ALMA-US

BIMONTHLY REPORT
PERIOD END NOVEMBER 30, 2003

1 Overview

ALMA officially broke ground in Chile on 6 November 2003 with a ceremony at the OSF site near the town of San Pedro de Atacama. The ceremony was attended by dignitaries from North America, Europe and Chile.

"The U.S. National Science Foundation joins today with our North American partner, Canada, and with the European Southern Observatory, Spain, and Chile to prepare for a spectacular new instrument," said Dr. Rita Colwell, director of the U.S. National Science Foundation. "The Atacama Large Millimeter Array will expand our vision of the Universe with "eyes" that pierce the shrouded mantles of space through which light cannot penetrate." Wayne Van Citters, Division Director for the NSF's Division of Astronomical Sciences represented Dr. Colwell at this ceremony.

"ALMA will be a giant leap forward for our studies of this relatively little explored spectral window towards the Universe," said Dr. Catherine Cesarsky, Director General of ESO. "With ESO leading the European part of this ambitious and forward-looking project, the impact of ALMA will be felt in wide circles on our continent. Together with our partners in North America and Chile, we are all looking forward to the truly outstanding opportunities that will be offered by ALMA, also to young scientists and engineers."

"ALMA will push the limits of engineering to provide a telescope array at a fantastic site for astronomers to peer at the beginnings of the Universe, galaxies, stars and planets, and perhaps even life," said Dr. Fred K.Y. Lo, director of the National Radio Astronomy Observatory (NRAO).

In addition to breaking ground, the project also unveiled the newly adopted ALMA logo. The logo, shown above, includes elements that represent both radio astronomy (the antenna array) and the southern sky (the Southern Cross).

2 Programmatics

2.1 Financial Statement

Table A2 in the Appendix of this report shows the actual and budgeted expenditures by WBS Level 1 category. $ 4.34M has been expended and committed fiscal 2004 to date. Project to date funds expended plus committed were $28.32M.

2.2 Personnel

The ALMA Project staffing is reported in Table A1 in the Appendix. This table shows the staffing by WBS Level-1 category based on the joint project WBS. The total number of full-time equivalent employees was 93.5.

2.3 Progress towards Project Milestones

The following level one and level two milestones were scheduled for completion during the current period.

WBS	Description	Planned Date	Actual Date Or Revised Date	Status	Resp
1.010 .8105	Designation of responsibility for Ph. 2 dev. work elements in Europe	03-Oct-15	03-Dec-31	Open	ESO
1.010 .8122	Executives submit 2004 budget and financial projections to JAO	03-Oct-08	Dec 15	Done	Both
1.015 .8227	ALMA Groundbreaking	03-Nov-06	03-Nov-06	Done	Both
2.025 .8222	AOS Foundations NA CDR	2003-Nov-30	Under Review	Open	NRAO
2.025 .8250	AOS Buildings Foundation/Envelope CDR complete	2003-Nov-30	2004-Feb-28	Open	NRAO
2.025 .8340	OSF Facilities Phase 1 EU Design/Eng contract awarded	2003-Oct-23	2003-Nov-1	Done	ESO
3.035 .8530	Shared access to AEC antenna	2003-Nov-15	2003-Dec-15	Open	ESO
3.035 .8540	Provisional Acceptance of AEC Antenna	2003-Nov-21	2003-Dec-21	Open	ESO
3.045 .8525	CFT/RFP Antenna Bid package submitted to JAO	2003-Oct-02	2003-Nov-30	Done	Both
3.045 .8535	Issue CFT/RFP for Production antennas	2003-Oct-31	2003-Dec-15	Open	Both
4.090 .8765	Freeze front end optics design	2003-Oct-10	2003-Oct-10	Done	ESO
4.100 .8820	Freeze design of DC support electronics	2003-Oct-09	2003-Oct-09	Done	NRAO
6.315 .9215	Pass Correlator CDR	2003-Oct-27	2003-Oct-27	Done	NRAO
7.340 .9495	Software subsystem Major Release 1(SR!)	2003-Oct-9	2003-Oct-9	Done	Both

9.380 .9820	Calibration strategy submitted	2003-Oct-31	2003-Dec-30	Late	Both

A complete list of the level one and level two milestones is included as an attachment to this report.

2.4 Earned Value Analysis

An Earned Value Analysis for those ALMA tasks assigned to NRAO is shown below for the period ending 30 November 2003.

Limitations in the tools currently used to time phase the budget assigned to individual tasks limits the absolute fidelity of the analysis, particularly where task costs are dominated by large contracts. The budget model used as the baseline for the Earned Value calculations assumes a fixed linear spending rate within each low level task. Actual spending in these cases occurs in discrete increments as commitments are made.

The project is currently investigating options to augment these tools and add resources to the project control function to improve the fidelity of the Earned Value calculations. While ESO does not currently utilize any Earned Value Analysis, we are working with the JAO and ESO to adopt a common set of tools, procedure and reporting formats across the entire project. A consulting firm, Triad Project Management, has been retained by NRAO on behalf of the JAO for a Phase 1 study of approximately four months. Phase 1 will be followed by a Phase 2 implementation expected to be complete by the end of calendar year 2004.

In the meantime, the current analysis remains a useful tool for the North American project to identify cost and schedule issues and measure the impact of specific interventions.

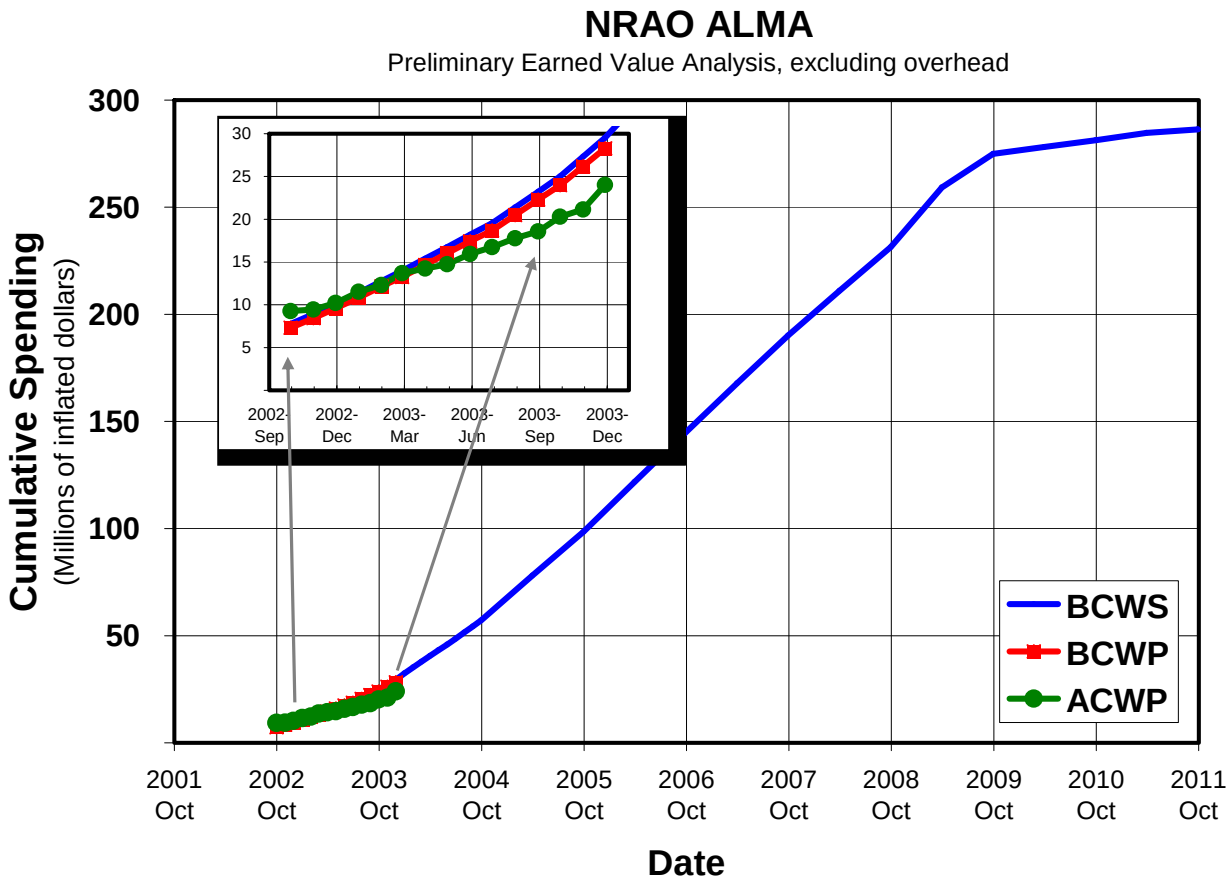
As compared to last reporting period, this earned value analysis shows a continuation of the positive cost variance. The overall schedule variance remains unchanged. The positive cost variance is dominated by the Site and Correlator WBS elements where the time phasing of large commitments are not well modeled by the cost database. This also creates the significant At-Completion positive variance. These anomalies will be attenuated when a number of large commitments are placed early in FY2004.

