NAOJ were organized by teleconference. We discussed open points such as the Compact Array Correlator, LO Solution and Band 10. Substantial progress was obtained on the definition of the technical aspects of the Japanese contribution to the ALMA Project.

1.2 JAO Goals

1.2.1 Goals for the Next Period

- *Construct a Project Schedule that links all the milestones and identifies all the dependencies*. Started but not complete. It will be a major goal for the next period.

- *Continue construction of a detailed Operations Plan.* An Operations Plan group was created and the final report is expected for the end of 2003.

- *Safety and Public Relations Plan.* Good progress was made in the Safety Plan and we expect to complete it in the next period. There is a need to improve the Public Relations Plan with the creation of an IPT.

2. Project Report

2.1 Management IPT

2.1.1 European Project Office

Discussions of the Phase 2 procurement strategy at the ESO Council meeting in June confirmed the belief that additional staff for ALMA is needed at ESO to effectively manage and control the large amount of work contracted to other institutions and industry. Correspondingly, five new positions in the ALMA Division were included in the updated ESO Long Range Plan to be submitted to Council in December. In addition, ESO proposes to be the central node of the European Regional Support Center and the corresponding staff positions were also added to the new Long Range Plan. Recruitment of the next European Project Manager moved ahead with a 31 August closing date for applications. Interviews of applicants on the initial short list were held in late September. Final interviews of European Project Scientist candidates were held in September. It was decided to hire an Instrument Scientist in addition to the European Project Scientist. Offers have been extended for both positions. In August David Silva from ESO's Data Management & Operations Division joined the ALMA Operations Working Group. Dave brings extensive experience with VLT scientific operations

Following approval by the ESO Finance Committee in June to award Phase 2 work package contracts, work has concentrated on finalizing the Technical Specifications and Statements of Work, for these work packages and getting approval of these documents by the relevant ALMA IPTs and the JAO. Only two of the contracts have been completed and signed by the end of September. Most of the balance of the contracts should be placed in October. However, extended negotiations with IRAM are required to reconcile differing positions of the ESO and IRAM Councils. The competitive procurement of design and engineering services for the Operations Support Facility in Chile was completed and approval of the ESO Finance Committee by written procedure was received. Approval by the JAO is pending. The contract should be signed by 1 October to maintain the construction schedule in Chile. Negotiations continued with STMicroelectronics to finalize the contract for production of the ALMA high speed digitizer custom integrated circuits. Working with the JAO and AUI/NRAO, a plan for joint, coordinated procurement of production antennas was agreed. On the ESO side the first step in this process was completed with issuance of a Preliminary Inquiry on 19 September.

During August and September the ALMA 2004 budget and financial projections to completion of the ALMA construction were compiled. The information has been submitted to ESO for inclusion in the ESO 2004 budget and updated Long Range Plan and to the JAO for inclusion in the ALMA 2004 budget submittal to the ALMA Board.

EPO Goals for the Next Period (4th Quarter 2003)

- Complete the award of European Phase 2 work package contracts (Milestones 8105 and 8110)
- Complete the recruitment of the European Project Manager and European Project Scientist

2.1.2 North American Project Office

During this period, the North American ALMA Project Office has made significant progress, in cooperation with ESO and the JAO, to finalize the planning for the antenna procurement process. A Preliminary Inquiry was released by NRAO/AUI in September and a Request for Proposals is expected to be released at the end of October. Two meetings are scheduled with prospective vendors prior to the release of the RFP; one in Europe and one in the US. The closing date for receipt of proposals is anticipated to be at the end of February 2004. The entire procurement process has been carefully coordinated with ESO and the JAO.

A Request for Proposals was issued by AUI for a JAO procurement of consulting services to develop a Project Management Control System. Two experienced firms have responded. Presentations by each firm are scheduled for October.

Renovations to the buildings that will house the NRAO Technology Center are progressing rapidly. Initial occupancy will be at the end of October and all CDL staff will be relocated at or near the end of the current year.

John Payne has transferred to Charlottesville from Tucson. This represents the beginning of the consolidation of the Tucson staff to Charlottesville. John has assumed supervision of all ALMA front end activities in Charlottesville as well as those activities in Tucson that will ultimately transfer to Charlottesville; this is in addition to his responsibilities for the LO systems John will work closely the Front End IPT leaders, Charles Cunningham and Gie Han Tan to insure that the NRAO front end activities satisfy ALMA requirements.

John Effland has been appointed Band 6 Project Manager. Working under John Payne, Effland will organize all aspects to the Band 6 effort.

Finally, Jeff Kingsley has left the ALMA project to take a position at Steward Observatory. Victor Gasho has been appointed interim Antenna IPT lead for North America. A search is underway for a permanent lead.

2.2 Site IPT

Main Activities :

During the reporting period :

AOS Antenna Stations
Due to continuous definition problems of the vertical layout of the antenna stations in the central cluster (79 stations: 1-78 and 84) at the AOS it was decided to continue the design process with prioritizing the antenna stations of the Inner Array (51 stations at less than 617 m from the array center: 79 – 83, 85 – 124, 127, 128, 140, and 170 – 172).

Technical Building at the AOS
The conceptual design review for the AOS Technical Building was during the ALMA week in Victoria, BC, Canada on 06-Jun-2003. The completion of the tender and "For Construction" documents is scheduled to be on 15-Mar-2004

Construction traffic access road
The contract for the establishment of a construction traffic access road to the OSF and the AOA was signed on 25-Jun-2003. The construction work for this road was started on 26-July-2003.

Permanent Access Road
The design and engineering work for the permanent access road to the OSF and the AOS progressed well. Design development review was at the ALMA week in Victoria, BC, Canada on 06-Jun-2003.

The design firm INGELOG, Santiago, Chile delivered the tender and "For Construction" documentation including drawings, Statement of Work, Technical Specifications, calculations, cost estimate and reports on 23-Sept-2003 for review and comments by ALMA.

ALMA and Contractors Camps at the OSF
The contract for the removal from the Paranal Observatory, transport and re-installation including site work of the ALMA and Contractor's Camp at the OSF site was signed on 17-Jul-2003. The dismantling of the camp at the Paranal Observatory started on the same day and was completed on 09-Sep-2003.

The ALMA camp containers are meanwhile all installed on their respective foundations. Approximately 20% of the containers for the Contractors Camp are installed at this date. Initial occupancy is planned for 01-Dec-2003 (ALMA Camp) and 01-Jan-2004 (Contractors Camp) respectively.

Proposals for the electrical and mechanical distribution and installations and for the architectural finishes are being solicited. This will involve a series of small contracts. The camps will be finished on an as-need basis.

Technical Facilities at the OSF
The contract for the design/engineering for the Technical Facilities of the OSF was awarded to the firm Fichtner, Germany. Contract signature will be during the first week of October 2003.

Milestone Revision
During the "Mini" ALMA week in Richmond, VA, USA, on 17-Sep-2003 the milestone dates were reviewed and updated. The revised dates are reflected in the following milestone reporting.

ALMA Project Power Supply Plan
During the "Mini" ALMA week on 18-Sep-2003, the JAO decided that the future power station of the project will be located at the OSF.

The JAO also announced Japanese involvement in the construction of the power generation and distribution facilities.

Soil investigations
Proposals have been requested and received for additional preliminary soil investigations for the central cluster and the projected Japanese areas and in order to obtain information regarding the levels and conditions of the substrate rock.

Conditions and Rules for Contractors working at the ALMA site
The Conditions, Rules and Regulations applicable to Contractors executing Atacama Large Millimeter Array (ALMA) Contracts on the ALMA Observatory were submitted for review and comments on 04-Sep-2003.

These Conditions, Rules and Regulations shall be applicable to all firms (ESO and NRAO) executing Work on the ALMA site of all IPT's.

Safety Services
A Statement of Work and Service Specifications for ALMA safety serviced during construction operations was prepared and a tender action was launched by ESO and NRAO. Five proposals for these services were received on 22-Sep-2003. These proposals are currently being evaluated. Contract signature for these services is anticipated to be during the second week of October 2003.

Joint ALMA Construction Management Team
The Joint ALMA Construction Management Team (JACMT) has been defined and confirmed. The NA side is now contracting a representative for this JACM team.

Environmental Aspects
The JACM team has retained the services of archaeological and botanical consulting services in order to fulfill the requirements of the resolution with respect to these aspects.
During a recent visit of the SAG (Servicio de Agricola y Ganadera i.e. local Agricultural Department) a "non compliant" report was issued. The report has now reached ESO and

NRAO and has been replied to by the ESO and NRAO representatives in Chile with the assistance of the JACMT.

Configuration Review
The review and comments (mainly check of soil conditions at the revised configuration layout) on document ALKMA-90.02.00.00-002-A-SPE Long Baseline (Y+) Array Configuration: Specifications and Requirements is being delayed by snow coverage of the subject areas(s).

Coordinate System
The coordinate system will be based in the existing reference point master 0.
The system will be decimal i.e. metric.
The true North will be determined by Astronomical Constellation.
The Constellation has been determined by a contracted topographical service firm with the help of the Universidad Catolica del Norte in Antofagasta (Dr. L. Barrera).
The four existing benchmark monuments will be referenced to Master 0 and the North.
A report of the above will be prepared.

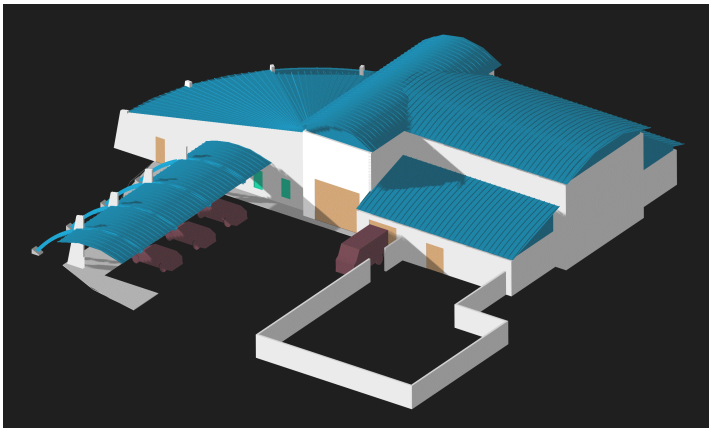
Milestone Reporting :

AOS Foundations N.A. Inner Array, Critical Design Review (Design-Development documentation Review) (30-Sep-2003)
The Design Development was reviewed during the ALMA week in June 2003. The documentation for the critical design review is being prepared by M3 Engineering, Tucson. Some documentation (85% Status) has been posted by M3 on ALMA edm on 12-Sep-2003. This documentation is currently being reviewed by the Site IPT and other involved parties.

2.025.8232 AOS Foundations N.A. Inner Array Tender and Construction Documents Complete (30-Nov-2003)
This documentation is being prepared by M3 Engineering, Tucson in conjunction with the documentation of milestone 8222 above. Prerequisite is the CDR taking place in late September 2003

2.025.8250 - Critical Design Review i.e. Design Development Review for the Foundations and Envelope of the AOS Buildings N.A. complete (31-Oct-2003)
The conceptual design review was held during the ALMA week in Victoria on 06-Jun-2003. The documentation for the CDR is being prepared by M3 Engineering, Tucson. Some changed drawings have been submitted by M 3 on 04-Aug-2003

2.025.8252 - AOS Buildings N.A. Foundations/Envelope Construction/Tender Documents complete (15-Mar-2004)
This documentation is being prepared by M3 Engineering, Tucson in conjunction with the documentation of milestone 8250 above. Prerequisite is the CDR taking place in late October 2003.



2.025.8294 – Construction Road Opening Eur. Provisional Acceptance (26-Jan-2004)
Construction activities for the establishment of the construction traffic road from the intersection of the Chilean Road CH-23 to the OSF and then on to the AOS started on 26-Jul-2003.

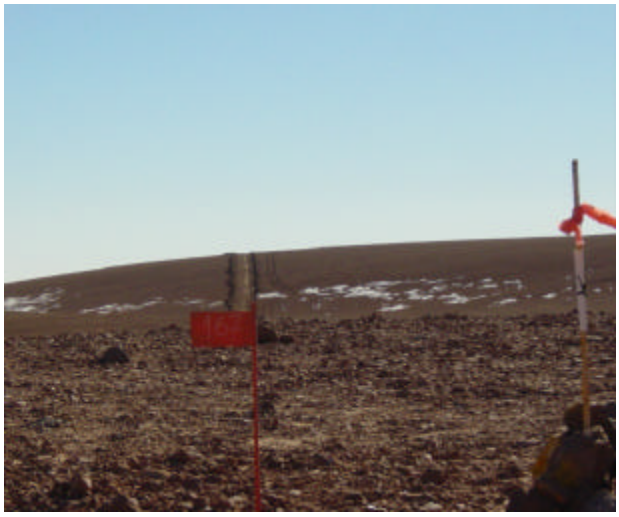
Meanwhile the road between the intersection with the Chilean Road CH-23 and the OSF has been completed.

At the section crossing the salar some additional work was performed by the contractor. This work includes the installation of Geotextile, the stabilization of the road bed under the geotextile with boulders, additional protection layers of sand below and above the geotextile and the widening of the road from 4 meters to 6 meters at the area of the geotextile

The road to the OSF is now usable with all type of vehicles up to speeds of 60 km/hour at straight sections and 30 km/hour at curves.

The road between the OSF and the AOS has been established up to km 42 close the telescope station 167 on 27-Sep-2003 at an elevation of approximately 5,000 meters above sea level. The road is usable in part with 2-wheel drive vehicles and at the upper part with 4-wheel drive vehicles. The application of the final layer of classified material of 15 cm thickness is under way.

Substantial completion of the road is still anticipated to be on 30-Nov-2003. Some blasting work will be required at the upper part.



2.025.8306 Access Road Eur. Tender and Construction Documents complete (22-Sep-2003)
The tender and "For Construction" documents including approximately 400 Drawings, Statement of Work, Technical Specifications, Cost Estimate, calculations and reports have been received on 22-Sep-2003 from INGELOG in Santiago.

The documentation will be posted on ALMAedm and will be reviewed and commented on by the site IPT and other parties involved

Possible slight delays in the review procedure will not cause any impact on the following milestone 2.025.8308 Access Road Eur. Construction Contract signed on 16-Jul-2004**.**

2.05.8326 and 2.025.8334 ALMA and Contractor's Camps, N.A. and Eur. Provisional Acceptance (initial occupancy 01-Dec-2003 and 01-Jan-2004 respectively)
The removal of the first camp containers from the Paranal Observatory started on 17-Jul-2003. Meanwhile all containers have been removed from the Paranal Observatory. Completion date of this was 09-Sep-2003 as anticipated.

Site work (excavation and fill of platforms, access roads, foundations) at the OSF site for the ALMA and Contractor's Camp has been substantially completed. The first containers arrived at the OSF site on 09-Sep-2003. All containers for the ALMA Camp are installed and finishing work is proceeding. Approximately 20% of the containers for the Contractor's Camp have been installed. All six water tanks have arrived at the site and two tanks have already been installed. Proposals for electrical and mechanical installations and finishing work for the camps will be solicited in the very near future. This will involve a series of small contracts. The camps will be finished on an as-needed basis.

2.025.8340 OSF Facilities Phase 1 (Technical Area) Eur. Design/Engineering Contract awarded (01-Oct-2003)
The incoming tenders were opened on 18-Jun-2003. The technical evaluation of the incoming tenders conducted by J. Eschwey, S. Radford, C. Haupt and C.Dichirico was completed on 30-Jun-2003. Clarification meetings were held on 2-Jul-2003 through 7-Jul-2003.
The Contract Award Committee's Report was issued on 16-Jul-2003. The award of the Contract to the engineering/design firm Fichtner, Germany was approved by the ESO Finance Committee on 12-Sept-2003. A draft contract has been submitted to Fichtner on 24-Sep-2003.

Contract signature is anticipated to occur during the first week of October 2003. The design concept will be discussed between the partners during a presentation at NRAO in Charlottesville on 02-October 2003. The kick-off meeting will follow shortly thereafter.

2.0258372 ALMA Project Power Supply Plan Approved (31-Aug-2003)
The power generation and distribution plan together with the power plan recommendations were presented during the "Mini" ALMA week on 18-Sep-2003 and the JAO decided that the future power station of the project will be located at the OSF. The JAO also announced Japanese involvement in the construction of the power generation and distribution facilities.

Concerns :

None in particular

Next Period :

AOS Foundations N.A. Inner Array, Critical Design Review (Design-Development documentation Review) (30-Sep-2003)

2.025.8250 - Critical Design Review i.e. Design Development Review for the Foundations and Envelope of the AOS Buildings N.A. complete (31-Oct-2003)

2.025.8230 AOS Foundations N.A. Inner Array Tender and Construction Documents Complete (30-Nov-2003)

2.025.8342 OSF Eur. Technical Area, initial CDR Complete (15-Jan-2004)

Elaboration of the site safety plan for construction operations (Safety Committee and ALMA safety engineer).

