MILLIMETER ARRAY/ALMA-US
DESIGN AND DEVELOPMENT

MONTHLY REPORT
MONTH END OCTOBER 2000

1 Executive Summary

At the meeting of the ALMA Coordinating Committee (ACC) on October 13, 2000 in Paris, Mr. Takayoshi Seiki, Director of the Research Institutes Division of the Japanese Ministry of Education, Science, Sports and Culture was invited to address the ACC. Mr. Seiki distributed a prepared statement in which he formally records the interest of Monbusho in being a third, equal, partner in the ALMA Project. His statement that Monbusho will use its best efforts to secure funding for ALMA is identical to the status of the commitments made so far by the U.S. and Europeans.

The ACC drafted a response which makes the following points: 1) It warmly welcomes Mr. Seiki's statement; 2) It affirms the desire of the American and European partners to work with Japan in common pursuit of a successful ALMA Project; and 3) It sets up a process tying confirmation of the tripartite project to an expansion of the ACC that will include members from Japan.

The ACC also endorsed a recommendation by the ALMA Executive Committee (AEC) to organize the international project using an Integrated Product Team (IPT) approach. IPTs are an established means of managing complex tasks that span organizational and geographic boundaries. They are well suited to the ALMA Project as they provide a means of bringing together the necessary resources under common technical leadership without requiring that those resources be part of a single organization. The AEC is currently using this approach to complete a detailed Management Plan that will be presented to the ACC for approval.

Programmatically, the project continues to make important progress across the entire WBS. Details of progress are reported in Section 4. Some of the highlights include:

- The antenna contractor for the prototype antenna being procured by AUI for the ALMA Project, Vertex Antenna Systems, LLC, is on-track to hold its Critical Design Review (CDR) in November.
- With agreements on requirements and implementation decisions for the production front ends, work is accelerating on the design. A PDR on the production front end is now planned for February.
- The design was completed for the data transmission protocol of the fiber optic link that carries information from each antenna. Detailed design of the embedded logic to implement the protocol is already under way.
- A Critical Design Review for the holography system was held. Holographic measurements of the prototype antenna's panel surface accuracy will be the primary means of demonstrating compliance with contract specifications.

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 04 October 2000.

In October one major milestone was scheduled for completion. This was the presentation by the Project to the ACC of the framework plan for management of the construction phase ALMA Project. That framework management plan was given to the ACC at their meeting of 13 October.

3 Meetings

3.1 Meetings held in October 2000

ALMA Joint DH/TL Teleconference - October 2
ALMA Joint Receiver Development Group Teleconference - October 5
ASAC Teleconference - October 9
ALMA Holography CDR - October 10
ALMA Test Interferometer Planning Meeting - October 11
ALMA LO Construction Planning Meeting - October 12
ALMA SSR Meeting - October 12-13
ALMA Coordination Committee Meeting - October 13
ALMA U.S. DH Meeting Teleconference - October 16
ALMA Executive Committee Meeting - weekly teleconferences
ALMA Test Interferometer Bi-Weekly Teleconferences
ALMA/NSF Meeting - weekly teleconferences
ALMA Lo/Rx Meeting - weekly teleconferences
ALMA Imaging and Calibration Meeting - weekly teleconferences

3.2 Meetings Planned for November 2000

ALMA Photonics Meeting - November 7-8
ALMA Site Teleconference - November 8
ASAC Teleconference - November 13
ALMA U.S. Antenna Prototype CDR - November 15-16
ALMA Joint Software Meeting - November 20-21
ALMA European Antenna Prototype CDR - November 28-29
ALMA Test Interferometer Bi-Weekly Teleconferences
ALMA U.S. DH Meeting Teleconferences
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

3.3 ALMA Technical Memos Distributed in October 2000

ALMA Memo	Title	Author(s)
331	On-The-Fly Fringe Tracking	L. R. D'Addario and D. T. Emerson
330	The Overlap of the Astronomical and WVR Beams	A. G. Gibb and A. I. Harris
329	Scattering of Solar Flux by Panel Grooves: Update	J. W. Lamb
328	Room Temperature Measurements of Various Absorbers with the HP8510 at 75-110 GHZ	G. A. Ediss
327	Reliability Calculation Guidelines	Carsten Egedal
326	Vertical Profiles of Soil Resistivity at Pampa La Bola and Llano de Chajnantor Locations	Seiichi Sakamoto, Hajime Ezawa, Toshikazu Takahashi, and Nobuyuki Yamaguchi
325	A Broadband In-Phase Waveguide Power Divider/Combiner	A.R. Kerr and N. Horner

4 Technical Progress Report

4.1 Antennas

Work continued on supervision of the prototype antenna contract with Vertex. ALMA-US personnel were at the Vertex facilities in Duisburg, Germany on 24-26 October for contract progress review and technical discussions. The option on the antenna contract for the installation of the laser metrology system was declined due to lack of funding. Quotations were received from Vertex for two additions requested by NRAO: a specialized forklift to enable receiver installation in the receiver cabin and an additional equipment enclosure mounted on the azimuth platform. A consultant in Carbon Fiber Reinforced Plastic (CFRP), Mr Robert Romeo, President of Composite Mirror Applications, Inc in Tucson, was engaged to advise the ALMA-US antenna group on CFRP issues. He will attend the Critical Design Review.

A major activity for the contractor during the latter part of the month was the preparation of the documentation for the CDR scheduled for 15-16 November. This documentation was received by NRAO at the end of the month and distributed to the reviewers. A significant design decision made by Vertex during the month was to fabricate the upper part of the antenna receiver cabin out of Invar in order to meet the thermal performance requirements. This decision will cause a small increase in the mass of the antenna and the cost of the production antennas.

