Atacama Large Millimeter Array

Quarterly Report

For the Period Ending
31 December 2002

Submitted to the ALMA Coordinating Committee
For the Joint ALMA Office
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Contents

Executive Summary

The JAO:

- continued to maintain contact with ALMA work sites, participated in the workshops conducted by the Front End, Back End, and Site IPTs, and worked to strengthen System Engineering and the general organization of the Project;
- organized joint ALMA Safety and Public Relations teams, each charged with the production of a plan by end of the first quarter 2003;
- negotiated with the Chilean government for access to the ALMA site and permissions required to build and operate ALMA;
- met with representatives of the NOAJ to make a technical assessment of the proposal for participation in ALMA by Japan;
- began studying the options for locating the ALMA Central Offices in Santiago and the process for selecting a location;
- held internal discussions on antenna procurement strategies.

Significant Activities of the Project:

- The European Project Office evaluated responses to their call for proposals on Phase 2 work packages;
- The ESO Council ALMA Working Group submitted a positive report to the ESO Council;
- The European ALMA Board held its first meeting;
- ESO Council met and authorized the Director General to sign the NSF-ESO bilateral agreement;
- The NRAO Director held a review of ALMA Front End activities at the NRAO;
- The North American Project Office made a number of new appointments and acquired new quarters in Charlottesville;
- The Site IPT held a site requirements workshop, prepared material for tendering two major contracts, and installed position markers for 172 antenna foundations;
- The Antenna IPT monitored the contracts for the prototype antennas, reporting good progress with both, although additional small delays have occurred;
- The Front End IPT held a workshop to discuss outstanding issues and set a process for definition of specifications and interfaces, and reports progress on development of components, the cryostat, and prototype antenna test facility;
- The Back End IPT held a workshop with the Front End IPT to discuss Local Oscillator issues and set a process for definition of specification and interfaces, with good progress on the development of components and subsystems;
- The Correlator IPT has met its goals for the this quarter and has proposed a potential enhancement for the baseline correlator that meets some of the goals of the second generation correlator;
- The Computing IPT conducted an audit of AIPS++ and held a workshop to prepare for a computing PDR;
- The System Engineering IPT acquired new leadership and filled open positions;
- The Science IPT concluded studies for the ALMA configuration and made good progress on array calibration, site characterization, and community relations.

1. Activities of the Joint ALMA Office

1.1 Project Management and Organization

1.1.1 The Management Team continued to hold weekly teleconferences during this quarter, with all IPT Leads joining the Management Team in a separate teleconference every other week. Members of the ALMA Coordinating Committee (ACC) have been issued passwords to the ALMA Electronic Document Manager (ALMAEDM). Planning has begun for "ALMA Week" in late March, a meeting where the entire Project can meet face to face.

1.1.2 Project Plan

The Project Plan was approved by the ACC at their October meeting with the understanding that certain changes would be made in the next version. The current approved version, dated xxxxx, has been posted to ALMAEDM […]. A draft of the next version has begun, reflecting the changes requested by the ACC and all the editorial suggestions received from ACC members. It will be presented for approval at the February meeting of the ACC.

1.1.3 Visits to Work Sites

The visits to ALMA work sites by the JAO were largely to NRAO this quarter, in connection with scheduled meetings. Next quarter we plan to visit HIA, OSO, JBO, and the MPIfR, as well as any sites where a visit might facilitate the contract negotiations with ESO for front end development work.

1.1.4 Safety

A joint ALMA Safety Committee has been appointed to develop an ALMA Safety Plan. The team consists of J. Bolyard, S. Radford, and B. Porter from NRAO, and M. Boecker, J. Eschwey, and U. Varas from ESO. The committee is chaired by M. Boecker. They are to report with a draft plan in February 2003.

1.1.5 Public Relations

A joint public relations team consisting of R. West and C. Madsen from ESO, and L. Shapiro, C. Blue, and D. Finley from NRAO has begun meeting regularly by teleconference to construct an ALMA Public Relations Plan. In addition, work has begun on specific tasks, NRAO taking the lead for a new ALMA brochure and drafting the plan for the ALMA web site, and ESO taking the lead for a new ALMA video and drafting the overall Public Relations Plan. Both teams are working to generate candidates for an ALMA logo. The group is chaired by C. Madsen.

1.2 Chile Issues

1.2.1 Negotiations with the Government

During the past quarter the Director had z meetings with C. Barros, Undersecretary of Foreign Affairs. Negotiations have proceeded to the point where there is agreement on the funds expected annually for the total of the rent for the land, the development of astronomy in Chile (CONICYT), and support of cultural/educational activities in the local communities (Region II). The procedure whereby ESO obtains permission to open another observing site remains to be concluded.

1.2.3 Location of the ALMA Central Offices in Santiago

Two offers of land for the ALMA Central Offices have been made, orally, at the last meeting of the ACC. The first was made by L. Bronfman, U. Chile, who offered land on Cerro Calan at no charge for a period of fifty years. The second was made by C. Cesarsky, Director General of ESO, who offered land at the site of ESO – Vitacura.

The ACC asked that the JAO study these possibilities and any others that may be made, including construction on another site and renting commercial office space. The JAO plans to report to the ACC at their meeting in February, both information learned and a proposed selection process.

1.2.4 ALMA Site Access Road Issues

Two issues have arisen with respect to the access road to be constructed from Route 23 to the OSF and thence to the ALMA site. First, the land for the road was requested from Bienes Nationales as part of the land concession for ALMA. It turns out that the first three kilometers of this route cross a Nature Reserve that borders the Salar de Atacama. Bienes Nationales is reluctant to remove this land from the Reserve and give it to ALMA, as this requires a public decree that projects a bad image for all involved. We have agreed to an alternative. The land concession for the road will only extend from the high site to the OSF. From that point to Route 23, ALMA will have a right of way (easement) over the Nature Reserve. We have been assured by Bienes Nationales and our own attorneys that this alternative is as secure as a concession.

Second, when the Executives obtained exploratory mining rights for the land needed for the access road, it was discovered that a mining firm had underlying claims for a portion of the route. Geological surface studies done by the firm at ALMA's expense demonstrate that it is highly unlikely economically recoverable copper lies under the surface. The mining firm would like to make test soil borings before giving up their claims in favor of ALMA, these borings to be ALMA's expense. We have refused, based the opinion of our geologist, one of the most distinguished in Chile, that there is little or no likelihood that copper is present. We expect the mining company may make a boring or two on its own in the near future and abandon the claims rather than continue the expense of maintaining them.

1.3 Interactions with the National Astronomical Observatory of Japan (NAOJ)

The Management Team has met with representatives of the NAOJ on three occasions: in Tucson, October 20; in Charlottesville, November 20; and by video conference on December 16. There has been gradual progress in these meetings in several areas: learning the priorities of the NAOJ while re-stating those of ALMA, identifying potential areas of negative impact on the baseline project of schedules proposed by Japan for their deliverables, and communicating the need for realistic costs and schedules. The NAOJ plans to deliver the "more detailed" proposal for Japanese participation in ALMA that was requested by the ACC at the meeting of the Expanded ALMA Coordinating Committee in Garching, September 18, by the end of the year, at least in draft form.

1.4 JAO Goals

1.4.1 Report on Goals for the This Period:

- *Define the requirements for the site.*

The Site IPT held a two-day workshop October 22-24 at which all relevant IPTs presented their site requirements. These requirements were then analysed by the Site IPT, and reviewed and clarified by the Management Team December 9-10. The Project is on-track to complete this process in the first quarter of 2003.

- *Conclude negotiations with Chile.*

The goal of concluding negotiations with Chile was met, but that is not the end of the process. Documents remain to be signed, the concession decree issued, the processes to grant ESO permission to open a new observing site and to review the Environmental Impact Study concluded, and the corporation to hold the concession formed, all goals for the first quarter of 2003.

- *Continue to develop antenna procurement strategy.*

The Project Manager worked with the Antenna IPT leadership and the project managers for the Executives to develop an antenna procurement strategy. The thinking is sufficiently well-developed to discuss the issues in general terms with the Executives and AMAC. A goal for the next quarter is to have a plan that can be presented to the ACC at their February meeting.

- *Develop a front-end production plan.*

Meetings were held in mid-November with the Front End IPT, and with the Back End IPT for issues related to the Front Ends, to set in motion a process to fix open issues and define interfaces. Once this is finished, a production plan can be constructed. The concept of a mini-series of eight front ends for initial production is now an accepted part of the plan, allowing the Project to meet the milestone for interim observing. All questions are being answered with an eye toward production. This work will continue in the first quarter of 2003.

- *Bolster systems engineering.*

There have been several hires in the System Engineering IPT as well as the appointment of a new leadership for the IPT. In addition, there have been hires of subsystem engineers in the Front End IPT.

- *Begin costing of proposed Japanese enhancements.*

This activity was begun in December, with the goal of reporting to the ACC Japan Negotiating Team well before the February meeting of the ACC.

1.4.2 Goals for the Next Period:

- Complete the definition of site requirements.

- Sign the agreements with the Comision Nacional de Investigacion Cientifica Y Tecnologica and Region II, enabling the land concession to take effect, that is, the contract to be signed between Bienes Nationales and the Chilean corporation (still to be formed) formed to accept the land concession, and complete the environment impact study process.

- Develop an antenna procurement strategy that can be discussed in broad outline with the ALMA Management Advisory Committee and refined for a detailed discussion with the Executives before presentation to the ALMA Board on February 24-25, 2003.

- Continue the current process of defining and fixing interfaces in the Front End and Local Oscillator (LO) subsystems, and construct a plan for receiver production.

- Construct the first draft of the ALMA Safety Plan.

- Develop an ALMA Public Relations Plan.

- Continue to support the ALMA Coordinating Committee (ACC) Japan Negotiating Team with technical advice.

2. Project Report

2.1 Management

2.1.1 European Project Office

In response to the Call for Proposals for European Phase 2 front end and back end subsystem work packages issued on 9 August, the European Southern Observatory (ESO) received 12 firm proposals for 10 development work packages and 15 preliminary proposals for 13 production work packages by the deadline of October 11. In most cases, only the organizations performing Phase 1 design and development proposed for the Phase 2 work. Two technical review panels were formed to evaluate the proposals. The front end panel members were: R. Blundell (CfA), C. Cunningham (HIA), H. Rudolf (ESO), A. Russell (UKATC), J. Kooi (CIT), and G.H. Tan (ESO). The back end panel members were: R. Bachiller (OAN), J. Cernicharo (IEM), M. Girard (CESR), R. Hills (MRAO), R. Sramek (NRAO), and G. Tofani (U. Bologna). The review panels met at ESO on November 4-7 for presentations followed by questions and answers by all proposing teams. Both review panels completed their evaluations and submitted a report to the European Project Office (EPO). Further discussions between the EPO and the proposing teams are underway to reach mutually agreed statements of work and prices. The goal was to complete these negotiations in time to obtain approval to proceed with contract awards at the ESO Finance Committee meeting of 4-5 December. This was only achieved for one of the 10 development proposals. The revised goal is to complete negotiations in January 2003 and prepare the approval packages for a special meeting of the ESO Finance Committee in February-March 2003. Subsequent contract awards should be completed in the first quarter 2003.