2.3 Antenna IPT

During the 3rd quarter the Antenna IPT continued in its efforts to get the AEC antenna delivered and to solve the issues linked to the VertexRSI antenna and contract. In parallel the antenna group supported the AEG effort to test the VertexRSI antenna and continued in the preparation of the documentation for issuing the Call for Proposals (Technical Specification, Statement of Work, ICDs and related documents) for the production antennas. Although considerable progress has been made, the documentation is not yet in its final form. The preparation of the Call for Proposals, including the Preliminary Inquiry activities, have been found to absorb considerably more resources than previously anticipated, and in general the group has been challenged by the parallel activities caused mainly by the delay of the prototype antenna contractors.

In addition the IPT leader J. Kingsley resigned from NRAO in September and left the project. S. Stanghellini, former deputy, took over the IPT lead. V. Gasho of NRAO Tucson, already a member of the antenna team, was appointed IPT deputy leader.

Figure 2.3: View of the Vertex and AEC antenna at the ATF site as of mid of September

2.3.1 Vertex Antenna

The VertexRSI antenna was in the testing phase during the 3rd quarter of 2003. Holography was completed in the first week of July and Optical Pointing tests were performed in the remainder of the time. During this time a total of six weeks were occupied by the contractor who were on-site to complete the remaining punch-list items. Nevertheless, for at least three weeks optical pointing tests could be performed at night. As anticipated in the last Quarterly Report, VertexRSI was on-site for three weeks in July but did not solve all issues. In September the contractor returned to the site to work on the remaining punch-list items. During this time the AEG group (J. Mangum) provided support to VertexRSI to identify and address various software problems on the punch-list. At the moment of writing, some items are still open, of which the most important are the testing of the subreflector mechanism, a tiltmeter giving wrong readings, over-the-top positioning error, and the ACU response time exceeding the 150 microseconds specified. On this last issue VertexRSI anticipates asking for waiver, not having an easy solution at hand. Some documentation is still outstanding.

Vertex RSI informed the Antenna IPT about planning the resolution of the punch list during the first half of October (except the ACU response time) and to complete the documentation by the end of October.

2.3.2 AEC Antenna

The AEC antenna is approaching delivery at the time of writing. On 11 July the BUS was mounted on the antenna, without difficulties. The interface with the CFRP cabin,

although not tested in the factory, mated correctly. In the following weeks the 600 panel adjusters and the 120 replicated panels were mounted and aligned on the BUS. This activity was completed around the mid of August.

Fig. 2.3.2.a: The BUS being installed on the antenna

Shortly after the complete quadripod structure with the subreflector mechanism and the subreflector itself were mounted on the BUS. A verification of the surface accuracy of the main reflector with the laser tracker provided a panel map with an accuracy of around 40 micrometers.

Figure 2.3.2 b: Main reflector and apex structure of the AEC antenna

In the following days the protection shelter for the assembly of the antenna was dismounted and the commissioning of the elevation axis started. A difficulty was encountered with the azimuth encoder mounting mainly due to thermal instability of the structure, not yet insulated. In the meantime the encoder was mounted and the axis is being commissioned at the time of writing. The installation of the metrology system is also progressing: the optical bench for supporting the laser and one tiltmeter is mounted inside the yoke structure. The thermal sensors (more than 100) have been installed and cabling is completed.

The antenna finishing work is proceeding, with personnel of Plyform (CFRP) mounting the skirt around the BUS and the panels and doing other detailed work. Painting has started and the activities of thermal insulation are planned to start the 1st week of October. Testing of the antenna by software through the Antenna Bus Master is also planned to start on the 1st week of October. The documentation for formal acceptance has been partially submitted and commented on by the IPT. Acceptance will start with subsystem testing and proceed towards a full antenna verification. The program of the Preliminary Acceptance activities (milestone which will allow access by the ALMA and AEG to the antenna on a shared basis) and of Provisional Acceptance is being discussed

with the Contractor. The possibility to start holography prior to the formal preliminary acceptance is also being considered.

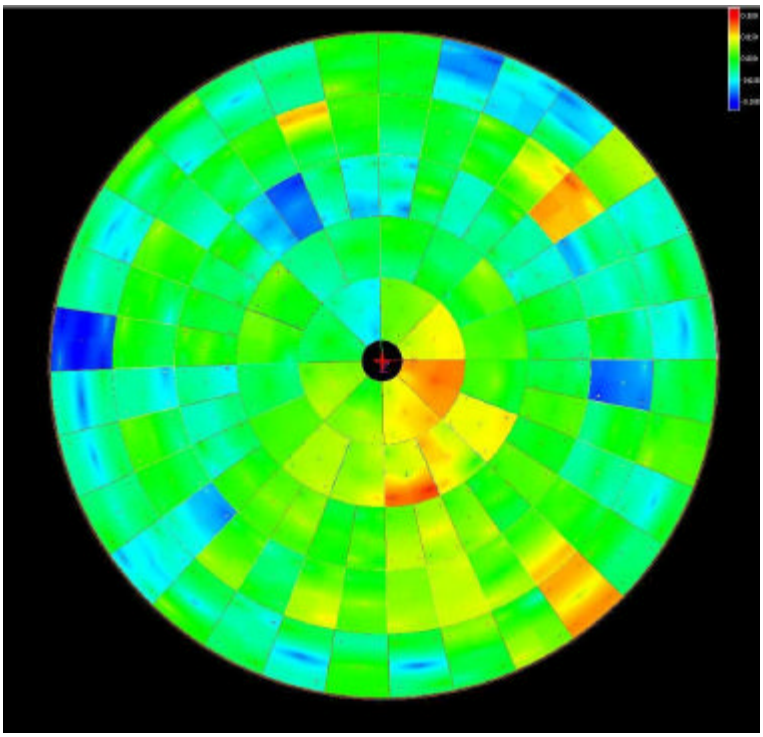


Fig. 2.3.2.c: Panel map at 14°C (RMS < 40 micrometers)

In addition to the finishing and testing of the antenna, the Contractor is busy with the completion of the documentation. A major part of the design and as-built documentation has been delivered, but there are still a number of open items.

2.3.3 AEC antenna outfitting

The outfitting of the AEC antenna by ALMA in order to perform the Antenna Evaluation has started. The digital and electronic cabinets are in the cabin, the optical pointing telescope was test installed in July, fitted to the antenna and finally installed by the antenna group into the reserved space above the receiver cabin. The cabling for communication and also for the equipment of the AEG (accelerometers) is routed. The Antenna BUS Master is installed and operational.

2.3.4 Nutating Subreflector

The nutating subreflector was installed on July 23rd on the VertexRSI antenna but had to be removed to introduce some improvements to the Gore-Tex skirt and to avoid stray light affecting the linear gap displacement sensors. During a subsequent laboratory test a 200 Hz resonance in the mechanism was found limiting the ability to tune the auxiliary servo system. This has now been eliminated by stiffening of the rocker mechanism. Adhesion of the mirror coating on the nutating subreflector was also found to be poor and

was redone. At the time of writing the nutating subreflector is finally installed on the Vertex telescope and is currently undergoing final checking.

Figure 2.3.4 a: Nutating mounted on the VertexRSI antenna.

2.3.5 Transporter

The two feasibility studies for the transporter were concluded with two reports. Their result permits us to conclude that the concept envisaged up to now for the transporter is validated by industry, including the issue of stability. Improvements were introduced in some areas. The budgetary estimate of the two studies are 100% and 120% of the cost estimated by the project. The design and construction time is consistent with the present project planning. Final data necessary for the finalization of the ICD to the antenna have been obtained. Similarly the data of the transporter, already used for the road and site construction, have been proven correct.

2.3.6. Production antenna procurement

Progress has been made on the preparation of the ICDs, Technical Specification and Statement of Work as well supporting and commenting on the various applicable documents to be produced. The documentation is however still in draft form. A preliminary inquiry has been issued to inform the companies of the procurement activities

for the antenna. As expressed in the summary, the preparation of the documentation for the procurement has proved to be a major task and conflicting with the other activities of the group, particularly those related to the follow-up of the two antenna prototypes.

2.4 Front-End IPT

Mini ALMA Week

At ALMA week on the 2nd – 6th June 2003 in Victoria, Canada, the current status of the Front End IPT was described to the rest of the project. In dedicated sessions, progress was made in developing the external ICDs between the front end and the following other ALMA sub-systems:

- Antenna: largely complete
- Back-end: awaiting input from the systems IPT
- Computing: in progress
- Site: in progress

Status European Front End Work Package Contracts

After the approval by the ESO Finance Committee of the award of contracts for the European Front End work packages in June ’03, the progress in placing the actual contracts has been much slower than foreseen. Main reason for this delay is the delivery of equipment with in general very detailed and demanding technical requirements on a strict schedule and against fixed prices for labour costs. Contractors, without exception either astronomical or R&D institutes, turn out to be reluctant to sign up. In general they are reluctant to sign up because of the risks involved and the legally binding nature of a contract.

By the end of September one contract was signed for the “Development and pre-production (8 units) of Cryostats” between ESO and PPARC in the UK. The actual work will be carried out by Rutherford Appleton Laboratory.

For the two contracts “Assembly and testing of 2 prototype Water Vapor Radiometers with PPARC/UK and Onsala Space Observatory, Chalmers University/Sweden” the negotiations are near completion. It is expected that these contracts will be signed in early October ’03.

The contracts to be signed with IRAM, “Development and pre-production (8 sets) of Common Optics, Windows and IR filters” and “Development and pre-production (8 units) of Band 7 cartridge” were in a dead lock situation because of the unwillingness by IRAM to accept a fixed labour price contract as was mandated by the ESO Finance Committee. A high level discussion between ESO’s Director General, Catherine Cesarsky, and IRAM Director, Michael Grewing, on the 15th of September ’03, resulted in a resolution and it is expected that the IRAM contracts will be signed before mid November ’03.

The two remaining contracts for "Development and pre-production (8 units) of Band 9 cartridge" with NOVA in the Netherlands and "SIS junction process development and technology support" with Chalmers University are expected to be signed in November '03 as well.

Summary of On-going Work

On-going work	Due date	Progress	Comments
Front-end specifications and requirements and external ICDs submitted for approval	2003-04-15	**Completed**	Submitted to ALMAEDM Document Approval Area
Front-end internal ICD's	2003-04-15	On going	Draft only, progress made at IPT meeting
Freeze dewar design	2003-07-15	**Completed**	Frozen at MRR on 2003-08-06
Local oscillator chains for all four bands delivered	2003-01-01	**Completed**	-
Pre-prototype DC support electronics and monitor and control modules delivered to cartridge manufacturers	2003-03-01	**Completed**	Delivered in May '03
Optics design frozen	2003-06-30	On going	Optics design complete and verified, except for Band 3.
Cartridge body design frozen	2003-09-01	On going	Pending input from cartridge design groups
DC support electronics design frozen	1 Oct 2003	On going	-
Monitor and control design frozen	1 Oct 2003	On going	-
Local oscillator design frozen	1 Oct 2003	On going	-
Chassis design frozen	1 Oct 2003	On going	-
Front end delta-PDR	1 Sept 2003	On going	Delayed, awaiting result of System Requirements Review
Integration center design finished	1 Oct 2003	On going	Delayed

Front End Sub-system engineering (ALMA Work Package: 4.075)

The FE sub-system engineers focused their efforts on completing the external Interface Control Documents between the FE sub-system and subsequently Antenna, Back-end, Computing and Site. In addition the FE specifications and requirements document was completed. All these documents were submitted for approval as part of the System Requirements Review as conducted by the SE&I IPT by the 1st of September '03.

Completing the internal FE ICDs was another major area of activity for the FE sub-system engineers.

Cryostat ((ALMA Work Package: 4.080)

Rutherford Appleton Laboratory

A major level 2 milestone for the FE IPT, 'Freeze dewar design' (#8720), was completed on 6th of August '03. At this date a Manufacturing Readiness Review (MRR) for the cryostat was held at Rutherford Appleton Laboratory in the UK.

The formal Phase 2 contract between ESO and PPARC for the detailed development and pre-production of 8 cryostats was placed at the end of September. This contract is one part in the completion of the level 2 milestone 'All FE Contracts/Agreements in place' (#8995).

Although the MRR was not formally passed on the 6th of August due to recently introduced, more stringent, review design rules, the review panel came to a positive conclusion of the meeting. The scope of the meeting was focused to review the long lead items for the first cryostat procurement to meet the delivery deadline for the delivery of the first cryostat. The review panel was impressed by the technical work done on the prototype cryostat and the achieved performance.

The MRR report contains a detailed action item list that needs to be completed to successfully pass the review. RAL is focusing currently focusing their activities using this list as a guideline.

The formal completion of the MRR according to ALMA-80.09.00.00-001-C-PLA will be held at the beginning of November 2003.

Directly following the MRR, the procurement of the cryo cooler for the pre-production series has started. This cryo cooler is one of the major long lead items of the cryostat.

One problem in the cryostat design reported previously has been solved and the fix has been demonstrated to work in the prototype cryostat. This problem was the too high thermal resistance and subsequently a too high temperature of the 90 K shield. Figures 1 and 2 show the revised design of the 90 K plates. The cryostat has been stripped following the manufacture of the parts for the new copper 90 K and 12 K stages.

Figure 1 New 90 K plate with thermal links fitted

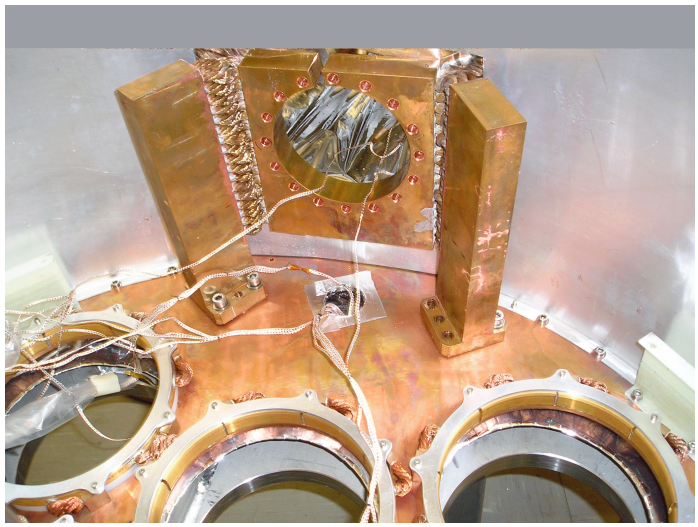


Figure 2 New design 90 K cooler link in cryostat

The cryostat has been rebuilt and is working well. The cryostat temperatures are all now well within specification as stated in the applicable contractual document.

Windows, IR filters and Common optics (ALMA Work Package: 4.090)

Institut de Radio Astronomie Millimétrique

The HDPE moulds for windows and IR filters are being completed and the manufacture of the moulds will start soon. The designs have been reviewed by the group responsible for the cryostat, RAL. Review by the individual cartridge design groups is imminent.

For the quartz windows quotations were received from Cardiff University. In collaboration with ESO an order for the pre-production series is being prepared. The IR filter supports for bands 3 and 4 were completed by the end of September and sent to RAL and Grenada.

The design for the new horn for band 3 has been completed. Subsequently the manufacture has started. By the end of September final testing of this horn was near completion.

Prototype mirrors for bands 3 and 4 have arrived at IRAM and are mounted on a dummy cryostat cover for testing. An alignment system for these mirrors with the cryostats has been integrated into the design of the cryostat.

Tests on the cartridge optics for band 6 are nearly completed. Initial measurements are looking good.

(Focal Plane) Calibration System (ALMA Work Package: 4.115)

Institut de Radio Astronomie Millimétrique

Due to the unclear situation about the type of amplitude calibration device the progress in this area has been negatively affected. The Science IPT indicated earlier that the originally foreseen semi transparent vane calibration device wouldn't reach the required accuracy and that another, more complex device would be necessary.

The FE IPT management has discussed this issue with the Science IPT management and is awaiting further input from this entity. In the meantime a proposal is being defined for the development and construction of this new amplitude calibration device, based on a combination of hot and cold loads coupled via a rotating grid to the input of a receiver.

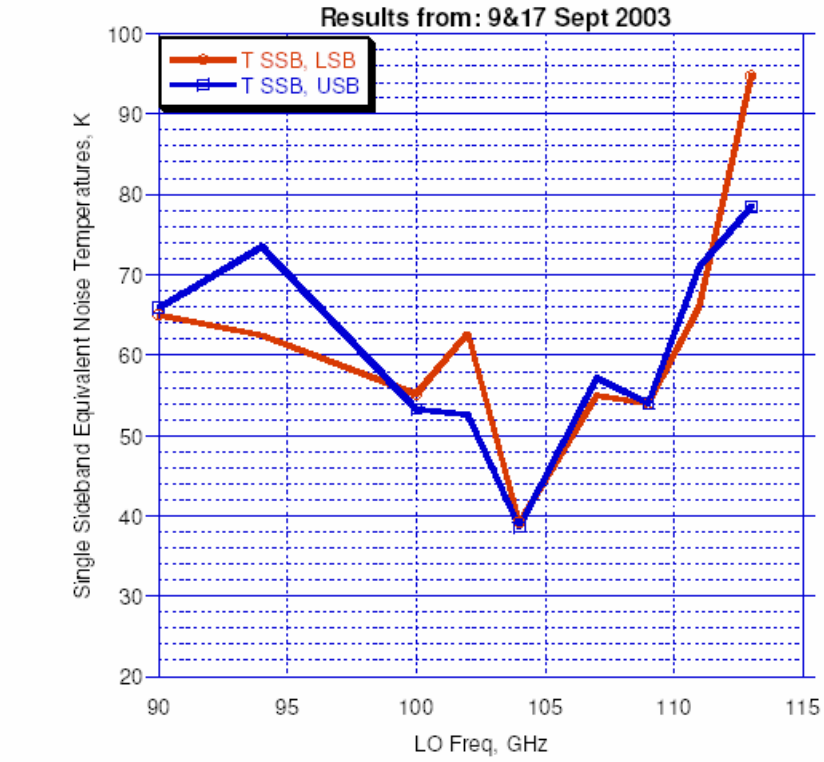
Band 7 cartridge (ALMA Work Package: 4.170)

Chalmers University of Technology / Onsala Space Observatory

For the 2SB mixer the scaled prototype mixer at 3 mm band is being improved. Latest results measured indicate 60 K SSB noise temperature and 17 respectively 18 dB USB /LSB sideband suppression.