WBS #	Task	Cumulative to 2003-Nov-30					Variance		At Completion		
		BCWS Budgeted Cost of Work Scheduled	**BCWP** Budgeted Cost of Work Performed	**ACWP** Actual Cost of Work Performed	**% Complete** BCWP / BAC	Cost Perform. **Index** BCWP / ACWP	**Sched** BCWP - BCWS	**Cost** BCWP - ACWP	**Budgeted** BAC 2003oct31b	**Projected** BAC / CPI	**Variance**
1	Management	2,152	2,152	1,859	16%	116%	0	293	13,105	11,322	1,783
2	Site	1,606	1,608	761	6%	211%	2	846	27,159	12,863	14,296
3	Antenna	1,618	1,730	1,243	1%	139%	112	487	124,948	89,757	35,191
4	Front End	9,683	8,986	7,955	24%	113%	(696)	1,031	37,751	33,418	4,333
5	Back End	4,963	4,503	4,661	12%	97%	(461)	(158)	37,948	39,280	(1,332)
6	Correlator	3,155	3,109	2,511	23%	124%	(46)	598	13,528	10,927	2,601
7	Computing	3,218	3,190	2,468	20%	129%	(28)	721	15,650	12,111	3,540
8	System	2,529	2,408	1,977	21%	122%	(120)	432	11,601	9,523	2,079
9	Science	600	600	569	13%	105%	0	31	4,665	4,424	240
	Total	29,523	28,286	24,005	10%	118%	(1,237)	4,281	286,355	223,625	62,731

Earned Value Analysis for tasks assigned to NRAO.
Cumulative from October 1, 2001 through November 30, 1003

Notes:

1. All amounts are in k$
2. Budgeted expenditures are reported in dollars of the year commitments are planned
3. Actual expenditures are in dollars of the year commitments are made
4. Budgeted amounts do not include contingency
5. Budgeted and actual amounts are exclusive of shared administrative functions



Earned Value Trends through 31 September 03

2.5 Concerns

While a unified antenna procurement strategy has been developed, approved and is being implemented at NRAO and ESO, the antenna procurement remains the largest risk area for the project schedule and budget.

Erection of the Alcatel antenna has taken longer than anticipated. There remains a significant risk that commissioning and acceptance tests could extend beyond the current schedule. Such a delay places the evaluation activity at risk. If sufficient radiometric tests cannot be completed prior to the end of the winter observing season, complete evaluation of the Alcatel antenna may not be possible prior assessing the proposals for the production antennas.

Other concerns are included in the individual reports of the Level 1 WBS reports.

3 ALMA Technical Memos Distributed This Period

479	Requirements for Subreflector and Feed Positioning for ALMA Antennas	Bryan J. Butler (NRAO)
481	Preliminary Tests of Waveguide Type Sideband-Separating SIS Mixer for Astronomical Observation	Shin'ichiro Asayama (OPU/NRO), 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 Antenna IPT effort during this period has been focused on completing the RFP/CFT documents (Technical Specification, Statement of Work, ICDs and related documents) for the production antennas. A meeting was held in Socorro, NM the week of November 24th to finalize the documents and resolve any outstanding issues related to the Technical Specification and Statement of Work. The RFP/CFT is expected to be released to the potential bidders the 15th of December.

Figure 1. View of VertexRSI and AEC antennas at the end of November.

Vertex RSI Antenna

The remaining punch-list items have been completed and all outstanding documentation for the Vertex RSI antenna has been delivered as of October 30th. The contract was closed November 6th and the antenna will be covered by the manufacturer's warranty until October 31st, 2004.

The Vertex RSI antenna is currently undergoing evaluation and testing by the Antenna Evaluation Group. The installation of the radiometer system (figure 2) was performed in mid October and radiometry began early in November. Part of this system is the nutating subreflector (figure 3), which was installed on October 23rd. The nutating subreflector operated normally until November 21st when a mechanical problem occurred, which is

currently being diagnosed and will be addressed shortly. The nutating subreflector can be stowed in a fixed position to allow total power observations to continue while a solution to the problem is being formulated.

Additionally, the first scheduled preventative maintenance for the antenna was arranged to take place the first week of December and to be performed by Vertex RSI. Various warranty items will also be addressed during this maintenance.

Figure 2. Evaluation Receiver Installed.

Figure 3. Nutating Subreflector Installed

AEC Antenna

The AEC antenna assembly is complete and is undergoing acceptance testing. Preliminary Acceptance of the AEC antenna is planned to be completed by the first week of December. Servo acceptance and software acceptance testing has been satisfactorily performed with a few minor details to be worked out, such as the azimuth acceleration not meeting the specification. This may require more work from the Contractor. The main antenna subsystems that remain to be accepted are the HVAC system and subreflector positioning mechanism.

The Holography Receiver is scheduled to be installed the second week of December with the holography measurements and panel setting to be performed after the first of the year 2004. The Optical Pointing telescope has been installed and initial tests indicate the system is functional. Actual measurements of the antenna pointing with the Optical Pointing Telescope are scheduled to begin in early 2004.

4.2 Frontend

Front End Management (ALMA Work Package: 4.075)
Herzberg Institute of Astrophysics

The main task has continued to be the planning and monitoring the work of the groups involved in the front-end IPT. Particular attention has been paid to work-packages that are to be delivered in the near future and that (if late) would delay progress by either partner. Weekly meetings involving the IPT lead and deputy and the two subsystem engineers have helped to coordinate front-end IPT activities.

Front End Development (ALMA Work Package: 4.100)
NRAO Tucson

Work on the detailed design of the front-end sub-system continues. Having finalized the external interface control documents, internal interfaces are being rapidly defined allowing the various groups to proceed with their work in parallel.

The monitor and control question mentioned in the previous report has been resolved with the adoption of the AMBSI 1 card as the ALMA standard. The front-end will use this as a bridge to a more capable commercial card. Several options for this hardware are under investigation. Progress with the detailed design of the monitor and control system is being hampered by the lack of knowledge of the calibration scheme and the photonic switch module. These issues are being actively pursued.

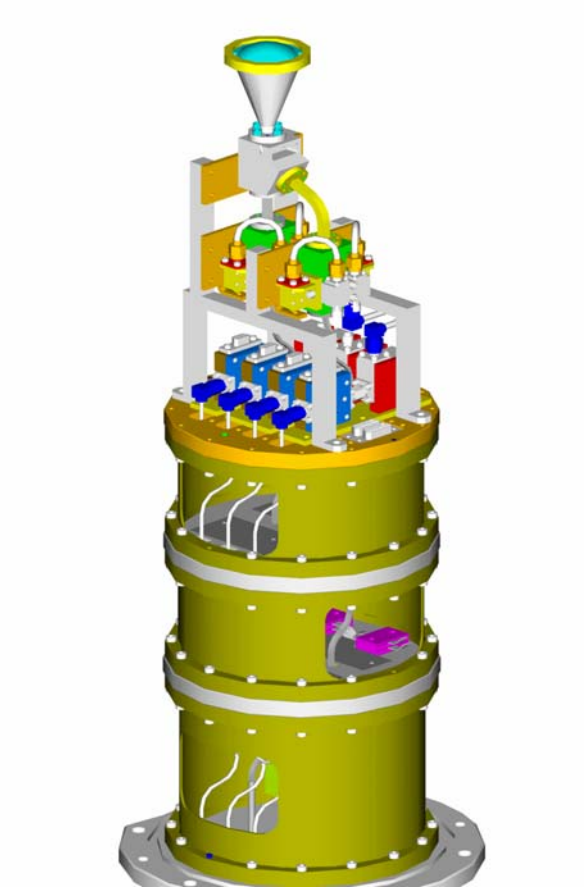
Several commercial suppliers for the IF switch/processor has been identified and a prototype of the front-end chassis has been built.

Band 3 cartridge (ALMA Work Package: 4.145)
Herzberg Institute of Astrophysics

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

Work on developing low-noise 4-8 GHz IF amplifiers based on commercially available InP transistors continues. The latest results are very encouraging and indicate a cooled performance of about 5-7 K and a gain of 30 +- 0.5 dB across the 4-8 GHz IF band. The Band 3 team is working with a Canadian company and expect to transfer this technology with the intention of purchasing finished amplifiers commercially.

The layout of the Band 3 cartridge has been finalized and is shown in the figure below. Detailed engineering drawings are now being prepared for each of the subsystems within the cartridge.



Work on the various test-sets continues. The mixer test set is complete and vacuum tests of the cryostat are expected to be complete by the end of the year.

A preliminary design review for the Band 3 work-package will be held in late January or early February.

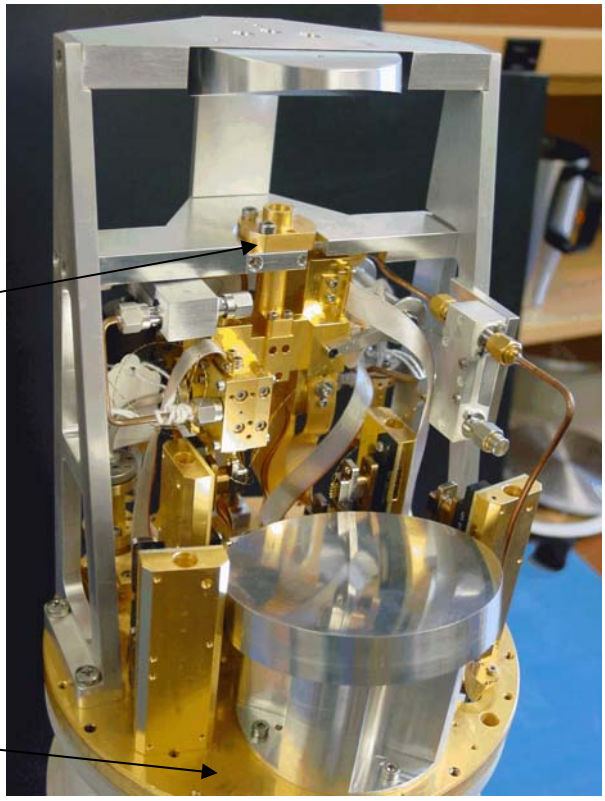
Band 6 cartridge (ALMA Work Package: 4.160)

