

Report of the AMAC Meeting

March 24-25, 2003

Socorro, NM, USA

AMAC Members:

Arnold van Ardenne, Robert Aymar, Sergio Bertini, Gordon Chin, John Credland, Gary Sanders (Chair), Herwig Schopper (absent), Domenick Tenerelli, Robert Wilson

The ALMA Management Advisory Committee (AMAC) met at the National Radio Astronomy Observatory (NRAO) site near Socorro, NM, USA on March 24 - 25, 2003 to review the status of the ALMA project. Our review followed a written charge from the ALMA Board. The charge is appended to this report. The site of the review was particularly advantageous as it afforded the AMAC the opportunity to observe the prototype ALMA antennas now being installed and undergoing testing at the NRAO site.

The agenda for the meeting is appended. Shortly before the AMAC meeting, we learned that Massimo Tarengi, the ALMA Interim Project Manager and to be named JAO Project Director, became ill and was hospitalized and unable to participate in this review. As a result of this situation, Massimo's presentations at the AMAC meeting were made by Paul Vanden Bout, Interim Project Director. The AMAC thanks Paul and the ALMA management team who made it possible to carry out the review successfully despite the absence of Massimo.

Our report comments on topics enumerated in the charge.

- **The overall status of the ALMA project, including its organization, management, and progress relative to previously-planned schedule milestones and budget. Are there significant management or project weaknesses which require attention or changes?**
- **The status of Phase I activities related to prototype antenna procurement.**
- **The first year of Phase 2 Project Plan activities with particular reference to**
 - **the ALMA Project Plan;**
 - **the ALMA WBS, division of tasks, and schedule; and**
 - **Operations Planning.**

The Bilateral Agreement was signed in January 2003 and the ALMA Board has held its first official face-to-face meeting. Thus, ALMA's Phase II has formally begun. The ALMA partners are to be congratulated for this singular accomplishment.

The AMAC is very encouraged by the progress made in forming the Joint ALMA Office (JAO) and in defining the management structure. The funding for both the North American and ESO halves of the project appears secure. Progress towards Phase II is evident. The steps taken at the Venice ALMA Coordinating Committee have borne fruit, aiding ALMA's accelerated forward progress. Paul Vanden Bout, serving as Interim Director, and Massimo Tarengi, serving as Interim Project Manager, have worked with the ALMA Board and the project teams to accomplish a great deal.

ALMA has taken major steps forward since our last review. Considering the intrinsic challenge of ALMA and the pathfinding creation of bilateral governance that has just now taken shape, the progress is extraordinary and it bodes well for the future. **Our detailed comments below, ranging over many topics, should be taken as constructive advice to a well-formed project making great strides.**

Project Plan: The AMAC endorses the Project Plan and the developing project structure and organization. The use of the Integrated Product Team (IPT) mechanism across the two Executives, with balanced leadership teams from the two partners to take the responsibility for each level 2 WBS task, is truly appropriate for the bilateral partnership and is already a powerful scheme to unify the Project.

Project Director: Massimo's appointment as Project Director is a very positive step. Massimo brings his experience with the construction of VLT in Chile, his rapid mastery of the elements of ALMA, and his impressive abilities as a manager of such a large project into ALMA at a crucial time.

Project Management: It is most important for the ALMA Board to progress forward to fill the remaining positions in the JAO with similarly experienced and expert persons. Within the JAO there must be sufficient experience in project management of large complex international projects, in addition to Massimo's experience, to assure that enough energy and attention is available to lead ALMA construction when the director is otherwise occupied. It would be imprudent to assume that since the ALMA director has strong project management experience and since the Executives each have project managers that this function is already "taken care of." The Director's energy and attention might be directed at other pressing concerns (as one example, the complex coordination with Japan of their proposed entry to ALMA or the pending antenna procurement strategy) and as a result the detailed day-to-day management might suffer as a result if the JAO team were not appropriately experienced. ALMA is a very complex project.

Project Scientist and Project Engineer: The Project Scientist will act as the main science spokesperson for the JAO. For this reason, the Project Scientist should be a scientist with millimeter radio astronomy experience. The Project Engineer should be an engineer/scientist with appropriate science/technical experience in project management and system engineering. As we discuss later in this report, experience in production engineering may be essential.