The design of a 4 - 8 GHz room temperature amplifier with a gain in excess of 45 dB and noise temperature of less than 80K is close to completion.

A design study for 3 stage cryogenic amplifier 4 - 8 GHz has been started. The goal is to keep the record low noise temperature demonstrated with a 2 stage amplifier, but to obtain a gain of not less than 45 dB to minimize contribution of the following stages in the receiver chain.



The SIS production now routinely delivers high quality junctions. One proceeds with further process calibration for achieving high current density junctions (above 8.5 kA/cm2).

Figure 3 SSB mixer equivalent noise temperature calculated by the measured Y factor at both IF outputs

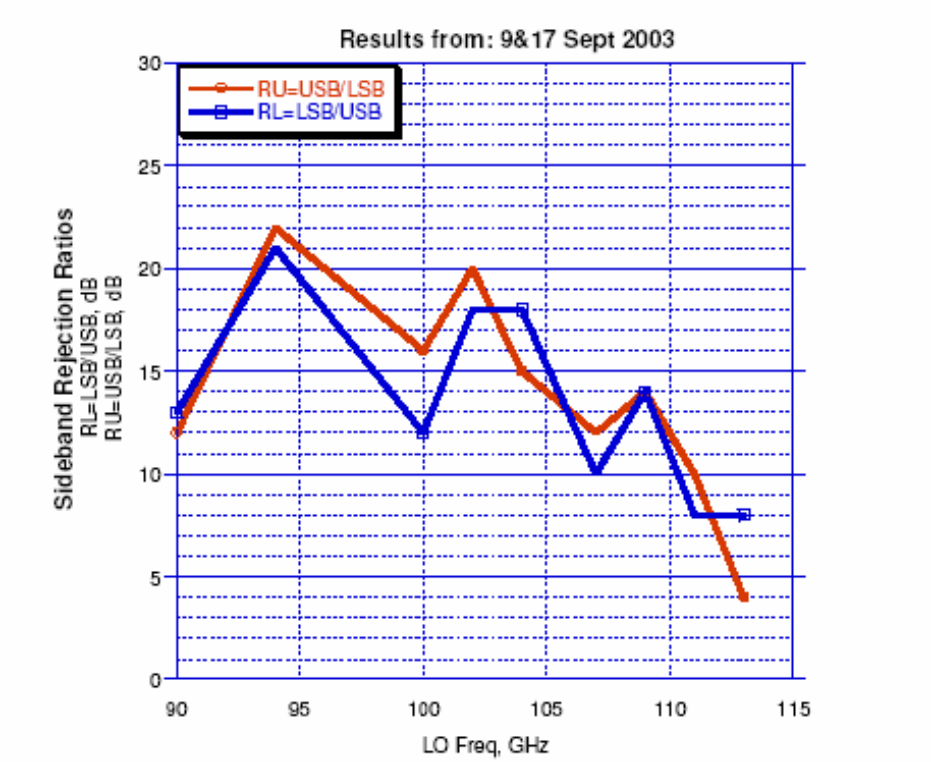


Figure 4 Sideband rejection ratios measured by injecting CW signal into USB and LSB

Institut de Radio Astronomie Millimétrique

Mixer related activities

A third wafer of the "type 2" junctions (low output capacitance, conservative technology) has been delivered by IRAM's SIS group. The normal resistance is slightly too high (30 Ohms instead of 25 Ohms). Two junctions were selected for their similar R_N values and similar RF performance in DSB tests (fig. 1). These junctions suffer from two problems:

a) The surface area of the junction is $1.5\mu m^2$ instead of $1\mu m^2$

b) An error in the handling of finite thickness metal layers in the 2.5D modeling of the tuning circuit. (This mistake has been addressed in a new design, which has not been fabricated yet.)

The SIS group continues to work to tune the process parameters to reach the prescribed barrier thickness and current density. The modeling error was recognized fairly early, but it was decided to carry on experiments with the initial mask set, to have a chance to correlate measured performance with a correct modeling of the structure as-fabricated. Indeed, the rise in receiver temperature above 340GHz is fully accounted for by the as-fabricated tuning structure. A corrected design is under way and should be ready by the time the process parameters have converged.

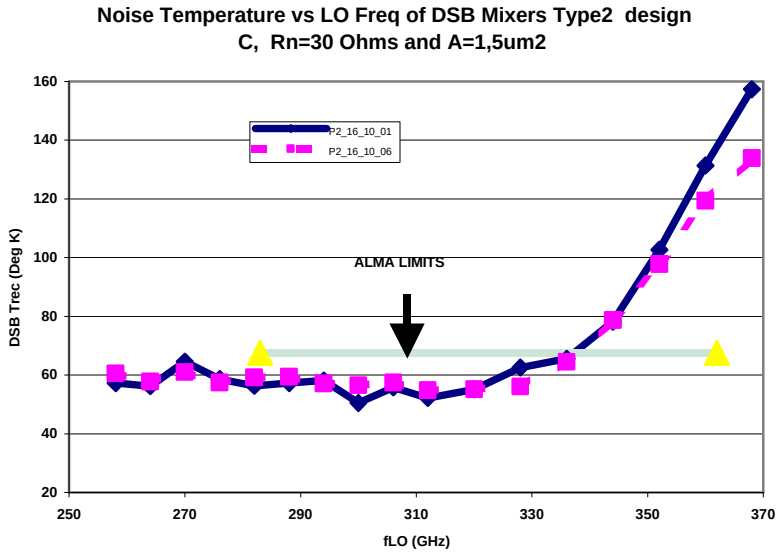


Figure 5. DSB performance of two selected junctions (low output capacitance type Design C). The horizontal line shows the ALMA specification for the noise of a Band 7 DSB frontend. The noise temperature shown is integrated over the full 4-8GHz IF bandwidth.

The IRAM mixer now meets the ALMA specs from the bottom of the LO frequency as opposed to 300 GHz upwards before. The noise temperature still goes up towards the top of the frequency range because of the fact that the surface is still too big.
The performance shown is without an IF matching circuit.

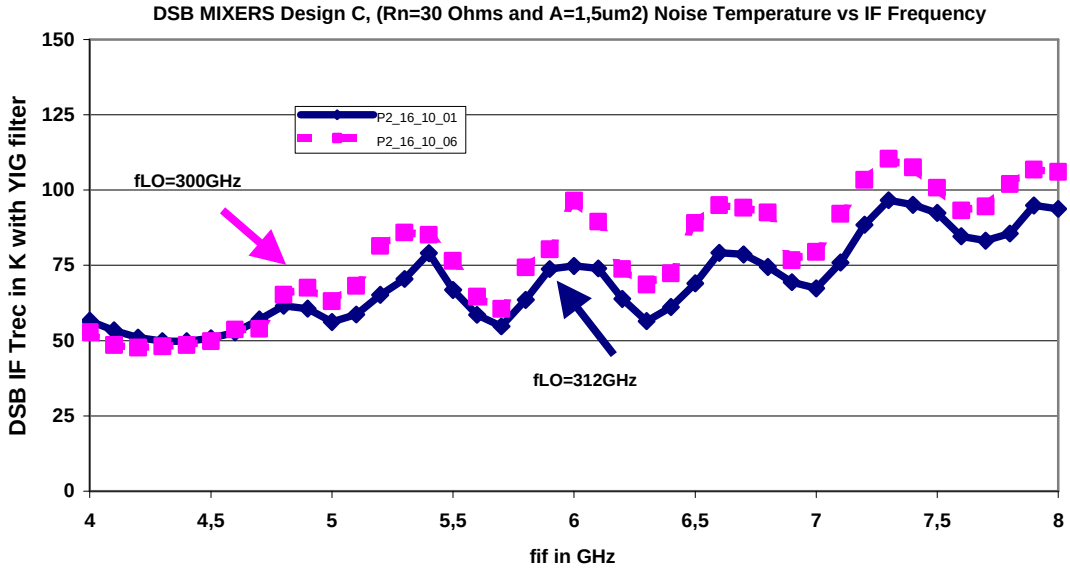


Fig 6. Performance across the IF bandwidth for two DSB mixer units, low output capacitance type 2 Design C, without IF matching circuit.

SB mixer assemblies

The two selected DSB unit mixers were assembled with the RF quadrature hybrid to constitute a 2SB mixer that was tested. The results are shown on fig.7. The steeper rise of the USB noise curve (relative to the LSB curve) at the high end of the band is consistent with the mean signal frequency being 12GHz higher (the frequency axis is LO frequency).

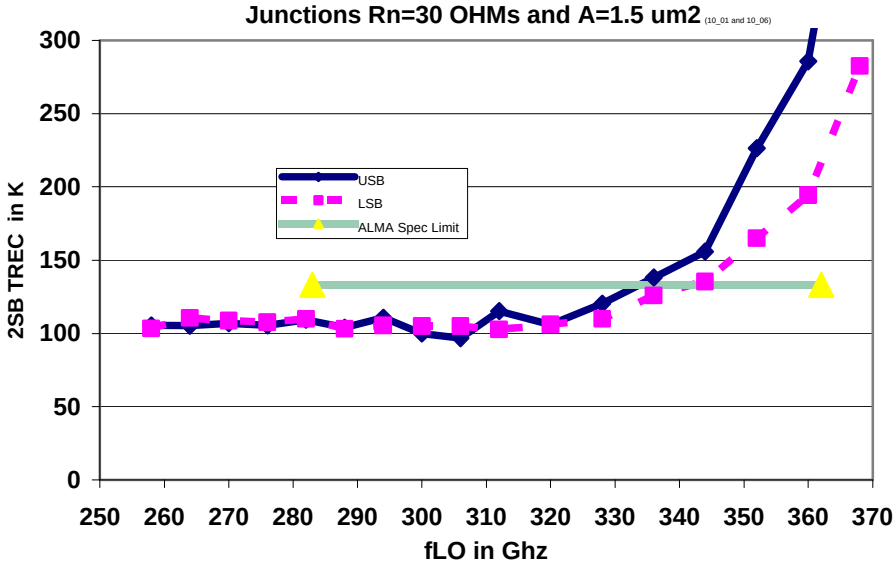


Fig 7. Second 2SB results with the type 2 mixer chip. Noise integrated over the full 4-8GHz IF band Three known issues that affect the performance are being addressed: a) junction surface area too big; b) a design fault; c) no IF matching network for the time being.

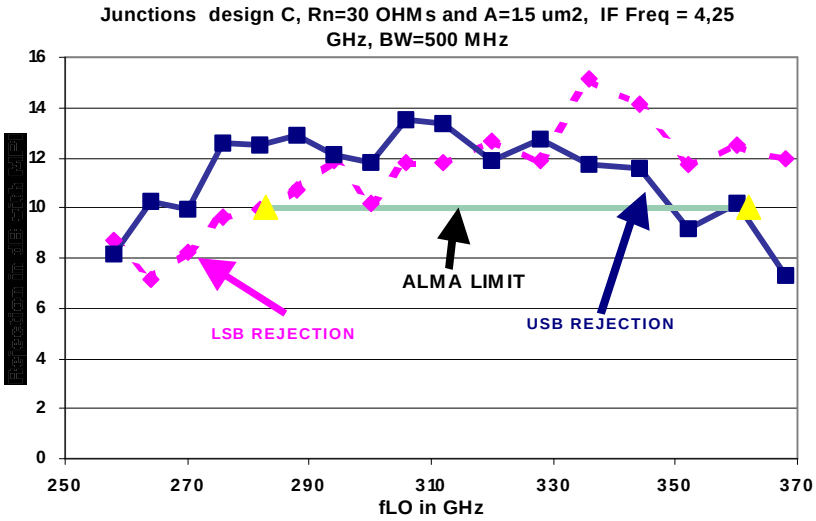


Fig 8. Image Rejection for the Second 2SB results with the type 2 mixer chip. Measurements were carried out with an IF freq of 4.25 GHz and BW of 500 MHz

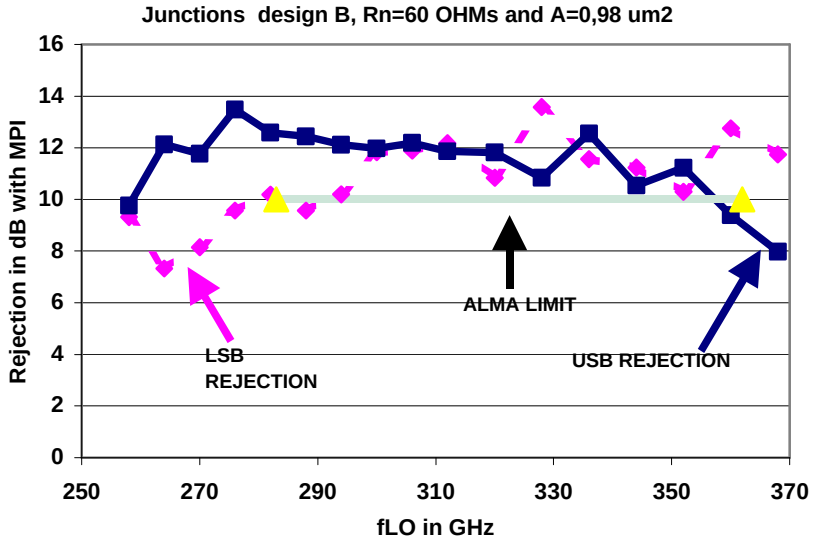


Fig.9. Image Rejection for the First 2SB results with the type 2 mixer IF freq of 4.25 GHz and BW of 500 MHz .

Figure 9 shows the Image rejection for the first 2SB mixer.

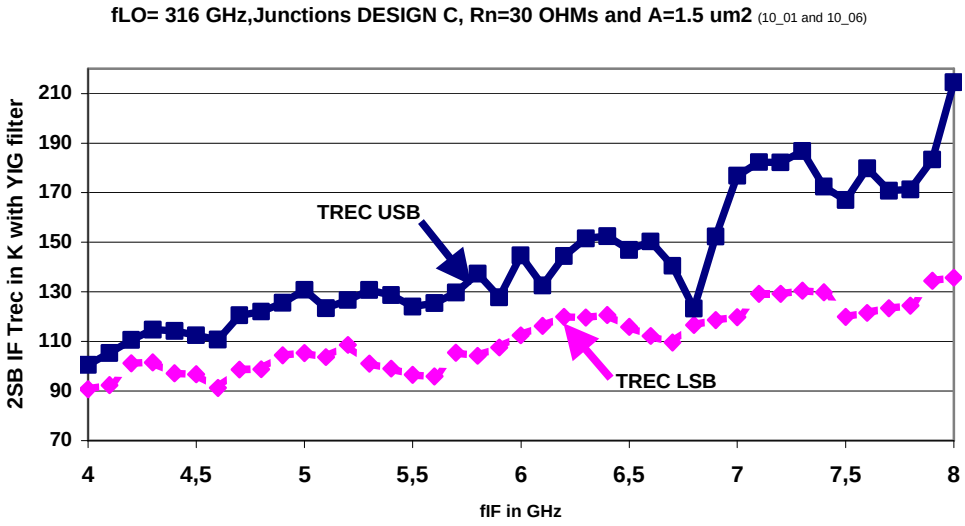


Fig.10 Noise Temperature vs IF freq for the type 2 mixer chip.

We can see that the Noise temp vs IF frequency has far less ripple than in the DSB case as mentioned earlier. We are planning to redo the USB measurement in order to check if it better follows the LSB at 6.8 GHz.

Cartridge

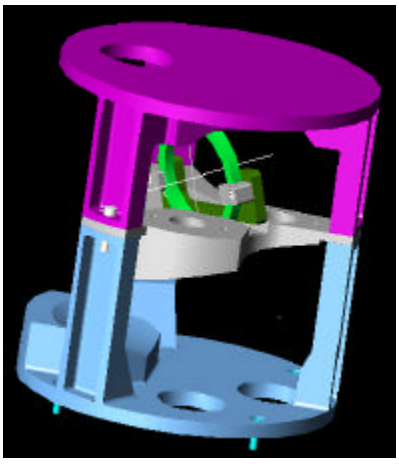


Fig.11 4K stage.

A mechanical design subcontractor (ERIA) for the 4K optics provided his final drawings (see fig.11).

On the 1st of August; IRAM sent our band 7 cartridge base plate drawing (see fig 12) showing the interface footprint position to RAL.