At NRAO work continued on the antenna components being built in-house, including the subreflector nutator and optical pointing camera.

4.2 Front End

Front End Status

Plans for the production of the ALMA receivers are evolving. An initial meeting between the European, Japanese, and US partners will take place at the ESO headquarters in Garching on 30 November. A draft agenda for this meeting has been prepared and it is expected that this will be refined over the next week or so.

The evaluation receivers are progressing, although our efforts are manpower-limited at present. Two engineers have accepted positions at NRAO in Tucson, so the situation is likely to improve in the near future. With the new staff engineers we expect this task to recover to the schedule.

Receiver Components

Tests continued on the 211-275 GHZ mixer with integrated preamplifier for the 4-12 GHZ IF band. Small variations in mixer noise temperature across the IF band have now been successfully modeled and are believed to be understood. Work is now concentrating on optimizing 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.

The first block for the 211-275 GHZ sideband-separating, balanced mixers has been completed except for installation of the MMIC mixer chip itself. The test hardware and software are complete and ready.

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. An effort to simulate the performance of overmoded waveguide (for carrying LO signals) has been held back by lack of a computer with sufficient memory to handle the very large number of 3-dimensional cells required for this problem. A new computer with 1 Gbyte of memory was ordered so that such very large computational problems will be amenable to solution. It was determined that the use of a supercomputer facility was not a viable option because the computational problem cannot efficiently be ported to a multiprocessor environment.

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 has been designed which, in theory, should solve this problem. Investigation of the performance of present bias circuits revealed subtle problems which will be corrected with modified circuits. Test of reed relays for providing programmable shorts for protection of the SIS mixer bias lines showed no unacceptable transients; this method of providing shorting protection will be pursued.

For the Band 6 receiver cartridge, a preliminary specification of the interface required to operate the sideband-separating, balanced mixers, LO multipliers, and two stages of IF amplifiers has been created and circulated. It appears that more than 100 wires will be required. Means of minimizing the conductive heat load produced by this large number of wires are being investigated.

Work continued on refining the data acquisition and processing software for automatic SIS mixer testing. The speed of data acquisition using a power meter was improved by a factor of 2. Further comparisons of noise temperatures measured with a conventional load cone covering the aperture and with a chopper wheel were made, and shown to agree within 5%, which is good enough for mixer testing. A new, smaller, much quieter chopper wheel was designed and built.

Further analysis of an SIS mixer capable of covering 86-116 GHz was carried out. This is an alternative to using an HFET amplifier, which although it is intrinsically single-sideband and available now with noise temperature comparable to an SIS mixer, has higher 1/f gain noise. Analysis of a previously designed waveguide probe revealed a resonance at 107 GHz which requires the probe to be slightly redesigned. The modified design will then be folded into the overall performance simulation to judge the overall predicted performance.

4.3 Local Oscillator System

Local Oscillator Multipliers

Measurements of the temperature sensitivity and long term phase drift of LO driver components and chains were further analyzed and work was continued on a memo describing the results; this will be complementary to ALMA Memo 311 which describes short-term phase noise characteristics. The settling time of the PLL circuit was investigated in the context of rapid frequency switching for single-dish spectroscopy.

A 2-stage 43-60 GHz power amplifier is being assembled and will be tested soon. The block for an integrated varistor doubler/power amplifier from 50-60 GHz is currently being machined. A design for a W-band balanced Schottky mixer using UVA mixer diodes has been designed and the block drawings have been submitted to the shop. 20 W-band power amplifier bodies are currently being machined in Green Bank. An engineer and technician will travel to JPL in November with several of these blocks to learn the JPL assembly procedure and take back several amplifiers for ALMA use. HRL MMIC power amplifier chips designed to cover 100-120 GHz with 50mW output should be available within a month.

Several different ways to configure the LO drivers were investigated in detail and discussed at length. It now appears that a Warm Multiplier Assembly will be installed on the outside of each cartridge; this WMA will contain at least the last stage of frequency multiplication and power amplification, in order to avoid distributing high power signals over long, lossy waveguide runs. The choice now appears to be between distributing intermediate frequency signals near 20 GHz over coaxial cable or higher frequency signals near 50 GHz in waveguide.

LO power and noise interface specifications were discussed with the European cartridge designers. A revised project book contribution will be released shortly detailing some of these points.

The major focus in frequency multiplier development continued to center around the evaluation of dielectric materials for use in integrated capacitor structures. These materials include sputtered SiO2, CVD SiO2, and SiN. Aside from the dielectric constant, the material's RF loss characteristics, which play an important role in setting the frequency multiplier's conversion efficiency, must also be measured at millimeter wavelengths. Several RF test structures, suitable for measuring both the dielectric constant and the loss at 100 GHz, were fabricated along with samples of the three materials. Sputtered SiO2 was chosen based on these test results. Design details for the 80/240 GHz tripler are currently being cast in final form; circuit fabrication should commence in November.

The details of the Michigan/JPL collaboration have been finalized. The plan involves transferring the wafer thinning and e-beam fabrication processes developed at JPL to Michigan over a period of nine months. Throughout this period, the Michigan group will concentrate on three ALMA objectives: 1) varactor diode structures suitable for the current ALMA 55/110 and 110/220 GHz doublers, 2) a monolithic 160/320 GHz doubler for Band 7 based on the wafer-thinning process, and 3) a monolithic 220/660 GHz tripler for Band 9 based on both the wafer-thinning and e-beam processes. The collaboration is expected to begin in November.

Local Oscillator Reference

The Xilinx composite signal was used to experiment with different methods of demodulating the 20.833 Hz from the 25 MHz. A logical X-OR of the composite signal with the phase locked 25 MHz VCXO seems to be a good way to recover the 20.833 Hz signal with a 2.12 nS rise time on the rising edge and to maintain the critical timing requirements. Progress was made on the Xilinx design and the PCB layout for the digital board.