The ESO Council ALMA Working Group held its second and final meeting on 14 October. The Group submitted its report to ESO Council on 1 November. The final recommendation was:

"The Group unanimously recommends that Council proceed with Phase 2 of ALMA according to the collaborative structure established through the Bilateral Agreement, the current plans and projections described in the ALMA Project Plan, as presented to Council in July 2002 and subsequently updated. It recommends the establishment by Associated Universities, Inc. (AUI) and ESO of a Chilean limited liability company to provide services under contract to AUI/ESO and employ the local staff under normal Chilean law."

The European ALMA Board (EAB), established by the ESO Council in July 2002, held its first meeting on November 11. The main purposes were to organize the EAB, to receive reports from the project, and recommend nominees for the European positions on the ALMA Board to ESO Council. The members of the EAB are:

- A. Freytag — President of Council, Chair
- C. Cesarsky — Director General
- M. Steinacher — Finance Committee Chairman

• to be announced	Belgium
• H. Jorgensen	Denmark
• L. Vigroux	France
• M. Metzger	Germany
• G. Tofani	Italy
• J. Bezemer	Netherlands
• T. Lago	Portugal
• C. Fransson	Sweden
• S. Lilly	Switzerland
• G. Gilmore	United Kingdom
• J. Cernicharo	Spain

At its meeting on December 4-5, the ESO Finance Committee recommended that Council approve the 2003 budget as submitted by the ESO management. The funding for ALMA included in the ESO budget and updated Long Range Plan (2003-2007) is in accordance with the funding projections for the European project contained in the current version (18 November 2002) of the ALMA Project Plan.

ESO Council met on December 17-18 and considered the following items regarding ALMA:

- Report of the Council ALMA Working Group
- ESO-Spain ALMA Agreement
- ALMA Bilateral Agreement
- Progress Report on the Installation of ALMA in Chile
- European ALMA Board and ALMA Board
- Appointments to the ALMA-Japan Negotiating Team

Council noted the positive recommendation of the ALMA Working Group and the progress towards installation of ALMA in Chile. Regarding the Bilateral Agreement, Council authorized (9 votes in favor and 1 affirmative vote *ad referendum*) the Director General to sign the NSF-ESO Agreement as soon as a signing ceremony with the NSF Director can be organized. To confirm Council's approval, the President of Council has initialed the final draft of the Agreement as transmitted by the NSF.

Noting that the Council of Ministers of the Spanish Government has approved Spain's ALMA budget for 2003-2012, which contributes 7.5% of the European share of Phase 2, Council also authorized the Director General to sign the ESO-Spain ALMA Agreement.

Council appointed Roy Booth and Richard Wade to join the President of Council and the Director General as members of the ALMA Board. The President of Council and the Director General were appointed to the ALMA-Japan Negotiating Team as well.

Finally, Council approved the creation of an ALMA Division at ESO, effective 1 January 2003, with R. Kurz appointed as Head of Division. The division will initially have 12 staff consisting primarily of the ALMA European Project Office and IPT Leads.

As previewed in the last report, H. Rudolf, E. Pangole, and C. Haupt have all started work at ESO and joined the EPO during the reporting period. Interviews with the short list of candidates for European Project Manager were held on December 12, consistent with plans to have the new European Project Manager on board in early 2003.

EPO Goals for the Next Period (1st Quarter 2003)

- EAB, ESO Finance Committee, and JAO approval and subsequent award of European Phase 2 work packages
- Completion of recruitment of European Project Manager
- Selection of European Project Scientist

2.1.2 North American Project Office

The Director of the National Radio Astronomy Observatory (NRAO) convened an internal review of the Front End (FE) activities within NRAO. The two day review covered technical, organizational, and planning aspects of the FE work carried out in Charlottesville and Tucson. A number of actions items were identified to improve efficiency of both the development and production tasks. A prime area of revised planning will be an increased emphasis on commercialization of production tasks.

Richard Sramek, formerly the Back End IPT Lead, has been appointed North American System Engineering IPT Lead replacing Peter Gray. Peter has left NRAO to join the Gemini Project. A search for a new North American Back End IPT Lead has begun. Clint Janes has been appointed (acting) Lead during the search. Clint was formerly head of VLA and EVLA electronics. He will join the ALMA System Engineering IPT full time as soon as a new Back End IPT Lead is in place. This will complete a major restructuring of the North American System Engineering organization. In addition to the personnel mentioned above, the group now includes Larry D'Addario, John Payne, Jeff Zivick, Jeff Mangum, and Stacy Oliver.

The North American Project Office has expanded and moved to a new office suite near the other NRAO facilities in Charlottesville. The move provides additional office space for the Project Office and project visitors (including the JAO). It also allows expansion of the Central Development Lab (CDL) into the space vacated by the current Project Office. It is anticipated that the CDL and the North American Project Office will both move to the enlarged NRAO headquarters when construction of the building addition is completed. Two new administrative positions have been filled and will start work in December. A full time secretary, Janet Bauer, has been hired to support the North American Project Office staff, as well as the JAO when they are in Charlottesville. In addition, an administrative assistant, Janet Lychock, will assist the business manager (Bill Porter) and the ALMA project controller (Richard Simon).

Congressional action on a FY2003 budget has been delayed. Until a budget is passed, funding for the North American portion of ALMA will be authorized by continuing resolutions at a pro rata rate of 95% of the FY2002 funding.

2.2 Site IPT

2.2.1 Main Activities

The infrastructure requirements review meeting was held 22-24 October in Tucson. The review documentation, including questionnaires, replies, and presentations of the individual IPT's, has been placed in ALMAEDM. The management requirement questions were addressed during a meeting in Chile on 9-12 December.

An analysis of the review replies and presentations of the various IPT's was completed.

The ALMA Board visit to Chajnantor on October 31 was organized and hosted.

Work with M3 Engineering, under a letter of intend pending the approval of the contract, is continuing. The initial scope includes the overall master plan, Array Operation Site (AOS) architectural programming, study of correlator cooling options, preliminary antenna station interconnections, road layout, and participation in requirements review.

The initial architectural programs for the technical building and the hangar at the AOS were delivered by M3 and are being reviewed by the Site IPT team in consultation with the other IPT's involved. The initial drafts of the master plan, of the AOS road layout, and of the correlator cooling study were also delivered by M3, and were presented during the management requirement clarification meeting in Santiago on December 10.

Assistance was provided for the visit of Bienes Nacionales and Estudio de Impacto Ambiental, Chilean government agencies, on October 8-10. Environmental Impact Study questions and replies have been reviewed and comments were returned to the JAO.

The preparation of the tender documentation for a major contract was completed during this period and that for another is expected to be completed in the next quarter:

1. The design, engineering, and preparation of construction documentation for the ALMA access road from the intersection of the road from San Pedro de Atacama to Toconao (C23) to the Operation Support Facility (OSF) and from the OSF to the to the Array Operation Site (AOS) has been completed. The tender documents were sent out by ESO Santiago to local Chilean contractors on December 4. Tender closing will be in January 2003 and provisional acceptance of the completed documentation is scheduled to be 16 July 2003.

2. Preparation for the architectural, design, and engineering services contract for the OSF is being continued, based on the completed requirement definitions.

The remaining documentation of the aerial photographic survey of the access road and the AOS site area has been received from Aerotop. The documentation has been clarified during a meeting with Aerotop on November 16.

The first meeting of the ALMA safety committee in Chile, including visits to the ALMA site and to the Collahuasi Mine, near Iquique in the North of Chile (over 4,500 m altitude), was organized, attended, and hosted.

The antenna configuration layout and associated report was received on November 27. A local surveyor was contracted and has installed position markers at 172 antenna foundation locations, including the array center (see Figure 1). Project benchmarks and reference points have also been installed.

A spectrum survey of the site was made from MHz to 20 GHz by the NRAO Green Bank spectrum coordination team. The equipment used can be seen in Figure 2.

Figure 1 - Surveyor working at ALMA site.

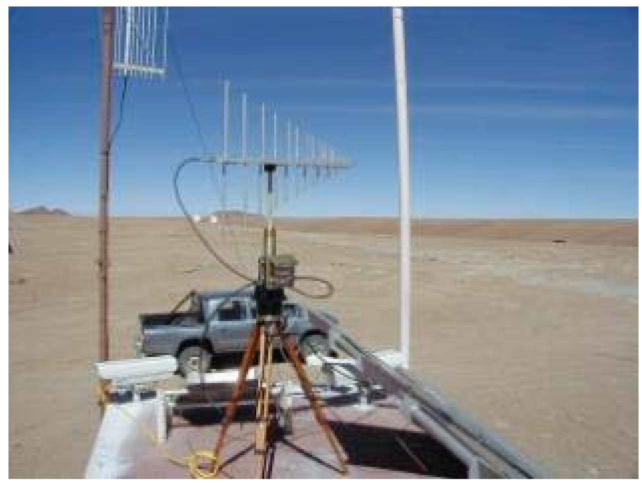

Figure 2 - Equipment for spectrum survey.

Cost estimates for the geotechnical studies for the center cluster of antenna foundations (both down and cross-hole investigations) have been requested and received from local Chilean contractors.

The power study was extended to include aspects pertaining to the entire project. In particular, the feasibility of the connection of the power station to the local gas pipe line in San Pedro de Atacama will be studied.

2.2.2 Concerns

Obtaining access to the land on 1 January 2003.

The length of time that would, be required for the incorporation of Japanese requirements into the current site design/engineering process, should Japan participate in ALMA.

2.2.3 Goals for the Next Period and Beyond

Item	Date
Construction of the project benchmarks and reference points at the AOS	1Q2003
Remaining requirement co-ordination and clarifications	1Q2003
Contracting and proceeding with the work for the design/engineering of the Access Road and the architectural design/engineering of the OSF	1, 2, 3Q2003
Tendering, contracting, and construction of the construction access to the OSF and the AOS as part of the ALMA Access Road	1, 2, 3Q2003
Tendering, contracting, and construction of the ALMA Access Road to OSF and AOS	2004 and beyond
Design, tendering, contracting, and construction of the temporary ALMA Camp at the OSF	1 & 2Q2003
Contracting and proceeding with the work for the soil mechanical investigations for the antenna foundations at the array center	1 & 2Q2003
Continued interaction with M3 Engineering for design/engineering of the AOS facilities	1, 2, & 3Q2003
Tendering contracting and implementation of the ALMA permanent power supply	2Q2003 and beyond
Tendering and construction start of the AOS Facilities	2 & 3Q2003
Tendering and construction of phase I of the OSF Facilities	2 & 3Q2003
Final evaluation of the ALMA project power study and decision of how to proceed	2Q2003
Tendering of the power supply for the ALMA project	3Q2003
Design Reviews for the AOS facilities	1 & 2Q2003

2.3 Antenna IPT

The Antenna IPT is focused on working with the Contractors to deliver the antennas as soon as possible to minimize delays to the project. This is and will be a significant challenge since the current antenna schedules have very little margin. Several other significant time critical tasks, as described below, are being pursued in parallel at this time but at a lower priority. Solid progress is being made in all areas. The Antenna IPT is working on having common contract verification and acceptance test documents that will be very similar for both antennas, where possible. The entire Antenna IPT will participate in the contract verification and acceptance testing of both antennas.

2.3.1 Alcatel EIE Consortium (AEC) Prototype Antenna

In this quarter the AEC concentrated mainly on the advancement of production by pursuing the procurement of all antenna subsystems, strongly advancing the production of the cabin and the Back-up Structure (BUS), and completing the pre-assembly in Europe of the antenna mount, now in shipment to the ATF in New Mexico.