NRAO Central Development Laboratory

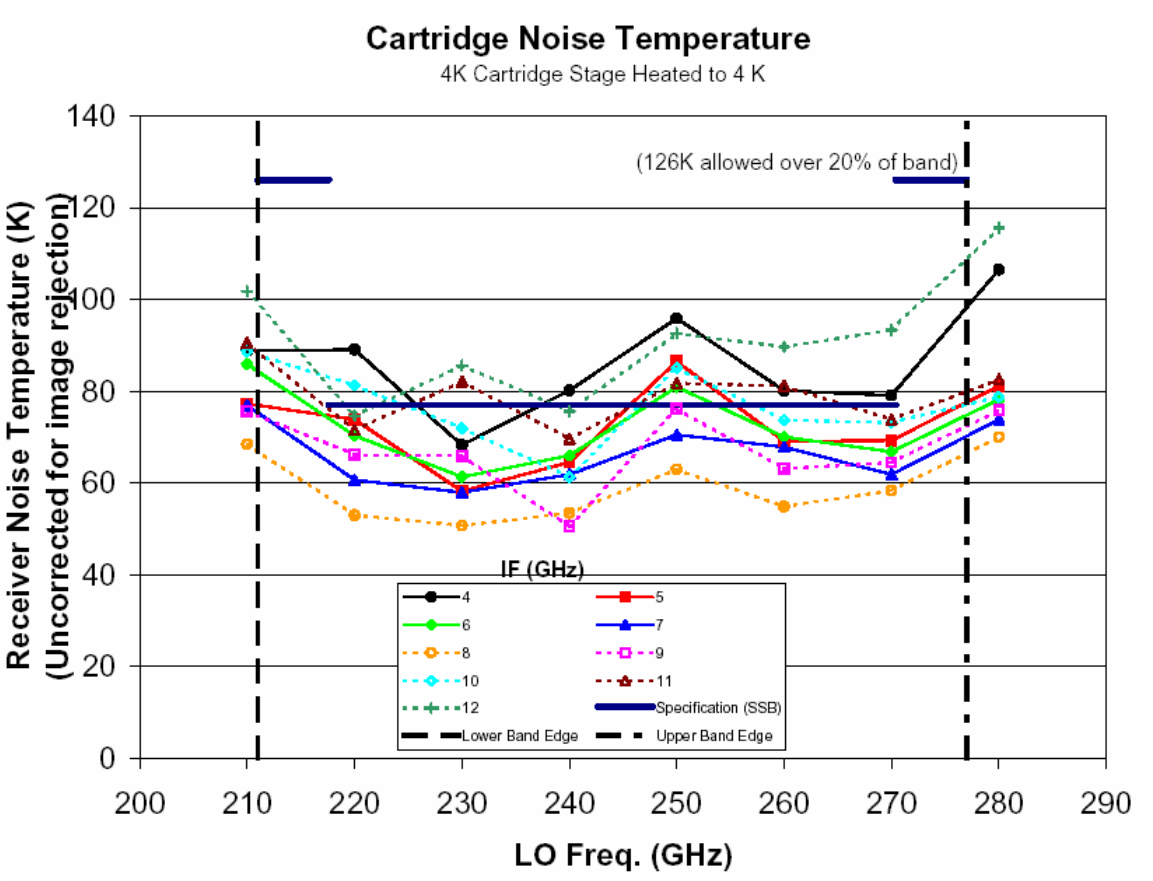
Having successfully developed a mixer design that meets the performance specifications of the ALMA project, work has concentrated on building and testing an extended series of mixer assemblies to investigate the yield and perfect the assembly process. The Band 6 team are investigating commercial sources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

Following technology transfer, a commercial company is currently building a run of three 4-12 GHz low-noise IF amplifiers. These will be tested shortly, and if the performance is satisfactory the team expect to purchase the amplifiers required for production. These amplifiers are based on a TRW InP transistor that is not commercially available and securing a supply of these devices remains a concern.

The design of the Band 6 cartridge is complete and a prototype cartridge has been assembled. In this prototype all components are as in a production cartridge except for the orthomode transducer, which has been replaced by a single channel dummy. A photograph of the complete cartridge and a close-up of components on the 4K stage are shown in the photographs below.



The prototype cartridge has been tested using the test cryostat supplied by the Japanese group and a rack of commercial and custom-built test and measurement electronics. The cartridge cooled successfully and RF measurements of the performance were made. The results, shown below, are very encouraging and come close to meeting ALMA RF specifications



Work on the mixer test set is mostly complete and mixers have been cooled and tested, yielding the same result as in the standard test set. Work continues on developing custom software to automatically operate the test sets and to archive/process the data.

A preliminary design review of the band 3 work-package will be held in late January or early February

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

NRAO Central Development Laboratory

Work continues on the final design details and documentation for the first local-oscillator chains for bands 3,6,7 and 9. A delay in the delivery of a wafer of devices from Hughes Research Labs has somewhat delayed the program and we currently expect to deliver local-oscillator chains for the four initial band in March 2004. This should not result in a delay to the delivery of finished cartridges.

Following the successful cryogenic testing of band 6 and 7 frequency multipliers an order for enough devices to satisfy our ALMA needs is being processed. An order for band 9 devices awaits further tests of the new power amplifier design.

4.3 Correlator

Prototype 2-antenna correlator

The only performance issue for the 2-antenna prototype correlator, occasional bit errors in transmitting filtered samples, was cured by a minor change in the clock distribution to the interface boards. The 2-antenna prototype correlator is ready to ship, although software development verifying operation for the supported modes continues.

A prototype optical receiver card minus the optical components was successfully plugged into the prototype correlator and powered up but not functionally tested.

Critical Design Review

The Critical Design Review was held in Charlottesville Oct 2-3, chaired by Brent Carlson of the Herzberg Institute for Astrophysics. It was a very useful meeting as well as an important design review. The committee briefly reported that the review of the baseline 64-antenna correlator is satisfactory and procurement should proceed rapidly. There were a few design issues mostly concerning detailed mechanical design and building interface which should be addressed in detail before procurement of related items such as racks. The Critical Design Review final report was released at the end of October.

Enhanced filter card

The CDR committee considered the CDR meeting to be, in effect, a Conceptual Design Review for the tunable 2-stage FIR filter option to enhance the Baseline Correlator, and endorsed the IPT recommendation that this option be adopted. A draft Change Request has been written but not yet submitted, pending a visit by NRAO engineers to Bordeaux in early December to discuss details of the interface and operation of the enhanced filter card.

New facility

The correlator group is scheduled to move to its new quarters at the NTC before the end of December. The room in which up to two quadrants of the 64-antenna correlator will be housed requires special flooring, power, air conditioning, and fire protection. Quotations for this work from two contractors are in progress. This work must be completed before integrated testing of the first quadrant can begin; this is currently scheduled for June 2004, which allows plenty of time for room outfitting to be completed.

Procurement Strategy

A detailed plan was laid out for buying the parts and contracting for the assembly of the hundreds of circuit boards and other components needed for the 64-antenna correlator. It was determined that there are significant cost savings if production of all circuit boards for all four quadrants are contracted at one time, rather than separately for each quadrant. Purchase orders were written accordingly for turnkey production of the first set of circuit boards, and the remaining orders will be placed in a timely manner.

The entire AC-to-DC power system, using standard commercial power supplies employed by the telecommunications industry, was purchased at substantial savings over piecemeal procurement.

Schedule

The goals for October-November 2003 were:

(1) Complete hardware revision and checkout of the two-antenna prototype correlator.
(2) Successfully pass the Critical Design Review.
(3) Make a decision about implementing the enhanced filter card.
(4) Begin ordering parts for the first quadrant of the 64-antenna correlator.

As of the end of November:

(1) The hardware checkout of the two-antenna prototype correlator was completed, and it is ready to ship.
(2) The CDR was held and the correlator passed review; the final report has been released.
(3) A Change Request has been drafted for formal adoption of the enhanced filter card.
(4) The first order for quantity production of circuit boards was placed.

The goals for December 2003-January 2004 are:

(1) Ship the 2-antenna prototype to the test facility in Socorro.
(2) Move the correlator group to the NTC.
(3) Place a contract for the correlator room work at the NTC.
(4) Place most of the remaining orders for 64-antenna production, with a few exceptions such as the full complement of racks (for which there is no convenient storage).
(5) Complete the external ICDs.
(6) Submit the Change Request for implementing the enhanced filter card.
(7) Determine the funding route by which production and testing of the enhanced filter card will be accomplished.

4.4 Computing

There were two major releases in this period. ALMA Computing had its first Integration Release (IR1). This release for the first time put all software systems together in an integrated package. Secondly, we had the third major release of the ALMA Common Software (ACS) infrastructure.

We released a detailed proposal for an ALMA Export Data Format (EDF). After we receive input on this proposal (most notably from the Science IPT) we will make a final version. This is a major interface for ALMA.

We held a week long design meeting to discuss matters arising from IR1, notably those related to the overall data flow and model.

We completed commissioning of the radiometry system at the ATF, including both control and data processing aspects. Both position switched and beam switched observing are supported. We participated in the acceptance testing of the AEC antenna (particularly the ACU communication aspects).

A "micro Pipeline" was implemented that demonstrates binding of AIPS++ computational elements into ACS, i.e. ALMA's software infrastructure. No major problems were uncovered in this process.

The Science Software Requirements (SSR) committee met face to face at the NRAO (AOC/ATF). Topics discussed included testing plans, the data model, and work towards validating the data rate specification based on the DRSP.

We had a major presence at the Astronomical Data Analysis Software and Systems (ADASS) conference. One invited talk and 8 poster presentations. We also had a significant presence at the International Accelerator and Large Experimental Physics Control Systems (ICALEPCS) conference with three papers presented.

4.5 Systems Engineering

Reviews

The System Requirements Review was the main activity of SE during this time period. The highest priority was to review before 15 December those documents needed for the antenna procurement bid package. After that Science, System, Front End, and Back End requirements documents are to be approved by 31 December 2003. Then, all of the remaining top level requirements documents and ICDs should be approved by 29 February 2004.

The original date for completing the full SRR was 31October 2003. This became unachievable as emphasis was concentrated on the antenna documentation plus some authors had to work on hardware deliveries instead on preparing documents. Also the document review and approval process was overloaded by the volume of work and thus the process took too long. The later delivery of these documents does not delay any development activity.

System Engineering staff participated in the following project reviews during this report period:

- AMAC presentation in Dwingeloo Oct 13, 14;
- Correlator CDR in Charlottesville Oct 2, 3;
- Digitizer review in Bordeaux Oct 16,17;
- Antenna procurement document review in Socorro Nov 24, 25;
- OSF Technical Facilities layout, several meetings ;
- ALMA Operations planning, several meetings;

The outline for a System Design Review was sent out to IPT leads for comment.

