MILLIMETER ARRAY/ALMA-US
DESIGN AND DEVELOPMENT

MONTHLY REPORT
MONTH END NOVEMBER 2000

1 Executive Summary

A major event during for the ALMA Project in November was the Critical Design Review for the antenna contract held at the facilities of the contractor, Vertex, in Duisburg, Germany on 15-16 November. Members of the review panel included 3 expert outside reviewers from the BIMA, OVRO and SMA projects, 3 members of the ALMA-Europe antenna group, 8 members of the ALMA-US technical groups and 3 members of the ALMA-US management group. The review went well with the contractor presenting analysis demonstrating that all performance specifications for the antenna will be achieved. No significant aspects of the design were found to be unacceptable. A similar review was held for the EIE antenna contract the following week.

Planning for the production of the Front End subsystem was the topic of a meeting held by the Joint Receiver Design Group at the ESO Headquarters in Garching, Germany. Among the many recommendations coming out of that meeting was that the project establish front end integration facilities located in the US and Europe. The detailed definition of the role of these facilities and their cost will be developed after the design of the front ends are reviewed at the Front End PDR in February.

A wideband source of random noise in the frequency range of 60-600 GHz has been designed and fabricated. This source provides much more intense signals than has been previously available. Such signals are required for device and material characterization at millimeter wavelengths.

An important milestone for the computing task was the first public release of the ALMA Common Software. This software package provides basic software infrastructure for the entire project.

2 Programmatics

2.1 Financial Statement

[Not Included.]

2.2 Personnel

The ALMA Project staffing is reported by WBS Level-1 category based on the joint project WBS. The total number of full-time equivalent employees was 58.4.

2.3 Progress Against Project Milestones

Attached to this report is the Project Gantt chart displaying the summary-level tasks of the Phase 1 Project WBS. For each of these summary tasks the progress against the baseline is reported as a percent complete. The same information is shown graphically; progress is reported as horizontal bars colored green; work still pending is shown in black or solid blue. Milestones are indicated by triangles, colored green for completed milestones and colored red for pending milestones. A vertical red line is used to indicate the date of the presentation; here progress is reported as of 14 December 2000.

In November, two major milestones were scheduled for completion. These were the Critical Design Reviews for the Vertex and EIE antennas. These reviews were successfully completed on 15 November and 23 November.

3 Meetings And Memos

3.1 Meetings Held During November 2000

ALMA Photonics Meeting (Japan) - November 7-8
ALMA Site Teleconference - November 8
ASAC Teleconference - November 13
ALMA U.S. Antenna Prototype CDR (Duisburg, Germany) - November 15-16
ALMA Joint Software Meeting (Socorro, New Mexico) - November 20-21
ALMA European Antenna Prototype CDR (Germany) - November 28-29
ALMA Receiver Production Plans Meeting (Garching, Germany) - November 30-December 1
ALMA Test Interferometer Bi-Weekly Teleconferences
ALMA U.S. DH Meeting Teleconferences - November 6, November 13, November 20
ALMA Joint DH/TL Meeting Teleconferences
ALMA/NSF Meeting - weekly teleconferences
ALMA Lo/Rx Meeting - weekly teleconferences
ALMA Imaging and Calibration Meeting - weekly teleconferences
ALMA Executive Committee Meeting - weekly teleconferences

3.2 Planned Meetings in December 2000

ALMA U.S. DH Meeting Teleconferences - December 4, December 11, December 18
ALMA Joint DH/TL Meeting Teleconferences - December 4
ALMA Joint Receiver Development Group Teleconference - December 7
ASAC Teleconference - December 4

ALMA Configuration Meeting - December 20
ALMA/NSF Meeting - weekly teleconferences
ALMA Lo/Rx Meeting - weekly teleconferences
ALMA Imaging and Calibration Meeting - weekly teleconferences
ALMA Executive Committee Meeting - weekly teleconferences