4.4 Back End Subsystem

Data Transmission Fiber Optic Link

The design of the Data Transmission link protocol was completed and a draft memo will be circulated. Block diagrams for the FPGA's can now be generated along with schematics, VHDL files and state machine diagrams for the various blocks using the Xilinx Foundation Software.

Module and bin requirements for the Test Interferometer were developed.

Downconverter

Schematics were generated for manual and computer control boxes to test 2x2 matrix switches. The re-analysis continued of mixer spurious responses in the test interferometer and construction versions of the downconverter.

4.5 Correlator

A backplane design for the filter card/station card test fixture was completed and is ready to be routed. A temporary test fixture for the filter card was fabricated by modifying a GBT spectrometer test fixture.

The prototype FIR filter card has begun initial tests. The CPLD which interfaces to the Xilinx Virtex-E chips was successfully programmed. The FPGA personalities for all 14 Xilinx chips on the card were successfully loaded. Work is now in progress on writing software required to test the filter card. It has been noted that the Virtex-E Delay-Lock-Loop circuits appear occasionally to lose lock for no apparent reason; we intend to use these circuits to adjust and distribute clock signals within and between chips. Further investigation is continuing.

A review of the custom correlator chip was held in Charlottesville with the chip designer, and a few final issues were resolved. The chip circuitry is now believed to be complete. Software needed in order simulate the custom correlator chip, now known as ALMA-1, was purchased and installed, and simulations have begun. Initial results indicate that the design meets the requirements as simulated so far.

4.6 Computing

The Control Software Group participated in the Holography CDR in Tucson. The review of the TI Design Concept document was completed. Continued work on porting the Antenna Mount System (AMS) and Antenna API code to ACE/VxWorks platform. Completed Front End Power Supply embedded code.

A revision of Test Correlator control computer software design document was completed. It will be read internally and then go to CDR.

The group began evaluation of a software testing tool for VxWorks/Tornado called CodeTest. This tool provides similar functionality to a commonly-used tool in Unix called Purify. CodeTest performs memory allocation error checking and code coverage. This type of tool should greatly enhance the quality of software delivered with the correlator control computer.

4.7 Systems Engineering

The most significant event of October was the Holography Critical Design Review (CDR), held in Tucson on october 10th. The report of this meeting is available on the ALMA web pages at http://www.alma.nrao.edu/administration/designreviews/holographycdr.html

Our European collaborators participated fully in this meeting, both in person and by teleconference, and Japanese observers were also present.

A considerable quantity of documentation was prepared for the review panel in advance of this meeting. An index and access to this material is avaialable from http://www.tuc.nrao.edu/~demerson/holocdr/ .

The meeting was very successful, with general approval being given by the review panel to the plans presented. In particular, the plans for a photonic holography transmitter were fully approved; this development had not been foreseen at the time of the PDR, but offers significant savings in cost and manpower over the original, more conventional approach, with little or no increase in risk to the schedule or budget. Some detailed tehnical points were made by the panel, as described in the report from the meeting.

Taking advantage of colleagues from both sides of the Atlantic being in Tucson for the Holography CDR, the following day a review of the Test Interferometer planning was held. This resulted in some action items to refine the schedule for the TI tests, and how the antenna tests will fit in with the timescale for laboratory tests for the electronics.

Similarly taking advantages of the presence of experts in Tucson, a another face-to-face meeting was held in Tucson that same week to discuss details of the ALMA Local Oscillator planning, primarily for the Test Interferometer.

4.8 Imaging and Calibration

The imaging and calibration group held several phone meetings during October, with the agenda, and linked documents to be found at: http://www.cv.nrao.edu/~awootten/mmaimcal/

Configuration Studies

The simulation efforts for the primary ALMA array have re-commenced during October. Steve Heddle in the UK continued to progress on the imaging simulation, producing 1km 'C' 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). A teleconference will be held when a sufficient body of intermediate array simulations has been assembled. A Review is planned for February 2001.

Site

G. Delgado has presented a report on a 52-year climatological study for the Chajnantor area done by a consultant; Radford circulated this to the site group. Some long term periodicities in weather can be detected in this data but their amplitude isn't extreme. Apparently, the site is now experiencing a weather nadir period. A meeting will take place next month in Charlottesville to review the CBI experience.

ACA

The ALMA ImCal group discussed the need for nutators on the antennas of the ACA. These should be incorporated in the design for at least one of the antennas.

Interferometer/Antenna Amplitude Calibration

Radford started an analysis of the 12m prototype nutator dynamics and control system. He also reviewed the nutator design and status with J. Baars. He also revised the nutator mechanical design for easier production. Lab tests of nutator hardware were performed.

Mangum worked on revisions to ALMA Memo 318 (Amplitude Calibration at Millimeter and Submillimeter Wavelengths). Most modifications are just window-dressing (a more general way to express chopper wheel calibration relation, for example). An analysis of the semi-transparent vane calibration will also be included. As part of his participation in the SSR group, Mangum wrote the use case for the amplitude calibration observing mode.

Pointing Calibration

Mangum made some progress on the software aspects of the optical pointing system. A frame grabber is now commandable and produces gif images at a user-specified rate. Mangum will continue to develop the image producing and analysis capabilities of this software.

ALMA studies, including the ASAC

Wootten wrote sections of the ASAC report for which he was the responsible party. The report was disseminated to the ALMA Division Heads/Team Leaders. He produced the agenda and moderated the ASAC teleconference which was held 10 October.

Butler (with Gurwell and Wootten) presented an ALMA poster at the DPS meeting in Pasadena. The spectral line capability of the instrument will allow for the observation of multiple molecular species in planetary and cometary atmospheres and protoplanetary disks, providing temperature and wind (for the atmospheres) profiles at high spatial and time resolution and clues as to the chemistry in these places.