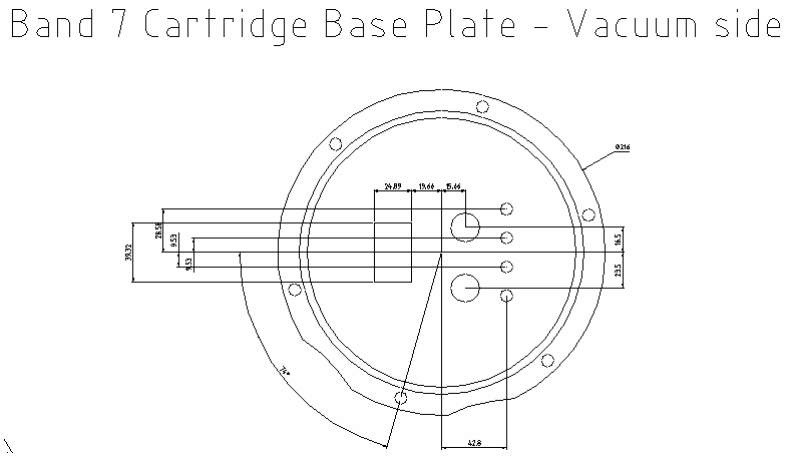


Fig.12 Band 7 Cartridge Base Plate.

IRAM is currently working on the cartridge other stages plate definitions with regards to the feed through and fixing holes.

Band 9 cartridge (ALMA Work Package: 4.190)

Netherlands Research School for Astronomy

Mixer related activities

- 4K Mirror design: This design is ready. NOVA is waiting to give a go for the manufacturing of a first model after the analysis of the 2-mirror test block. In case the 2 mirror block has been proven to work satisfactory, a first version of the full 4K mirror set will be made.
- 2-mirror block: To prove the concept of the integrated mirror block NOVA wishes to test the mirror block design first. For this they want to use a corrugated horn. But the delivery of it is delayed due to problems at the manufacturer.
- Fixture for the mixer clamping: A design of just the clamping mixer clamping section was made. This design allows evaluation in a small cryostat.

A more advanced version of two-mirror block was tested. Results were satisfactory. Measurement report is being prepared.

Small series mixer production at WITEC

The first real batch of backpieces from WITEC, which were delivered in May were measured mechanically again and are being prepared for RF testing.

Quintupler development collaboration

A new version of the quintupler for the LO Chain has been tested with a Gunn Oscillator (both provided by NRAO). Test report is available. It was possible to pump an SIS mixer using a new version of the quintupler. A repaired version of lab prototype LO chain was received and tested. Spurious signals were discovered both in heterodyne and FTS tests. The problem was reported to NRAO, the reason of spurious signal was isolated and it

was repaired on the exact copy of the chain. NOVA is waiting for repaired components to arrive.

NOVA acknowledges the very good level of collaboration to the NA partner, NRAO/CDL on this matter.

Stability test setup
ALMA laboratory test set up has been modified for Allen variance measurement of system stability. The development was so successful that it was used partially for other groups to investigate their systems stabilities.

Precision optical measurement, mounting and alignment set-up
On August 13 this system was delivered. It is meant to enable proper inspection of fine mechanical components and also as to tool to do accurate mounting of junctions into backpieces.

The possibility of using UV-curing glue was investigated for junction mounting. It was found to work much better than conventional type of glue. It also requires different type of solvent that makes it more convenient because contacts to the junction cn be prepared separately.

Water Vapour Radiometer (ALMA Work Package: 4.210)

Cambridge Astrophysics / Onsala Space Observatory

WVR Interfaces
Work on various internal ICDs to the WVR continued. External ICDs with the WVR have been completed and submitted to ALMAEDM in preparation for the SSR.

Internal Optics
Most of the mechanical work on the new optics plate and brackets has been made. Front-end components are assembled into this new layout.

Control Electronics & embedded processor
Detailed workpackages for the control system were agreed and the contract placed. Analysis of ALMA standard embedded processors was carried out and an AMBSI-2 device was selected for the CAN interface for the WVR.
Design/prototyping of the core system (data collection, etc.) has been completed and activity is now focused on ancillary systems like temperature monitoring of the WVR. At OSO more software for the Dicke switched version must be written. The Observatory was exposed to burglars. About ten new computers were stolen, among them the WVR lab computer. Two weeks work of not backed up software were lost.

Integration
Integration of both receivers in the final enclosures is taking place.

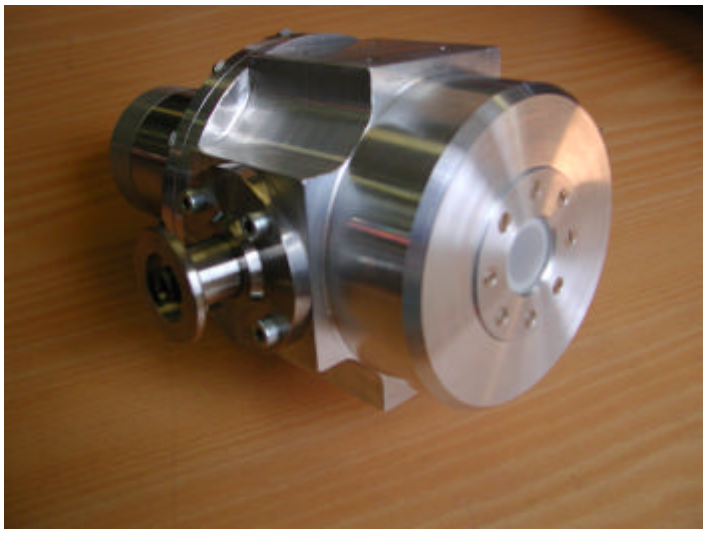


Figure 13. WVR cold load with Sterling cooler

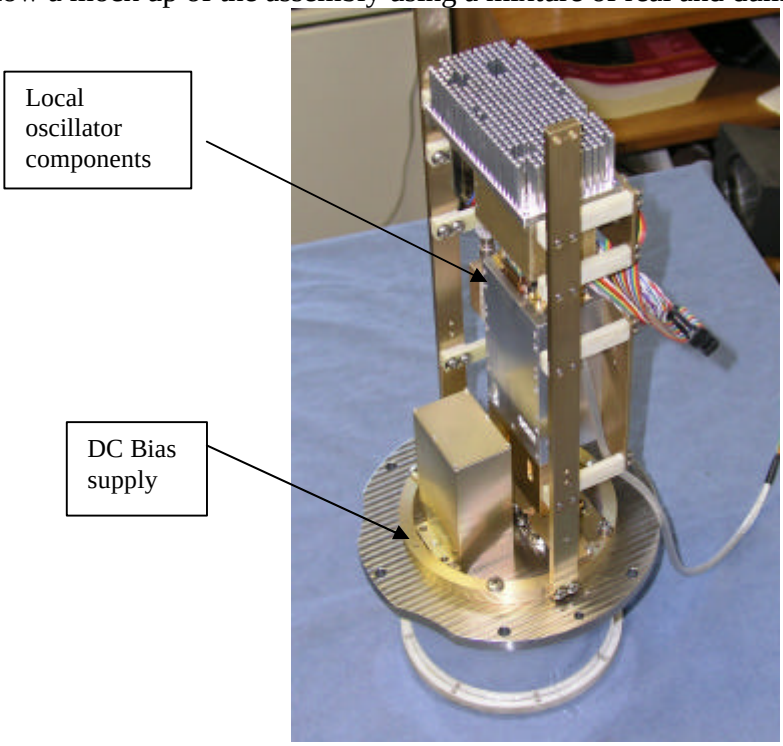
Front End ITP: Status of North American Front End Work Package Agreements

The statement of work, specifications and requirements and MOU between the HIA and the NRAO for band 3 are being negotiated. The statement of work and specifications and requirements documents will form of basis for the band 6 documents. Similar documentation for other North American work packages has yet to be started. Contracts with the University of Virginia for the provision of SIS devices for bands 3 and 6 and with a commercial supplier for frequency multipliers for bands 6,7 and 9 will be signed in October.

Front End Development (ALMA Work Package: 4.100)

NRAO Tucson

Working closely with NRAO colleagues at the CDL and the cartridge manufacturers, the layout of the warm components attached to the bottom of the cartridges has been finished. The assembly houses local oscillator and DC bias modules. The photographs below show a mock up of the assembly using a mixture of real and dummy components.



Cartridge support electronics

The design utilizes blind-mate connectors and an innovative non-contacting waveguide flanges to allow easy field maintenance. Work continues with a finite element analysis of the stability and detailed thermal tests using dummy thermal loads.

Work on the detailed design of the receiver continues. An analysis of the gain distributing within the front-end is nearly complete. This is required before the gain requirements of the individual cartridges or the IF switch/processor can be assigned. Input from the systems IPT on phase and amplitude stability and IF slope and ripple is urgently required and this will be resolved at the system requirements review.

The monitor and control question mentioned in the previous report has been resolved with the adoption of the AMBSI 1 card as the ALMA standard. The front-end will use this as a bridge to a more capable card that will be a commercial product.

Band 3 cartridge (ALMA Work Package: 4.145)

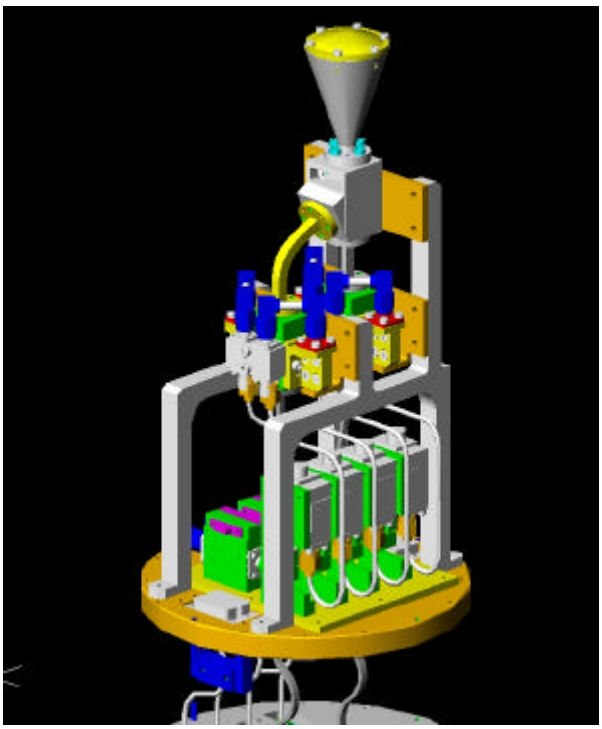
Herzberg Institute of Astrophysics

Work on developing low-noise 4-8 GHz IF amplifiers based on commercially available InP transistors continues. The latest results indicate a room-temperature performance (noise-figure) of 1.2 dB and a gain of 30 +- 0.5 dB across the band. The goal is a noise figure of 1.0 dB. The band 3 team is working with a Canadian company and expect to transfer this technology with the intention of purchasing finished amplifiers commercially.

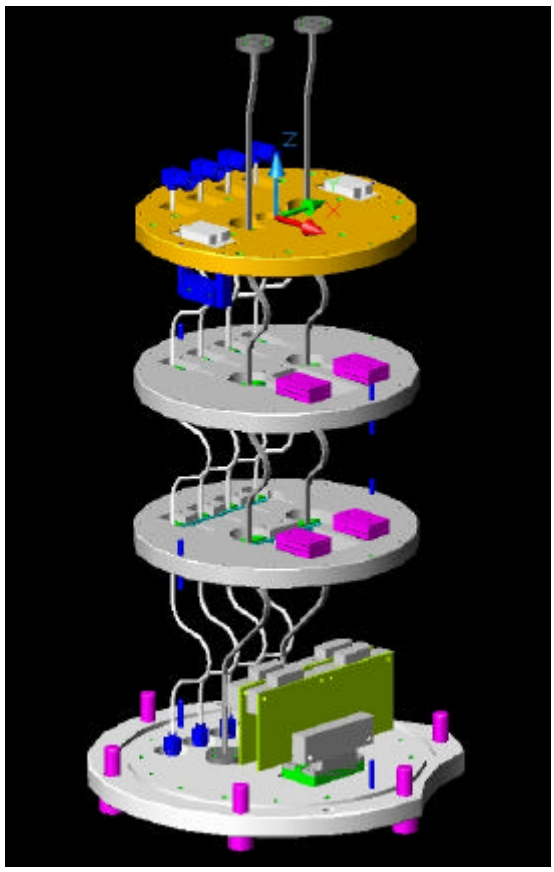
Having achieved the performance required by ALMA the HIA mixer group are concentrating on developing assembly techniques that are suitable for use in production quantities. They have also embarked on an extensive series of thermal cycles to determine the expected MTBF for the mixer assemblies.

Work on the various test-sets continues. To meet the required production delivery rate the mixer test set cryostat allows four mixers to be tested at each cool-down. Assembly of the test set is almost complete and vacuum tests of the cryostat are expected to start on October.

The mechanical layout of the band 3 cartridge is complete and is illustrated in the following figures (note that the spacers separating the cold stages of the cartridge are omitted for clarity). Continued work focuses on a finite element analysis of the structural stability of the cartridge assembly and a detailed thermal analysis.



Mixers and other components on the 4 K stage



Components on outer flange and intermediate cold-stages

The arrangement of components within the cartridge has been carefully considered to ensure that cartridge assembly as simple as possible. A request for expressions of interest for the assembly of all or parts of the band 3 cartridge was issued to Canadian industry and six companies have responded.

Band 6 cartridge (ALMA Work Package: 4.160)

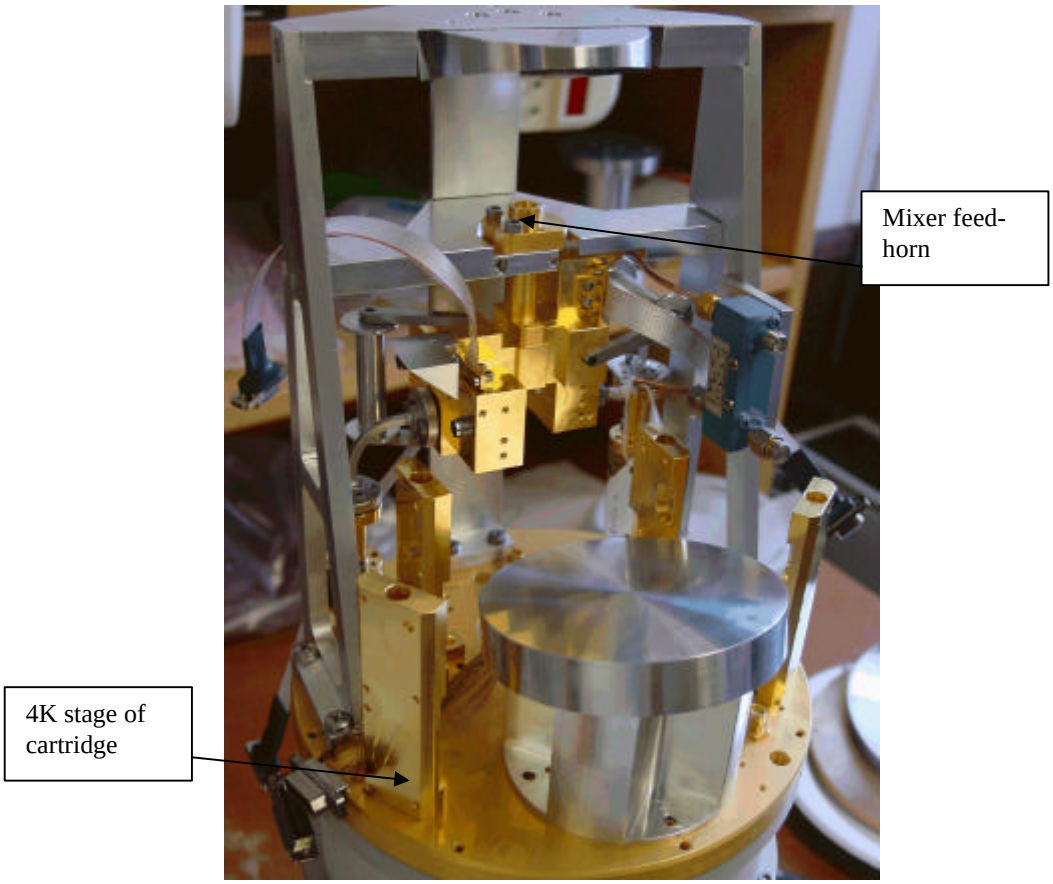
NRAO Central Development Laboratory

Having successfully developed a mixer design that meets the performance specifications of the ALMA project, work has concentrated on building and testing an extended series of mixer assemblies to investigate the yield and perfect the assembly process. The band 6 team are investigating commercial sources for the mixer blocks and expect to out-source these during production.

Following technology transfer, a commercial company is currently building a run of six 4-12 GHz low-noise IF amplifiers. These will be tested shortly, and if the performance is satisfactory the team expect to purchase the amplifiers required for production. These

amplifiers are based on a TRW InP transistor that is not commercially available and a securing a supply of these devices remains a concern.

The design of the band 6 cartridge is complete and a mock-up has been assembled. A photograph of the components on the 4K stage is shown in the figure below.



View of the components on the 4K stage

The mock-up includes some dummy components (such as the ellipsoidal mirror in the foreground) and allows potential layout and assembly problems to be identified and addressed. In addition the thermal design can be verified by cooling the mock cartridge in the cartridge test cryostat. Recent test have shown that the cartridge cools as expected.