3.3 ALMA Technical Memos Distributed in November 2000

ALMA Memo	Title	Author(s)
337	Frequency Multipliers for ALMA	Richard Bradley, Kamaljeet Saini, Eric W. Bryerton, and Dorsey L. Thacker
336	Simulations and Analysis of Phase Switching of the ALMA LO Source PLL	Dorsey L. Thacker, Eric W. Bryerton, Richard Bradley, and Kamaljeet Saini
335	Phase Drift Measurements of YIG-Tuned Oscillator Sources for the ALMA LO	Dorsey L. Thacker, Eric W. Bryerton, Richard Bradley, and Kamaljeet Saini
334	Atmospheric Transparency at 225 GHz over Chajnantor, Mauna Kea,and the South Pole	Simon Radford and Richard A. Chamberlin
333	52 Years of Climatological Data for the Chajnantor Area	Ricardo Bustos, Guillermo Delgado, Lars-Ake Nyman, and Simon Radford
332	Phase Correction of Interferometer Data At Mauna Kea and Chajnantor	Guillermo Delgado, et al.

The full catalog of the ALMA Memo Series can be found at the ALMA web site at http://www.alma.nrao.edu/memos/.

4 Technical Progress Reports

4.1 Antennas

The major event during the month was the Critical Design Review for the antenna contract held at the facilities of the contractor, Vertex, in Duisburg, Germany on 15-16 November. Members of the review panel included 3 expert outside reviewers from the BIMA, OVRO and SMA projects, 3 members of the ALMA-Europe antenna group, 8 members of the ALMA-US technical groups and 3 members of the ALMA-US management group. The review went well with the contractor presenting analysis demonstrating that all performance specifications for the antenna will be achieved. No significant aspects of the design were found to be unacceptable. A list of issues arising from the review was transmitted to Vertex; these issues were primarily requests for

further information or additional supporting calculations. Vertex is scheduled to respond to these issues in early December. Detailed designs were not presented at the CDR for one or two of the less important subsystems such as the HVAC system for the Receiver Cabin and the overall plan for Electromagnetic Compatibility (EMC), but it is not expected that this will prevent the major parts of the antenna from moving into the detailed design phase. The missing subsystems, together with the results of tests on the first section of the reflector backup structure (BUS) will be reviewed in a Delta-CDR during the first quarter of 2001.

After the CDR the contractor started the detailed design phase of the project, including the detailed analysis of local stress and buckling problems and the design of local stiffeners to meet the requirements. Final tests were carried out on the model mold which will be used for constructing the BUS fabrication tool. Construction of this tool should begin in December.

At NRAO, in conjunction with the CDR, a significant effort was made during the month to finalize those Interface Control Documents (ICDs) which were still outstanding. This included in particular the Antenna Transporter and Receiver ICDs. Work continued on the NRAO-supplied subsystems, including the subreflector nutator and optical pointing telescope.

4.2 Front End

Front End Status

During the month of November, an ALMA receiver production meeting was held in Garching. A report on that meeting is being prepared by Richard Wade of Rutherford Appleton Laboratory (RAL) and should be released in the next few weeks. One of the main outcomes of the meeting was a recommendation that there be receiver integration facilities located in Europe and the U.S.

Further work on the ALMA receivers has resulted in an update of the Project Book receiver chapter, although much work remains.

Work on the Evaluation Receivers has continued in Tucson and tests made on bias tees suitable for use in the receivers have recently been completed. These components were tested at 4K using our recently developed 4K system. One item of note is that this system, along with the entire evaluation receiver system runs from the electrical power that is available in Chile. The 50 Hz line frequency used in Chile results in the derating of various components . The most affected system is the cryogenic system. These tests indicate that we now have a system that meets the specification for our application on the ALMA receivers.

Receiver Components

Work is continuing on the 211-275 GHz mixer with integrated preamplifier for the 4-12 GHz IF band. Detailed modeling is being employed in order to optimize the interface circuit between the mixer and the first IF amplifier (and perhaps slightly modifying the input side of the IF amplifier) in order to achieve flat noise across the IF band. Some improvements in the mechanical interface between SIS mixer and preamplifier were

completed and drawings submitted to the machine shop for fabrication. A copy of the prototype amplifier was finished for the SIS development group at SRON for use in 650 GHz mixer IF development. A paper on the successful integration was prepared for presentation at the 2001 IEEE MTT International Microwave Symposium.