Wootten (with Gallimore) finished a paper illustrating the ability of ALMA to image galaxies in the distant Universe in the submillimeter. ALMA's detailed imaging capabilities will be a major step for astronomy, making it possible to study the origins of galaxies, and the state of gas and dust in forming and interacting distant galaxies.

Crystal Brogan has assembled a list of molecular lines (http://www.cv.nrao.edu/~awootten/mmaimcal/Alma_zeeman.pdf) which will be of particular importance for polarization work on ALMA-she noticed that they come at band edges, by a perfidy of nature, and hence might pose a problem for tuning the polarization response of ALMA to the lines of most interest.

MILLIMETER ARRAY/ALMA-US
PROJECT STAFFING

MONTH END OCTOBER 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:	76	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.

Atacama
Large
Millimeter
Array

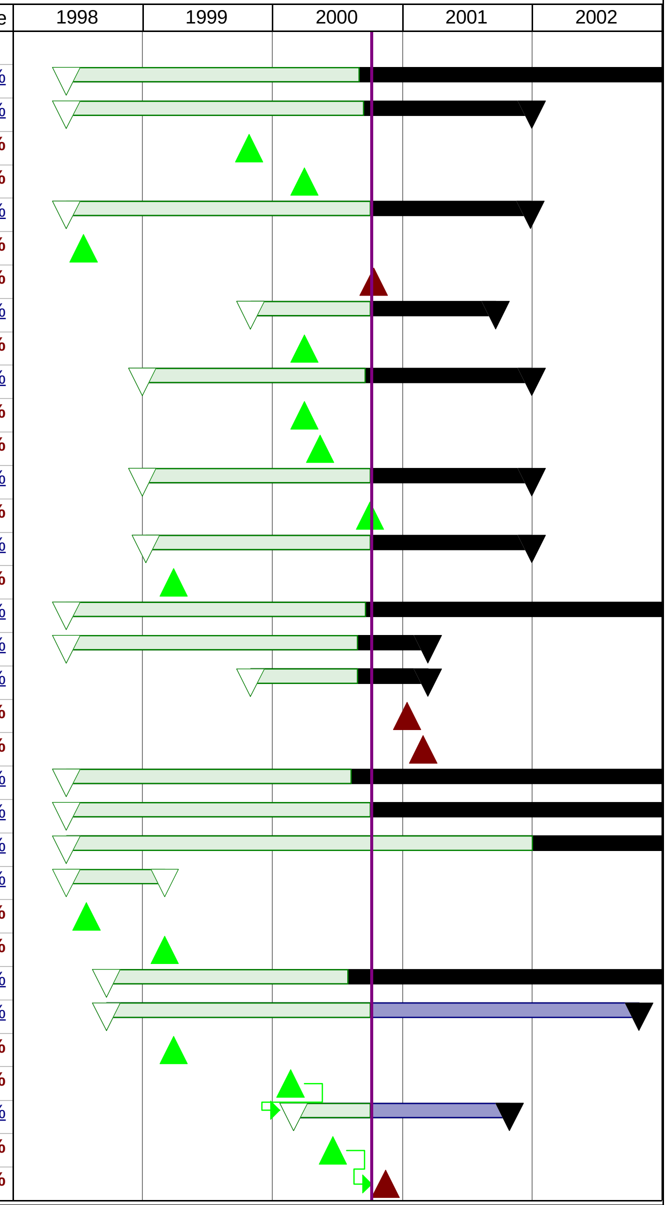
ALMA Phase 1 Milestone Progress

(as of 2000-10-04)

Phase 1 Major Milestones selected

File: almaplan2000dec13.mpp
View: ALMA Phase 1 Progress
Printed: 12:10 PM 2000-12-14

ID	WBS (f)	Task	Start	Finish	% Done
0		ALMA Joint Work Plan	1998-06-01	2010-12-31	
1	1	Management/Administration	1998-06-01	2010-12-31	39%
2	1.05	Phase 1 Management	1998-06-01	2001-12-31	64%
4	**1.05.10**	**Deliver WBS for ALMA D&D phase**	**1999-10-28**	**1999-10-28**	**100%**
6	**1.05.20**	**Deliver final WBS for ALMA project**	**2000-03-31**	**2000-03-31**	**100%**
7	1.05.25	Project Book	1998-06-01	2001-12-28	65%
9	**1.05.25.10**	**MMA Project Book: Version 1**	**1998-07-20**	**1998-07-20**	**100%**
10	**1.05.25.15**	**ALMA Project Book: Joint Version**	**2000-10-13**	**2000-10-13**	**0%**
11	1.05.30	Phase 1 Joint Management Plan	1999-11-01	2001-09-21	46%
13	**1.05.30.10**	**Deliver Phase 1 Joint Management Plan**	**2000-03-31**	**2000-03-31**	**100%**
53	1.10	Phase 2 Planning	1999-01-01	2001-12-31	54%
56	**1.10.15**	**Deliver Baseline Scope of Phase 2**	**2000-03-31**	**2000-03-31**	**100%**
58	**1.10.25**	**Deliver Draft Phase 2 Plan**	**2000-05-15**	**2000-05-15**	**100%**
60	1.10.35	Management Planning	1999-01-01	2001-12-31	62%
61	**1.10.35.05**	**Deliver Management Plan for Construction**	**2000-10-02**	**2000-10-02**	**100%**
85	1.25	Partnerships and Agreements	1999-01-11	2001-12-31	51%
87	**1.25.10**	**Partnership Recommendations to NSF**	**1999-03-30**	**1999-03-30**	**100%**
94	2	Site Development	1998-06-01	2010-12-31	17%
100	2.10	Development Plans	1998-06-01	2001-03-14	92%
110	2.10.10	Estimate Development Costs	1999-11-01	2001-03-14	72%
129	**2.10.10.15**	**PDR: Review Site Development Plan**	**2001-01-15**	**2001-01-15**	**0%**
131	**2.10.10.25**	**Deliver revised development Plan**	**2001-03-01**	**2001-03-01**	**0%**
247	3	Antenna Subsystem	1998-06-01	2010-12-31	12%
248	3.05	Antenna Management/Subsystem Engineering	1998-06-01	2010-12-31	18%
251	3.05.10	Antenna Subsystem Engineering	1998-06-01	2010-07-01	16%
252	3.05.10.05	Antenna Subsystem Design & Specification	1998-06-01	1999-03-05	100%
258	**3.05.10.05.30**	**Antenna PDR**	**1998-07-28**	**1998-07-28**	**100%**
260	**3.05.10.05.40**	**CDR: Antenna RFP/CfT**	**1999-03-05**	**1999-03-05**	**100%**
262	3.10	Prototype Antennas	1998-09-22	2003-04-01	20%
263	3.10.05	U.S. Prototype Antenna	1998-09-22	2002-10-29	27%
266	**3.10.05.15**	**Issue Prototype Antenna RFP**	**1999-03-30**	**1999-03-30**	**100%**
270	**3.10.05.35**	**Sign Contract (Prototype Antenna #1)**	**2000-02-22**	**2000-02-22**	**100%**
271	3.10.05.40	US Prototype antenna contract supervision	2000-03-02	2001-10-30	35%
273	**3.10.05.40.10**	**Vertex Prototype antenna PDR**	**2000-06-20**	**2000-06-20**	**100%**
274	**3.10.05.40.15**	**Vertex Prototype antenna CDR**	**2000-11-15**	**2000-11-15**	**0%**