Work on the cartridge and mixer test sets continues and is making good progress.

Investigations aimed at estimating the likely amplitude stability of the front end have been undertaken. While these experiments do not reproduce the exact front-end environment they are a good approximation. Recent results indicate that an amplitude stability of a few times 10-4 should be attainable.

First Local Oscillator (ALMA Work Packages: 4.250 / 4.258)

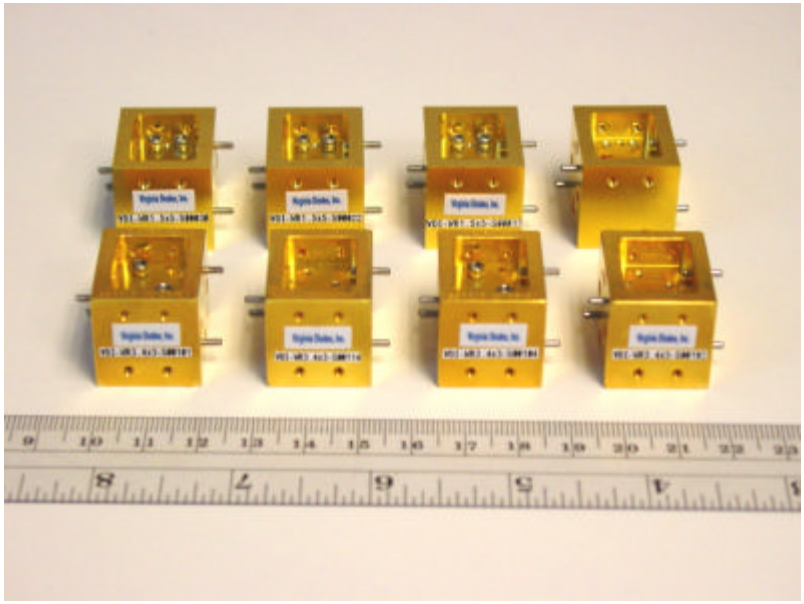
NRAO Central Development Laboratory

Work on the warm assembly that attaches to the bottom of the cartridge has continued and was described in the front-end development section.
Evaluation of the new wafer of high frequency power amplifier devices from Hughes continues with very positive results. It appears that it will be possible to obtain enough power to pump the band 9 frequency multiplier without resorting to a power combining technique.

In this reporting period band 7 and band 9 frequency multipliers were received from the commercial supplier and tested at cryogenic temperatures. The band 7 device performed as expected and meets our needs. The efficiency of the band 9 device did not increase on cooling as expected (probably due to self-heating of the very small anodes) and did not meet our specifications. Despite this, the question of whether it would meet our needs was open. To resolve this a band 9 frequency multiplier and high frequency Gunn oscillator were supplied to the band 9 team at SRON. Their tests indicate that it should be possible to pump the band 9 mixers with an adequate margin using the current multiplier and the new more powerful amplifier designs.

Recent experiments have demonstrated that one can use the dc bias of the power amplifiers to regulate the power output of the local oscillator chain. This eliminates the need for a variable attenuator.

In October we expect to place a contract for the procurement of all the frequency multipliers required for the production of bands 6 and 7.



Four band 9 multipliers (top) and four band 6

2.5 Back End IPT

2.5.1 Data Transmission System (DTS)

A board layout for a digital formatter which uses three ½ transponders instead of the JBO (Jodrell Bank Observatory) laser daughter cards and separate laser controller card is being prepared in cooperation with the EVLA (Expanded VLA) project. Target date for testing the new design is early in 2004.

An end-to-end DTS test was conducted successfully using an EVLA prototype DTS transmitter and receiver. In a separate test, three optical wavelengths were transmitted on a single fiber and synchronized. Sufficient formatter and deformatter

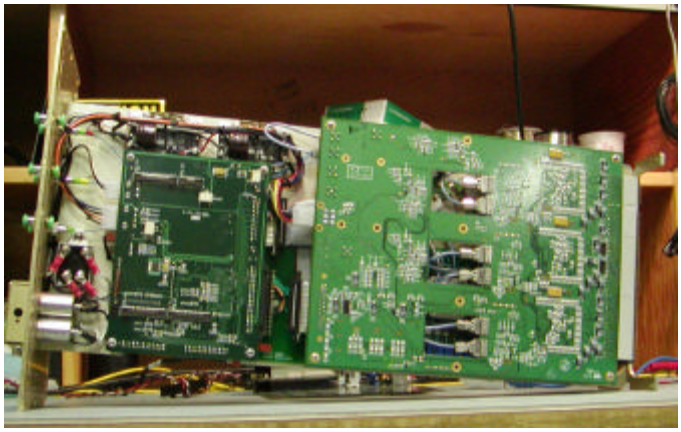


Figure 1: EVLA Transmitter module showing 3-channel ALMA/EVLA formatter.

boards for the ATF System Integration are now being assembled as a result of the successful tests. To correct some timing problems, the design has been modified to use faster Xilinx Virtix version 6 FPGAs (Field Programmable Gate Arrays). Mechanical drawings have been released to an outside vendor for quote on module hardware for the DTS XMTR.

Fifteen FOXC (Fibre optic transmitter controller board) circuit boards are being assembled by an outside vendor; the boards are scheduled for testing in October. The Test Jigs for testing Laser Diodes are complete and operating. The prototype FOR (Fibre optic receiver controller board) boards are being tested, and an order for construction will be placed later this month. Eight FOXT-M (Laser daughter boards) are complete and working. A further 24 boards are being assembled.

The 8 channel JBO (Jodrell Bank Observatory) test-link is up and running with measurements on power levels (to compare with the theoretical design) and stability (power and wavelength) in progress. Current indications are that the link should produce better than expected error rates, but the use of the EDFA (Erbium Doped Fiber Optic Amplifier) in constant gain mode may not be optimum for ALMA in the face of changing

link paths when antennas are moved. The use of the EDFA in constant power mode will be investigated over the next few months. The ALMA memos on link design have been amended to show minor changes to the expected power levels. An updated memo will be released soon.

A consultant is working on the hardware design for the FOA and FOD (Amplifier and de-Mux) module. The module will contain the EDFA, the de-MUX and a control card. A custom heat sink and a front panel with fibre-optic connectors is also required. This unit will be made commercially when the design is complete. Electronic design of the control board is progressing. The design diverges from the EVLA which uses a COTS (Commercial Off-The-Shelf) EDFA that includes the heat sink and controller. Further study of the EDFA shows that the unit is necessary as long as the optical switch remains optional. The switch is proposed to route the same IF to multiple correlator quadrants.

Two alternative optical Muxes have been lent by manufacturers for testing. A design review for these components will be held after the prototypes have been tested.

Specification of the fiber optic cable still awaits an engineering study of direct burial vs. conduit and single vs double armor for direct burial. The Site IPT has agreed to have the study performed.

Space in the AOS TB (Array Operations Site technical building) for fiber management was finalized on the basis of a partially-completed fiber management plan.

Modules ready for testing are scheduled for October and for delivery to ATF System Integration in January ’04.

2.5.2 Digitizer Sampler, Demux, and Clock

Failure analysis of observed defects on bare demux chips after shipment from the foundry has been completed; special Gel Pack protection will be used at production stage to avoid further difficulty. The main difficulties in wedge bonding the demux chips on carrier PCBs are understood. In response, ball bonding could be used for new trials. The older 2.5 W version of demux will be used for the ATF System Integration tests until the new demuxes are available (next foundry run in December 2003).

The first demux chip (DEIMOS design) was successfully bonded with resin protection on a test PCB (Figure 2). Tests have been conducted for the DEIMOS design in full operational configuration mode with shift register 4 GHz frequency and 250 MHz sync clock. Proper operation was observed up to 6 GHz and 300 MHz. Results of lab measurements (Figure 3) show that the DEIMOS design behaves as predicted from the latest simulations made before our layout was sent to the STM foundry.

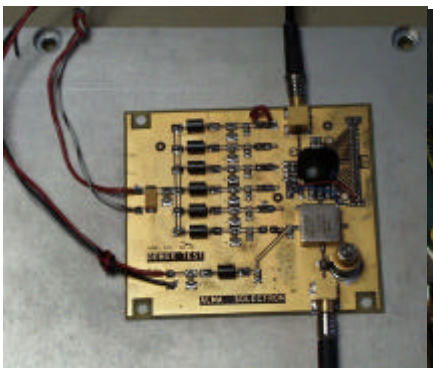


Figure 2: Close-up of demux on test PCB

Figure 3: Demux test setup

The design of demux multi-chip board and 'service board' for the complete DG module has now been validated and a list of components and providers finalized. BE Socorro has sent a test back plane with connector to better determine the location/positioning of the complete DG assembly in the digital rack.

First unit sub-assembly of ALMA sampler has been completed for the new ANTARES design: all components and packaged chip on 6-layer PCB within its mechanical housing. This digitizer sub-assembly (Figure 4) is now undergoing oscilloscope tests in the lab. First tests show that performances seem nominal with excellent sensitivity to the input signal. This sub-assembly will probably be the final model before production for life tests with STM (an external vendor). A technical specification and SOW (Statement of Work) for the digitizer assembly was approved.

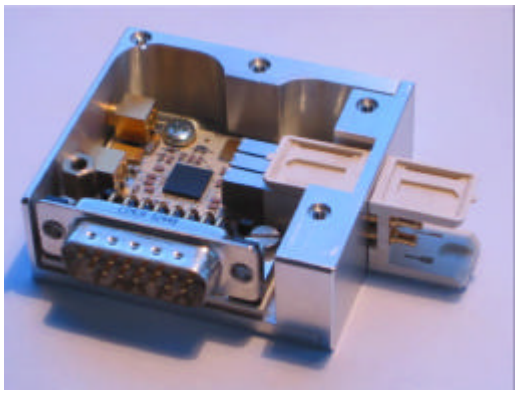


Figure 4: Digitizer in mechanical housing

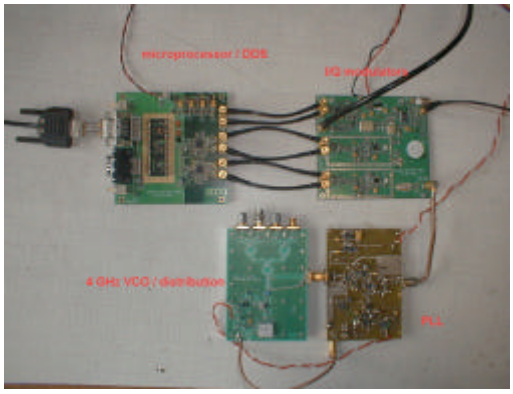


Figure 5: Sampler clock test setup

IRAM has completed the digitizer clock prototype and tests (Figure 5) are satisfactory. Three digitizer clock modules are planned for shipment to Socorro by the end of the year for incorporation into a module. IRAM has not yet received funding from ESO for this work but a draft of Digitizer Clock Technical Specifications has been issued to prepare the IRAM/ESO contract for Digitizer Clock production.

A review of the digitizer/demux/clock review has been scheduled for Bordeaux Oct 16 and 17.

2.5.3 IF Downconverter

An RFQ (Request for Quote) for an outside vendor to produce 3 "integrated" downconverter modules has resulted in 8 bids, which have been evaluated. The leading quote is within 10% of the amount estimated. Release of the purchase order to the successful bidder is planned for November with delivery scheduled for 33 weeks after receipt of order. If the integrated units are tested successfully, then production units will be procured starting in 2004. It may be necessary to pay additional NRE (non-recurring engineering) charge at that time to provide for changes in the system requirements, which are currently not finalized.

The circuit board and parts for an "SMT" (surface mount technology) DC (downconverter) design are currently being assembled to compare performance and cost with both the RF-connectorized and integrated DC versions. The RF-connectorized version of the IF base band converter has been assembled for testing (Figure 6).

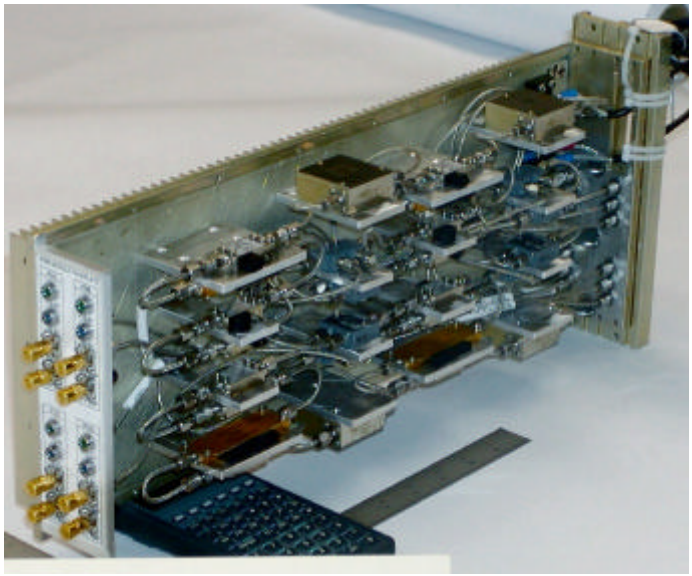


Figure 6: RF-connectorized version of the IF Baseband Downconverter

Allan deviation tests show the ATF (ALMA Test Facility) 4 – 12 GHz total power detectors contribute 50 ppm to amplitude instability over 0.3 – 10 seconds. A LabView-controlled test station for the power detectors has been built to permit rapid and automatic testing of power detectors. The software for the test stand uses a GPIB bus to control the output of a frequency synthesizer to the detector and to compare measurement of the detector output with a power measurement of the synthesizer output. Finally, a prototype 33 MHz V/F converter is being built for the total power digitizer to provide true 16 bit

equivalent full scale digitization and 100% integration of total power over each 2 msec interval.

2.5.4. Project support

To support the Computer IPT, BE has procured and populated ~50 AMBSI 2 interface boards.

A BE Requirements document has been written and submitted to EDM DAR for review and comment.

BE IPT has cabled ATF #2 to prepare it for AEG testing. It was necessary to design and construct 8 cable feed-through panels for ATF #2 that were not required on ATF #1. As well, the IPT is helping the NJAO ATF telescope with implementing 48 ms timing. The CRD (Central Reference Generator) for the ATF was modified to provide synchronized LO timing to all 3 ATF antennas, following a modification planned for the ALMA timing modules.

2.5.5 Milestones and schedule.

2.5.5.1 ICDs

Interface Control Documents (ICDs), which define the interface between the BE IPT and the Correlator, Front End, Site AOS TB (Array Operations Site Technical Building, and the Antenna are all on EDM DAR under technical review and commment. The Computer ICD, which consists of multiple ICDs, one for each CAN (Controller Area Network serial bus) Node on the Monitor and Control (M&C) interface, are either awaiting review by the Computer IPT or are on EDM DAR under technical review and comment. The Site ICD for fiber optic management is awaiting input from the Site IPT.

The BE IPT has elected to use seismic zone 4 equipment racks in the AOS TB to provide for the seismic conditions described in the environmental requirements. The racks will be anchored to the concrete foundation through the raised floor. Heavy duty racks anchored top and bottom will be sufficient for the antennas.

2.5.5.2 System Integration

The BE IPT still plans to provide modules for System Integration in the 3 phases described in the previous report. The SE & I IPT System Integrator is reviewing the plan and coordinating it with other IPTs. Six equipment racks have been ordered to provide for the System Integration tests.

2.5.5.3 Production schedule.

The current plan calls for the BE CDR by May 2004 and the Production Plan by September 2004, even though the ATF System Integration tests are unlikely to be

completed until the end of 2004. The CDR and plan will be completed early to allow time for delivery of the first production units to Chile by the end of 2005.

2.6 Correlator IPT

2.6.1 Prototype 2-antenna correlator

The station bin motherboard for the prototype two-antenna correlator was corrected and the new version completely verified. An optical simulator card was completed and tested. This allows testing the interface to the optical simulator card and also provides a means for sending real digitizer data (acquired at 250 MHz) into the correlator. Using an input broadband noise source combined with a sine wave signal, this permitted successfully sending autocorrelation data through the correlator with a development version of the operational software and displaying the spectrum of the original signal on a monitor.

Only a few minor hardware anomalies remain in the 2-antenna prototype, which is scheduled to be shipped in December 2003.

2.6.2 Enhanced filter card

Further study and design of a possible enhancement of the baseline correlator performance has been done. By substituting an advanced filter card with multiple simultaneous output bands for the single-band output present filter design, it is possible to achieve much greater frequency resolution in the widest bandwidths, or to analyze several narrow bands simultaneously with even higher frequency resolution.

Two methods of providing this advanced capability have been investigated. The NRAO group has developed and simulated a design for a 32-band polyphase filter implementation. The European group has developed and simulated a design for a 32-band filter card with independently tunable 2-stage filters, which has a significant performance advantage over the polyphase filter. The European design is only slightly more costly than the NRAO baseline or enhanced designs, and the correlator IPT recommends that it be adopted.

2.6.3 Schedule

The goals for June-August 2003 were:

(1) Complete hardware checkout of the two-antenna prototype correlator;
(2) Write preliminary version of firmware needed for the test interferometer;
(3) Complete design and simulation of the enhanced filter card;
(4) Hold a Critical Design Review.