The first block for the 211-275 GHz sideband-separating, balanced mixers was completed including installation of the MMIC mixer chip itself. The first chip cracked due to using a "crush wire" of 18 micron diameter (the calculated value) instead of 13 micron diameter (the empirical value). A second chip was successfully installed, but the mixer temperature was unexpectedly high. Tests of a third chip will occur in early December.

Work is continuing on improved optics for the test system, including matching layers for windows, lenses, and IR filters. Some experiments in machining the plastic materials are in progress in the shop, and some materials have been characterized. Most of the measurements have been made with an HP 85106 vector network analyzer at 100 GHz.

The design and fabrication of a new, wideband source of random noise in the frequency range 60-600 GHz which is much more intense than any other source except a synchrotron was used in conjunction with the University of Virginia Fourier Transform Spectrometer to make additional measurements. The use of such a noise source constitutes a major advance in the technology of millimeter wave measurements and may be of great interest to the tens of thousands of users of such instruments around the world.

Thermal loading problems due to conduction of heat from warm stages through bias and sensing wires to the SIS mixer stages can result in elevated receiver temperatures. An investigation of the improvements which might be made by employing phosphor bronze wire instead of beryllium copper (the traditional material) is underway. Preliminary results are that one can use a thicker phosphor bronze wire, resulting in greater mechanical strength, and still improve the temperature of the SIS mixer stage.

The second closed-cycle test dewar for SIS mixers, named JT1, has now been successfully cooled. Much work remains to be done on this system to equip it for routine use.

Providing clean bias supply current for SIS mixers has been a perennial problem due to multiple grounds in the cables connecting electronics to a typical dewar. A new circuit using two independent current sources was tested and found to give improved I-V curves.

Work began on providing an increased magnetic field strength for the cryogenic electromagnets used to suppress SIS junction noise. The present circuit saturates at about 150 gauss, which is sufficient for 230 GHz operation but may not be sufficient for higher frequencies. A literature source on the magnetic properties of materials at 4K is underway; such data appear to be rare.

Work continued on refining the data acquisition and processing software for automatic SIS mixer testing, with emphasis on sequencing the parameter stepping.

The first production of the coated vacuum windows for the evaluation receivers was completed and units were shipped to Tucson.

A contribution on SIS mixer development for the Project Book chapter on the ALMA Front End was completed and submitted.

4.3 Local Oscillator System

Local Oscillator Drivers and Multipliers

A great amount of effort was expended in the study of the configuration of the LO drivers and cooled multipliers, in the light of newly acquired information about the performance of practical devices. This resulted in both a contribution to the Project Book and a plan for continued work which is expected to yield a final recommended configuration following multiplier tests in the first quarter of 2001.

A 2-stage 43-60 GHz power amplifier was successfully tested; it provides useful gain out to 65 GHz and will be an important part of several LO driver chains for different bands. An engineer and technician traveled to JPL with several power amplifier blocks machined in Green Bank to learn the JPL assembly procedure. They successfully assembled and brought back six amplifiers covering frequencies from 65 to 115 GHz for ALMA use.

Local Oscillator Reference System

The printed circuit board layout for the prescaler used in the Central Reference Generator is nearly complete and should be sent out for fabrication shortly. The digital board layout and component selection has begun. The layout for the Reference Receiver has begun.

Module descriptions and specification for use in the ALMA project book were submitted.

4.4 Backend Subsystem

Data Transmission Fiber Optic Link

Development of the top level schematic of the Xilinx FPGA is underway. This involves writing VHDL code modules or drawing schematics for most internal blocks of the design. In general, the Pipelined Register Transfer Logic style of this design lends itself very nicely to VHDL design techniques. Some of these designs will be tested on our Xilinx FPGA evaluation board.