Other document activity by SE included:

- Finalization and agreement with the Antenna and Site IPTs on the ALMA Coordinate System Specification;
- Commented on Antenna Technical Specifications and Statement of Work;
- Provided comments to Antenna IPT regarding the inclusion of Product Assurance requirements in antenna contract document.

Reliability

One of the goals of SE is to estimate total system reliability and to identify critical items that will needed special design consideration. The Relex software package was procured for NRAO to analyze hardware reliability. This is the same software used at ESO so both institutions now have the same reliability analysis tools.

Relex was installed in November and SE has delivered preliminary reliability analysis for the Back End 2nd LO assembly. Reliability analysis of printed circuit boards for the correlator has begun. Additional training on Relex will be organized at ESO in the beginning of January for a few ESO and NRAO System Engineering people.

ALMAEDM

SE provided ALMAEDM support for the Site IPT staff and Fichtner staff in Chile.
The search functionality is now working on a development where a new ALMAEDM release is being tested.

System Integration

A draft plan for prototype system integration was circulated for comment 31-October. Also, a draft plan for ALMA system integration in Chile was distributed on 28-Nov.

System Design

- SE participated in a meeting with Site, BE, Correlator and Computing IPTs to set requirements for a UPS system at the AOS.
- SE participated in meetings on the amplitude stability specification for the FE IPT.
- A discussion was held between BE, CMP and SE IPTs regarding critical timing of LO functions (phase switching, phase tracking and delay tracking).
- ALMA System Block Diagram is currently undergoing revision update. Should be available early 2004 on ALMAEDM (Rev H).

4.6 Imaging and Calibration

Overview

Science IPT Activities

During October-November, Science Group activities centered around revision of the ALMA Science Requirements document, preparation of the ALMA Calibration Strategy Plan, completion of the Design Reference Science Plan, construction of an Operations Plan in concert with the Operations Group, including how the plan described in Chapter 6 of the Project Plan might be improved, and also how the ALMA Science Center will operate. During this period a transition occurred in EU Project Scientist from Ewine van Dishoeck to Tom Wilson. Brian Butler left the ALMA Science IPT at the beginning of the period.

Joint NA/EU Science IPT staff and Calibration Group telecons were held monthly, and the weekly NA Science IPT telecons continued, beginning their sixth year (Agendas and notes for all meetings are available; this period's include telecons on 7, 14, 20 (Science IPT), and 28 October; and 11, 18 (Science IPT) and 25 November. During these telecons, progress on action items is tracked toward meeting milestones and assignments (new action items) are made to assure their timely completion. One Level 2 Milestones scheduled during October-November 2003 has been postponed owing to its Lead, Brian Butler, departing. It is expected to be complete by 2003-Dec-31. There was one level 3 milestones met during the period and one of Level 3 and below was deferred owing to departure of the responsible party. Two minor milestones have been delayed.

Activities involving the ALMA Community in North America

The Science IPT arranged the agenda, minutes and telecon for the monthly ASAC telecons (held on 12 November 2003; agendas and minutes in ALMAEDM). The related ALMA North America Science Advisory Committee (ANASAC) group also held telecons (held on 27 June and 25 July; agendas and minutes available) facilitated by the Science IPT. In conjunction with the ANASAC and NRAO, the NA Science IPT planned a town meeting to be held at lunchtime on January 8, 2004 during the American Astronomical Society meeting in Atlanta. Planning commenced for a general North American ALMA Science Meeting to be held at the University of Maryland conference center on 14-15 May 2003. These items, and the plans for the ALMA proposal review process were the subject of an ANASAC telecon held in October.

Science IPT was represented at the AMAC meeting by van Dishoeck, who made presentations on the Science IPT and on the Design Reference Science Plan. Wootten and van Dishoeck both represented the Science IPT at the Board meeting in Santiago in November and at the subsequent ALMA Goundbreaking ceremony. A great deal of planning was accomplished in discussions with other Board 'Closed Meeting Outcasts'. Pictures and information about that ceremony was distributed to interested scientists via a special web page.

Wootten assisted NRAO Director Lo in compiling material for his presentation to NSF on ALMA.

Interactions with Other IPTs

The Science IPT held discussions with the FE IPT on tests of calibration devices. A plan for further tests was conveyed, including the design of the design of the amplitude calibration device described in ALMA Memo No. 461. Implementation of this device in the Array was sought by way of a change request.

The Science IPT participates in the Operations Group. Version D of the Operations Plan was written as of the end of November, for further iteration toward an end of the year submission to the Project.

Wootten attended the Correlator CDR, serving on the review committee for the Science IPT. Although there are software details to be worked out, the Correlator itself meets the ALMA science requirements.

A major activity has been construction of the Calibration Plan, some details of which are described below under anticipated activity during the next two months.

At a Science IPT telecon on 11 Nov; discussion on antenna specifications document included study assignments on science implications for various specific specifications. Comments, including simulation results on the effects of the lower acceleration values

requested in the revised specifications, were delivered to the JAO and are available at NA Science IPT telecon agenda of 18 Nov, where further discussion ensued.

Stability issues for the system were also discussed at the telecon preparatory to a telecon with SE and FE on 13 November. At the latter telecon specifications were agreed between the three IPTs. At a later meeting of the Change Control Board, gain stability specifications were adopted. For the ALMA system, gain stability must not be worse than one part in 10-3 in one second. On the total power antennas, system gain stability must be better than 4 parts in10-4 s-1 total. Sramek noted that the Systems group would then settle on an allocation of 7 parts in 10-4 s-1 to front end and same to back end. Out of 80 ALMA needs four receiver packages which meet this specification. It was noted that good polarization measurements require better than five parts in 10-4 s-1 over five minutes gain stability as in the original draft specification.

Loosened phase stability specifications proposed by D'Addario express more pessimism about schemes for removing atmospheric phase instabilities than those expressed by the Science IPT. Fast switching simulations, much more elaborate than any heretofore designed, were carried out by Holdaway in coauthorship with D'Addario. These simulations have been published in draft form and details continue to be worked out. However, the bottom line is that past estimates of the efficacy of fast switching in removing atmospheric phase components are supported. The new simulations show that if good a good high frequency calibrator net can be established, fast switching at the target frequency works quite well, even compared to switching to a low frequency band. Water vapor radiometry will correct phase variations on one second scales; on shorter scales coherence will be lost. The Science IPT continues its efforts to convince skeptics that the WVR system will work as intended, and to the specifications advertised by the WVR team and the Science IPT.
The final details were addressed in the Design Reference Science Plan, and van Dishoeck wrote a set of introductory remarks for it. This Plan will be released to the project in the first weeks of December, though it has already proven useful. At its face-to-face meeting, the Science Software Requirements group used several of its elements to calculate data rates from ALMA. Using the results of the new fast switching simulations, calibration overhead rates for typical ALMA experiments were estimated for the first time. These could reach 30% for difficult experiments.

Anticipated activity in the next two months:

Early in December, the Design Reference Science Plan will be released.

The Calibration Strategy for ALMA should be finished in its draft form. In twelve major sections, all elements of ALMA calibration will be addressed. For each, a description of the calibration technique will be provided, along with a description of hardware required and a note of the budgeted allocation for this hardward, with references. For each, the frequency of the calibration observation and the dependence of frequency upon wavelength will be discussed. Quantities to be archived will be detailed (along with the rate), and it will be noted which systems will need to access them. If a particular

calibration device involves another IPT, the need for an ICD will be noted and all ICDs required tabulated. Furthermore, for each technique there will be a note of what further tests and/or development is required, with a recommended implementation plan.

Science IPT ALMA Papers, Memos and Studies

Joint Distributon of Atmospheric Transparency and Phase Fluctuations at Chatnantor Larry D'Addario and Mark Holdaway

Simulation of Atmospheric Phase Correction Combined with Instrumental Phase Calibration Using Fast Switching. M. A. Holdaway and L. D'Addario.

Plans for a 1% Absolute Flux Experiment at 100 Ghz. Proposal from J. Gibson and J. Welch.

ALMA Memo 478 Distance to Possible Calibration Sources as a Function of Frequency for ALMA Bryan Butler

ALMA Memo 475 Observing Stars & Extrasolar Planetary Systems with ALMA Bryan Butler, Alwyn Wootten, & Bob Brown

ALMA Memo, Rejected. Notes on Axis Intersection for MMA Antennas Bryan J. Butler

APPENDIX

TABLE A1
ALMA-US
PROJECT STAFFING
PERIOD END NOVEMBER 30, 2003

WBS Task Name	Full-time Equivalent Employees
Administration	2.4
Site Development	1.3
Antennas	4.0
Front End	33.7
Back End	16.6
Correlator	5.6
Computing	18.2
System Integration	9.4
Calibration	2.3
TOTAL:	93.5

Note: The FTE totals above include an allocation for 16 FTE paid by ALMA for shared administrative functions.

TABLE A2
ALMA-US
PROJECT FINANCIAL SUMMARY

Project Expenditures and Commitments
Period End November 31, 2003

WBS	FY04 to Date FY 04 Budget	FY04 to Date Actual	Project To Date Project Budget	Project To Date Actual
1. Management	1,338,401	282,569	13,104,632	1,859,464
2. Site	4,583,331	13,449	27,159,458	761,492
3. Antenna	7,085,970	92,170	124,948,355	1,242,803
4. Front End	6,528,183	632,078	37,750,775	7,955,053
5. Back End	3,984,478	755,072	37,974,784	4,660,701
6. Correlator	4,702,358	1,438,307	13,527,810	2,510,997
7. Computing	1,864,686	278,644	15,650,451	2,468,196
8. Systems	1,549,748	177,781	11,601,488	1,976,838
9. Science	547,658	34,971	4,664,559	569,266
Shared Admin	3,029,132	635,490	20,106,395	4,316,255
Totals	$ 35,213,945	4,340,531	306,488,707	28,321,065

TABLE A3

Project Commitment Authority
Period End November 2003

Commitment Authority	Amount
Received in FY2002	12,486,017
Received in FY2003	29,794,397
Received in FY2004	9,900,000
TOTAL	52,180,414
Expended & Committed	28,321,065
Remaining Commitment Authority	23,859,349

Notes:

1. Budget allocations based on current ALMA Project Plan. Budget allocations to IPTs do not include contingency.

2. Shared Admin expenses include administrative personnel and facilities costs and are included in the ALMA budget estimate and managed outside the IPTs.