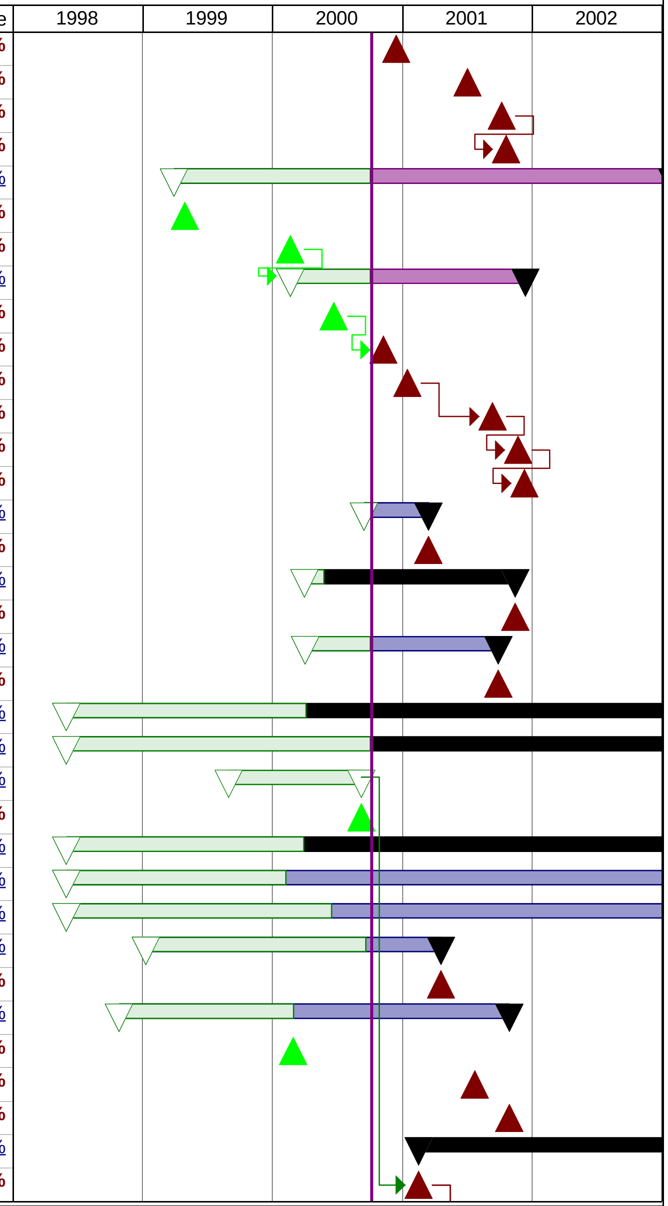
Milestones: **bold type**
Summary Tasks: underline

ALMA Phase 1 Milestone Progress

(as of 2000-10-04)