System Engineering: A great deal of progress has been made in developing the System Engineering IPT, consistent with our previous recommendations. The role of System Engineering needs to be made more visible within the joint ALMA management structure. Indeed in large projects, the System Engineer (or possibly the Project Engineer in the ALMA organization chart) as well as the Project Scientist reside at the highest level reporting to the Project Manager. Because of the structure of the JAO and its NRAO and ESO parallel implementation arms some indication of this level of importance within the project should be conveyed in the organization chart and implemented functionally and substantively as well. The AMAC understands that the System Engineering IPT is located in the organization to foster close coupling to the subsystem IPT's. We concur in this strategy but urge that the reporting of the System Engineering IPT to the JAO be made clear and evident. In fact, the Management IPT should consist of the JAO, the regional project offices and the System Engineering IPT operating in a coordinated and coherent manner.

Unifying ALMA: The interim Director identified some challenges that must be addressed by the JAO team - how to instill a one ALMA team attitude over a globally, culturally, and organizationally dispersed structure, the complexity of management in such a complex structure, and administrative effectiveness when some critical functions are dependent on time-consuming processes at the NSF or ESO (approval of major procurements for example). We urge that such matters be given high and persistent attention. ALMA's success depends upon a unified team culture.

Uniting Cost and Schedule Planning for Earned Value Performance Management: Regarding schedule, milestones and measurement of progress, ALMA has been well served by the preparation of a very detailed WBS, cost estimate and a schedule based upon bottom up planning. Very detailed lists of milestones have been defined at three hierarchical levels

corresponding to ALMA Board, JAO and Executive/IPT levels of responsibility. This planning has underpinned the detailed division of responsibilities between the executives and has guided progress in the Phase I ALMA and early Phase II activities. The WBS facilitated the separation of deliverable work packages. The cost estimate has provided the valuation basis for measuring the contributions of the two executives. The milestones have paced the work.

With a new Project Director and foreseen completion of the staff in the JAO, it is most important for ALMA to build upon this successful base and create the planning and performance measurement basis for the increasingly complex ALMA project. The AMAC strongly urges that the present planning be extended to a full earned value system for defining the baseline ALMA project program and for measuring performance.

The present detailed milestone structure is defined at Levels 1, 2 and 3. The lowest level structures the work of the IPT's. The higher levels structure oversight by the JAO and ALMA Board. The AMAC has observed that the detailed milestone definition is developed to the point that hundreds of milestones are defined. This "inchstone" method of pacing a program signals careful planning and is consistent with the impressive diligence of the ALMA team that has brought ALMA to the present point.

However, this method of defining and measuring the program will not be sufficient during full ALMA project execution. As project developments occur that fall outside the plan, whether adverse or favorable, the very detailed milestone system will be cumbersome to replan for each eventuality. The milestone technique does not permit analysis of the project's critical paths nor recalculation of the critical and noncritical paths as the project is adjusted to experience. The milestone technique does not combine the cost/value estimate with the scheduled work packages in a way that permits measurement of the fraction of substantive work accomplished in the plan, namely the earned value. It supports progress tracking against a parallel or lightly networked schedule and separate tracking of costs against budget, but not value earned for the costs expended. It does not support early visibility of emerging variant trends in project performance.

For a project of the scale and complexity of ALMA an earned value management system, in association with all of the other practices employed by ALMA, is the only reliable way to detect early project variances, replan the project's logic and recalculate critical paths and support the JAO's inevitable project workarounds. Such a system should be based upon the careful development of a detailed and integrated project task network and schedule, built upon the WBS. This network should include the milestone planning. It should be combined with the cost/value estimate to produce a budgeted cost of work scheduled, the basis for an earned value management baseline. From this, the work packages to be managed by the IPT's can be clearly defined and tracked.

ALMA is at a stage where activity is building up. Developing an earned value management system adds to the burden of building up the project. It may be helpful to consider two techniques to accomplish the goal efficiently.

First, in order to accomplish the establishment of an earned value system, we recommend that outside experts be contracted to support the JAO and Executives in the selection, installation and implementation of the software tools and industry standard management systems needed to develop, control and track the project baseline and progress measurement.