A decision about the coating of the reflector panels has been taken with the selection of a Rhodium coating. This is the easiest coating to apply to the replicated Nickel panel, has good scattering and thermal performance, and has the required durability for the operating conditions of Chajnantor.

A meeting was held at the Very Large Array (VLA) site together with NRAO to familiarize the AEC with the rules and conditions in force and to discuss issues of safety. The AEC is working to provide the required information, for example, an on-site safety plan.

The paper work for the import of the antenna into the United States has been done in close collaboration of ESO and the AEC, with support from NRAO. A duty free import application has been filed.

The antenna steel structure was completely manufactured and pre-assembled at the Galbiati plant in northern Italy. The assembly included the base, the azimuth bearing, the yoke, and the yoke arms up to the elevation boxes. In addition, various parts and subsystems, like azimuth cables wrap, azimuth direct drive (magnets), and azimuth brake rings were mounted and aligned in the system. A delay of some days was encountered when tests of the azimuth bearing showed stiffness inferior to the specification. The problem was tackled with direct intervention of the bearing manufacturer who exchanged the rollers for a new set of larger diameter, without dismounting the structure. Friction was then tested and found within specification. The structure has been disassembled and moved to Genoa for shipment on December 19.

Major progress was made on the carbon fiber reinforced plastic (CFRP) cabin. The two halves were joined together and roof, with the reference receiver flange installed. The next operation will be the installation of motor segments on the outside perimeter, after which all the cabin interfaces will be machined. The assembly operation, taking longer than anticipated, will push the completion of machining to January 2003.

Figure 3. Mount structure during measurements of alignment with laser tracker.

Excellent progress has been achieved on the BUS. The manufacturing process is adjusted and stable and all sixteen sectors of the BUS have been delivered to the Galbiati factory. Each part undergoes 3-dimensional measuring, preparation, and gluing of interfaces for the joining of the sectors. The various tools, templates and jigs for the assembly of the bus are at the factory. Joining of individual sectors will start, subject to optimisation of the sequence and work load of the teams, to ensure that no gap in time exists during the measuring, gluing, assembling, and curing sequence.

Figure 4. Mount disassembled for packing. Azimuth cable wrap and magnets of the direct drive motor (protected) are mounted inside the base.

Additional analysis work was done on the metrology system, for which all thermal load cases were updated, in collaboration of the Institut Radio Astronomie Millimetrique (IRAM), to take into account the new structure thicknesses and more refined thermal conditions. The effect is a further improvement of the antenna performance and a reduction of the operating ranges of the laser sensors used in the system. Work was also done on the definition of the various interfaces of the system with the mount. The completion of the Critical Design Review data package, including the final error budgets and the refinement of the displacement correlations under wind loads, has shifted to January 2003. Long lead items have been ordered by the AEC on the basis of the results obtained at the Preliminary Design Review (PDR) in October 2002. The system will be integrated directly in Socorro.

All panels are produced and dimensionally controlled. Internal acceptance by the AEC of the last batch occurred on December 10. The panels need to be sealed and coated. Rhodium has been selected for the coating and the tools for the galvanic deposition are ordered. The tests done on the Rhodium coating have shown good performance.

A number of complete adjusters (a pre-series), incorporating the update of design that resulted after the first prototypes tests, were manufactured and are undergoing final tests. Serial production of the long lead items has nevertheless begun. Visual inspection has confirmed the very good quality of these devices.

Figure 5. First angular slice of the BUS ready for assembly.

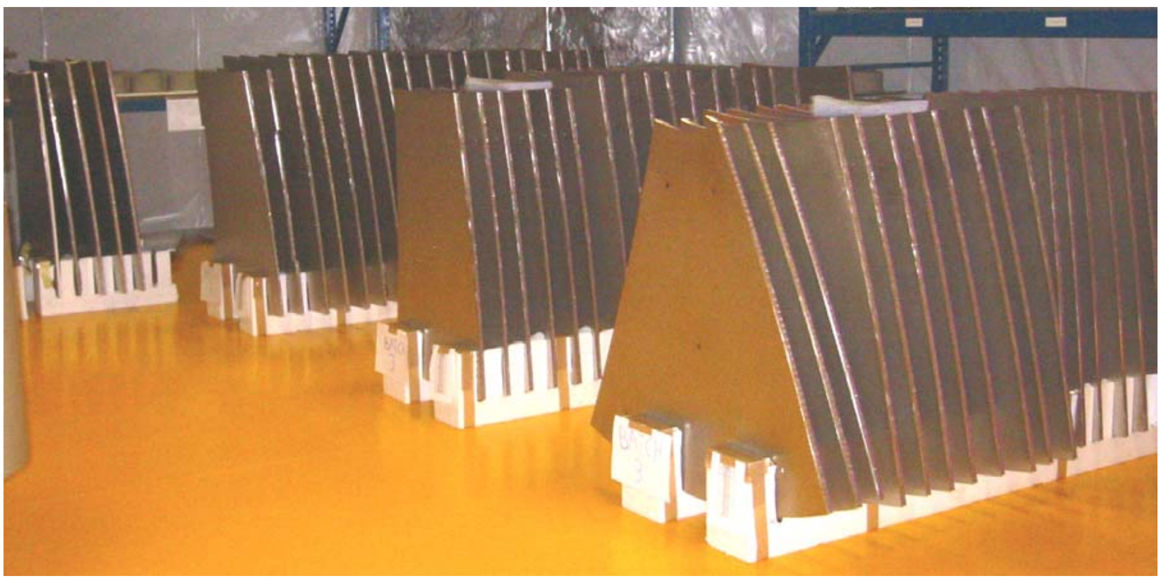

Figure 6. Finished panels in storage ready for coating.

Good progress has been made on the Antenna Control Unit (ACU) and its software. The software is very well advanced, and the ACU has been manufactured. A communication test was done successfully. A closed loop test should also have occurred by this time, with a direct drive motor, although no information is available at the time this report was written.

The shipment of the antenna mount was delayed by 10 days and it is now scheduled to leave Genoa on the December 19, with an estimated arrival at the VLA site before the end of January 2003. The exact date of the arrival on site of the AEC personnel is not yet known.

The plan is to ship the cabin only after it has been trial fitted to the BUS structure. The completion date for this work was delayed to January 2003. If there are positive results on the BUS, it could also be ready before the end of January. This will be confirmed once the assembly of individual BUS slices has started. It is planned that both cabin and BUS will be air shipped with an Antonov cargo airplane.

Work is still on-going on the optimization of the on-site activity schedule. The announced dates of Preliminary Acceptance (AEG-ESO shared access to the antenna) and Provisional Acceptance (final delivery) are now 30 April 2003 and 26 June 2003, respectively. This is a delay of approximately 10 days compared with the contractual milestones.

2.3.2 VertexRSI Prototype Antenna

The VertexRSI prototype antenna is scheduled for delivery to the ALMA project on December 22. The schedule delay is due to the late delivery of panels and an elevation drive motor that was intermittently failing. All panels have been installed and the motor has been replaced with normal elevation drive function. The commissioning of the antenna is in process by the Contractor. Figure 2.5 below shows the panels installed on the antenna. The antenna acceptance test will begin on December 13 and proceed with round the clock testing until December 22.

The ACU, PoinTing Computer (PTC), and ALMA Bus Master (ABM) are all installed on the antenna and have been undergoing interface and system testing. A host of problems have been identified and are being resolved during the routine weekly joint testing. This is the ongoing process of early testing of the interface and operation of the system with the intent to minimize problems during acceptance testing by both parties.

The heating, ventilation, and air-conditioning system is fully installed and has been tested by the Contractor. This system is currently running and operational.

The surface of the antenna was set using photogrammetry to an accuracy of 75 μm rms by the Contractor and Geodetic Services. The contract specification is <100 μm rms. Final setting of the surface will be done by the ALMA team using holography.

Currently, the main activity of the Contractor is the commissioning of the antenna. That includes tuning the servo system and testing of the ACU and PTC. Once this is completed, the acceptance testing and contract verification will begin. It is expected that the challenge will be demonstrating the 2 arc-sec full-sky pointing specification.

Figure 7. The VertexRSI antenna – assembled with panels installed.

2.3.3 Antenna Transporter

On October 24 there was a transporter requirements review in Tucson in conjunction with the site requirements review. This has led to a draft interface control document (ICD) summarizing the requirements of the transporter related to site preparation. An analysis of antenna transport in and out of the compact array was made, and recommendations for the road layout were provided to the configuration group. Vibration issues for transporter and equipment are being studied in collaboration with an external institute. The requirements document for the transporter is complete in draft form.

2.3.4 Optical Pointing Telescope

The optical pointing telescope for the VertexRSI antenna is completed, installed on the antenna, and undergoing final software and system testing in preparation for acceptance testing. Parts have been ordered for the second optical pointing telescope that will be used on the AEC antenna. Construction will begin in January 2003, once several mounting and clearance issue are resolved, with a completion date of 1 April 2003.

2.3.5 Nutating Subreflector

Closed-loop testing is occurring on the nutating subreflector system and embedded software. The system is now ready and available to test in conjunction with the ABM. Tuning of the system will continue through December, with an antenna test to occur at the end of the month. Delivery of the system will occur in January 2003.

2.3.6 Antenna Test Facility Foundations

The AEC foundation contract has been awarded to Cone Construction, the contractor that built the VertexRSI foundation. The AEC foundation is progressing well and expected to be complete by the end of the year. The current progress of this foundation is shown in Figure 2.6. The work remaining is placement of the embedded beam and pouring the top layer of concrete in the foundation.

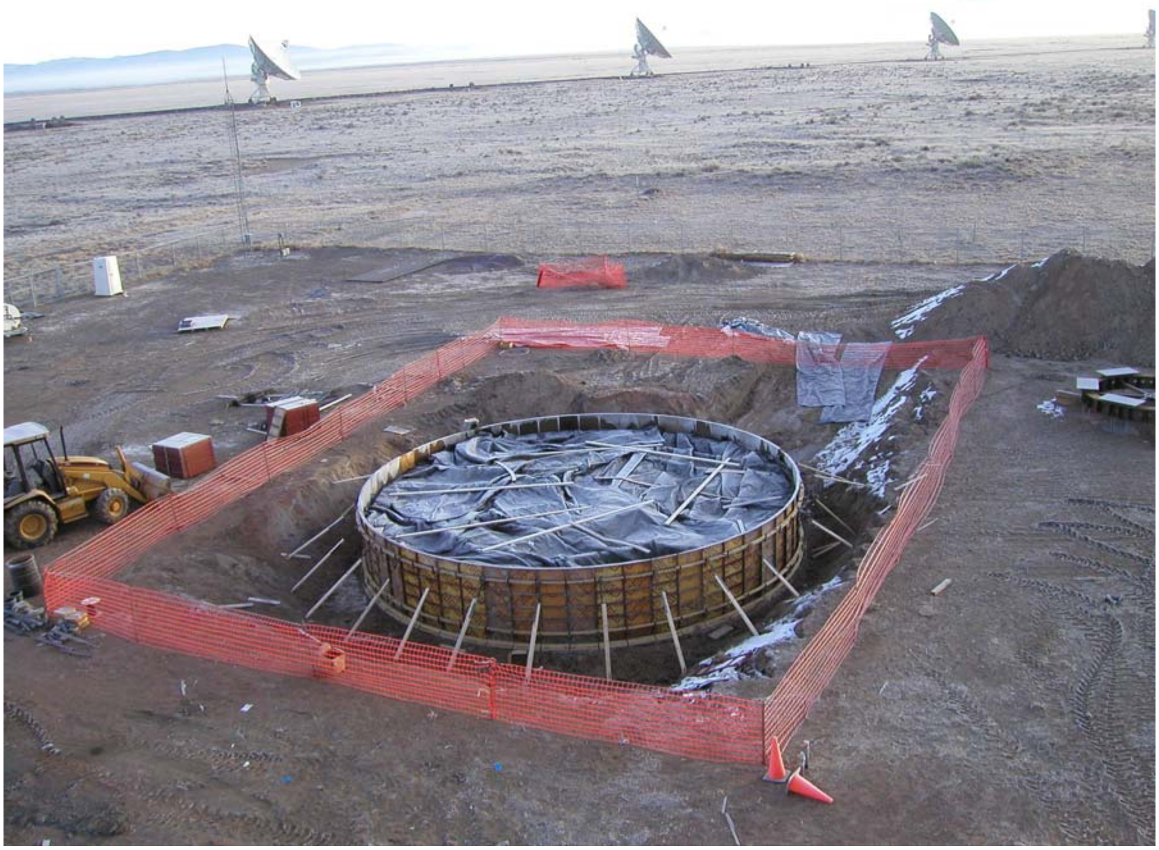

Figure 9. The AEC foundation as of December 6, 2002.