3. The financial data contained in this report are unaudited and are provided here for reference. The NRAO fiscal division supplies audited financial data.

ALMA Milestone Summary (Version: 2003nov20a)

Legend: Level 1:1 Level 2:X Level 3: o (Original dates in gray)

Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
8105	1.010.8105	Designation of responsibility for Phase 2 development work elements in Europe	2003-Oct-15	2	Late		X	X									EU	167
8110	1.010.8110	Designation of responsibility for Phase 2 production work elements in Europe	2004-Jul-01	2				X									EU	0
8120	1.010.8120	Executives submit 2003 budget and financial projections to JAO	2003-Feb-05	2	Done		X										Both	0
8121	1.010.8121	Executives submit 2002 financial report (actual expenditures and value earned) to JAO	2003-Apr-28	2	Done		XX										Both	59
8122	1.010.8122	Executives submit 2004 budget and financial projections to JAO	2003-Oct-08	2	Done		X	X									Both	37
8123	1.010.8123	Executives submit 2003 financial report (actual expenditures and value earned) to JAO	2004-Feb-28	2				X									Both	0
8124	1.010.8124	Executives submit 2005 budget and financial projections to JAO	2004-Sep-01	2				X									Both	0
8410	1.010.8410	Start Operations Budget	2005-Jan-01	2					X		X						Both	-911
8125	1.010.8125	Executives submit 2004 financial report (actual expenditures and value earned) to JAO	2005-Feb-28	2					X								Both	0
8126	1.010.8126	Executives submit 2006 budget and financial projections to JAO	2005-Sep-01	2					X								Both	0
8127	1.010.8127	Executives submit 2005 financial report (actual expenditures and value earned) to JAO	2006-Feb-28	2						X							Both	0
8128	1.010.8128	Executives submit 2007 budget and financial projections to JAO	2006-Sep-01	2						X							Both	0
8129	1.010.8129	Executives submit 2006 financial report (actual expenditures and value earned) to JAO	2007-Feb-28	2							X						Both	0
8130	1.010.8130	Executives submit 2008 budget and financial projections to JAO	2007-Sep-01	2							X						Both	0
8131	1.010.8131	Executives submit 2007 financial report (actual expenditures and value earned) to JAO	2008-Feb-28	2								X					Both	0
8132	1.010.8132	Executives submit 2009 budget and financial projections to JAO	2008-Sep-01	2								X					Both	0
8133	1.010.8133	Executives submit 2008 financial report (actual expenditures and value earned) to JAO	2009-Feb-28	2									X				Both	0
8134	1.010.8134	Executives submit 2010 budget and financial projections to JAO	2009-Sep-01	2									X				Both	0
8135	1.010.8135	Executives submit 2009 financial report (actual expenditures and value earned) to JAO	2010-Feb-28	2										X			Both	0
8136	1.010.8136	Executives submit 2011 budget and financial projections to JAO	2010-Sep-01	2										X			Both	0
8137	1.010.8137	Executives submit 2010 financial report (actual expenditures and value earned) to JAO	2011-Feb-28	2											X		Both	0
8050	1.015.8050	Completion of Construction Project	2011-Dec-31	1												1	Both	0
8165	1.015.8165	Site available for Work	2003-Jul-25	2	Done		XX										JAO	115
8170	1.015.8170	Submit 2003 budget and financial projections to ALMA Board	2003-Feb-11	2	Done		X										JAO	0
8171	1.015.8171	Submit 2002 financial report (actual expenditures and value earned) to ALMA Board	2003-May-26	2	Done		XX										JAO	56
8227	1.015.8227	ALMA Groundbreaking	2003-Nov-06	2	Done			X									JAO	3
8172	1.015.8172	Submit 2004 budget and financial projections to ALMA Board	2003-Oct-27	2	Done		X	X									JAO	27
8173	1.015.8173	Submit 2003 financial report (actual expenditures and value earned) to ALMA Board	2004-Mar-31	2				X									JAO	0
8174	1.015.8174	Submit 2005 budget and financial projections to ALMA Board	2004-Sep-30	2				X									JAO	0
8175	1.015.8175	Submit 2004 financial report (actual expenditures and value earned) to ALMA Board	2005-Mar-31	2					X								JAO	0
8176	1.015.8176	Submit 2006 budget and financial projections to ALMA Board	2005-Sep-30	2					X								JAO	0
8177	1.015.8177	Submit 2005 financial report (actual expenditures and value earned) to ALMA Board	2006-Mar-31	2						X							JAO	0
8178	1.015.8178	Submit 2007 budget and financial projections to ALMA Board	2006-Sep-30	2						X							JAO	0
8179	1.015.8179	Submit 2006 financial report (actual expenditures and value earned) to ALMA Board	2007-Mar-31	2							X						JAO	0
8180	1.015.8180	Submit 2008 budget and financial projections to ALMA Board	2007-Sep-30	2							X						JAO	0
8181	1.015.8181	Submit 2007 financial report (actual expenditures and value earned) to ALMA Board	2008-Mar-31	2								X					JAO	0
8182	1.015.8182	Submit 2009 budget and financial projections to ALMA Board	2008-Sep-30	2								X					JAO	0
8183	1.015.8183	Submit 2008 financial report (actual expenditures and value earned) to ALMA Board	2009-Mar-31	2									X				JAO	0
8184	1.015.8184	Submit 2010 budget and financial projections to ALMA Board	2009-Sep-30	2									X				JAO	0
8185	1.015.8185	Submit 2009 financial report (actual expenditures and value earned) to ALMA Board	2010-Mar-31	2										X			JAO	0
8186	1.015.8186	Submit 2011 budget and financial projections to ALMA Board	2010-Sep-30	2										X			JAO	0
8187	1.015.8187	Submit 2010 financial report (actual expenditures and value earned) to ALMA Board	2011-Mar-31	2											X		JAO	0
8208	2.025.8208	Final Approval of Architectural program for all AOS buildings	2003-Mar-03	2	Done		X										NA	30
8212	2.025.8212	Draft Joint Antenna Foundation Interface	2003-Mar-06	2	Done		X										Both	33
8213	2.025.8213	Freeze Joint Antenna Foundation Interface	2003-Jun-30	2	Done		XX										Both	135
8216	2.025.8216	Freeze Central Cluster Configuration	2003-Mar-01	2	Done		X										NA	0
8220	2.025.8220	Award Contract Design / Engineering for AOS Facilities NA	2002-Oct-09	2	Done	X											NA	0
8222	2.025.8222	AOS Foundations NA CDR	2003-Nov-30	2	Delay		X	X									NA	274
8224	2.025.8224	AOS Foundations NA Central Cluster Construction Tender Docs Complete	2004-May-30	2	Delay		X	X									NA	411
8226	2.025.8226	AOS Foundations NA Central Cluster Construction Contract Signed	2004-Nov-30	2	Delay		X	X									NA	426
8010	2.025.8010	Begin initial Phase of Civil Work in Chile	2003-Jul-26	1	Done		1 1										Both	-158
8228	2.025.8228	AOS Foundations NA Central Cluster Provisional Acceptance	2007-Jun-30	2	Delay				X		X						NA	730
8230	2.025.8230	AOS Foundations NA Remaining Construction / Tender Docs Complete	2004-Jun-30	2				X	X								NA	-244
8232	2.025.8232	AOS Foundations NA Remaining Construction Contract Signed	2004-Jun-30	2				X	X								NA	-428
8234	2.025.8234	AOS Foundations NA Remaining Provisional Acceptance	2006-Jun-01	2						X	X						-	-365
8236	2.025.8236	AOS Foundations EU Design/Eng Contract Awarded	2007-Jan-01	2							X						-	0
8238	2.025.8238	AOS Foundations EU CDR Complete	2007-Apr-01	2							X						-	0
8240	2.025.8240	AOS Foundations EU Construction / Tender Docs Complete	2007-Jul-01	2							X						-	0
8242	2.025.8242	AOS Foundations EU Construction Contract Signed	2008-Mar-01	2								X					-	0
8244	2.025.8244	AOS Foundations EU Provisional Acceptance	2011-Oct-01	2											X		-	0

ALMA Milestone Summary (Version: 2003nov20a)

Legend: Level 1:1 Level 2:X Level 3: o (Original dates in gray)

Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
8250	2.025.8250	AOS Buildings NA Foundations/Envelope CDR Complete	2003-Nov-30	2	Delay		X	X									NA	243
8252	2.025.8252	AOS Buildings NA Foundations/Envelope Construction / Tender Docs Complete	2004-Mar-15	2	Delay		X	X									NA	289
8254	2.025.8254	AOS Buildings NA Foundations/Envelope Construction Contract Signed	2004-Sep-15	2	Delay			X	X								NA	259
8258	2.025.8258	AOS Buildings NA Foundations/Envelope Provisional Acceptance	2005-May-31	2	Delay			X	X								NA	273
8260	2.025.8260	AOS Buildings Finish & Installations NA CDR Complete	2004-Apr-30	2	Delay		X	X									NA	243
8262	2.025.8262	AOS Buildings Finish & Installations NA Construction / Tender Docs Complete	2004-Aug-31	2	Delay		X	X									NA	275
8264	2.025.8264	AOS Buildings Finish & Installations NA Construction Contract Signed	2005-Feb-28	2	Delay			X	X								NA	242
8266	2.025.8266	AOS Buildings Finish & Installations NA Provisional Acceptance	2006-Mar-31	2	Delay				X	X							-	274
8025	2.025.8025	Initial Phase of Civil Work in Chile Complete	2005-Jun-30	1					1								Both	0
20701	2.025.20701	AOS Interconnect Roads & Trenches NA Provisional Acceptance	2007-Jun-30	2							X						-	0
8284	2.025.8284	AOS Interconnect Roads & Trenches EU Provisional Acceptance	2011-Oct-01	2											X		-	0
8286	2.025.8286	Complete AOS Construction	2011-Oct-01	2											X		-	0
8290	2.025.8290	Construction Road Opening EU Construction / Tender Docs Complete	2003-Feb-26	2	Done		X										EU	11
8292	2.025.8292	Construction Road Opening EU Construction Contract Signed	2003-Jun-25	2	Done		X										EU	85
8294	2.025.8294	Construction Road Opening EU Provisional Acceptance	2003-Nov-30	2	Delay		XX										EU	61
8300	2.025.8300	Access Road EU Design/Eng Contract Awarded	2003-Mar-17	2	Done		X										EU	32
8302	2.025.8302	Access Road to OSF EU CDR Complete	2003-Jun-09	2	Done		XX										EU	70
8304	2.025.8304	Access Road OSF to AOS EU CDR Complete	2003-Jun-09	2	Done		X										EU	55
8306	2.025.8306	Access Road EU Construction / Tender Docs Complete	2003-Sep-22	2	Done		X										EU	68
8308	2.025.8308	Access Road EU Construction Contract Signed	2004-Jul-16	2	Delay			XX									EU	47
8310	2.025.8310	Access Road OSF-AOS ready to accommodate transporter	2005-Jun-30	2					X								-	0
8312	2.025.8312	Access Road EU Provisional Acceptance	2008-Dec-31	2								X					-	0
8334	2.025.8334	Contractors Camp Initial Occupancy	2004-Jan-01	2	Delay			XX									EU	63
8340	2.025.8340	OSF Facilities Phase 1 (Tech area) EU Design/Eng Contract Awarded	2003-Oct-23	2	Done		X	X									EU	144
8342	2.025.8342	OSF Facilities Phase 1 (Tech area) EU CDR Complete	2004-Jan-15	2	Delay			X	X								EU	122
8344	2.025.8344	OSF Facilities Phase 1 (Tech area) EU Construction / Tender Docs Complete	2004-May-01	2	Delay			X	X								EU	122
8346	2.025.8346	OSF Facilities Phase 1 (Tech area) EU Construction Contract Signed	2004-Oct-01	2	Delay				X	X							EU	183
8348	2.025.8348	OSF Facilities Phase 1 (Tech area) EU Provisional Acceptance	2006-Feb-01	2	Delay					X	X						-	185
8350	2.025.8350	OSF Facilities Phase 2 (Res. / Visitor) EU Design/Eng Contract Awarded	2008-Oct-01	2								X					-	0
8352	2.025.8352	OSF Facilities Phase 2 (Res. / Visitor) EU CDR Complete	2009-Mar-31	2									X				-	0
8354	2.025.8354	OSF Facilities Phase 2 (Res. / Visitor) EU Construction / Tender Docs Complete	2009-Jul-01	2										X			-	0
8356	2.025.8356	OSF Facilities Phase 2 (Res. / Visitor) EU Construction Contract Signed	2010-Jan-01	2											X		-	0
8358	2.025.8358	OSF Facilities Phase 2 (Res. / Visitor) EU Provisional Acceptance	2011-Oct-01	2											X		-	0
8360	2.025.8360	Freeze Fiber Optics and Electrical Specifications	2003-Dec-31	2	Delay		X	X									Both	274
8362	2.025.8362	Fiber Optic Cables and Electrical Cables in Chile, N.A.	2004-Sep-30	2	Delay			X									NA	15
8364	2.025.8364	OSF-AOS Fiber Optics Link Installed	2006-Dec-31	2						X							-	0
8366	2.025.8366	Fiber Optic Cables and Electrical Cables in Chile, Eur.	2008-Sep-01	2								X					-	0
8370	2.025.8370	Power Feasibility Study Completed	2003-Apr-07	2	Done		XX										EU	7
8372	2.025.8372	ALMA Project Power Supply Plan Approved	2004-Jan-31	2	Delay			X	X								Both	153
8374	2.025.8374	ALMA Permanent Power Supply Tender Docs Complete	2004-Mar-31	2	Delay			XX									Both	91
8376	2.025.8376	ALMA Permanent Power Supply Contract Signed	2004-Aug-31	2	Delay			XX									Both	92
8378	2.025.8378	Provisional Acceptance Power Supply Contract Phase 1	2005-Sep-30	2	Delay				XX								Both	92
8380	2.025.8380	Provisional Acceptance Power Supply Contract Last Phase	2006-Dec-31	2						X							-	0
8390	2.025.8390	Board Decision Location/Size Santiago JAO Office	2004-Jul-01	2				X									JAO	0
8391	2.025.8391	Architectural Design Contract awarded Santiago JAO Office	2004-Sep-01	2				X									EU	0
8392	2.025.8392	CDR Santiago JAO Office	2004-Nov-01	2					X								EU	0
8393	2.025.8393	Construction Tender Docs Complete Santiago JAO Office	2004-Dec-01	2					X								EU	0
8394	2.025.8394	Construction Contract signed Santiago JAO Office	2005-Jan-01	2					X								EU	0
8395	2.025.8395	Provisional Acceptance Santiago JAO Office	2006-Jan-01	2						X							EU	0
8502	3.035.8502	Shared Access VertexRSI Antenna	2002-Nov-15	2	Done	X											NA	0
8503	3.035.8503	Deliver Foundation Design requirements	2003-May-02	2	Done		XX										Both	76
8505	3.035.8505	Provisional Acceptance of VertexRSI Antenna	2003-Mar-20	2	Done		X										NA	59
8510	3.035.8510	Complete Technical Performance Report-VertexRSI Antenna	2003-Dec-10	2	Delay		X	X									NA	265
8530	3.035.8530	Shared Access AEC Antenna (Preliminary Acceptance)	2003-Nov-15	2	Late		X	X									EU	171
8540	3.035.8540	Provisional Acceptance of AEC Antenna	2003-Nov-21	2	Late		XX										EU	120
8545	3.035.8545	Complete Technical Performance Report-AEC Antenna	2004-Jan-21	2	Delay			X	X								EU	120
8500	3.045.8500	RFQ for VertexRSI Antenna Delivered to Project Office	2003-May-20	2	Done		XX										NA	106
8524	3.045.8524	Prototype Antenna released to Contractor for Refurbishment / Transport to Chile	2004-Aug-28	2	Delay				X								Both	31
8525	3.045.8525	CFT/RFQ Bid Package Submitted to Project Office (AEC/VertexRSI)	2003-Oct-02	2	Done		X	X									Both	124

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Legend: Level 1:1 Level 2:X Level 3: o (Original dates in gray)

Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
8535	3.045.8535	Issue CFT/RFQ for Production Antenna Design(s)	2003-Oct-31	2	Late		X	X									Both	123
8550	3.045.8550	Closing Date for Production Antenna Bids (Competitive Tender)	2004-Feb-28	2	Delay			XX									Both	121
8560	3.045.8560	Bid Evaluations Due to Project Office	2004-Apr-30	2	Delay			XX									Both	94
8565	3.050.8565	Sign Contract for 31+1 North Am. Production Antennas	2004-Jul-28	2	Delay			XX									NA	61
8575	3.050.8575	Sign Contract for 32-Euro Production Antennas	2004-Jul-28	2	Delay			XX									EU	59
8585	3.050.8585	First Antenna Arrives at OSF (Retrofitted prototype TBC)	2005-Oct-31	2					X								-	0
8035	3.050.8035	First Production Antenna available in Chile at OSF	2005-Dec-31	1					1								Both	0
8600	3.060.8600	8th Antennas Preliminary Accepted at OSF	2007-Feb-28	2							X						-	0
8605	3.060.8605	20th Antennas Preliminary Accepted at OSF	2008-Jun-12	2								X					-	0
8610	3.060.8610	30th Antennas Preliminary Accepted at OSF	2009-Jun-12	2									X				-	0
8615	3.060.8615	50th Antennas Preliminary Acceptance at OSF	2010-May-31	2										X			-	0
8620	3.060.8620	All Antennas Preliminary Accepted at OSF	2011-Jun-30	2											X		-	0
8625	3.060.8625	All Antennas Provisionally Accepted in Chile at AOS	2011-Dec-16	2												X	Both	0
8555	3.065.8555	Nutator Critical Design Review Completed	2004-Oct-28	2	Delay			X	X								NA	386
8590	3.065.8590	All Nutators Accepted at OSF	2006-Apr-15	2						X							NA	-61
8569	3.070.8569	Transporter Critical Design Review Complete	2003-Dec-17	2	Delay		X	X									EU	277
8571	3.070.8571	Transporter Contract signed	2004-Mar-31	2				X									-	0
8580	3.070.8580	First Transporter Accepted at OSF	2005-Sep-30	2					X								-	0
8595	3.070.8595	Second Transporter Accepted at OSF	2006-Sep-15	2						X							-	0
8700	4.075.8700	Initial set of FE specs and interface-control documents discussed	2003-Apr-01	2	Done		X										Both	0
8705	4.075.8705	FE specifications and requirements plus ICD's submitted for approval	2003-Sep-01	2	Done		XX										Both	139
8990	4.075.8990	Front end sub-system Delta PDR	2003-Dec-01	2	Delay		XX										Both	91
8995	4.075.8995	All FE Contracts / Agreements in place	2004-Jan-31	2	Delay		X	X									Both	305
9020	4.075.9020	RECEIVER CDR	2006-May-01	2						XX							-	-106
9023	4.075.9023	FE Production authorized	2006-May-01	2						X							-	0
8720	4.080.8720	Freeze Dewar design	2003-Aug-31	2	Done		X										EU	47
8740	4.080.8740	Prototype cartridge bodies (plus dummies) delivered	2003-Jan-01	2	Done		X										EU	0
8750	4.080.8750	Cartridge body design frozen	2003-Dec-01	2	Delay		XX										EU	91
8730	4.085.8730	Receiver Dewar #1 delivered to integration centre	2004-Mar-15	2	Delay			X									EU	74
8735	4.085.8735	Receiver Dewar #8 delivered to integration centre	2005-Jul-01	2					X								-	0
8755	4.085.8755	Cartridge bodies for first receiver delivered	2004-Apr-01	2	Delay			XX									EU	91
8760	4.085.8760	Cartridge bodies for eighth receiver delivered	2004-Jul-01	2				X									EU	0
8765	4.090.8765	Freeze optics design	2003-Oct-10	2	Done		X	X									EU	163
8770	4.090.8770	Freeze windows/IR filters design	2003-Jun-17	2	Done		X										EU	48
8775	4.095.8775	Warm optics for receiver #1 delivered	2004-Feb-01	2	Delay			X									EU	31
8780	4.095.8780	Windows/IR filters for receiver #1 delivered	2004-Jan-01	2				X									EU	0
8785	4.095.8785	Warm optics for receiver #8 delivered	2005-Jul-01	2					X								-	0
8790	4.095.8790	Windows/IR filters for receiver #8 delivered	2005-Jul-01	2					X								-	0
8810	4.100.8810	Deliver lab-prototype DC bias circuits	2003-Apr-24	2	Done		XX										NA	54
8820	4.100.8820	Freeze the design of the DC support electronics	2003-Oct-09	2	Done			X									NA	8
8835	4.100.8835	Deliver lab prototype M/C circuit	2003-May-22	2	Done		X										NA	51
8845	4.100.8845	Freeze hardware design M&C circuit	2004-Jan-01	2	Delay			XX									NA	92
8856	4.105.8856	Deliver the final monitor and control circuitry to each of the cartridge builders	2004-Mar-01	2				X									NA	0
8860	4.100.8860	Deliver receiver control software to users	2004-Mar-15	2	Delay			X									NA	74
8865	4.100.8865	Deliver FE software req. to computing IPT	2004-Jan-01	2				X									NA	0
8905	4.100.8905	Freeze the design of the IF switch/processor	2004-Jan-01	2				X									NA	0
8920	4.100.8920	Freeze the design of the FE chassis	2003-Dec-01	2	Delay			X									NA	61
8922	4.100.8922	Freeze FE Design	2004-Jul-01	2	Delay			X	X								Both	182
8825	4.105.8825	Deliver DC bias electronics for cartridge #1	2004-Jan-01	2				X									NA	0
8830	4.105.8830	Deliver DC bias electronics for cartridge #8	2004-Jul-01	2					X								NA	0
8850	4.105.8850	Deliver the monitor and control module for front-end number one	2004-Mar-15	2	Delay			X									NA	14
8855	4.105.8855	Deliver the monitor and control module for front-end number eight	2004-Sep-01	2					X								NA	0
8910	4.105.8910	Deliver the IF switch/processor for the first front-end	2004-Oct-01	2					X								NA	0
8915	4.105.8915	Deliver the IF switch/processor for the eighth front-end	2005-Jul-01	2					X								-	0
8925	4.105.8925	Deliver the FE chassis for receiver #1	2004-Mar-01	2	Delay			X									NA	60
8930	4.105.8930	Deliver the FE chassis for receiver #8	2004-Sep-01	2	Delay				X								NA	62
8935	4.145.8935	Band 3 Cartridge #1 delivered	2004-Oct-01	2					X								NA	0
8940	4.145.8940	Band 3 Cartridge #8 delivered	2006-Jan-01	2						X							-	0
8945	4.165.8945	Band 6 Cartridge #1 delivered	2004-Oct-01	2					X								NA	0

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Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
8950	4.165.8950	Band 6 Cartridge #8 delivered	2006-Jan-01	2						X							-	0
8955	4.175.8955	Band 7 Cartridge #1 delivered	2004-Oct-15	2	Delay			X									EU	14
8960	4.175.8960	Band 7 Cartridge #8 delivered	2006-Jan-01	2						X							-	0
8965	4.195.8965	Band 9 Cartridge #1 delivered	2004-Oct-01	2				X									EU	0
8970	4.195.8970	Band 9 Cartridge #8 delivered	2006-Jan-01	2						X							-	0
8795	4.210.8795	Delivery of 2 WVR development prototypes	2004-Sep-01	2				X									EU	0
8800	4.215.8800	Deliver WVR #1 to OSF	2006-Jan-01	2						X							-	-14
8805	4.215.8805	Deliver WVR #8 to OSF	2006-Dec-01	2							X						-	-14
8975	4.220.8975	FE Test & Integration centre design ready	2004-Jun-01	2	Delay			X X									NA	244
8040	4.230.8040	Initial Front End Subsystem available at OSF	2005-Dec-31	1					1								Both	0
8980	4.230.8980	NA FE Test & Integration centre operational	2005-Jun-01	2	Delay			X	X								NA	243
8985	4.230.8985	EU FE Test & Integration centre operational	2005-Jun-01	2	Delay			X	X								EU	243
9000	4.230.9000	Deliver Receiver #1 to the ATF	2005-Oct-01	2	Delay				X X								-	92
9005	4.230.9005	Deliver receiver #2 to OSF/AOS	2006-Jan-01	2	Delay				X X								-	90
9010	4.230.9010	Deliver receiver #7 to OSF/AOS	2006-Mar-15	2						X							-	0
9015	4.230.9015	Deliver receiver #8 to OSF/AOS	2006-May-01	2						X							-	0
9025	4.240.9025	Issue RFP for FE Service & exchange vehicle	2004-Jun-01	2				X									Both	0
9030	4.240.9030	FE Service & exchange vehicle #1 available	2005-Oct-01	2	Delay				X X								-	183
8870	4.258.8870	LO review	2002-Nov-21	2	Done	X											Both	0
8880	4.258.8880	Deliver lab prototype LO chain to each cartridge man.	2003-Aug-22	2	Done		X X										NA	174
8890	4.258.8890	Freeze LO design	2004-May-01	2	Delay			X X									NA	213
8895	4.258.8895	Deliver LO chain(s) for cartridge #1	2004-Apr-01	2	Delay			X X									NA	91
8900	4.258.8900	Deliver LO chain(s) for cartridge #8	2005-Jan-01	2					X								-	0
9100	5.260.9100	Deliver BE modules for system integration	2004-Apr-01	2	Delay			X X									Both	91
9106	5.260.9106	Deliver Back End Production Plan	2004-Sep-01	2				X									Both	0
9120	5.260.9120	All BE production contracts placed	2005-Jan-01	2					X								-	0
9105	5.262.9105	Install BE hardware on two ALMA prototype antennas at the ATF	2004-May-01	2				X									Both	0
9110	5.262.9110	Complete BE Critical Design Review	2004-Jul-01	2				X									Both	0
9115	5.295.9115	LO Phase Correction Demonstration	2003-Dec-31	2			X										NA	0
9117	5.295.9117	End to End LO Demonstration	2004-Dec-31	2				X									NA	0
9119	5.295.9119	Pre production LO Review	2005-Mar-31	2					X								NA	0
8020	5.305.8020	Central Back End System Ready to Install at Array Site	2005-Mar-31	1					1								Both	0
8030	5.305.8030	First Antenna based Back End Subsystem Ready for Installation at OSF	2005-Nov-01	1	Delay				1 1								Both	124
9122	5.305.9122	Deliver Back End Assemby, Test, & Verification Plan	2004-Nov-30	2				X									Both	0
9125	5.305.9125	All ALMA assembly, test and verification equipment in place	2005-May-01	2					X								-	0
9130	5.305.9130	Deliver BE antenna hardware for first three antennas	2005-Nov-01	2						X							-	0
9135	5.305.9135	Deliver BE central electronics hardware for first three antennas	2005-Nov-01	2						X							-	0
9140	5.305.9140	Deliver BE antenna and central hardware for antennas #4 - 9	2006-Jul-01	2							X						-	0
9145	5.305.9145	Deliver BE antenna and central hardware for antennas #10 - 17	2007-Jan-01	2								X					-	0
9150	5.305.9150	Deliver BE antenna and central hardware for antennas #18 - 37	2008-Jan-01	2									X				-	0
9155	5.305.9155	Deliver BE antenna and central hardware for antennas #38 -57	2009-Jan-01	2										X			-	0
9160	5.305.9160	Deliver BE antenna and central hardware for antennas #58 - 64	2009-Oct-01	2											X		-	0
9200	6.315.9200	Complete design of pre-production boards for prototype correlator	2002-Dec-30	2	Done	X											NA	0
9205	6.315.9205	Begin integrated testing of prototype correlator	2003-Jan-06	2	Done		X										NA	0
9208	6.315.9208	Correlator ICDs submitted for approval	2003-Aug-13	2	Done		X X										NA	166
9215	6.315.9215	Pass Critical Design Review	2003-Oct-27	2	Done		X X										NA	133
9225	6.315.9225	Prototype Correlator shipped to ATF	2003-Dec-15	2			X										NA	0
9220	6.320.9220	Contract signed for Custom Correlator chips	2003-Dec-05	2	Delay		X X										NA	95
9222	6.320.9222	Contract signed for Correlator PCB assembly	2003-Nov-19	2	Done		X										NA	19
9230	6.320.9230	Begin assembly of first quadrant	2003-Nov-19	2	Done		X X										NA	79
9235	6.320.9235	Begin board testing for first quadrant	2004-May-01	2	Delay			X X									NA	180
9240	6.320.9240	Begin integrated testing for first quadrant	2004-Jun-01	2	Delay			X									NA	61
9250	6.320.9250	First quadrant shipped to Chile	2005-Dec-31	2	Delay				X X								-	153
9255	6.320.9255	Begin Integration of second quadrant*	2005-Oct-01	2	Delay				X X								-	267
9260	6.320.9260	Begin board testing for second quadrant	2004-Oct-31	2				X X									-	-121
9265	6.320.9265	Begin integrated testing for second quadrant	2006-Jan-01	2	Delay				X	X							-	245
9275	6.320.9275	Second quadrant shipped to Chile	2006-Dec-31	2	Delay					X X							-	358
9280	6.320.9280	Begin Integration of third quadrant*	2006-Oct-01	2	Delay					X X							-	267
9285	6.320.9285	Begin board testing for third quadrant	2005-Oct-31	2					X X								-	-121