In addition to the Giga LVDS 10 Gb/s Mux and Demux IC's, a new set of Mux/Demux devices are now being advertised by AMCC. These appear to be functionally the same as the the Giga devices; data sheets and availability information have been requested from AMCC. This required signing a non-disclosure agreement with AMCC.

The CSA8000 communication analyzer arrived from Tektronix but failed on the bench after a few hours of use and was shipped back. This instrument is needed to test the 10 Gb/s link.

Collaboration with the Jodrell Bank Observatory fiber optic group has begun. They have agreed to supply the fiber optic receiver mezzanine board for the prototype data link. To aid in our mutual component selection and evaluation, all of the optical components available in Socorro were catalogued and the model numbers and specification sheets made available to the Jodrell group.

Downconverter

Interface requirements for suppression of spurious frequencies from the second local oscillator synthesizer were developed. Also specs for input and output filters on the power supply modules were developed. Variable gain amplifiers were found to be unlikely alternatives to absorptive diode attenuators for level control because these amplifiers use a single diode reflective attenuator between stages which causes additional passband ripple and large changes in phase.

Two 2x2 matrix switches were assembled and tested with the scalar network analyzer. Basic throughput transmission, isolation and reflection characteristics of both switches were about as expected. The output-to-output isolation of one matrix switch was tested and found to be somewhat poorer than expected, and of course highly dependent on the source impedance match at the inputs. This is critical to suppress crosstalk and LO2 leakage between output channels. The long awaited Maury VNA calibration kit arrived, so precision measurements can begin with the HP8510C Vector Network Analyzer.

Proper setup codes were found to get the ADI sigma-delta digitizer to encode, but it still needed some obscure dc offset to do so usefully. Several other sigma-deltas as well as SAR digitizers will be evaluated.

Text for the Downconverter section of the ALMA Project Book was written and an updated block diagram was prepared.

4.5 Correlator

Simulation of the ALMA-1 custom correlator chip has been very intensive. A series of test vectors using pseudo-random inputs was generated and submitted to simulation of various parts of the chip, up to simulation of one-fourth of the total chip. The results were compared to the calculated outputs from a C program written to correlate the input data in software. The results so far have been good. A minor problem in the design was identified and the information was used by the chip designer to make a correction. A new computer with 1 Gbyte memory, purchased for use in electromagnetic simulations by the SIS mixer group, will be used by the correlator group during December to simulate the entire chip. The simulation runs a factor of 108 slower than real time.

The prototype FIR filter card has completed initial tests. Every feature of the card has been tested except for the data interfaces to the external world (this awaits the complete test fixture). Every printed circuit board trace is correct. Every solder joint works. Every aspect of programming the FPGA chips works perfectly. Every one of the 576 on-card signal interfaces, which are required to work at 125 MHz, works perfectly up to 145 MHz. The use of the programmable-phase clock system of the FPGA chips works perfectly and has excellent timing tolerances. The only problem encountered has been a clock bounce due to a reflection in the clock signal distribution wiring; this was easily overcome by a digital timing circuit, and it will probably be fixed on the final version of the card by minor changes in the clock distribution network, going from 2 to 4 clock drivers. The success of this card validates a number of elements of the correlator design procedure. It demonstrates the excellent properties of the Xilinx Virtex-E FPGA family and the Xilinx support software. It gives us high confidence in the Orcad PCB layout

package. It gives us high confidence in our PCB suppliers and the prototype assembly work performed in Tucson.

The only slightly negative feature of the FIR filter tests so far is the power dissipation with random multiplier tap weights; each tap weight FPGA consumed almost 4 watts, which would require a heat sink on each chip. However, it is believed that with real tap weights the power consumption will be significantly less; this cannot be tested until the complete test fixture is ready.

The prototype station card and FIR filter test fixture card have been received from the printer circuit board manufacturer and shipped to Tucson for assembly. Testing is expected to begin in December.

A revised version of the Project Book was produced which included minor changes in the description of the baseline correlator and a section on the Future Correlator.