The foundation for the National Astronomical Observatory of Japan (NAOJ) is underway with the piers and a base mat that have been poured. The rebar is just starting to be installed as shown in Figure 2.7. This foundation is scheduled to be completed in early January 2003.

Work has started on a production Antenna/Foundation ICD that can be used by either the VertexRSI or AEC antenna. Analysis will occur over the next month on the feasibility of having a common foundation design that meets the specifications of both antenna designs.

Figure 10. The NAOJ foundation as of December 6, 2002.

2.4 Front End IPT

2.4.1 Management

At the site requirements meeting held in October, the Front End IPT presented its requirements for the OSF. The decision was taken to carry out all receiver maintenance at the OSF, that is, no front-end maintenance will be undertaken at the high site.

In early November, the European responses to the ESO call for proposals for front-end development work-packages were reviewed by the IPT management and an external panel of experts. A total of eight responses were received for the following work-packages:

- ALMA Work Package 4.080: Cryostat Design/Prototype
- ALMA Work Package 4.090: Windows/IR/Common optics Development
- ALMA Work Package 4.115: (Focal Plane) Calibration System Development
- ALMA Work Package 4.170: Band 7 Cartridge Design/Development
- ALMA Work Package 4.190: Band 9 Cartridge Design/Development
- ALMA Work Package 4.210: WVR Cartridge Design/Development

Contract negotiations are being conducted by ESO, based on these proposals. These contract negotiations also address the addition of a pre-production phase, that is, producing a series of eight pre-production units.

At the local oscillator review meeting held in November the parts of the baseline design that are covered by the front-end IPT were presented and discussed. Directly following this meeting, a specifications and requirements meeting was held to review and expand the existing front-end specifications document, "Specifications for the ALMA Front End Assembly", version 2.0, dated 4 May 2001. No major changes were made to the key specifications, but ambiguous specifications were corrected and missing engineering specifications were added, as required. A revised document will be submitted to the project shortly. The meeting also dealt with the internal front-end interface-control documents. These were discussed and assignments for writing draft documents made.

Two front-end sub-system engineers joined the IPT, Hans Rudolf will be located at ESO in Garching and Robert Freund will be located at NRAO, Tucson. These engineers will work closely with the IPT management on front-end system engineering issues.

On-going work	Due date	Progress	Comments
Revised front-end specifications and requirements	1 Jan 2003	On going	
Front-end internal ICD's	13 Dec 2002	On going	Draft only
Performance of cryostat determined	1 Jan 2003	On going	Could extend to February
Prototype cartridge bodies delivered	1 Jan 2003	Complete	
DC bias and monitor and control circuits (for lab tests) delivered	1 Jan 2003	On going	Likely delayed until March, due to ATF work
Local oscillator chains for all four bands delivered	1 Jan 2003	On going	Bands 7 and 9 delayed by multiplier supplier
Cold multiplier performance verified	16 Dec 2002	Complete	Band 6 only
First local oscillator – internal review	19 Nov 2002	Complete	Minutes/action items being complied
Specifications and requirements workshop	21 Nov 2002	Complete	Minutes/action items being compiled
Band 3, 6, 7 and 9 cartridge and test sets design		On going	Level three milestone(s)
Optics and calibration design frozen	2Q 2003	On going	
Integration center design meeting	Jan 2003	Pending	To be scheduled
Front-end design (conceptual)	13 Dec 2002	On going	
ATF – Deliver holography transmitter and receiver	31 Dec 2002	On going	
ATF – Deliver first evaluation receiver	31 Jan 2003	On going	Second receiver follows 12 weeks later

2.4.2 Herzberg Institute of Astrophysics

The Band 3 elemental mixer has been tested at the HIA using a revised experimental setup that allows the use of a cooled feed-horn. Previous tests of this mixer at the NRAO used a warm feed that added excess noise. These experiments show that the noise temperature is improved by about ten degrees.

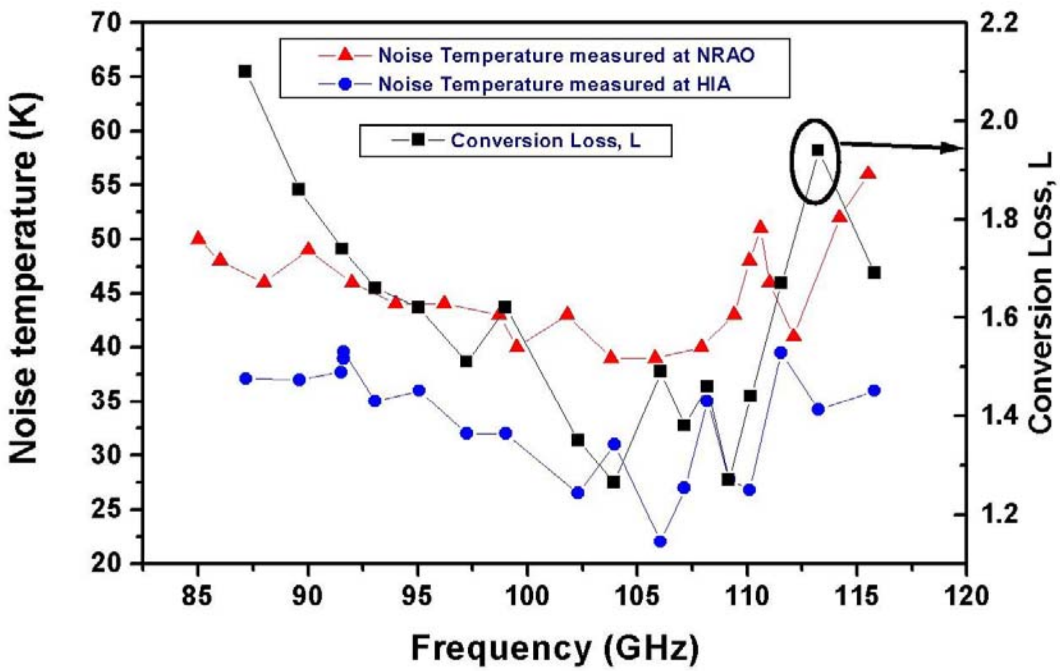

Figure 11. Noise temperature and conversion loss of the Band 3 mixer.

Although the radio frequency (RF) bandwidth appears to be adequate, the noise temperature of ~35K double sideband (DSB) is about twice the specification, and was obtained in a relatively narrow intermediate frequency (IF) bandwidth of 3.5 to 4.5 GHz. A 4-12 GHz low-noise amplifier recently delivered by the NRAO CDL is being tested at 15K and will be installed in this test system. It is expected that this will improve the performance by a few degrees. All aspects of the receiver design are being reviewed in a effort to meet the ALMA performance specifications.

The design of a waveguide quadrature-hybrid has been completed and is being fabricated by a precision machine shop. This will be used to convert two of the elemental mixers described above into a sideband separating mixer. Hybrid components are shown below:

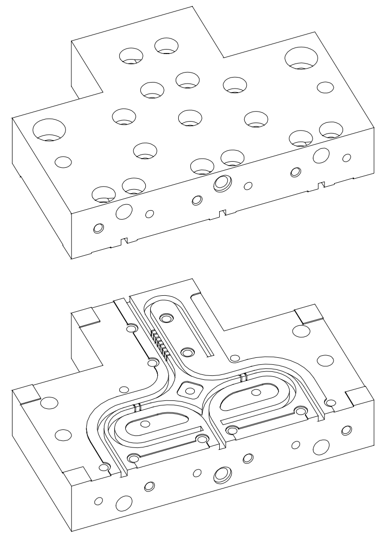

Figure 12. Waveguide quadrature hybrid components.

Work on designing test and measurement equipment continues with the emphasis on finding commercial products that can replace custom-built apparatus and software. A mixer test cryostat that allows simultaneous testing of four devices is under development. Infrastructure changes are being made to allow the use of the Japanese cartridge test cryostats, due to arrive later this month.

2.4.3 NRAO Central Development Laboratory

The optical design for Band 6 has recently been completed and drawings of the feed-horn and cooled mirrors have been sent to commercial manufacturers. The cartridge layout is underway and, as a result, the sideband-separating mixer and amplifier bodies are being redesigned to reduce their size so that they can fit into the cartridge.

A contract for the supply of superconducting-insulator-superconducting (SIS) devices has been signed with the University of Virginia and negotiations for access to TRW InP transistors for low-noise IF amplifiers have been successfully completed. Commercial suppliers for these amplifiers have been identified and detailed design information has been transferred from the CDL to them. Cost estimates are expected from these companies shortly and it is expected that finished amplifiers will be available to all cartridge builders.

Sideband-separating mixer blocks based on the wave-guide approach have been received from the machine-shop and RF tests will start shortly.

The design of test and measurement hardware and software continues and by increasing the use of existing equipment the budget estimate for Band 6 has been reduced.

Pre-prototype local oscillator chains that will assist cartridge groups in their RF tests are being built and are due for delivery at the end of the year. Unfortunately the supply of commercial frequency multipliers for Band 7 and Band 9 remain a concern and the situation is being monitored closely. Thorough testing of a Band 6 frequency multiplier at cryogenic temperatures has been completed with very successful results.

Level Three Milestones and an extensive list of internal interface control documents are being worked on.

2.4.4 NRAO Tucson

The work on the Antenna Test Facility (ATF) instrumentation continues. The holography transmitter and receiver require some further software work and will be delivered to the AFT in early January. One compressor has been delivered to the ATF and another is nearing completion.