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Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
9290	6.320.9290	Begin integrated testing for third quadrant	2007-Jan-01	2	Delay					X	X						-	245
9300	6.320.9300	Third quadrant shipped to Chile	2007-Dec-31	2	Delay						X	X					-	358
9305	6.320.9305	Begin integration of fourth quadrant*	2007-Oct-01	2	Delay						X	X					-	267
9310	6.320.9310	Begin board testing for fourth quadrant	2006-Oct-31	2						X	X						-	-121
9315	6.320.9315	Begin integrated testing for fourth quadrant	2008-Jan-01	2	Delay						X	X					-	245
9320	6.320.9320	Fourth quadrant shipped to Chile	2008-Dec-31	2	Delay							X	X				-	359
9350	6.325.9350	Second Generation Correlator Feasibility Study	2002-Mar-27	2	Done	X											EU	0
9355	6.325.9355	2GC System Requirements Review	2003-Nov-30	2	Delay		X	X									EU	194
9360	6.325.9360	2GC Conceptual Design Review	2004-Mar-19	2				X									EU	0
9365	6.325.9365	2GC Preliminary Design Review	2005-Feb-28	2					X								-	0
9400	7.340.9400	Computing Subsystem Start (T0)	2002-Jun-01	2	Done	X											Both	0
9405	7.340.9405	Internal Design Review (IDR)	2002-Dec-09	2	Done		X										Both	0
9410	7.340.9410	Preliminary Design Review (PDR)	2003-May-08	2	Done			X									Both	27
9415	7.340.9415	Subsystem pre-release (R0)	2003-May-16	2	Done			X									Both	15
9420	7.340.9420	Subsystem Critical Design Review 1 (CDR1)	2003-Aug-01	2	Done			X									Both	23
9495	7.340.9495	Subsystem Major Release 1 (R1)	2003-Oct-09	2	Done			X									Both	8
9515	7.340.9515	Integration Release 1 (IR1)	2003-Dec-01	2				X									Both	0
9422	7.340.9422	Submit Computing Communications Study	2004-Jan-01	2				X									Both	0
9425	7.340.9425	Deliver ALMA Operations Plan, Software Aspects	2004-Jan-01	2				X									Both	0
9430	7.340.9430	Subsystem Minor Release 1.1 (R1.1)	2004-Apr-01	2				X									Both	0
9435	7.340.9435	Critical Design Review 2 (CDR2)	2004-May-01	2				X									Both	0
9500	7.340.9500	Subsystem Major Release 2 (R2)	2004-Oct-01	2					X								Both	0
9520	7.340.9520	Integration Release 2 (IR2)	2004-Dec-01	2					X								Both	0
9440	7.340.9440	Subsystem Minor Release 2.1 (R2.1)	2005-Apr-01	2					X								-	0
9445	7.340.9445	Subsystem Critical Design Review 3 (CDR3)	2005-May-01	2					X								-	0
9505	7.340.9505	Subsystem Major Release 3 (R3)	2005-Oct-01	2						X							-	0
9525	7.340.9525	Integration Release 3 (IR3)	2005-Dec-01	2						X							-	0
9450	7.340.9450	Subsystem Minor Release 3.1 (R3.1)	2006-Apr-01	2						X							-	0
9455	7.340.9455	Subsystem Readiness Review (RR)	2006-Jun-01	2						X							-	0
9460	7.340.9460	Subsystem Major Release 4 (R4)	2006-Oct-01	2							X						-	0
9465	7.340.9465	Subsystem Preliminary Acceptance Review (PAR)	2006-Dec-01	2							X						-	0
9530	7.340.9530	Integration Release 4 (IR4)	2006-Dec-01	2							X						-	0
9480	7.340.9480	Computing Preliminary Acceptance (CPA)	2007-Mar-01	2							X						-	0
9510	7.340.9510	Subsystem Minor Release 4.1 (R4.1)	2007-Apr-01	2							X						-	0
9470	7.340.9470	Software Agreements, Final Construction Phase	2007-Jun-01	2							X						-	0
9475	7.340.9475	Support Completion (T1)	2007-Jun-01	2							X						-	0
9485	7.340.9485	Computing Readiness for Interim science observation	2007-Jun-01	2							X						-	0
9535	7.340.9535	Integration Release 4.1(IR4.1)	2007-Jun-01	2							X						-	0
9490	7.340.9490	Complete Subsystem Upgrade	2011-Jun-01	2											X		-	0
9603	8.365.9603	System Requirements Review 1	2003-Dec-31	2				X									-	0
9604	8.365.9604	System Requirements Review 2	2004-Feb-29	2				X									-	0
9602	8.365.9602	System Requirements Review (SRR) - System Requirements Finalized	2004-Feb-29	2	Delay			X	X								Both	181
9605	8.365.9605	ALMA System Design Review	2004-Mar-31	2	Delay			X	X								Both	121
9615	8.365.9615	ALMA System CDR	2005-Jul-01	2						X							-	0
9650	8.370.9650	Prototype Integration & Verification Plan (Q4 '03 thru Q4 '04) approved for Lab & ATF	2003-Dec-31	2	Delay			X	X								Both	152
9653	8.370.9653	All hardware for Prototype System Lab Integration accepted and delivered	2004-Jan-01	2				X									Both	0
9656	8.370.9656	AEG Releases Antennas to ALMA System Prototype Integration Group	2004-Jul-23	2	Delay				X	X							Both	113
9659	8.370.9659	ALMA prototype electronics and software installed on ATF	2004-May-01	2					X								Both	0
9662	8.370.9662	First interferometer fringes using prototype antennas at ATF	2004-Sep-01	2						X							Both	0
9665	8.370.9665	Discontinue interferometer hardware and software system testing and commisioning	2005-Jan-01	2					X								-	0
9668	8.370.9668	Finish testing of ALMA prototype and production hardware / software on ATF	2006-Jul-01	2						X							-	0
8005	8.370.8005	Start Antenna Evaluation at ALMA Test Facility	2003-Mar-22	1	Done		1	1									NA	81
9718	8.370.9718	NA Prototype Evaluation Report	2004-Apr-22	2	Delay			X	X								Both	112
9721	8.370.9721	EU Prototype Evaluation Report	2004-Jul-23	2	Delay			X	X								Both	204
9750	8.375.9750	ALMA Integration & Verification Plan - Q1 2005 through Q4 2007 for OSF and AOS	2004-Jan-01	2				X									Both	0
9753	8.375.9753	Establish Integration office at OSF	2005-Feb-15	2					X								-	0
9756	8.375.9756	Integration team and infrastructure ready at OSF.	2005-Sep-01	2						X							-	0
9759	8.375.9759	Initial central electronics and computing - integrated, tested and accepted at OSF	2005-Nov-15	2						X							-	0
9762	8.375.9762	Initial antenna electronics and computing - integrated, tested and accepted at OSF	2005-Nov-15	2						X							-	0

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Milestone #	WBS #	Milestone Name	Due Date	Level	Status	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Responsible	Delay (days)
9765	8.375.9765	First fully outfitted antenna integrated and accepted at OSF	2006-Feb-15	2						X							-	0
9768	8.375.9768	First fully outfitted antenna integrated and accepted at AOS	2006-Apr-01	2						X							-	0
9771	8.375.9771	Phase 2 ALMA Integration and Verification Plan Q1 2008 and beyond	2006-Jul-01	2						X							-	0
9774	8.375.9774	Three antenna array integrated & functioning at AOS	2006-Aug-01	2						X							-	0
9800	9.380.9800	Plan for compact and intermediate configurations submitted	2002-Nov-27	2	Done	X											Both	0
9805	9.380.9805	Review of calibration requirements with science examples complete	2003-Feb-28	2	Done		X										Both	13
9812	9.380.9812	Document on how calibration reqs flow down to instrumental specs	2003-Jun-30	2	Done		X										Both	0
9815	9.380.9815	Plan for Y+ configuration submitted	2003-Jun-30	2	Done		X										Both	0
9818	9.380.9818	ICD between Science and Site Approved	2004-Jan-31	2				X									-	0
9820	9.380.9820	Calibration strategy submitted	2003-Oct-31	2	Late		XX										Both	31
9825	9.380.9825	Science aspects of operations plan complete	2004-Jun-30	2	Delay		X	X									Both	182
9830	9.380.9830	Plan for early science configurations complete	2004-Jun-30	2				X									Both	0
9835	9.380.9835	Report WVR strategy / implementation / operations	2004-Sep-30	2				X									EU	0
9840	9.380.9840	Review of tests of calibration strategies on prototype interferometer complete	2004-Dec-31	2				X									Both	0
9843	9.380.9843	Review of tests of calibration strategies on ATF interferometer	2005-May-30	2					X								-	0
9845	9.380.9845	Science verification plan for commissioning submitted	2005-Jun-30	2					X								-	0
9870	9.380.9870	Definition of site characterization instrumentation for ALMA operations	2006-Jan-31	2						X							-	0
9850	9.380.9850	Science verification of ALMA early science array Bands 3, 6, & 7 complete	2007-Jul-31	2							X						-	0
8045	9.380.8045	Start Early Science Operations	2007-Sep-30	1							1						Both	0
9855	9.380.9855	Science verification of ALMA Band 9 complete	2008-Sep-30	2								X					-	0
9860	9.380.9860	Science verification of ALMA imaging quality	2009-Dec-31	2									X				-	0
9865	9.380.9865	Final Science verification complete array	2011-Dec-31	2											X		-	0
8055	9.380.8055	Start of full Science Operations	2012-Mar-31	1												1	Both	0