Item (1) is complete except for a few bin-to-bin interfaces which show very low level bit errors; this will require further work. Items (2) and (3) are complete. Item (4) was delayed because of scheduling conflicts and is scheduled for October 2-3, 2003.

The goals for September-November 2003 are:

(1) Refine the designs and cost estimates for the enhanced filter card;
(2) Hold and pass the Critical Design Review;
(3) Eliminate the last residual hardware problems in the 2-antenna prototype;
(4) Place initial orders for the 64-antenna correlator.

2.6.4 ALMA Second Generation Correlator (2GC)

The 2GC correlator group concentrated on design and simulation of the 2-stage tunable filter design and its implementation for use in the baseline correlator.

2.7 Computing IPT

Summary

In this quarter the Computing IPT held its CDR1. CDR1 consisted of 14 1-2 hour telecons, with written comments and replies distributed in advance of the meeting. The material may be found at: http://almaedm.tuc.nrao.edu/forums/alma/dispatch.cgi/ipt70designreviews/folderFrame/100050/0/def/bcbe. As discussed in the approved Computing Management plan and by the PDR panel these reviews are internal to the Computing IPT, excepting CDR2 (Summer 2004) which will be external to evaluate the impact of the report of the operations working group and will reconfirm the use of AIPS++.

Given the proximity (3.5 months) to PDR, CDR1 concentrated on items related to the first major release R1, scheduled for Q4 2003. The detailed action list per subsystem is available at: http://almaedm.tuc.nrao.edu/forums/alma/dispatch.cgi/ipt70designreviews/docProfile/100098/d20030808161817/No/t100098.htm

While a number of important issues were raised and require follow-up, all subsystems passed CDR1.

The AIPS++ software package – now being managed directly by the ALMA and eVLA projects – made significant strides in demonstrating that it does not have fundamental performance issues. While more work remains to be done, we are now confident that we will be able to satisfy the ASAC call for a performance within a factor of 2 of comparable packages. More details are given in the description of the Offline subsystem, below.

All subsystems are presently engaged in preparing for the first major release (R1), scheduled for Q4 2003. As part of this process we introduced an intermediate software

release (named R0+), in which the interfaces with little working software behind them were integrated. This process revealed certain mutual dependency problems which we believe have been resolved by separating the interface build from the implementation build in a 2-stage process. This will be demonstrated in the R1 process.

Support for antenna evaluation continued in the quarter, with efforts to support optical pointing and other tests on the Vertex antenna, radiometry lab integration in Tucson, and communications tests in AEC facilities (and very late in the quarter at the ATF). This has generally proceeded satisfactorily, although the nutator integration has not been as rapid as we would have liked.

Finally, our preparation for science-requirements based testing of ALMA advanced significantly in the quarter. Most subsystems now have initial use cases from which test cases and planning is to be derived.

Milestones

The Computing IPT Level 2 Milestones for the current, and next quarter are as follows.

Milestone	**Original**	**Current**	**Actual**
Subsystem Critical Design Review 1 (CDR1)	2003-07-09		2003-08-04
Subsystem Major Release 1 (R1)	2003-10-01		
Integration Release 1 (IR1)	2003-12-01		

Significant Issues

The Telescope Calibration and Offline (AIPS++) subsystems require the availability and suitable rights to distribute the ATM library. While this is expected to be allowed, the discussions are not yet concluded.

The PDR panel noted that in the data processing area, notably Pipeline, there were some issues related to distributed development with groups with different backgrounds in software development. Regretfully we have concluded that the collaboration within the Pipeline team was not likely to succeed and we have reconstituted the Pipeline heuristics portion of the team (staying within Europe). While most of the current Pipeline effort is aimed at technology development, this will somewhat delay the production of the first Pipeline for mm data in 2004.

The control and correlator teams expect to migrate from the VxWorks real-time OS to a real-time version of Linux. Testing this will require time at the ATF, which is lower priority than antenna evaluation. Delaying the final decision to use real-time Linux increases the possibility of rework. We are also under some pressure on the number of real-time systems we have access to (e.g., for integration and test) because we have minimized the purchase of these expensive systems until a decision this decision is made.

Work Element Reports

All software subsystems and activities participated in CDR1 (including post-review document revisions) and participated in the R0+ release and prepared for the R1 release. These common activities are not repeated for each subsystem. Similarly, considerable progress towards use-case based testing was carried out. This work is likewise not repeated for each subsystem.

Management (2640)

The project has introduced the use of a "Wiki" collaborative web environment to enhance technical communications. While the final decision has not been taken, it turns out that it is very popular and is likely to be adopted.

Management attended, and made presentations, at the ANASAC, ASAC, and mini-ALMA week meetings.

A communications study (including options for telephones, internal networking, and networking between the OSF and Santiago) was started. It is being lead by the ESO IT, with an NRAO collaborator. A report is to be available by the end of the year.

Science Software Requirements (2680)

Progress: Significant effort towards science-requirements based testing was carried out this quarter. A "framework" plan was discussed and established, a large number of use cases were developed, and detailed test plans have been started. The first such test (for the observing preparation subsystem) is expected before the end of the year. The material developed to date can be found at: http://www.aoc.nrao.edu/~dshepher/alma/

Issue: There is a vacant staff position in Europe

Analysis and Design (2700)

Progress: The team issued an integrated R1 release definition for subsystems to implement. This was to improve the coherence of the overall release process. The team also participated in discussions related to VOTable output definitions for the correlator (i.e., ALMA's major bulk data item). It also participated in discussions relating data collections (output) to the ALMA Project definition (input).

Software Engineering (2720)

Progress: Python coding standards for ALMA were established http://almaedm.tuc.nrao.edu/forums/alma/dispatch.cgi/officialcomp/docProfile/100008/d20030912215258/No/t100008.htm. Various makefile improvements to support development were made. An automated metrics reporting infrastructure was developed

and brought into production (http://websqa.hq.eso.org/alma/snapshot/). Monthly SPR meetings were held.

Issues: Vacant position, access to real-time systems.

Common Software (2740)

Progress: Two updates (2.1.1 and 2.1.2) were made to the current release while development of the new (3.0) release was made. A major switch to the GCC 3.2.x compiler suite was made, which will allow us to have access to native C++ exceptions on all platforms. A Python component infrastructure, important for the Pipeline, was developed and delivered in early form to the Pipeline team for testing. A new Error system was introduced which allows for XML configuration. It is backwards compatible with the current implementation.

Issues: Unfilled position in Canada. The various CORBA implementations we are using have some incompatibilities, most notably with the JacORB IDL preprocessor. More documentation effort would be useful in maintenance of high-level introduction documents.

Executive Software (2750)

Progress: UserAdmin and Executive packages were implemented for R1.

Control Software (2760)

Progress: Two vacancies at NRAO/Socorro filled, bringing the control software team up to strength. Some work on ICDs, although more effort is needed. We have implemented the software necessary to replace the ABM software. It now needs testing at the ATF. Various support at the ATF and at AEC development facilities. Lab integration of radiometry system completed, excepting the nutator which has lagged.

Issues: The control group remains under great pressure (Vertex, AEC, radiometry, R1, ICD development). Slow progress on the nutator. Real-time Linux test timetable.

Correlator Software (2780)

Progress: Successful end-to-end test of the prototype correlator were made, from control of it with the CCC, to handling the lags with the CDP. In conjunction with the archive and analysis teams a VOTable format for correlator data was established. A correlator configuration validator in Java was developed, and a subscription to the control software geometric delay event channel was achieved.

Pipeline Software (2800)

Progress: Several AIPS++ components were bound to the prototype pipeline. This involved replacing the AIPS++ Tasking system with ALMA technology equivalents (common software, CORBA). No major issues were encountered. The ½ FTE vacancy at NRAO was filled. The understanding of the requirements on the quick-look pipeline advanced significantly. Several use cases were developed.

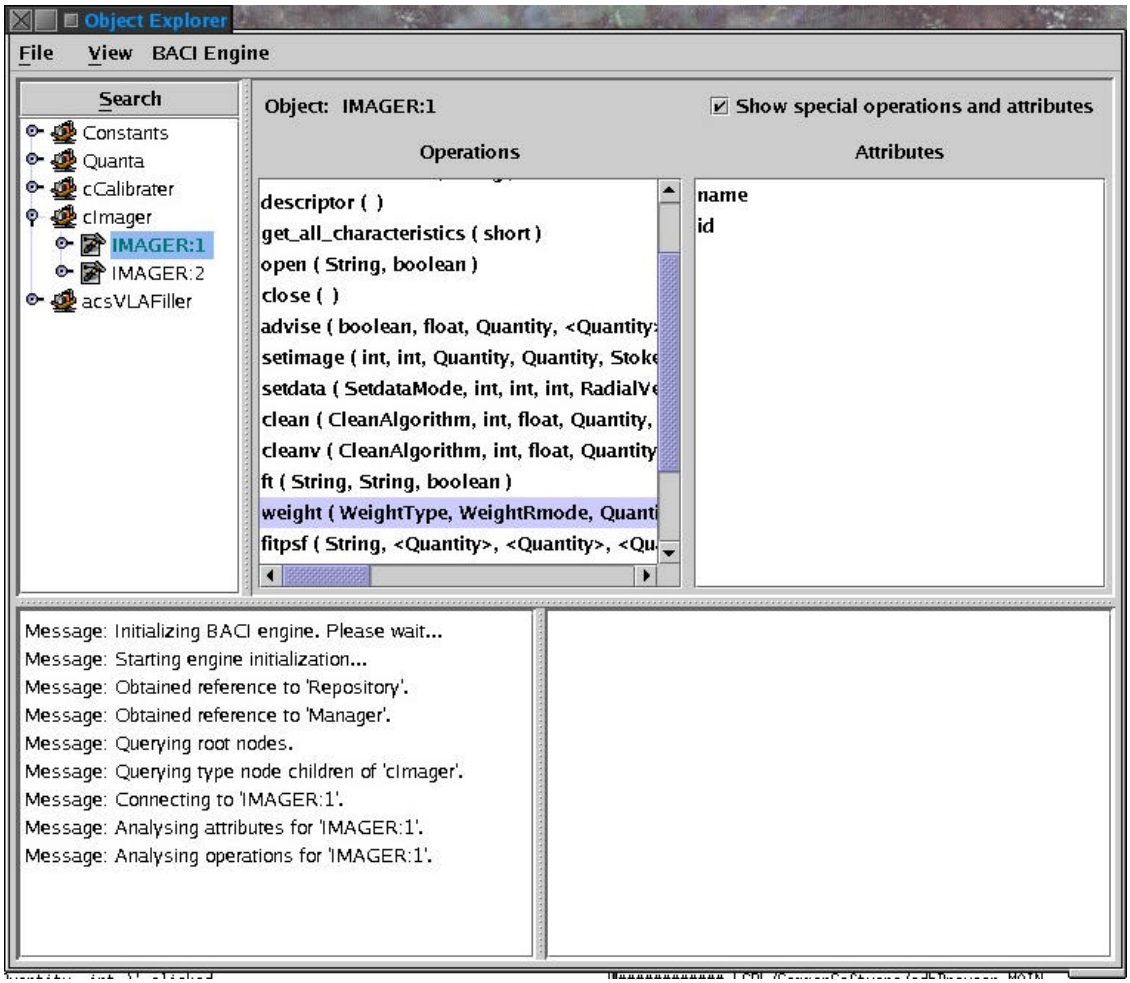


Figure 3 - AIPS++ Imager object viewed in generic ALMA Object Explorer

Issues: Delay in Pipeline heuristics.

Archiving Software (2820)

Progress: Interfaces to store monitor and bulk data were implemented for R1. A VOTable structure for correlator data was defined with the correlator and analysis teams. Discussions with IBM related to both pricing and future features of their DB2 database were undertaken.

Scheduling Software (2840)

Progress: A stand-alone simulator framework defined and largely implemented. This is to enable the scheduling software to both run within the ALMA system (e.g., for R1) and in a standalone mode to allow for simulation of scheduling strategies.

Observing Preparation and Support (2860)

Progress: A top-level GUI has been implemented, as has been a batch/text mode to allow for automated testing. A specification and detailed design of a spectral editor was made. An editor/model interaction framework was adopted and modified for the Java Swing framework used by ALMA. A basic Project repository was implemented for both local and remote use, and an exposure time calculator was integrated into the tool.

Off-line Data Reduction (2880)

Progress: A vacant (50%) position at NRAO was filled. A discussion paper for the ALMA export data format was prepared (it is in final editing). New functionality for continuum subtraction (UV-plane and image-plane) was implemented. Calibration routines were changed to be based on scan boundaries. A blinking capability in the AIPS++ viewer was implemented. Selectable waiting for single-dish data when used with interferometric data was implemented. Full primary-beam IQUV imaging was made available.

The major issues addressed this quarter have related to performance. There have been questions raised about whether poor reported AIPS++ performances have arisen from fundamental flaws in AIPS++ or in lack of attention to these issues. While the work is not completed, dramatic speedups have already been demonstrated which seem to indicate that the problems are not fundamental.

For example, the AIPS++/IRAM Phase 3 (benchmarking) results are as follows:

	GILDAS/CLIC	AIPS++	A/G	Comments
Filler	1873	10939	5.8	
Init (write header info)	385		n/a	
Fill model/corr data cols.		2140	n/a	
PhCor (Check Ph-corr data)	889	3484	3.9	(AIPS++ Glish)
RF (Bandpass cal)	5572	2298	0.4	
Phase (Phase cal)	3164	1111	0.4	
Flux (Absolute flux cal)	1900	2093	1.2	(AIPS++ Glish)
Amp (Amplitude cal)	2242	614	0.3	
Table (Split out calib src data)	1200	5150	4.3	(AIPS++ fits write)
Image	332	750	2.3	
Total	17600s	28600s	1.6	

This shows that AIPS++ is 1.6 times slower than Gildas for this test. Note that without the filler AIPS++ and Gildas would run at nearly the same rate. However the data format used for this test (the ALMA test-interferometer format) has some peculiarities and has a very limited lifetime so it has been decided that optimizing this would not be an effective use of time. Note also that the AIPS++ values with comments are also amenable to significant improvement. For further details the ALMA Memo (submitted but not yet on the web) should be consulted. An important caveat is that currently an AIPS++ bug requires that more memory (1.7GB vs 1.0GB) is needed for AIPS++ than Gildas. Without enough memory AIPS++ time is dominated by paging.

As a further example of recent progress see the following two figures:

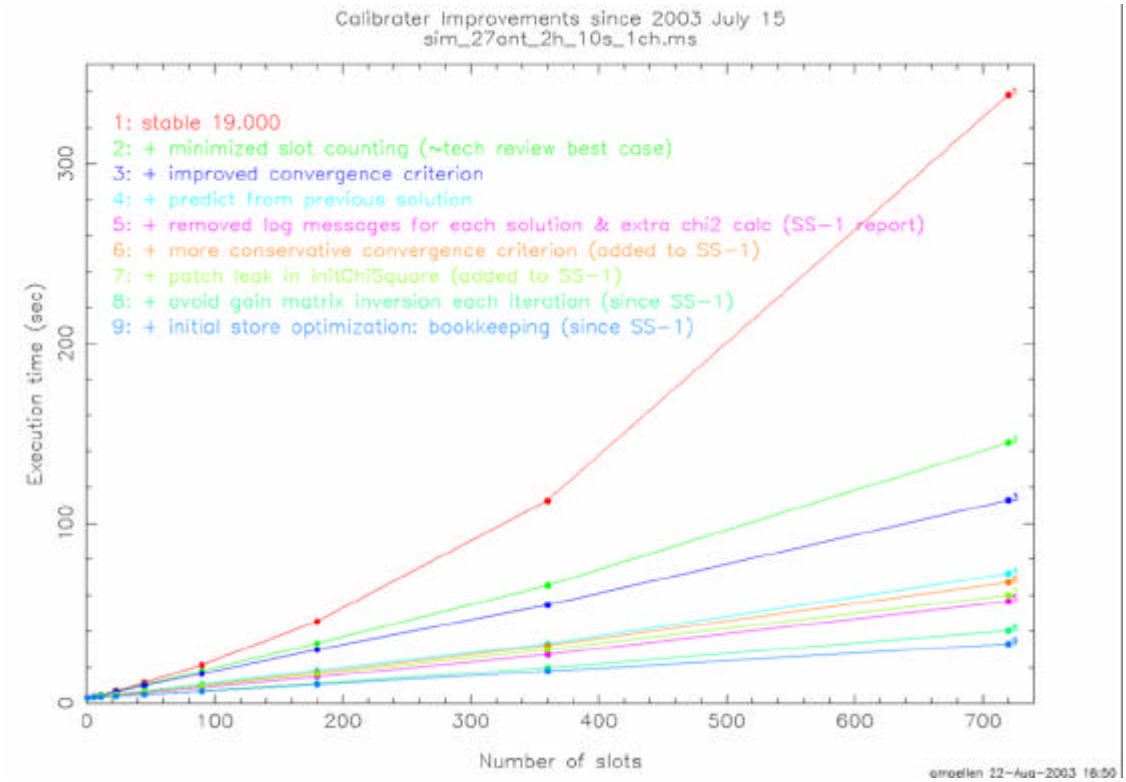


Figure 4 - Improvements in Calibrator Performance since 2003-07-15

In Figure 4 the relative improvements in Calibrater performance are broken down. Nearly an order of magnitude improvement has been made. In Figure 5 the Calibrater performance from the bottom curve of Figure 4 is compared to AIPS with varying number of channels. AIPS++ is faster than AIPS for 128 channels (and greater, presumably), and for some other combinations of channels and solution "slots." Multi-channel data is expected to dominate the ALMA data rate.