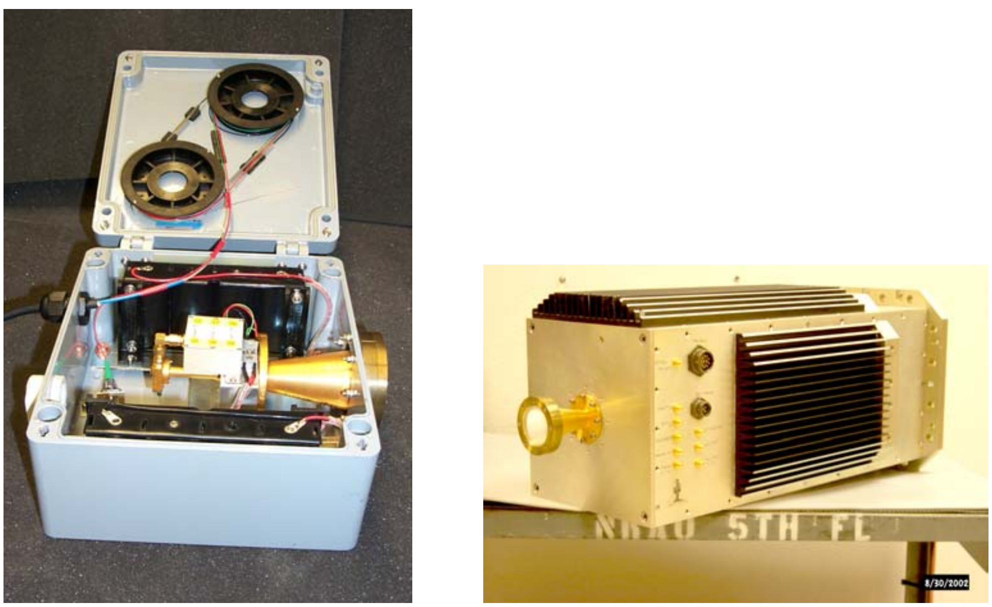

Figure11. Holography transmitter and receiver

As work continued on the two evaluation receivers, problems were encountered with standing-waves in the Band 3 channel causing large ripple in the IF band-pass. This fault was traced to a poorly matched commercial mixer and work is underway to rectify it. Delivery of this receiver to the ATF is scheduled for the end of January although we intend to trial-mount it on the antenna on January 2nd. The continued ATF work remains a serious concern as it impacts the capacity for receiver and integration center design work.

Figure 13. Cryostat compressor and two evaluation receivers.

The Band 6 ortho-mode transducer design has been tested at room temperature and works very well. Four devices were tested and all gave similar results, this is excellent news as this is a critical component of the Band 6 cartridge design. In the future, testing of these devices will be aided by a recently delivered vector network analyzer (50 to 270 GHz) and by a cryostat that will allow cooled measurements.

Figure 14. Vector Network Analyzer

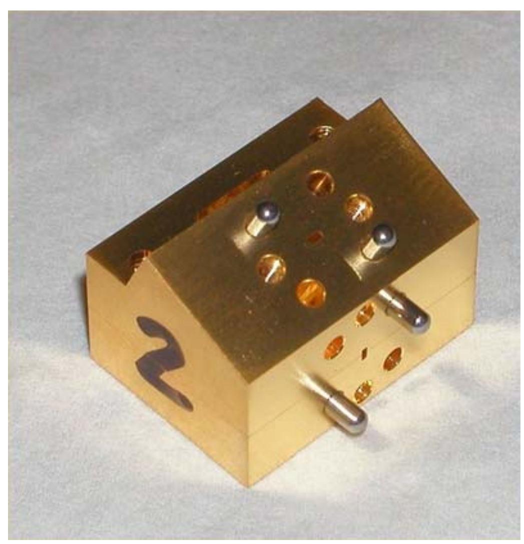

Figure 15. Band 6 Orthomode Transducer

The fabrication and test of monitor&control and direct current (DC) bias circuits will start shortly and will be provided to cartridge manufacturers to assist with their laboratory tests.

Work started on the detailed design of the receiver, concentrating on the overall layout and critical monitor and control and DC bias issues. An extensive list of internal front-end interface control documents are being produced.

2.4.5 Rutherford Appleton Laboratory

Testing of the prototype cryostat continued. Initial analysis of the temperature stability of the cryostat showed that it is better than 10 mK, close to the 2 mK specification.

The cartridges mounted inside the prototype cryostat have been rewired and are awaiting delivery of the final temperature sensors. The cryostat temperature sensors have been fitted. Work on the data acquisition system is underway.

Figure 16. Prototype cryostat under test at Rutherford Appleton Laboratory.

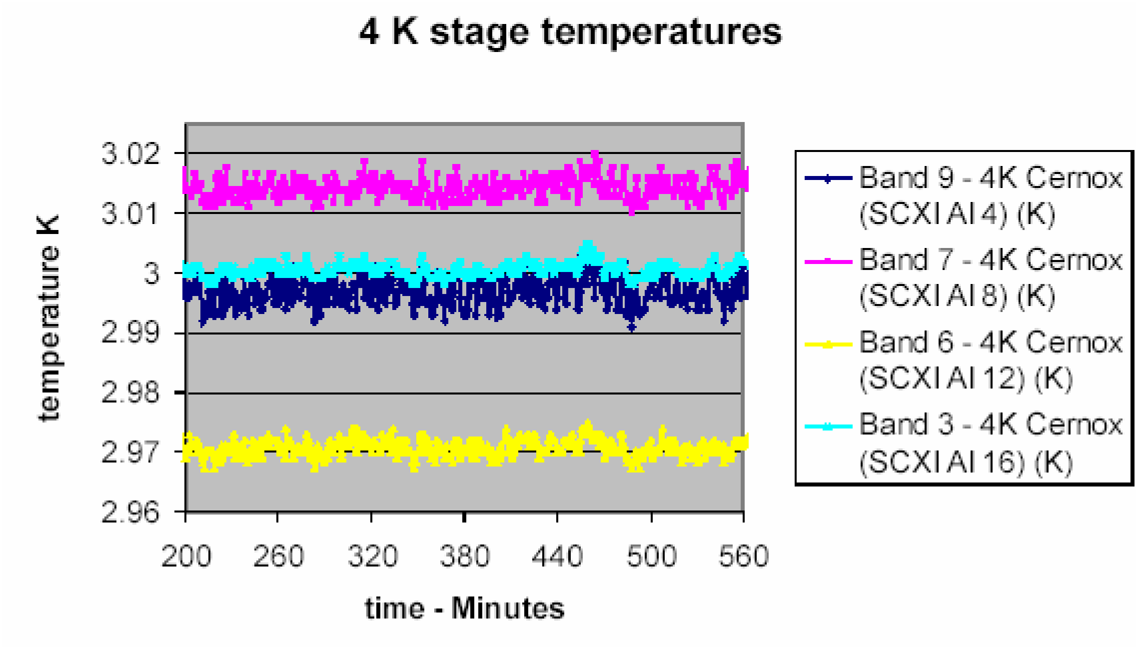

Figure 18. Temperature of the 4 K cryostat stage vs. time.

Rutherford Appleton Laboratory (RAL) agreed with IRAM that the latter would supply plastic windows and prototype infrared (IR) filters by December 2002. These plastic windows will be mounted in the prototype cryostat for leak testing.

Prototype cartridges were shipped to the groups responsible for the four different bands in the first half of November. This was well in advance of the planned delivery deadline, a Level 2 Milestone, which was set for January 2003.

Figure 19. Prototype cartridges in production at Rutherford Appleton Laboratory.

An additional cryostat top plate was manufactured and delivered to IRAM. This top plate will be used to integrate a prototype of the common optics system and the focal plane calibration unit.

2.4.6 Chalmers University

Work at Chalmers University on Band 7 development consisted of the following activities:

DC measurements began of the test SIS junctions that have been fabricated for a scaled Band 7 DSB mixer.

Three components of 4-8 GHz circulators were completely evaluated, in combination with amplifiers, and Chalmers worked with the producer to solve minor problems.

A 100 GHz DSB mixer was installed in the test cryostat, which is now completed, and the unit is awaiting SIS structures.

In October, production of 100 GHz DSB mixers on quartz substrate started (previous test batches were fabricated on glass substrates). These mixer junctions became available in November. They are being tested at DC and we plan to have preliminary results in December at 100GHz;
Modeling was finished and the first (and very successful) scale model measurement was made for a bias tee for the DSB 345 GHz mixer (scaling up the 100 GHz existing design).

Super-thin crystal quartz substrates were evaluated, to be used directly for fabrication of the Band 7 mixer.

2.4.7 IRAM

The Band 7 DSB mixer has noise performance that degrades above 6 GHz (4-8 GHz nominal IF). An analysis of the circuits involved shows that the results are sensitive to the length of the bonding wire which connects the quartz substrate to the Duroid substrate when that length exceeds approx. 400 µm. The masks for the low capacitance mixer chip, version 2, have been received from Du Pont Photomask and production activities are ready to start in IRAM's SIS group. Feed-horns have been fabricated by two different routes. In both cases, the aluminum mandrels were machined by IRAM's workshop, with electroforming made in parallel at IRAM and Waveform Electroforming of the United Kingdom.

A first mechanical design for the 4K Optics/RF Assembly was found to be unsuitable because of tolerance buildup in the assembly. A new study was contracted to an engineering firm. A conceptual design has been accepted that consists of essentially three monolithic parts. A more detailed version of the design has been verified for rigidity by finite element analysis. The third and last stage, preparation of fabrication drawings, is about to start.

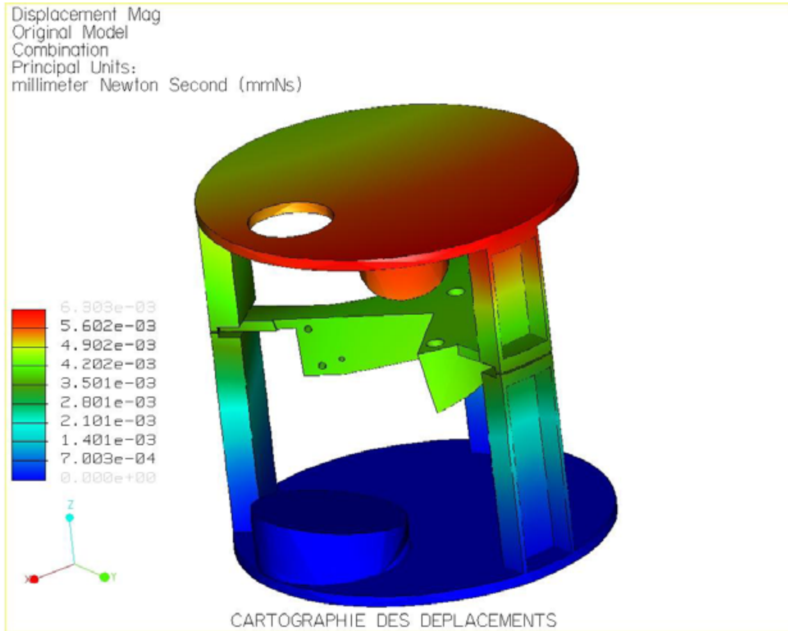

Figure 18. Finite element model of Band 7 cartridge

One wafer of the Design 2 low capacitance chip has been processed by IRAM's SIS group. This is the first such wafer processed. The junction definition and the junction barrier may need to be optimized following this first run. DC measurements are expected in December.

The manufacture of the windows for the prototype cryostat is following the schedule. Windows for the test cryostat have been designed and will be delivered to Japan before the end of 2002.

The IR filters for the prototype and test cryostats are being made and will be delivered in early 2003. A subcontractor has been selected to perform a minimal-cost trial of the molding of plastic, corrugated windows/filters. The aim of this work is to establish a low cost manufacturing method for large quantities of these devices as are necessary for the final series production.

A new optical design for the Band 3 receiver has been made. This design would help the cryostat manufacture by easing the problems of the windows and filters in this band. The design uses a phase corrected horn with a larger waist to allow the horn to be below the level of the 15K shield. Work is still being carried out on the phase correcting horn. Also work is underway to see if the phase correcting horn could be changed with a profiled horn.