Phase 1 Major Milestones selected

ID	WBS (f)	Task	Start	Finish	% Done
275	**3.10.05.40.16**	**Vertex Design Approval**	**2000-12-15**	**2000-12-15**	**0%**
280	**3.10.05.40.22**	**Vertex Prototype Site Assembly Start**	**2001-07-04**	**2001-07-04**	**0%**
282	**3.10.05.40.40**	**Begin Vertex Prototype ant. on-site acceptance tests**	**2001-10-08**	**2001-10-08**	**0%**
283	**3.10.05.40.45**	**Deliver Vertex Prototype Antenna**	**2001-10-20**	**2001-10-20**	**0%**
286	3.10.10	European Antenna Prototype Procurement	1999-03-31	2003-01-30	35%
288	**3.10.10.10**	**Issue prototype antenna CfT**	**1999-04-30**	**1999-04-30**	**100%**
292	**3.10.10.30**	**Sign prototype antenna #2 contract**	**2000-02-21**	**2000-02-21**	**100%**
293	3.10.10.35	Prototype antenna contract supervision	2000-02-21	2001-12-13	34%
295	**3.10.10.35.10**	**EIE Prototype antenna PDR**	**2000-06-22**	**2000-06-22**	**100%**
296	**3.10.10.35.15**	**EIE Prototype antenna CDR**	**2000-11-09**	**2000-11-09**	**0%**
298	**3.10.10.35.25**	**Prototype antenna final design approval**	**2001-01-15**	**2001-01-15**	**0%**
301	**3.10.10.35.30**	**Prototype antenna fabrication complete**	**2001-09-12**	**2001-09-12**	**0%**
302	**3.10.10.35.35**	**Prototype antenna site assembly complete**	**2001-11-23**	**2001-11-23**	**0%**
305	**3.10.10.35.45**	**Deliver EIE Prototype Antenna**	**2001-12-11**	**2001-12-11**	**0%**
308	3.10.15	VLA Site foundation	2000-09-15	2001-03-15	9%
312	**3.10.15.20**	**Foundation completed**	**2001-03-15**	**2001-03-15**	**0%**
313	3.10.20	Prototype Metrology/Test Equipment	2000-04-01	2001-11-15	7%
338	**3.10.20.40**	**Deliver Prot. Antenna Metrology System**	**2001-11-15**	**2001-11-15**	**0%**
339	3.10.25	Prototype Nutator	2000-04-03	2001-09-28	33%
342	**3.10.25.15**	**Deliver Prototype Nutator**	**2001-09-28**	**2001-09-28**	**0%**
377	4	**Front End Subsystem**	1998-06-01	2010-12-31	19%
378	4.05	Front End Management/Subsystem Engineering	1998-06-01	2010-12-31	25%
383	4.05.10	Front End Subsystem Design & Specification	1999-09-01	2000-09-08	100%
387	**4.05.10.20**	**Final Front End Specifications**	**2000-09-08**	**2000-09-08**	**100%**
391	4.10	SIS Mixer Development	1998-06-01	2003-12-17	68%
399	4.10.10	Balanced, sideband separating SIS mixers	1998-06-01	2003-12-17	72%
463	4.10.10.40	Mixers	1998-06-01	2003-12-17	61%
468	4.10.10.40.10	230 GHz	1999-01-11	2001-04-20	79%
516	**4.10.10.40.10.2**	**Deliver prototype 230 GHz Mixer**	**2001-04-20**	**2001-04-20**	**0%**
617	4.20	Antenna Evaluation Front Ends	1998-10-27	2001-10-29	56%
625	**4.20.40**	**CDR: Evaluation Front End**	**2000-02-29**	**2000-02-29**	**100%**
631	**4.20.70**	**Deliver Antenna Test Eval Front End #1**	**2001-07-24**	**2001-07-24**	**0%**
633	**4.20.80**	**Deliver Antenna Test Eval Front End #2**	**2001-10-29**	**2001-10-29**	**0%**
634	4.25	Prototype Front Ends	2001-02-16	2003-09-17	0%
635	**4.25.05**	**PDR: Front End Subsystem**	**2001-02-16**	**2001-02-16**	**0%**



Milestones: **bold type**
Summary Tasks: **underline**

Atacama
Large
Millimeter
Array

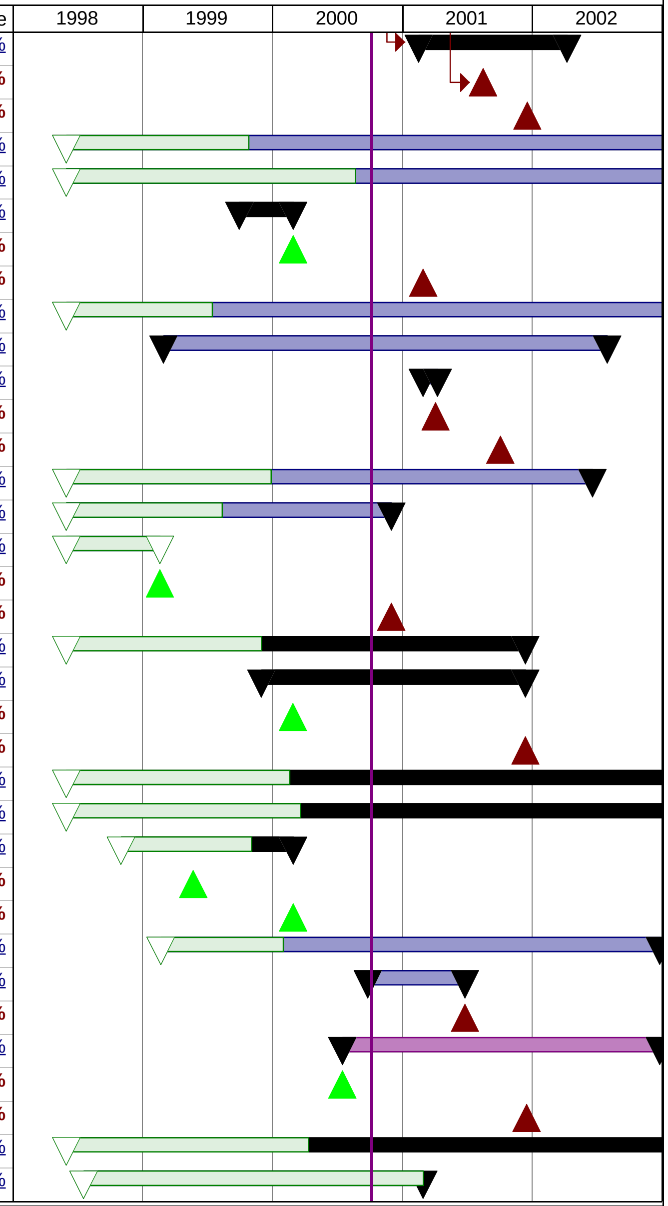
ALMA Phase 1 Milestone Progress

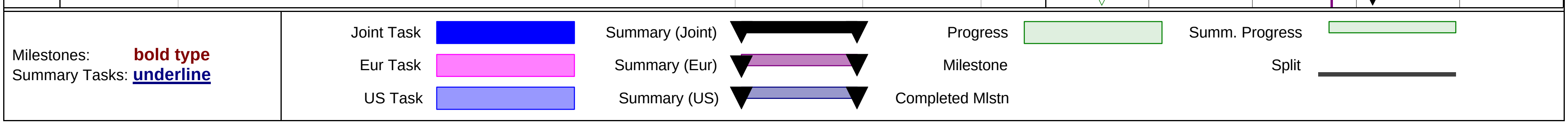
(as of 2000-10-04)