While this work needs to be extended in various ways, and performance enhancement effort is still required, there is now a strong indication that the previous reports of poor AIPS++ performance do not arise from fundamental technical reasons.

Further details and up to date information on all these performance issues can be found at: http://aips2.nrao.edu/projectoffice/

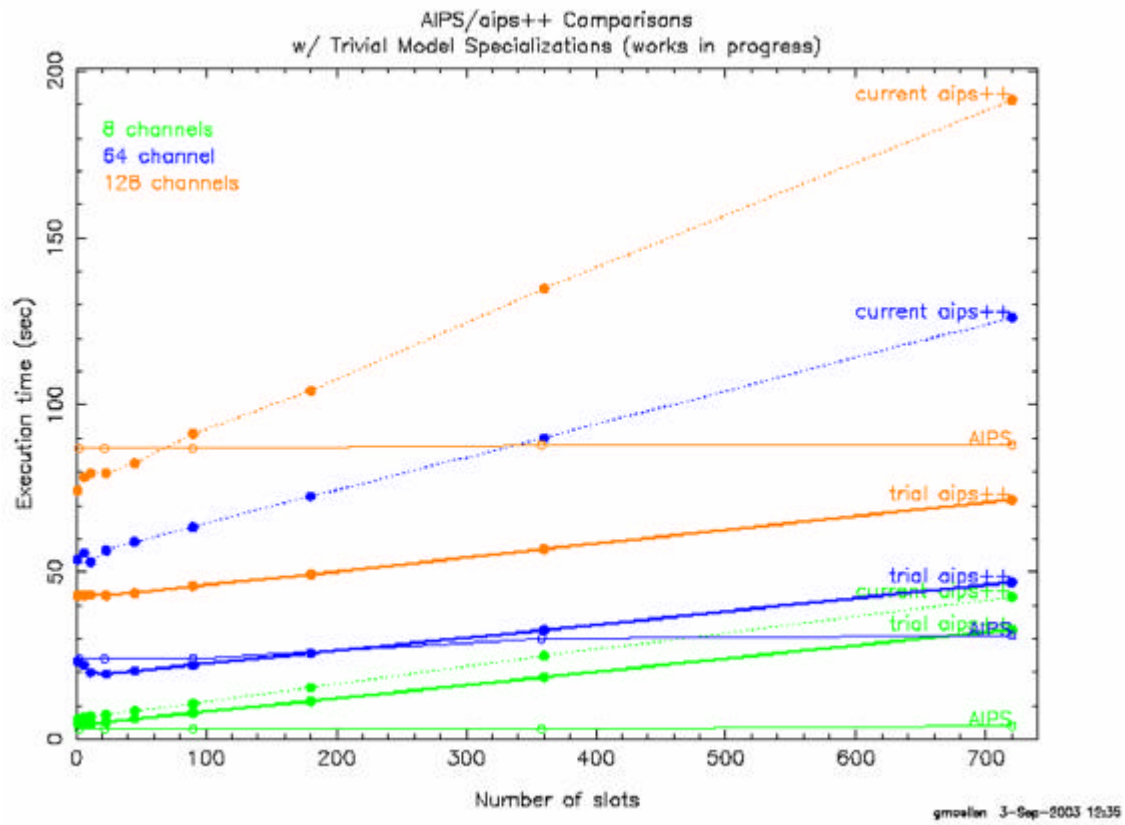


Figure 5 – Calibrator performance, AIPS vs. AIPS++

Issues: Unfilled position in Canada.

Telescope Calibration (2900)

Progress: Single dish pointing and focus routines have been implemented for R1. The Publisher and TelCalManager interfaces and implementations have been updated.

Integration, Test, and Support (2920)

Progress: The monthly integrations and R0+ release were handled by this team. Due to a departure from the Project (Uphoff, NRAO), the leadership of this team will be changed (Sivera, ESO).

Issues: Vacancy at NRAO due to Uphoff departure, unfilled 0.5FTE position in Europe.

2.8 System Engineering and Integration IPT

During the third quarter 2003 the System Requirement Review (SRR) continued with the finalization and approval of several top level technical documents. Some of the documents presented at the ALMA week in June, were updated and approved. Others were generated and submitted for approval. A complete list of the SRR documents and its status is attached.

The scope of Product Assurance was more precisely defined and an ALMA PA requirement document was prepared. The documentation and configuration procedures have been further consolidated and simplified by updating the corresponding documents. System block diagrams have been refined and a system design description emphasizing the signal path was prepared. The error budget allocation progressed further and is nearly finalized. System Engineering participated in several ALMA progress meetings and reviews, including the cryostat manufacturing readiness review, FE and LO progress meetings and the OSF tender evaluation.

2.8.1 Management

An updated System Engineering Management Plan draft was prepared. The Level 2 and 3 milestones were revised and updated. Weekly progress meetings of the SE&I IPT are held and an Action Item list is maintained to track progress on issues needing resolution. Communication with the other IPTs is done through regular working meetings with the North American and European groups individually and jointly. This quarter, mini ALMA week was an opportunity for the SE&I IPT to work with the other IPTs and to consolidate pending issues.

Based on the AMAC recommendation the Product Assurance (PA) area was strengthened by nominating a PA manager and the PA requirement document was submitted for CCB approval. Top level design safety documents were prepared in collaboration with the ALMA joint safety group.

2.8.2 Engineering

System Performance Requirements

A system performance requirement table was prepared based on the system design description which provides a detailed explanation of the signal path from the antenna through the Front End, Back End and Correlator sub-systems, thus providing the linkage between the science, system and sub-system requirements.. The consistency of the ALMA requirements needs to be ensured by co-operation with the other IPTs. Figure 1 shows the performance requirements document tree. It also has to be ensured that all these documents comply with the project plan and other board level documents.

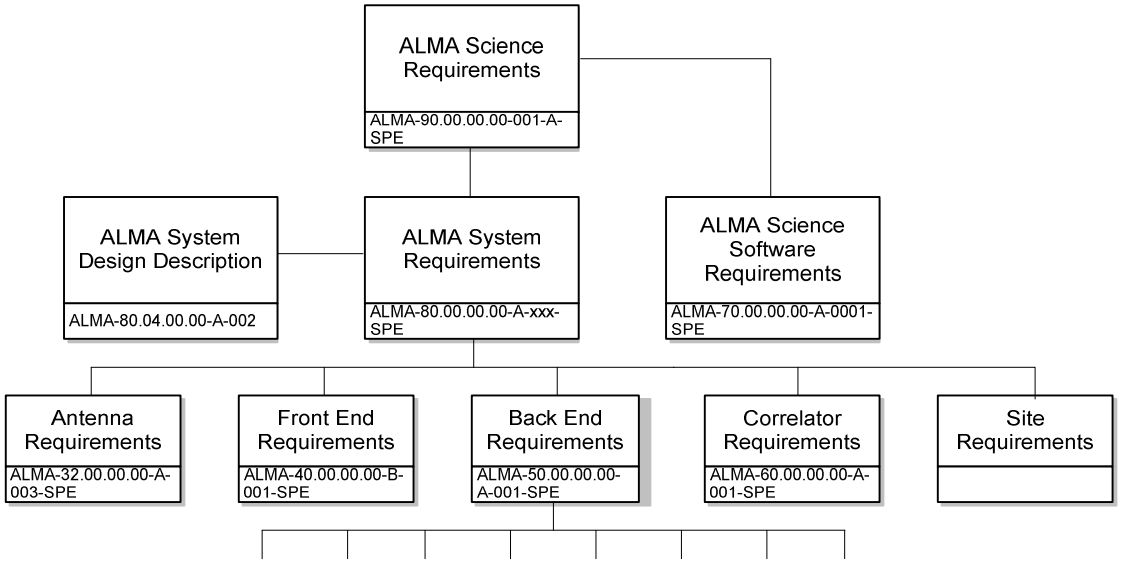

ALMA Science Requirements
ALMA-90.00.00.00-001-A-SPE
ALMA System Design Description
ALMA-80.04.00.00-A-002
ALMA System Requirements
ALMA-80.00.00.00-A-xxx-SPE
ALMA Science Software Requirements
ALMA-70.00.00.00-A-0001-SPE
Antenna Requirements
ALMA-32.00.00.00-A-003-SPE
Front End Requirements
ALMA-40.00.00.00-B-001-SPE
Back End Requirements
ALMA-50.00.00.00-A-001-SPE
Correlator Requirements
ALMA-60.00.00.00-A-001-SPE
Site Requirements

Table 1: Engineering Spec Status

Electronic Design Specification and Guidelines	ALMA-80.05.00.00-005-A-SPE	submitted
EMC Requirements	ALMA-80.05.00.00-005-A-SPE	submitted
Power Quality (Compatibility) Specification	ALMA-80.01.00.00-005-B-SPE	approved
Standard for Plugs, Sockets outlets and Couplers	ALMA-80.04.00.00-005-A-STD	approved
ALMA Site Environmental Specifications	ALMA-80.05.02.00-001-A-SPE	approved
General Safety Design Specification	ALMA-10.08.00.00-003-A-SPE	approved
PA requirements	ALMA-80.11.00.00-001-A-SPE	approved

Table 2: CCB approved and submitted ICDs

ICD between Antenna and Back End	ALMA- 30.00.00.00-50.00.00.00-A-ICD	in IPT approval
ICD between Antenna Control and Control Software	ALMA-34.00.00.00-70.35.20.00-A-ICD	submitted
ICD between Antenna an Front End	ALMA-34.00.00.00-40.00.00.00-A-ICD	in IPT approval
ICD between Antenna and Service Vehicle	ALMA-34.00.00.00-40.09.06.00-A-ICD	in IPT approval
ICD between antenna stations and antenna	ALMA-20.02.00.00-34.00.00.00-A-ICD	approved
ICD between Array site power generation and antenna Power connection	ALMA-20.05.00.00-34.00.00.00-A-ICD	submitted
ICD between Back End and Correlator	ALMA-50.00.00.00-60.01.01.00-A-ICD	submitted
ICD between Front End / 1st LO and Backend / LO	ALMA-40.10.00.00-50.03.00.00-A-ICD	in IPT approval
ICD between Front End / IF and Backend / IF Downconverter	ALMA-40.08.00.00-50.01.01.00-A-ICD	in IPT approval
ICD between WVR and LO & Time Reference	ALMA-40.07.00.00-50.03.00.00-A-ICD	in IPT approval
ICD between AOS Technical building and Backend Central Equipment	ALMA-20.01.00.00-50.00.00.00-A-ICD	in IPT approval

2.8.3 Product Assurance

The ALMA Product Assurance requirements document has been updated with the feedback received during the IPT review and is awaiting CCB approval. Project documents such as Statements of Work have begun being reviewed and PA has started participation in several review meetings specifically to focus on PA concerns.

2.8.4. Documentation and Configuration Change Control

The document approval and change request process for project level and IPT level documents has been simplified to eliminate unnecessary or repetitive steps. These revised procedures are detailed in the 'ALMA Documentation Control Plan'. The standards which apply to all ALMA documentation were also updated and are defined in the 'ALMA Documentation Standards. The Configuration Control Board (CCB), which controls the ALMA documentation generation and revision process, met regularly during the last quarter. The status of each of the documents submitted for approval or revision is visible on ALMAEDM.

The following changes to ALMAEDM and the documentation were implemented:
Creation of a controlled area where approved project level and IPT level documents are located and maintained by SE.
All Board level, project level and IPT level document sent to suppliers or sub-contractors need to be signed. A decision was made to use digital signatures in addition to handwritten signatures.
Digital signature process was implemented
The next version of the documentation control software used by ALMAEDM was installed and is running on a test server. The rollout of this new software version for use by the general ALMA project is planned for the next quarter.

2.8.6 Integration

The Integration Plan for the lab system integration of ALMA prototypes hardware and software is in preparation and will be available during the fourth quarter. The outline of the Integration Plan of the System in Chile should be available by the end of this year.

The activities of the ALMA Antenna Evaluation Group (AEG) are given elsewhere in this report.

2.8.7 Safety

SE&I IPT supported the ALMA safety committee in the generation of safety design documents.

2.8.8 Level 2 Milestones Status for 2003

MS #	MS Name	New Due date	Justification for new due date
9602	System Requirements Review (SRR) – System Requirements Finalized	2003-10-31	SRR Documents were prepared late. No impact on overall ALMA schedule.
9605	ALMA System Design Review	2004-2-27	Due to late MS 9602 also 9605 needed to be rescheduled.
9650	Prototype Integration and Verification Plan (Q4 2003 through Q4 2004) approved for Lab and ATF	2003-10-31	Delayed owing to lack of SE manpower.

2.8.9 Critical Areas

- Some ICDs originally identified for the SRR will only be available after than the updated MS 9602 date. These documents are identified. The late delivery of these documents will not delay the overall project. The critical documents e.g. top level specification and antenna documents shall be ready at the rescheduled date.
- Existing inconsistencies between Science, System and Sub-system requirements needs to be resolved. To resolve these inconsistencies is one major goal of the SRR.
- There are still negotiations ongoing about some ALMA wide applicable standards. These are the electrical buildings standards (IEC versus NEC) and the applicable Lightning Electro Magnetic Pulse (LEMP) standard.
- The document approval process is still slow. After approval of the updated 'Document Control Plan' the approval process should accelerate.
- A decision needs to be made on the date for moving one or both ALMA antennas from the ATF site.

ATF Antenna Evaluation Group
Prototype Antenna Evaluation Planning

Communications

Teleconferences: The Antenna Evaluation Group (AEG) continues to hold monthly teleconferences. During these teleconferences the detailed planning associated with the evaluation of the VertexRSI and AEC prototype antennas is discussed. The discussions in these teleconferences revolve around:

1. Planning for the installation and use of measurement systems to be used to characterize the prototype antennas.

2. Further definition and planning associated with the major antenna evaluation tasks, which are pointing, surface, radiometric, and monitoring and diagnostics evaluation.
3. Organization of the manpower necessary to execute the major antenna evaluation tasks.
4. Updates to the antenna evaluation task planning resulting from changes in the prototype antenna delivery dates.

With the start of evaluation activities in mid-March came the need for a regular teleconference involving the IPTs responsible for the delivery of instrumentation used in the prototype antenna evaluation process. To meet this need, a weekly teleconference involving the AEG, Computing, Backend, Frontend, Antenna IPTs is held.

Documentation: The AEG and AEWG continue to develop the ATF workspace within ALMAEDM as an information storage and distribution system for ATF activities.

Organization: The AEG has developed two information systems, available from the ATF web page at http://atf.nrao.edu to serve as communication tools for the ATF activities:

1. *ATF Calendars. Two web-based calendars are used to track daily work schedules at the site and coordinate staffing.*
2. *ATF Problem Reports. Based on the popular "wreq" system used to track computing problems at the NRAO Socorro and Tucson sites, this system allows ATF support staff to track and solve hardware and software problems at this facility.*

ATF Activities

During this quarter the AEG has continued evaluation of the VertexRSI prototype antenna and begun evaluation preparation on the AEC prototype antenna. Evaluation activities have included:

1. Holographic measurements of the VertexRSI prototype. This major evaluation task proceeded very smoothly and was completed ahead of schedule.
2. Optical pointing telescope studies of the VertexRSI prototype antenna pointing performance. This work is now proceeding following antenna positioning repairs made by VertexRSI.
3. Monitoring and diagnostics equipment installation preparation on the AEC prototype antenna. Mountings, cabling, and other installation infrastructure are being prepared for the measurement systems to be used on the AEC prototype.
4. Monitoring and diagnostics testing of the VertexRSI prototype. Measurements using our API 5D laser interferometer, quadrant detector, temperature sensor, accelerometer, and weather monitoring systems have provided measurements of some of the basic antenna characteristics. These measurements have included:

- API5D laser interferometer measurements of the antenna path length stability. Data acquisition is complete for two of the four paths that account for this path length stability specification.
- Temperature sensor system characterization. The system of 93 temperature sensors installed by the contractor has been diagnosed and characterized by Nicholas Emerson and Angel Otarola. Readout of all sensors through the PTC has been accomplished. A minor problem with incorrect placement of a few sensors has been solved. This system is now making continuous temperature measurements of the antenna.
- Accelerometer system installation and characterization. Ralph Snel and Angel Otarola have installed the system of 10 accelerometers on the VertexRSI antenna. During the two-week period beginning on 2003/08/25 a dedicated series of measurements with this system were made. Analysis of these data is in progress.

Current AEG Evaluation Task Timetable

The current major evaluation task completion schedule is listed below. Note that the AEC antenna evaluation task timetable is currently in flux, due to uncertainty regarding the AEC antenna delivery schedule.

VertexRSI Holography	2003-07-03
VertexRSI Optical Pointing	2003-10-17
VertexRSI Radiometric Evaluation	2004-02-16
AEC Holography	2003-11-03
AEC Optical Pointing	2004-01-05
AEC Radiometric Evaluation	2004-04-30

Problems and Concerns

1. Even though the first major evaluation task on the VertexRSI antenna was completed ahead of schedule, significant hurdles exist on our path to a full evaluation of this antenna. The poor state of the antenna positioning system has delayed evaluation activities by at least 16 weeks, in total. Most of the problems associated with the antenna positioning system have now been solved, but we unfortunately cannot recover the time lost.