Studies are underway for the implementation of the external horns and mirrors of the common optics system. The cryostat front plate has been delivered and inspected at RAL, and will be delivered to IRAM next week.

Work on a transparent vane test system is well underway. This test system will be used on the IRAM Pico Veleta 30m telescope to assess how accurate this calibration method is. This work is done in close collaboration with members of the Science IPT.

2.4.8 SRON

The development with Witec b.v. of an industrial process for diagonal horn fabrication continues. According to Witec, the problem of aligning the waveguide with respect to the reference circle has been solved. Measurements and confirmation at SRON are pending. The quality of the waveguide groove was improved. Witec started a production run of five complete mixers (diagonal horn + backpiece). The goal is to have the production of a complete prototype mixer with diagonal horn demonstrated by end 2002.

Two engineers from IRAM visited SRON to carry out measurements of windows and IR filters across the 650 GHz band, using a NOVA-SRON 650 GHz prototype receiver. Data are being analyzed by IRAM. The NOVA-SRON group prepared the receiver and assisted the IRAM group during the measurements.

NOVA-SRON attempt to hire a front end specialist for Band 9 cartridge development through active head-hunting was unsuccessful.

A meeting was held to start a small project to produce an ALMA Band 9 signal optics pre-prototype. It will include production of two mirrors and mounting bracket to check: a) possibility of achieving alignment by machining tolerances, b) quality of mirrors produced by computer numerical controlled machining, c) physical optics calculations, and d) design concept. The verification will be done in spring 2003 by measuring antenna beam patterns at IRAM. Selection of suitable company for machining mirrors will be made as well.

Development of a high resolution Fourier Transform Spectrometer setup was continued. The setup will allow: a) measurement of the frequency response of SIS mixers, b) provision of sufficient resolution to measure sideband ratios of SIS mixers, and c) measurement of the harmonic content of an LO or test source in the range of 100-2500 GHz. A proof-of-principle sideband ratio measurement was done. The frequency response of the Band 9 mixer was also measured.

Band 9 cartridge structure detailed production drawings were received from RAL solely to be used for designing the rest of the Band 9 cartridge. A model, developed in SolidWorks, was made on the basis of these drawings to start detailed design. Preparations were made for the design and specification workshop in Charlottesville. This included, among other things: working out results of the temperature stability measurement that was done for Band 9 prototype mixers, and preliminary measurement of the test cryostat system relative stability.

Preparation for writing ICD's was begun by designing a full logically complete diagram of the Band 9 cartridge.

A request for delivery of a copy of the ATF bias system was made.

SRON participated in negotiations with Yebes Observatory (Spain) about a possible IF amplifier development/production program.

2.4.9 Cambridge/Onsala

Work at both Mullard Radio Astronomy Observatory (MRAO) and Onsala Space Observatory (OSO) on the Water Vapor Radiometer (WVR) development continued:

A proposal for the various interfaces between the WVR and other parts of the front end was made. This work was done in close collaboration with the groups responsible for those other parts.

Detailed testing and characterization of RF and IF electronics was done, in particular, the temperature stability was assessed.

Various options for calibration sources are still being investigated. This includes solid state noise sources, hot/cold loads and semi-transparent vanes.

A Pickett-Potter feed-horn for the WVR is being developed using EM-modeling. Two independent EM simulations have been used in this design process by MRAO and OSO giving nearly identical results. Based on these results a final design is near completion.

2.5 Back End IPT

2.5.1 Management

The Back End Level 2 Milestones were delivered to the JAO. Development of the Level 3 milestones is underway. Work Element descriptions are being prepared.

Presentations were made at the European Phase 2 Back End proposal review in Garching on November 6 for the Digitizer, Data Transmission System (DTS), Photonic LO Development, and 2nd Generation Correlator.

Presentations were made at the ALMA Infrastructure Requirements Review on October 22-24 in Tucson.

A Local Oscillator (LO) design group meeting was held Nov 19, 20 in Charlottesville to bring together the Front End and Back End engineers working on the 1st LO system. Emphasis was on understanding the risks and uncertainties in the current baseline design and exploring alternatives. A plan will be produced by January 16 leading to retiring the risks and delivering an ALMA prototype system by the end of 2003.

Task	Target Date
Deliver plan for ALMA LO prototype development	16/01/03
Deliver Back End IPT Level 3 milestones	17/01/03
Deliver TPBE for integration with Evaluation FE	20/01/03
Ship DTS formatter and deformatter boards to JBO	24/01/03

2.5.2 IF Down Converter

Fabrication continues on the Total Power Back End (TPBE) modules for ALMA prototype antenna evaluation. Assembly of the field module should be done by the end of the year with delivery to Tucson for integration with the Evaluation Front End planned for the third week of January. This module uses several sub-assemblies that are ALMA IF Downconverter prototypes.

Component placement was completed on the ALMA prototype integrated IF Down Converter evaluation board. This is a highly integrated design for the 2nd IF module. Testing of the design is underway.

2.5.3 Digitizer/Sampler Modeling and Tests

Modeling of the most recent 3-bit sampler design (ALTAIR) continued with two main goals: improving the power consumption as this is an important parameter for lifetime; improving the linearity of the amplifier/adapter in the input stage of the sampler ASIC. The power consumption is now below 1.5 W for the complete sampler, the improvement coming from optimization in the comparator cells and D flip-flops. The linear range of the input amplifier/adapter extends to 400 mV.

The packaged sampler chips for the ALTAIR design have not yet been sent back to us by STMicroelectronics (STM), but the test printed circuit boards (PCBs) have been fabricated and populated with components for laboratory measurements.

Naked dies, as soon they are sent by STM, will also be mounted on special PCBs with the help of the Solectron/Technology Center to compare performance with sampler chips packaged by STM.

The new ALTAIR design delivers low voltage digital signals (LVDS) with lower voltage swing for better performance. We have modeled and developed a special interface to adapt these outputs to the SCFL logic of the Test Bench used at IRAM for sampler qualification. (Unfortunately there was no commercial device available for this adaptation.)

IRAM has prepared the 3-bit demux board to be installed in the Test Bench for full long-term stability and auto-correlation tests of the ALTAIR 3-bit design.

2.5.4 Digitizer Demux

Two demultiplexer models have started in parallel for later selection. One model is developed in Bordeaux to provide three 1:16 demux chips for each of the 3 bits delivered by the sampler. Design has started with SiGe technology. The goal is to be ready for the ST foundry deadline of February 2003. The second model developed in Florence uses GaAs technology to fabricate 1:8 demux chips followed by a field programmable gate array (FPGA) with 1:2 demux. The two models deliver 96 LVDS signals to the output multi-point connector and the backplane to join the digitizer and digital formatter assemblies.

Detailed discussions on interface issues have begun with NRAO in view of an ICD for the sub-assemblies.

2.5.5 Clock Distribution and Digitizer Module Assembly

Distribution of clocks within the digitizer assembly has been extensively discussed together with the signals to be delivered by the sampler clock module. A complete block diagram of the antenna electronics concerning the digitizer and sampler clock is in progress; it includes the phase comparator to master the “drifting eye” problem.

A proposal to integrate two sampler and six demux chips on 2 PCBs in a single mechanical package is in progress for further refinement with Solectron/Technology Center.

2.5.6 Data Transmission System

The layout of a revised digital formatter board is nearing completion and will be submitted for fabrication by the end of this quarter. This is the first revision to the original formatter that has been in use in the test system for over a year. Numerous design improvements have been incorporated, including use of the faster Vertex-2 FPGA chips. After testing, a copy of this board will be sent to Jodrell Bank Observatory (JBO) to allow their fiber optics group to test their transmitter / receiver boards with complex digital signals.

The layout of the fiber optic transmitter control board is being done in Socorro and will be sent to JBO for fabrication by the end of the year. The firmware for this control board is being done at JBO. Evaluation of fiber optic lasers at JBO will begin in February of 2003 when the transmitter control board and the digital formatter and deformatter boards are all in place.

2.5.7 Low Frequency LO & Timing

The LO Reference Receiver module for the ATF is in the final stages of fabrication. This is not an ALMA prototype, but will only be used with antenna evaluation electronics. Delivery to Tucson will be done before the end of this quarter.

Recruiting is underway for a LO engineer to continue the design work on the ALMA 2nd LO.

2.5.8 Photonic LO Distribution

A portable, modified laser synthesizer has been assembled in Tucson to allow testing of the laser synthesizer and line-length corrector concepts using a highly stable and narrow linewidth master laser located in Japan. The test device will be taken to Japan and the tests conducted the third week of December.

Fabrication continues on the photonic microwave source for the holography transmitter.

2.6 Correlator IPT

2.6.1 Prototype correlator

Work continued on the prototype two-antenna correlator. An agreement was reached with the Back End Subsystem Group on the interface details for the optical receiver/demultiplexer card which plugs into the correlator station bin. Designs were completed for the quadrant control card, correlator motherboard, and front panel data port card. Printed circuit board layouts were completed: 100% for the station motherboard, 95% for the front panel data port card, and 90% for the correlator motherboard. Modifications of the prototype designs were completed 100% for the filter card and station card, and 95% for the long term accumulator card (LTA).

Printed circuit boards were ordered and received for the filter card, station card, station interface board, station motherboard, and correlator interface board. Quotations were solicited for commercial assembly of all the boards in the prototype correlator, and some bids were received.

Assembly work began on the prototype correlator rack, and was 90% complete at the end of November (see photos).

Firmware development for advanced operation modes continued. Most of this is required in the LTA card, including:

(1) Special adder tree modes required by the two-antenna prototype system;
(2) Support of LTA bin selection for subarray-based binning (e.g., use of the nutating subreflector) and baseline-based binning (e.g., sideband separation)
(3) Support of the operational environment of the two-antenna prototype system.

Figure 20. Partially populated prototype correlator station bin.

Figure 21. Front (left) and rear of prototype 2-antenna correlator rack showing card cages, cards, backplanes, fans, and power supplies mounted.

2.6.2 Possible performance enhancement

A preliminary study of a possible enhancement of the baseline correlator performance resulted in ALMA Memo 441, "Enhancing the Performance of the Baseline ALMA Correlator." 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. It is likely that this could be achieved at modest cost without serious effect on the baseline correlator delivery schedule.

2.6.3 Schedule

The goals for October-November were:

(1) complete the designs for all prototype correlator cards;
(2) achieve 90% completion on remaining printed circuit board layouts;
(3) receive printed circuit boards for at least 4 newly-laid-out cards;
(4) achieve 90% completion of rack assembly.

All these goals were met.

The goals for the next quarter are:

(1) complete assembly of all printed circuit boards for the prototype correlator;
(2) begin integrated testing of cards in the rack;
(3) achieve 90% completion of integrated testing of at least 50% of the cards in the rack.

2.6.4 ALMA Second Generation Correlator (2GC)

The European 2GC team met in October to review three different finite impulse response (FIR) filter bank options, including polyphase filter, and to 'freeze' the 2GC system block diagrams.

A two-stage FIR filter architecture with a quadrature LO has been adopted. The baseband converter allows us to select a 62.5 MHz portion anywhere within the 2 GHz input baseband. The 2 GHz baseband is synthesized with partly overlapping sub-bands to achieve good control of edge effects. The 2-stage FIR filter comprises a 128-tap coarse filter and a 64-tap sharp filter equivalent to 2048-tap filtering; it is followed by a 16-bit complex-to-real output conversion stage and 3- or 4-bit re-quantization. Simulations have been completed and various implementations in existing FPGAs have been considered. VHDL description at different levels of the FIR filter has started.