Phase 1 Major Milestones selected

File: almaplan2000dec13.mpp
View: ALMA Phase 1 Progress
Printed: 12:10 PM 2000-12-14

ID	WBS (f)	Task	Start	Finish	% Done
636	4.25.10	Front End Engineering Model	2001-02-16	2002-04-10	0%
649	**4.25.10.20**	**Front End Eng. Model Progress Review 2**	**2001-08-16**	**2001-08-16**	**0%**
650	**4.25.10.25**	**Deliver Front End Eng. Model Components**	**2001-12-19**	**2001-12-19**	**0%**
715	5	**Local Oscillator Subsystem**	1998-06-01	2010-12-31	8%
716	5.05	LO Management/Subsystem Engineering	1998-06-01	2010-12-31	15%
720	5.05.15	LO Ref system definition	1999-10-01	2000-02-29	0%
724	**5.05.15.20**	**PDR: LO Reference**	**2000-02-29**	**2000-02-29**	**100%**
725	**5.05.17**	**PDR: LO Subsystem**	**2001-03-01**	**2001-03-01**	**0%**
731	5.10	Prototype LO	1998-06-01	2009-12-24	22%
735	5.10.05	LO Reference Prototype	1999-03-01	2002-07-31	0%
983	5.10.05.15	LO Ref Bench system, integrate and test	2001-02-28	2001-04-10	0%
986	**5.10.05.15.15**	**Deliver LO Ref bench prototype**	**2001-04-05**	**2001-04-05**	**0%**
988	**5.10.05.25**	**Deliver LO Ref field prototype**	**2001-10-04**	**2001-10-04**	**0%**
991	5.10.10	Multiplier Chain LO Prototype	1998-06-01	2002-06-20	55%
1010	5.10.10.15	Multiplier R&D	1998-06-01	2000-12-01	72%
1011	5.10.10.15.05	Prototype multiplier development	1998-06-01	1999-02-19	100%
1014	**5.10.10.15.05.1**	**PDR: Multiplier Chain LO**	**1999-02-19**	**1999-02-19**	**100%**
1056	**5.10.10.15.40**	**CDR: Multiplier Chain LO**	**2000-12-01**	**2000-12-01**	**0%**
1089	5.10.15	Photonic LO Distribution Prototype	1998-06-01	2001-12-13	15%
1092	5.10.15.48	Photonic Distribution Development	1999-12-01	2001-12-13	0%
1093	**5.10.15.48.05**	**PDR: Photonic Distribution**	**2000-02-28**	**2000-02-28**	**100%**
1126	**5.10.15.50**	**Deliver Photonic LO Dist Prototype**	**2001-12-13**	**2001-12-13**	**0%**
1183	6	**Backend Subsystem**	1998-06-01	2010-12-31	9%
1184	6.05	Backend Management/Subsystem Engineering	1998-06-01	2010-12-31	20%
1187	6.05.10	Backend system definition	1998-11-02	2000-02-29	78%
1192	**6.05.10.25**	**Decision: Analog/Digital Transmission**	**1999-05-24**	**1999-05-24**	**100%**
1194	**6.05.10.35**	**CDR: Backend Subsystem**	**2000-02-29**	**2000-02-29**	**100%**
1198	6.10	Prototype Backend Subsystem	1999-02-22	2002-12-26	11%
1478	6.10.20	Bench system, integrate and test	2000-09-26	2001-06-26	0%
1481	**6.10.20.15**	**Deliver Backend bench prototype**	**2001-06-26**	**2001-06-26**	**0%**
1485	6.10.45	Prototype Digitizer/Sampler	2000-07-17	2002-12-26	0%
1487	**6.10.45.10**	**Pre-prototype ASIC design to foundry**	**2000-07-17**	**2000-07-17**	**100%**
1493	**6.10.45.40**	**Prototype Sampler Final Report**	**2001-12-17**	**2001-12-17**	**0%**
1510	7	**Correlator**	1998-06-01	2010-12-30	17%
1518	7.10	Test Correlator	1998-07-20	2001-03-01	99%