4.6 Computing

In November, software group members prepared for and attended both the Vertex and EIE antenna CDRs, paying particular attention to the control software aspects. B. Glendenning presented an invited talk at the "Astronomical Data Analysis Software and Systems" conference on "ALMA Computing Challenges." A joint meeting was held in Socorro at which nearly all people participating in ALMA software development were able to attend, and present status reports. The computing construction project book contribution was substantially revised.

The Science Software Requirements (SSR) committee and high-level analysis committee spent time revising the use cases and requirements list, based on discussions from the October Berkeley meeting.

An important milestone was the first project wide release of ALMA Common Software, which provides some basic software infrastructure for the entire project. The control software group released for internal comment design and requirements documents, particularly aimed at the test interferometer.

Embedded code and LabView test interfaces supporting the Front End Power Supply module were developed and tested. In addition, embedded code to support access over the CAN bus to VME crate fan and power supply monitoring hardware was prototyped.

Further comments on the Test Correlator design document were incorporated and a final version for review is in preparation.

A group of people from ESO, IRAM, and the NRAO prepared intensively for the Kitt Peak test period, scheduled for the beginning of December.

Next Month

We will carry out tests for 8 days on the Kitt Peak 12m telescope (now operated by the University of Arizona). Subsequently, we will install ESO's ACS and development environment in Tucson.

4.7 Systems Engineering

Holography: Following the successful CDR in October, parts are now being ordered for the ALMA holography system; in view of the long lead time for certain specialised components, this has been a high priority.

Project Book: The joint US/Europe Systems Group has responsibility for compiling the ALMA Project Book; this is the document that describes the overall baseline plan for the ALMA project. The Systems Group is also responsible for ensuring that the Project Book remains current, is accurate and self-consistent. A great deal of time was spent this month in correspondence with authors of chapters of the Project Book, and in producing systems-related chapters. The first substantially complete version of the ALMA Construction Project Book is expected to be available in early December. Soon after that point, a formal "change control" process will be put into place to ensure that future changes to sub-systems of the ALMA project do not have undesired implications elsewhere in the system.

The current version of the ALMA Construction Project Book is available at: http://www.tuc.nrao.edu/~demerson/almapbk/construc/ .

International Meetings: This month one member of the US Systems Group attended the ALMA Photonics meeting in Tokyo, and also the Vertex Antenna CDR in Duisburg. The European ALMA receiver group and junction fabrication facilities at Chalmers University in Sweden were visited.

4.8 Imaging and Calibration

Major accomplishments November 2000

I. Imaging - Configuration Studies, Site and Water Vapor Radiometry

The imaging and calibration group held several phone meetings during November; the agenda, indices and linked documents at: http://www.cv.nrao.edu/~awootten/mmaimcal/

Configuration Studies

The simulation efforts for the primary ALMA array reached a nearly final stage during November.

Steve Heddle in the UK continued to progress on the imaging simulation, producing 1.6km 'B' Array snapshots and 4 hour tracks for simulations of objects in the image library using both the Kogan double ring and zoom spiral configurations (http://www.stevenheddle.co.uk/ALMA/ALMA_IND.HTM).

Wootten arranged and moderated a teleconference between ALMA collaborators in Europe, the United States and Japan to assess these simulations and to plan the final stages of the simulation process. He wrote and circulated the minutes from this meeting. A Preliminary Design Review is planned for 26-27 February 2001 in Grenoble. The current set of simulations doesn't address the addition of total power/mosaicing, many error sources, or the addition of the ACA, topics to be discussed at the meeting and pursued afterward.

Butler, Radford and Otarola published ALMA Memo No. 338, The Best Sites for the Compact ALMA Configuration. They present considerations involved in finding the best location for the compact (maximum antenna separation <~ 200 m) ALMA configuration on the science preserve. Several candidate locations for the compact configuration are then suggested.

Site

With the approach of the austral summer, activities centered on site characterization and plans for the seasonal campaigns there.