The 2GC System Design Study document and system block diagrams have been updated. The complete set of 2GC specifications reflecting our filter bank technical choice and simulations has been issued. It will be sent to the ALMA Science Advisory Committee (ASAC) for information and comments together with revised illustrations of spectral flexibility.

The 2GC correlator chip architecture and design is ongoing at the Netherlands Foundation for Research in Astronomy. Following the study of possible configurations with our serial backplane demonstrator a market survey is in progress.

In November the European team has proposed to ESO detailed Phase 2 work units and a top level planning with a first milestone in April 2003 (System Requirements Review).

2.7 Computing IPT

2.7.1 General

The two top-level activities in the Computing IPT were preparation for Internal Design Review (IDR) to be held in Garching the week of December 9, and preparations for Vertex antenna testing. As to the latter point, a significant event occurred December 3, when the Vertex antenna was moved under ALMA Computing control for the first time. Another notable item relates to the imminent release of ALMA Common Software, Release 2.0, which has major new functionality in the area of the configuration database and considerably simplifies the software through the elimination of dependencies on complex legacy systems.

The IDR documentation set may be found at: http://tinyurl.com/39ob

2.7.2 Milestones

The Computing IPT Level 2 Milestones for the current quarter and following two quarters are as follows:

Milestone	Original	Current	Actual
Internal Design Review (IDR)	2002-12-09	2002-12-09	
Preliminary Software System Design Review	2003-03-15	2002-03-15	
Subsystem Software Release R0	2003-05-01	2003-05-01	

2.7.3 Significant Issues

The AIPS++ offline software system, part of the baseline Computing Plan, is a major external package to be reused by ALMA. Significant concerns have been raised about its suitability both externally (the September ASAC report for example) and internally to the Computing IPT. These issues will be extensively discussed at IDR and potentially at the PDR.

The compressed period of antenna testing as well as the compressed period between antenna acceptance and start of evaluation observations is putting considerable strain on the control software group.

A decision to host the ALMA archive and pipeline at the Science Operations in Santiago rather than the OSF would have ramifications for the software group that have still not been determined but might be significant.

Staffing, particularly at the NRAO, is still below plan, however, most open positions are now being actively recruited and most openings are expected to be filled by the end of the first quarter 2003.

2.7.4 Work Element Reports

For all work elements besides 2660 (equipment and software) significant documentation was prepared for the IDR.

2.7.4.1 Management (2640)

Progress: Computing IPT management organized many of the items listed in this report. In addition we represented the Computing IPT in discussions with other IPTs, most notably at the Site Requirements meeting. In Europe, work agreements were signed with ALMA Data Analysis Center (ADACE) at IRAM and with the Particle Physics and Astronomy Research Council (UK). We updated the overall computing plan for IDR. We participated in various outreach activities, notably the European ALMA Science Operations meeting.

Issues: Contact meetings with all Computing subsystem groups have not started yet.

2.7.4.2 Science Software Requirements (2680)

Progress: A draft update to the Scientific Software Requirements (SSR) document was made (http://tinyurl.com/39py) incorporating changes suggested at recent reviews. It is being used by developers but still needs to be finalized.

Issues: The AIPS++/IRAM test still has not concluded – there are some differences still between the AIPS++ and IRAM images. It has become clear that the SSR will have to define more clearly the role of the data reduction user interface.

2.7.4.3 Analysis and Design (2700)

Progress: The overall system architecture document was updated (http://tinyurl.com/3135). The team commented on all draft software/software ICDs, which are to be updated for IDR. The prototype implementation of the technical architecture proceeded, notably in the area of the container/component model for Java and in the development of an interim Extended Markup Language (XML) persistence mechanism and a "micro-archive".

Issues: The scope of the Executive subsystem needs to be clarified. The question of the internal format (FITS or XML) needs to be decided.

2.7.4.4 Software Engineering (2720)

Progress: Several tools were evaluated for C++, Java, and XML development. JTest and XML Spy have been purchased. A concurrent version system (CVS) server was evaluated to replace the configuration management system currently based on Configuration Module Manager (CMM). The Observing Tool prototype was migrated from CMM to CVS. The evaluation was successful and it will be phased in next year. Automated metrics calculation was implemented.

2.7.4.5 Common Software (2740)

Progress: ACS2.0 development has nearly completed – a pre-release has been made and the final release will be made before the end of the year. A well-attended (14 people, both ALMA and other) ACS course was prepared. License issues related to use of external libraries have forced us to abandon the GNU Public License in favor of the less restrictive GNU Lesser General Public License. A major upgrade is being planned with the implementation and integration of the technical framework software to be used by the subsystems.

Issues: Effort will be below plan in the short term due to Vertex support, and unfilled HIA position.

2.7.4.6 Executive Software (2750)

Progress: All effort was aimed at IDR.

2.7.4.7 Control Software (2760)

Progress: Patches were made to the TICS 0.5 release (to be used initially at the ATF) to correct outstanding problems, most notably a memory leak. Developments for the next (0.8) release are progressing well, particularly related to the holography devices. Development for the next (1.0) release has started as a parallel task to gain schedule time. Several simulators and distributed objects have been written. We have had some limited test time at the ATF which has uncovered some problems with M&C of the ACU and PTC (on both the ALMA and Vertex sides of the interface). Resolving these now has saved us time during later commissioning and acceptance.

Issues: Evaluation of real-time Linux as a potential replacement for VxWorks has stalled due to an emphasis on ATF activities. The compression of integration time on the antenna as mentioned above is a concern.

2.7.4.8 Correlator Software (2780)

Progress: All work for IDR.
Issue: Some correlator requirements still need clarification, notably the consequences of 90 degree phase combination binning.

2.7.4.9 Pipeline Software (2800)

Progress: Leadership of this group changed (to Cornwell) during the period and is still interim. All work towards IDR.

Issues: Group leadership post-PDR needs to be defined. Transfer of observing intent between the observing tool and the pipeline needs better definition. The nature of the encapsulation of AIPS++ within the Pipeline is presently controversial, as is the relation between the ALMA Archive data and the AIPS++ MeasurementSet.

2.7.4.10 Archiving Software (2820)

Progress: Prototype efforts (e.g., simple container, command class, micro-archive) made good progress. Various technology investigations, most notably for the Fast Data Store, were undertaken. Discussions with the analysis group to determine the important properties for identifiers for archive entities occurred.

Issues: Responsibility for development of the Fast Data Store needs to be assigned.

2.7.4.11 Scheduling Software (2840)

Progress: Effort largely for IDR. Commenced hiring for vacant position.

Observing Preparation and Support (2860)

Progress: Face to face meeting held October 7-11. Discussions covered design issues and early drafts of IDR documents and lessons learned from the prototype (e.g., the role of classes automatically generated from XML by the Castor framework). The prototype was brought to the level in which very simple observations can be entered and saved and derived scheduling blocks generated.

Issues: Incomplete requirements covering operational issues that affect Observation Preparation.

2.7.4.13 Off-line Data Reduction (2880)

Progress: Leadership of this position changed (to Golap). Started joint meetings with the pipeline and other related data reduction areas. Significant discussions related to simulator requirements.

Issues: AIPS++ as described above.

2.7.4.14 Data Reduction User Interface (2890)

Progress: Related to IDR.

Issues: The relation between this subsystem and the pipeline and offline subsystems needs to be clarified.

2.7.4.15 Telescope Calibration (2900)

Progress: A face to face meeting was held in Granada in September. Use cases (a formal method of specifying requirements) were prepared as an input to the IDR design process. Draft programmer's documentation for the ATM library (an external library, but being revised in coordination with this work element).

Issues: Division of responsibility with AIPS++.

2.7.4.16 Integration, Test, and Support (2920)

Progress: A tutorial for the Tool for Automated Test (TAT) unit testing framework was written. TAT was also ported to use the new configuration database from ACS2.0. A new CVS based integration procedure was tested on the observing tool prototype.

Issues: Will TAT have a continuing role within ALMA.

2.8 System Engineering IPT

The recruitment of new staff for the System Engineering IPT has continued. In North America two new system engineers have been appointed, Clint Janes (formerly Head of the NRAO Socorro Electronics Division) and Jeff Zivick (formerly with Ericsson, Inc. as a consulting engineer). Also Dick Sramek has taken the post of System Engineering IPT Lead, effective December 2. Discussions are underway to further increase the staffing within System Engineering.

In Europe, one position was filled by Eric Pangole, who started work October 1. Another position was filled by Christoph Haupt, who started work December 2.

A System Engineering IPT meeting was held on November 21 in Charlottesville, where many of the System Engineering IPT and the Front End IPT system engineers happened to be present for the local oscillator and front end workshop.

A high priority for the System Engineering IPT in the next quarter will be to review, revise, (or write for the first time) the various top level ALMA documents, including a review of the change request and document approval process. Another high priority will be to help the project staff make the transition to ALMAEDM.

2.9 Science IPT

2.9.1 Overview

During October-November, the Science IPT activity was again centered on the final definition of the array configuration. Late November, a Level 2 Milestone was met by delivering the document containing the positions for the inner 172 antenna pads. The final configuration was altered from the design approved by the JAO on October 1 due to a new, more accurate digital elevation model. Work commenced on design of a long baseline part of the plan, compatible with this new inner portion.

There was also considerable activity on calibration. Final testing of one of the two amplitude calibration devices being considered for ALMA, the subreflector dual load device, commenced with the Berkeley Illinois Maryland Association (BIMA). A plan for initial testing of the other device, incorporating a semi-transparent vane, at the IRAM 30m, was discussed at a calibration teleconference. Progress was made on the calibration memo review process.

The project scientists continued to develop the Science IPT organization and refine the Level 3 and 4 Milestones. A lively and well attended "Science Operations with ALMA" meeting for the European astronomical community was held on November 8 at ESO Garching.

2.9.2 ASAC

The Science IPT arranged the agenda and minutes for the ASAC teleconferences on November 6 and December 4, and commented upon the ASAC report to the ACC. Following the Chile ACC meeting, the ASAC Report was distributed to the Project and made public on the ALMA web sites.

The ASAC has made the following recommendation to the Project on the baseline correlator following its December 4 teleconference:

"The ASAC has read with interest the proposal in ALMA Memo 441 by Escoffier and Webber to enhance the performance of the baseline ALMA correlator. The proposed enhancement will increase the number of channels in the wide band mode from 256 to 4096 points in each 2 GHz of the 16 GHz available and therefore allow for better resolution. The relatively small number of spectral channels currently available in the wide bandwidth modes is a major scientific limitation of the baseline correlator that would be remedied if this enhancement could be carried out. Therefore, the ASAC encourages the ALMA project to see if this enhancement to the correlator can be implemented within the baseline ALMA project."