2. The delays in the delivery of the AEC antenna continue to shift the point at which evaluation of this antenna can be completed further into the future. The AEG has also become concerned about the state of completeness of the AEC antenna system when it is delivered at provisional acceptance. If a lengthy commissioning period is needed to bring the AEC antenna system to the point where the AEG can begin evaluation, further delays in the completion of the evaluation of the AEC antenna will be unavoidable.

2.9 Science IPT

During July-September, Science IPT activity concentrated on ALMA calibration, configuration, imaging and operations considerations. A complete revision of the ALMA Scientific Requirements, previously available as Chapter II of the Project Book, was submitted. A calibration plan for ALMA was also submitted. The ICD for the design of the long baseline pads in the configuration was submitted at the close of the previous quarter; the plan for moving among the innermost arrays was submitted in September. Investigation of system amplitude stability quantified the effects of different levels of electronic stability, sky stability and thermal noise on imaging performance. To aid in development of scientific aspects of ALMA Operations, the Science IPT undertook development of the ALMA "Design Reference Science Plan" (DSRP) which has as its goal to translate the ALMA science case into a more detailed plan of 3 years of observing with the full ALMA array. The DRSP will serve as a quantitative reference for developing the science operations plan, for performing imaging simulations, for software design, and for other applications within the ALMA project.

The Science IPT arranged the agenda, minutes and telecon for the monthly ASAC telecons and facilitated the ASAC face-to-face meeting in Hamilton, Ontario Sept 5-6 to develop its report to the ALMA Board addressing the charges it received. In Europe and North America, the related ESAC and ANASAC groups also hold telecons facilitated by the Science IPT. The Science IPT participated in miniALMA Week, the ANASAC and ESAC face-to-face. Joint NA/EU Science IPT staff and Calibration Group telecons were held monthly, and the weekly NA Science IPT telecons were continued.

ASAC

Figure 6 The ASAC on the sunny campus of McMaster University, Hamilton, Ontario

The Science IPT facilitated the ASAC Telecons held on 2 July, 6 August and 24 September. It supported the ASAC in the ASAC responses to the Charges posed to it by the ALMA Board, including discussions at the face-to-face meeting 5-6 September in

Hamilton, and in preparing the written response to be presented to the Board at its 2 November 2003 meeting in Santiago. Studies supporting the ASAC investigations are covered below.

Science Requirements

Butler drafted and circulated a new version of the ALMA Scientific Requirements into which Wootten incorporated comments from van Dishoeck and others; it was finished and submitted as ALMA-90.00.00.00-002-A. This document is meant to describe and specify the scientific requirements for ALMA. It draws from a long list of historical documents describing the desired scientific emphasis of ALMA (and the MMA and LSA), but most directly from the Project Plan v1.0 and the Project Book Chapter II. It is the defining document for the high level science requirements for ALMA. The implications of these requirements on the instrumental hardware, software, and operations (including calibration) plan are to be laid out in separate documents. The Science Requirements document covers key science experiments to be performed with ALMA, including precision imaging of normal galaxies at high redshift, the gas kinematics in protostars and protoplanetary disks around young Sun-like stars. It then shows how accomplishing these key science elements results in requirements on various parts of the complex ALMA design.

Design Reference Science Plan

The Design Reference Science Plan attracted over 113 proposals from 75 scientists. The results were collected into web-accessible format, and also placed into a worksheet format for easy statistical study. Pseudo-proposals were collected for 4 themes and 21 sub-themes from the ESO proposal and from topics addressed at the 1999 ALMA Conference in Washington. The Plan can be used to:

- allow cross-checking of the ALMA specifications against "real" experiments
- allow a first look at the time distribution for
    - configurations
    - frequencies
    - experimental difficulty (fraction of projects that are pushing ALMA specs)
- start developing observing strategies
- derive "use-cases" for the Computing IPT

In addition, the pseudo-proposal process, which used a JAVA-based exposure time calculator at ESO, provided a learning experience for the community on how to use ALMA and what it can and cannot do in practice. Some new projects were submitted, which help to update and amplify the ALMA science case. Additionally, by reminding them of why ALMA is being built, it provided some fun for Science IPT members.

At present, the proposals are undergoing review by ASAC members. The DRSP is due for release to the project for a 15 October Milestone.

Some conclusions may already be drawn from the tabulation to date:

- Overall distribution over receiver bands reasonably consistent with weather statistics
- Fraction of continuum-only programs varies per receiver band and theme: Band 6 pre-dominantly line; Band 7 and 9 large fraction continuum
- Fraction of proposals which require total power continuum >10%
- Fraction of proposals which require baselines of at least 1 km: 50-60% (with peak around 0.1-0.2")

Configuration

The main activity in this quarter was in making a final design for the reconfiguration logic for those configurations using the inner 172 pads. This reconfiguration logic defines how antennas are moved between pads; or alternatively how the pads are occupied in any given configuration.

Two reconfiguration sequences have been produced; one to be used when the array starts in its most compact array and is expanding outward, the other when the array is being reconfigured inward. The former reconfiguration sequence is optimized for observations of sources which have high elevation (i.e. for declination -55 to +15). In contrast for the inward reconfiguration sequence the pad occupation scheme of the smaller sized arrays is optimized to reduce the impact of shadowing for observations of far North or South sources. In these modified configurations the occupation pattern of pads is stretched North-South to both reduce shadowing and give a closer to circular beam for observations of sources at these high and low declinations. For the larger sized arrays, where shadowing is not a problem, simulations have shown that re-weighting the data can give close to a circular beam for losses of order only 10% in sensitivity - hence for these larger arrays the inward occupation scheme is chosen to be similar to the outward scheme. The reconfiguration schemes also make provision for the cases of a variable number of antennas (between 60 and 64) in the array. An example set of moves is shown in Figure 2.

A detailed description of the design philosophy adopted and the reconfiguration schemes themselves is given in submitted document ALMA-90.02.00.00-003-A-SPE.

Holdaway finished Specifications and Requirements for the Long Baseline (Y+) Array Configuration; see ALMA-90.02.00.00-002-A- SPE Version A. Holdaway also prepared a document which shows the Fourier plane coverage and beam properties for the entire set of Y+ array configurations.

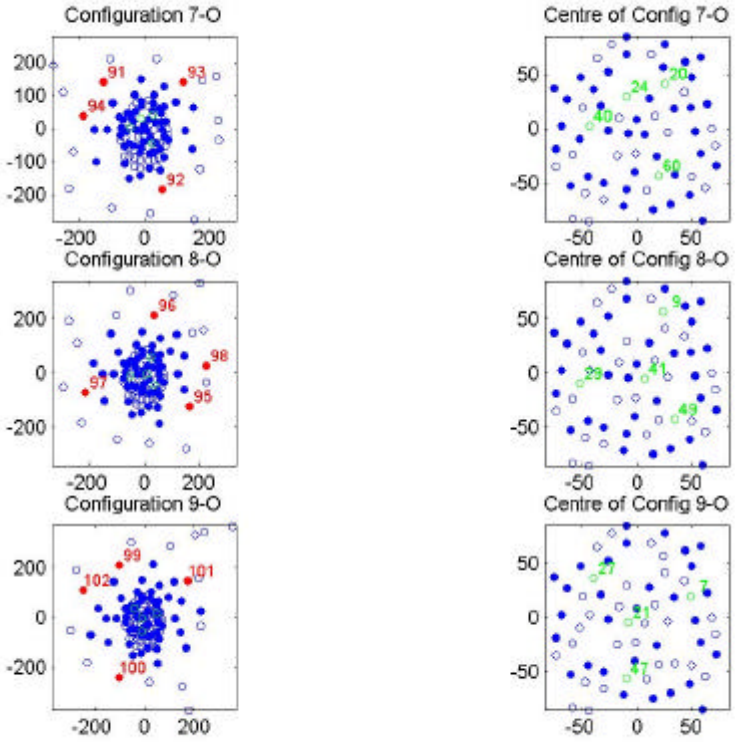


Figure 7 A portion of the outward reconfiguration sequence, showing newly deposited antennas (red) and recently vacated antenna pads (green).

Calibration

The Calibration of ALMA document by Butler, Guilloteau, Holdaway, Wootten and others, outlines the various quantities that will need to be measured or taken into account in order to collect and calibrate ALMA data. The document was submitted to the Project. It is an update of Chapter 3 of the old Project Book, and supersedes it. Traditionally, "calibration" has often been thought of as strictly a post-processing exercise in radio interferometry, essentially only involving things done to data after it has been collected. In this document we take a broader view, and include all things that must be measured *before* correlation of the antenna signals as well. These are still formally "calibrations", since they are measurements of instrumental parameters – they are generally just measured less frequently. They are, however, no less important than the post-processing calibrations. In addition, we address some topics that are not even direct measurements, but are rather things that affect the measurement of our desired quantities. An example is the relativistic deflection of radio waves in the gravitational potential of the sun, which is not really a directly measured or calibrated quantity (except indirectly), but does certainly affect our ability to properly calculate delay, which in turn affects our ability to calibrate, for example, antenna station locations.

Accounting for all of these types of calibrations, measurements and effects is critical for ALMA to achieve its full potential. We must understand what effects must be accounted for, and how we will measure and/or correct for them during the data collection and post-processing. Never before has a radio astronomical instrument been built with such a detailed understanding of the site and its impact on the telescope. With this knowledge in hand, we can optimize the full measurement and calibration strategy to produce the maximum scientific output for ALMA.

In addition to simply describing the different types of calibrations, measurements and effects anticipated for ALMA, we also provide some specifications on the accuracy to which the measured quantities must be determined or effects must be accounted for.

During the next month, the ALMA Calibration Plan, a more complete treatment which will include description of the techniques, with references if available how often the calibration observation(s) need(s) to be performed; and whether this is a function of frequency; how long it takes to do the calibration observation(s) and whether this is a function of frequency; what quantities need to be archived (and at what rate), and what further tests and/or studies are needed.

As contribution to the discussions on the Science Requirements and System Design documents, Hills made estimates of the sensitivity to path length fluctuations that can be expected from the water vapor radiometers. Also in MRAO Cambridge, recruitment of a new Science IPT member to work principally on issues relating to phase calibration with Richer and Hills, has been successfully completed. Alison Stirling will start work in early October. Work between the MRAO group and the Spanish group on ATM software related to 183 GHz water vapor monitors will begin in November.

Mangum worked at the ALMA test facility much of the month characterizing the pointing of the VertexRSI prototype antenna. With Mangum and Butler, Wootten supplied details of weather monitoring equipment to be installed on production antennas to be included in the Request for Proposals for those antennas.

Site Characterization

The Site Characterization group kept the flow of data from the site coming through the austral winter. A solar power system problem was identified and corrected on the ESO instrumentation, and a problem wind direction sensors was repaired with new sensors and a data logger. The main analytical work has been focused on the determination of the wind power spectrum, on which a memo is presently being produced. Most of the 183 GHz radiometer data has been reanalyzed with an improved algorithm. The control software for the two 183 GHz radiometers has been modified in order to allow them to point in different directions. This will allow us to determine the critical height of the turbulent layer without having to depend on wind speed data..

ALMA Memo No. 470 was published, reporting a radio frequency interference survey covering 10 MHz – 18 GHz which was conducted at Chajnantor, Chile on 2002

December 6 – 9. The survey provides a “snapshot” view of existing RF activity in the area. The detected signals fell into these categories: noise from nearby electronic equipment, broadcast TV and FM radio, and terrestrial and satellite radio services.
ALMA Memo No 471 was also published. The memo, “Site Properties and Stringency” contains the ASAC working group's response to a charge from the ACC to ‘evaluate all available site (225 GHz opacity, 12 GHz phase stability, 350 micron and >1 THz) data for Chajnantor, and to discuss any significant trends and issues which may impact the scientific mission, design or mission emphasis of the baseline instrument.’

Imaging

A telecon on the subject of gain stability was held in July with members of the Science and Front End IPTs in attendance. At this telecon, results on measurements with pre-prototype ALMA receivers were exchanged with the Science IPT for use in simulations.

Hills circulated a note on the issue of total power stability, making a number of suggestions about scanning strategies and possible courses of action in the event that the proposed requirement of 1 part in 10^4 in one second cannot be met.

Mark Holdaway performed detailed numerical simulations of ALMA total power continuum observations. These simulations dealt with a range of On-The-Fly (OTF) and Beam Switching (BS) observing strategies with realistic antenna and subreflector motion, and included issues such as the range of observing frequencies (bands 1-10), a realistic distribution of variable atmospheric emission which is based on the site testing data, and 1/f-type gain errors. For the first time, our simulations sought to choose observing conditions using the joint probability distribution of opacity and stability. Using this, we matched the conditions to the observing frequencies, and found that the atmospheric stability accommodates the full complement of observing bands -- in other words, the atmosphere above Chajnantor will usually not add appreciable noise beyond the thermal noise. OTF is the favored method, being superior to BS in all but the most compact sources. 1/f noise at the level of 1×10^{-4} in 1 second will result in noise comparable to the thermal noise, thereby increasing the noise level by as much as 50%. However, if the proposed 1/f noise spec of 1.5×10^{-3} in 1 second is used, this increases the noise level by a factor of about 15. While this noise will average down like sqrt(N), such a large noise increase will clearly be detrimental to ALMA's ability to make conintuum observations of sources larger than the primary beam. This study was forwarded to the ASAC to aid in their consideration of a charge from the board on ALMA’s amplitude stability.

Pety continued to help our Japanese colleagues in using the IRAM interferometric simulator with the goal to precise the design of ACA.

Organization, interaction with other IPTs

A monthly telecon continues for the whole Science IPT, and there is a weekly telecon of the NA Science Team. Topics under intense discussion continue to center on the calibration plan, discussed in several telecons of the Calibration Group. In addition,

several discussions on Operations and on imaging, particularly with respect to amplitude stability, were held.

During August, the Science IPT supported the LO Group in further tests of the prototype ALMA 'conventional LO' in Green Bank, West Virginia. The Green Bank Telescope Spectrometer provided the back end and was found to dominate amplitude stability in the system.

Meetings, Outreach and Public Education

Anne Dutrey presented a talk "Science with ALMA" at the "long baseline interferometry in mid-IR" workshop held in Ringberg Castle on September 5. Wootten made ALMA presentations at the University of Texas at Austin, and to the ANASAC and ASAC face-to-face meetings. van Dishoeck addressed a meeting of chemists in Dijon.

Concerns

During this period the Science IPT lost some of its most productive members. Stephane Guilloteau left the project at the beginning of July, though he continues occasional participation in email discussions. Aurore Bacmann and Bryan Butler left at the end of the period. Bacmann will continue to contribute to the Science IPT at a reduced level from her new position in Bordeaux. A search has begun for a successor to Butler.

Acronym Definitions

ABM	ALMA Bus Master
ACA	Atacama Compact Array
ACE	Alcatel/Costamasnaga/EIE
ACS	ALMA Common Software
ACU	Antenna Control Unit
AEG	Antenna Evaluation Group
AEWG	Antenna Evaluation Working Group
AIPS++	Astronomical Information Processing System
ALMAEDM	ALMA Electronic Document Manager
AOS	Array Operations Site
ASAC	ALMA Science Advisory Committee
ATF	Antenna Test Facility
BIMA	Berkeley Illinois Maryland Association
BUS	Back Up Structure
CDR	Critical Design Review
CFRP	Carbon Fiber Reinforced Plastic
CSIC	Consejo Superior de Investigacion Cientificas
CVS	Concurrent Version System
DC	Direct Current
DSB	Double Side Band
DTS	Data Transmission System
EAB	European ALMA Board
ESAC	European Scientific Advisory Committee
ESO	European Southern Observatory
FE	Front End
FEIC	Front End Integration Center
FIR	Finite Impulse Response
FPGA	Field Programmable Gate Array
FO	Fiber Optics
FTE	Full Time Equivalent
FTS	Fourier Transform Spectrometer
HIA	Herzberg Insititute of Astrophysics
ICD	Interface Control Document
IF	Intermediate Frequency
IPT	Integrated Product Team
IRAM	Institut Radio Astronomie Millimetrique
JAO	Joint ALMA Office
JBO	Jodrell Bank Observatory
LO	Local Oscillator
LORR	Local Oscillator Reference Receiver
LTA	Long Term Accumulator
LVDS	Low Voltage Digital Signal
MMIC	Millimeter Integrated Circuit

MRAO	Mullard Radio Astronomy Observatory
NAOJ	National Astronomical Observatory of Japan
NOVA	Netherlands Research School for Astronomy
NRAO	National Radio Astronomy Observatory
OAN	Observatorio Astronomico Nacional
OSF	Operations Support Facility
OVRO	Owens Valley Radio Observatory
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PTC	PoinTing Computer
RAL	Rutherford Appleton Laboratory
RF	Radio Frequency
SE&I	System Engineering and Integration
SIS	Superconducting Insulator Superconducting
SRON	Space Research Organization Netherlands
SSR	Scientific Software Requirements
XML	Extended Markup Language
YO	Yebes Observatory
2GC	2nd Generation Correlator