On 2000 November 6, Monday, Tony Readhead, Bob Brown, Al Wootten, Simon Radford and Bryan Butler met in Brown's office to discuss observing and operating conditions at the Chajnantor site. The Cosmic Background Imager (CBI) group has learned a lot about Chajnantor while operating the CBI this past year and what wisdom they can provide to the ALMA project so that it can benefit from that knowledge.

The primary recommendation from the CBI experience is to understand micro climate episodes, where clouds form over Chajnantor but not over Pampa la Bola. By correlating the CBI logs with the data from the other instruments (tippers, etc.) we hope to recognize these episodes. A plan was developed to identify these episodes and characterize their traits in the data collected by our site instrumentation. The effects of the microclimatic events can then be assessed relative to ALMA's needs. The plan is now being executed.

A milestone in the project was reached with the site characterization review at the IAU technical workshop in Morocco. Lars-Ake Nyman, Guillermo Delgado, Simon Radford, Yasmin Robson, Gie Han Tan, Andre Erasmus, Mark Sarazin, Angel Otarola, Bryan Butler, Seiichi Sakamoto, Masato Ishiguro, Richard Kurz, Juan Pardo, Satoki Matsushita, Roy Booth, Masuo Tanaka, Yoshiharu Asaki, Riccardo Giovanelli, Martina Wiedner, and Michael Bremer met during the workshop. Items discussed included determination of the scale height of water at the site, methods for assessing anomalous refraction at Chajnantor, methods for determination of the height of the turbulent layer above the site, and coordination of instrumentation on the site. The implementation of some of these items was to begin during December with visits to the site. At the review, Radford and Butler presented papers describing their work on the characterization of Chajnantor as a site for ALMA.

Radford completed and released Memo 334, Atmospheric Transparency at 225 GHz over Chajnantor, Mauna Kea, and the South Pole, by Radford and Chamberlin. Measurements of the 225GHz atmospheric transparency with functionally identical tipping radiometers at Mauna Kea, the South Pole, and Chajnantor indicate periods of excellent observing conditions at all three sites. Conditions at Chajnantor and the South Pole are better than at Mauna Kea. The first quartile zenith transparency at Chajnantor and the South Pole are roughly equal. During the best conditions at Chajnantor, however, the zenith transparency is better than during the best conditions at the South Pole. Median conditions at Chajnantor and the South Pole are similar for observations near meridian transit when observing geometry is considered.

II. Calibration

Interferometer/Antenna Amplitude Calibration

Mangum represented Imaging and Calibration at the Antenna PDR in Germany. Radford continued development of the nutator system for the antennas. As part of his participation in the SSR group, Mangum worked on various use cases for the Use Case documentation being prepared. Wootten also attends these meetings and works on special modes.

Pointing Calibration

Mangum worked with Kevin Long to finish modifications to optical pointing computer setup and progressed on the analysis system for optical pointing data. He started formulating a plan for a CFRP-based optical pointing/tracking system following discussions with Jack Welch.

III. Science

ALMA studies, including the ASAC

Wootten arranged and moderated the monthly ASAC meeting which was held 13 November. He corrected and arranged posting of those minutes at the ALMA WWW site.

Plans for next month

The ASAC teleconference will be held on 11 December. A campaign on the site will be conducted by Radford and Butler. Objectives include the maintenance and installation of equipment and the reconnaissance of locations proposed for antennas in the Kogan-Yun and Conway configurations. Wootten will assess the terrain near the antennas, based upon map data, and provide a list of possible problem locations. Configuration work will continue, with a focus on finishing the intermediate array set of the simulations.

MILLIMETER ARRAY/ALMA-US
PROJECT STAFFING

MONTH END NOVEMBER 2000

WBS Task Name	Number Of Persons Participating in Activity*	Full-time Equivalent Employees
Administration	11	6.9
Site Development	1	0.0
Antennas	5	4.0
Front End	21	14.8
Local Oscillator	11	8.8
IF and Fiber Optics	5	5.0
Correlator	5	4.0
Computing	9	8.5
System Integration	5	4.5
Calibration	2	2.0
TOTAL:	75	58.4

* Several persons in this column are counted two or more times. These particular individuals are involved part-time in more than one activity.