2.9.3 Configuration

In early October, the JAO approved the plan delivered by Conway for configurations covering less than 4km in extent. New data on the terrain at Chajnantor spurred revision of the array configuration to better conform to the landforms on the site. In particular, the site characterization group received the new aerial photographs and an autocad file of the site contours from the Chilean company Aerotop. Otarola and Holdaway converted the contour information into a digital elevation model (DEM) with 5m horizontal resolution and 0.5m vertical resolution which could later be turned into a mask for pad placement in the array optimization algorithms. They also studied the details of the new DEM and determined that it was of far superior quality to the old one, but that the coordinates showed a systematic offset from the Universal Transverse Mercator (UTM) frame. Communications with Aerotop indicated that the coordinates were in fact not UTM and that the coordinate offset changes slightly over the image. Large offsets (>100 m) which were coherent over 1 km scales, but which varied over the 5 km x 5 km DEM, were found between the new and old DEM, and were attributed to errors in the old DEM. As a result, adjustment of the original pad positions was required to avoid quebradas and to more accurately place the center of the array.

At the end of November, Conway delivered the engineering specifications document for the inner 172 pad positions using the new DEM. The array was re-optimized to reduce sidelobes and the required precision on the station coordinates for uv coverage/beam constraint purposes has been quantified. Reconfiguration schemes for four antenna moves at a time rather than three, and accommodation of observations at extreme declination, for example, north of +35 degrees, have been investigated. Conway also developed software to evaluate the beam and shadowing effects of having different heights for pads in the compact array, since this is an important specification for the cost of construction of the compact array. They will be submitted as a second specification document by year end.

2.9.4 Calibration

Butler, as leader of the Calibration Group, together with Wootten, organized and moderated two ALMA Calibration Group teleconferences. Reviews of memos were discussed and minutes of the meeting are available. Several memos will be revised; in particular, Mangum revised ALMA Memo 434 on "Load Calibration at Millimeter and Submillimeter Wavelengths" in light of the reviewers' comments.

Final testing of the subreflector dual load device for amplitude calibration commenced at BIMA, involving Mangum, Bock, and Welch. Carter and Navarro, together with Martin-Pintado and Cernicharo, have designed a device to test the alternative semitransparent vane calibration scheme at the IRAM 30-m telescope. The device will allow to check the main assumptions of this calibration scheme and to establish the typical accuracy one can achieve with a single dish telescope. A draft document describing the tests to be performed will be circulated in the Calibration Working Group before the Leiden December meeting.

Bacman, together with Guilloteau, has started working on the bandpass calibration. They are considering separating the bandpass calibration into "large scale bandpass calibration" (atmosphere + antenna + receivers) and "fine scale bandpass calibration" (downconverter + digitizers + filters). With this approach, three steps would be needed for the calibration: a wide-band calibration with one receiver, a wide band calibration with a second receiver (so that the contribution of the common acquisition system can be eliminated by taking the difference), and a narrow, that is, user-configuration band calibration.

The ATM atmospheric modeling package, written by Pardo, Cernicharo, and Sempere, is currently being transformed and cleaned by Pardo for specific use in the ALMA project. The current version performs forward radiative transfer calculations in user-defined bands, providing atmospheric brightness temperatures, opacities and H2O phase factors (deg/mm) for phase correction. It also allows to retrieve water vapor columns from radiometric data from devices like WVR's. The package is being installed in an array simulator, written by Viallefond et al., where it is tested for many different ALMA uses. Improvements suggested after a meeting of the software ADACE group in Grenoble are being implemented.

Van Dishoeck and Guilloteau planned a joint ALMA/Herschel-HIFI calibration meeting to be held in December in Leiden.

In the next quarter, there are many upcoming Level 3 Milestones on calibration, leading up to the Level 2 Milestone of September 2003 to have a complete calibration plan. This includes: phase, amplitude, bandpass, polarization, antenna location, illumination offset, pointing , focus, delay, opacity, and decorrelation correction. The first milestone is a draft of the calibration requirements document to be produced for reviews in December 2002 and finalized by February 2003 (see Table). This is a modification of Chapter 3 of the Project Book, complete with scientific examples for drivers. The Project Scientist issued a call to the ASAC during November to provide some examples for this exercise.

Two milestones during the upcoming quarter lead to the June 2003 Level 2 Milestone of the review of how calibration requirements flow down to instrumental specifications, including special calibration devices.

Leading to the September 2004 Level 2 Milestone on WVR strategies (Level 2), a December 2002 Level 3 Milestone will present a draft document on technical aspects of the WVR, along with the Front End IPT.

There is concern whether the Level 2 Milestone of "Review of tests of calibration strategies on prototype interferometer complete" can be met by December 2004. Although most elements of the prototype interferometer will be in place at the ATF by early 2004, the prototype receivers may not arrive until mid 2005 for testing later that year. The Science IPT believes that this must be done earlier, if these calibration tests are to involve the actual ALMA receivers. Differences between the evaluation receiver interfaces and those of the prototype receiver suggest that substantial work would be required to implement the evaluation receivers for the prototype interferometer. The project should construct a plan for component verification at the prototype interferometer as soon as possible.

2.9.5. Site Characterization

As described in 2.9.3, a new map of the site, much more accurate than those previously available, was delivered. Radford and Nyman, as subgroup leaders, held an organizational meeting and proposed a plan for construction phase activities.

Radford spent much of November at the site upgrading, repairing and testing NRAO equipment This included replacement of computers for the 225 GHz tipper and the Site Testing Interferometer, installation of two new surveillance cameras, reinstallation of the seismometer, restarting the lightning detector, installing updated radiosonde software, and diagnosing and repairing the submillimeter tipper at Sairecabur. Radford also observed with the Smithsonian Astrophysical Observatory team at Sairecabur.

Similarly, Rivera and Perez spent much of this period repairing and maintaining the ESO site-testing equipment. Together with Rantakyro and Nyman, they are continuing Delgado's work on atmospheric phase correction by means of the differential analysis of PWV data and by correlating these results with the residual phase noise measured with the site testing interferometer.

Holdaway and Otarola have started to investigate whether current models can predict weather and atmospheric conditions at the site at different timescales sufficiently accurate to help planning more efficient and safe site operations. Butler and Holdaway held discussions on site data analysis, particularly on water vapor scale height and on the hygrometer data.

2.9.6. Science Software Requirements

Myers continued to work with the Science Software Requirements group on audit requirements for AIPS++. Mangum, Lucas and others also work with this group. See computing IPT report for more details.

2.9.7. Imaging

Holdaway has added 1/f noise to the total power atmospheric simulations, which observe in both beam-switched and on-the-fly modes. He has also started to investigate the effects of different levels of receiver stability on the images.

Holdaway has made a preliminary study of a fast switching decorrelation correction, in which the atmospheric phases measured on the calibrator are used to estimate not only the mean phase correction to apply to the target source visibilities, but also the degree of decorrelation to correct the amplitudes by. This work indicates that the correction works well to correct the flux scale and recover the correct peak flux, but that it increases the image noise level. More detailed studies will follow.

2.9.8. Meetings, Outreach and Public Education

Most of the North American members of the Science IPT, along with Conway from Europe, met face-to-face in Tucson in October during the site PDR, whereas most of the European members of the Science IPT met in Garching in November, to refine Level 3 and 4 Milestones. Numerous teleconferences were held between the Project Scientists, subsets of the Science IPT, and the entire Science IPT. Guilloteau and Wootten attended the ALMA Front End specifications and requirements meeting and the Back End LO design meeting in Charlottesville. Most of the European members of the Science IPT will meet during a three-day workshop in Leiden in December, focusing on calibration issues.

Guilloteau, Wiesemeyer, Gueth, van Dishoeck, and others organized the 3rd Millimeter Interferometry School held at IRAM, Grenoble, September 30-October 5. This school was attended by 52 PhD students and postdocs from many different countries and nationalities. Lectures were provided by Guilloteau and several science IPT members (Gueth, Hills, Dutrey, Lucas, Pety, Pardo, and van Dishoeck), and included talks on ALMA.

A European "Science Operations with ALMA" meeting was held on November 8 at ESO, organized by van Dishoeck and Shaver. The meeting was very well attended, with the ESO auditorium filled to capacity (~100 participants) leading to lively discussions. The aim of the meeting was to inform the European astronomical community of the status of the ALMA project and to solicit feedback from the community on specific operational issues, in particular the planning for the European Regional Support Center. Details of the program and presentations can be found at http://www.eso.org/projects/alma. A questionnaire was distributed to the participants afterwards, with responses due in early December.

Van Dishoeck, Cox, Booth, Shaver, and Richer continued to investigate possibilities for EU support for ALMA within the Framework 6 program, which included a visit to meet with representatives of the European Commission program in Brussels on October 18.

Wootten visited with scientists at the Arizona Radio Observatories during his trip to Tucson in October. Van Dishoeck gave several seminars and public lectures on science with ALMA to Dutch communities, including a presentation at an astrophysics symposium at the Technical University of Delft on December 3, attended by 270 students.

Table of upcoming milestones:

Milestone	Level	Schedule	Status
Revised configurations incl. Y+ after site survey	3	March 2003	in progress
Draft configuration antenna motion logic	3	March 2003	in progress
Calibration requirements review	2	February 2003	in progress
Draft specifications calibration devices	3	March 2003	in progress
Draft calibration plan; many individual components	3	March 2003	in progress
Draft WVR technical aspects (with FE IPT)	3	December 2002	near completion

Acronym Definitions

ABM	ALMA Bus Master
ACC	ALMA Coordinating Committee
ACU	Antenna Control Unit
ADACE	ALMA Data Analysis Center
AEC	Alcatel EIE Consortium
AIPS++	Astronomical Information Processing System
ALMA	Atacama Large Millimeter Array
ALMAEDM	ALMA Electronic Document Manager
AOS	Array Operations Site
ASAC	ALMA Science Advisory Committee
ATF	Antenna Test Facility
AUI	Associated Universities, Inc.
BIMA	Berkeley Illinois Maryland Association
BUS	Back Up Structure
CDL	Central Development Laboratory (NRAO)
CESR	Centre d'Etude Spatiale des Rayonnements
CfA	Center for Astrophysics
CIT	California Institute of Technology
CMM	Configuration Module Manager
CVS	Concurrent Version System
DC	Direct Current
DEM	Digital Elevation Model
DSB	Double Side Band
DTS	Data Transmission System
EAB	European ALMA Board
EIE	European Industrial Engineering
EM	Electro Magnetic
EPO	European Project Office
ESO	European Southern Observatory
EVLA	Expanded VLA
FE	Front End
FIR	Finite Impulse Response
FITS	Flexible Image Transport System
FPGA	Field Programmable Gate Array
GNU	GNU Not Unix
HIA	Herzberg Insititute of Astrophysics
ICD	Interface Control Document
IDR	Internal Design Review
IEM	Instituto de Estructura de la Materia
IF	Intermediate Frequency
IPT	Integrated Product Team
IR	Infrared
IRAM	Institut Radio Astronomie Millimetrique
JAO	Joint ALMA Office
JBO	Jodrell Bank Observatory
LO	Local Oscillator

LTA	Long Term Accumulator
LVDS	Low Voltage Digital Signal
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
OSO	Onsala Space Observatory
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PTC	PoinTing Computer
RAL	Rutherford Appleton Laboratory
RF	Radio Frequency
SIS	Superconducting Insulator Superconducting
SRON	Space Research Organization Netherlands
STM	STMicroelectronics
SSR	Scientific Software Requirements
TAT	Tool for Automated Tests
TICS	Test Interferometer Control Software
TPBE	Total Power Back End
UK	United Kingdom
UKATC	United Kingdom Astronomy Technology Centre
UTM	Universal Transverse Mercator
VLA	Very Large Array
WVR	Water Vapor Radiometer
XML	Extended Markup Language
2GC	2nd Generation Correlator