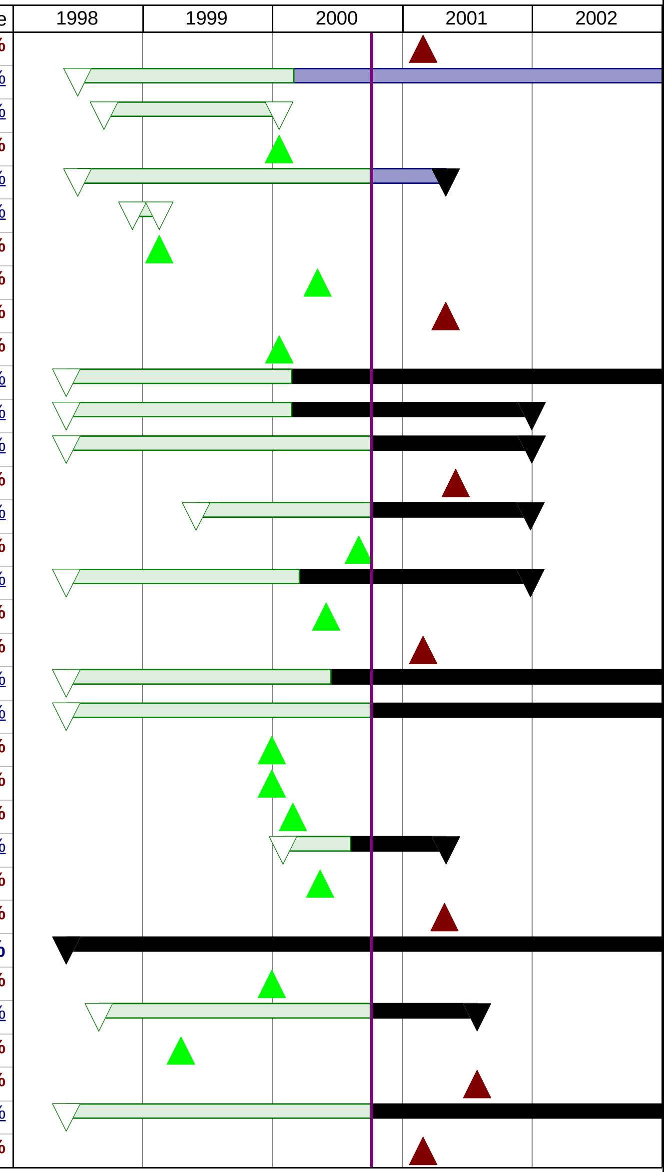


ALMA Phase 1 Milestone Progress

(as of 2000-10-04)

Phase 1 Major Milestones selected

ID	WBS (f)	Task	Start	Finish	% Done
1524	**7.10.30**	**Deliver Test Correlator to Alma Test site**	**2001-03-01**	**2001-03-01**	**0%**
1525	7.15	Baseline Correlator	1998-07-03	2007-11-29	32%
1526	7.15.05	Baseline Correlator Preliminary Design	1998-09-15	2000-01-20	100%
1531	**7.15.05.25**	**PDR: Correlator**	**2000-01-20**	**2000-01-20**	**100%**
1532	7.15.10	Finite Impulse Response Filter Development	1998-07-03	2001-05-03	83%
1535	7.15.10.15	Implementation decision	1998-12-04	1999-02-18	100%
1538	**7.15.10.15.15**	**Decision: FIR Filter or Analog BBC**	**1999-02-18**	**1999-02-18**	**100%**
1543	**7.15.10.40**	**PDR: Finite Impulse Response Filter**	**2000-05-08**	**2000-05-08**	**100%**
1549	**7.15.10.75**	**Deliver Prototype FIR Filter**	**2001-05-03**	**2001-05-03**	**0%**
1613	**7.15.30**	**CDR: Prototype Correlator**	**2000-01-21**	**2000-01-21**	**100%**
1652	8	Computing Subsystem	1998-06-01	2010-12-31	12%
1653	8.03	Computing Development (Phase 1)	1998-06-01	2001-12-31	44%
1654	8.03.05	Management	1998-06-01	2001-12-31	65%
1656	**8.03.05.10**	**Deliver Phase 2 Computing Plan**	**2001-06-01**	**2001-06-01**	**0%**
1657	8.03.10	Science Software Requirements	1999-06-01	2001-12-28	52%
1659	**8.03.10.10**	**Deliver Science Software Requirements v2**	**2000-09-01**	**2000-09-01**	**100%**
1674	8.03.30	Control Software	1998-06-01	2001-12-28	41%
1678	**8.03.30.20**	**PDR: Control Software**	**2000-06-01**	**2000-06-01**	**100%**
1679	**8.03.30.25**	**CDR: Control Software**	**2001-03-01**	**2001-03-01**	**0%**
1717	9	System Engineering & Integration	1998-06-01	2010-12-31	9%
1720	9.10	System Engineering	1998-06-01	2010-12-31	22%
1722	**9.10.10**	**System Block Diagram for Array**	**1999-12-31**	**1999-12-31**	**100%**
1723	**9.10.15**	**Test System Block Diagrams**	**1999-12-31**	**1999-12-31**	**100%**
1724	**9.10.20**	**System Design Review**	**2000-02-28**	**2000-02-28**	**100%**
1729	9.12	Test Site Preparation/Outfitting	2000-02-01	2001-05-04	35%
1731	**9.12.10**	**Design Review: Test Int. Site Preparation**	**2000-05-15**	**2000-05-15**	**100%**
1738	**9.12.35**	**Test Interferometer Site Complete**	**2001-04-30**	**2001-04-30**	**0%**
1739	**9.15**	**ALMA Prototype Interferometer Evaluation**	**1998-06-01**	**2003-04-09**	**0%**
2	**9.15.10**	**Deliver Prot. Ant. Testing Plan**	**1999-12-31**	**1999-12-31**	**100%**
1752	9.20	Holography System	1998-09-01	2001-07-30	17%
1755	**9.20.15**	**Design Review: Holography System**	**1999-04-19**	**1999-04-19**	**100%**
1758	**9.20.30**	**Deliver Holography System**	**2001-07-30**	**2001-07-30**	**0%**
1767	10	Science	1998-06-01	2009-12-31	47%
1771	**10.17**	**CDR: ALMA Array Layout**	**2001-03-01**	**2001-03-01**	**0%**



Milestones: **bold type**
Summary Tasks: **underline**

Joint Task
Eur Task
US Task
Summary (Joint)
Summary (Eur)
Summary (US)
Progress
Milestone
Completed Mlstn
Summ. Progress
Split