Second, we recommend that ALMA consider establishing a hierarchy to separate out the top level milestones from the more detailed project network so that top level oversight can be visible apart from the detailed lower level planning and tracking. This may make the development of the project network less burdensome. In considering this, the key requirements that we recommend are that the system should support replanning, critical path management and true earned value analysis.

The planning should also clearly identify the phases of the ALMA project such as Phase I, Phase II construction, pre-operations and operations. The interfaces should be clear and should be reflected in the budgeting for each phase.

Reporting Performance: Performance reporting within the JAO, to the Board and to external agencies should include earned value status at the appropriate level in the WBS and performance against the top level milestones. This will require additional effort in the project controls function and the supporting institutions. Regular progress reports should be created to a well defined template that displays project status in appropriate graphical and tabular manner, with supporting narrative providing additional detail. Each report should clearly describe progress against the established baseline, represent issues and variances, describe recoveries and work around strategies and forecast project evolution through completion.

Presentations at future AMAC meetings should follow a uniform template across all IPT reports as we have previously requested. ALMA reporting should be unified in form as well as focus.

"Mass" Production: As ALMA will fabricate many components and subsystems in large quantities for a 64 antenna array, a key area of expertise that must be represented in JAO and Executive management, and in the engineering teams, is production engineering. ALMA will encounter serious difficulties if 64 antennas and 64 front ends are fabricated in a manner that makes each assembly into a prototype. It is essential that the transition from prototyping to full production be managed with careful attention to production engineering, perhaps by employing several stages of advancement to "mass" production. We comment on this later in this report.

Operations Planning: Planning for the use of ALMA is described in the Project Plan. But the planning for operations is most evident in the planning and designs for the physical facilities in Chile. The ALMA Project has made very significant progress towards initiating the civil phase of ALMA construction and the siting and specification of the OSF and AOS, with the road system, is evidence of this planning and the early stages of execution.

■ The production antenna procurement strategy

The AMAC was provided an opportunity to inspect the Vertex antenna prototype now installed and under test in New Mexico. The ACE prototype was undergoing early installation, and the Japanese supported Mitsubishi prototype was being installed. This is very tangible and satisfying evidence that ALMA is entering a new stage of activity. Seeing the prototype antenna was a historic day for the ALMA project. All on the project who accomplished this are congratulated for this major achievement.

However, the Vertex prototype antenna procurement is currently running some 6 months behind the previously announced schedule and will start evaluation during the second quarter of 2003. The original planning called for the Vertex production contract to be let by mid-2004 to utilize the budget for FY2004. The ACE antenna is not expected to start evaluation until the end of 2003. There are concerns about the ever-sliding date for the availability of the ACE prototype antenna for testing.

The JAO plan for antenna procurement has been presented to the ALMA Board. It calls for a single competitive procurement leading to a single antenna type for ALMA production. This approach can result in significant long term cost savings and operational efficiency during the production, installation, operation and maintenance of ALMA. The procurement strategy calls for review of a full procurement package in the fall and open bidding near the end of the year. It is intended to follow expected EU requirements. The strategy may require a departure from the original intention to enter into negotiations with the preferred provider following the prototype stage. The AMAC has previously supported such a competitive strategy and endorses this again.

However, in order for a truly effective and competitive procurement process to succeed by yielding informed and competitively priced bids, the testing and design documentation presented to the bidders must be as complete as possible. It is extremely challenging to transfer the detailed design of a prototype from an originator to a new supplier. Drawings and design documentation cannot completely convey critical technical details of processes. There is very high leverage in complete design descriptions that provide clarity and reduce uncertainty with bidders. This may be key in permitting the lowest possible costs and reducing technical errors and rework during production. For these reasons, we recommend that the procurement be paced and even delayed slightly to gain greater definition and advantage.

Having said this, we urge that the ALMA Board consider defining a firm cutoff to limit additional delays in the ACE contract delivery schedule. At a point very soon, the burgeoning delays in this contractor's performance may force an end to the consideration of that prototype. Elements of the attractive design in the ACE prototype could be included in the selected design, though at the risk of cost and schedule delay to requalify the resulting design.

ALMA will require 64 identical antennas at the lowest possible cost. To achieve this, successful "mass" production will have to be mastered at this scale. The production strategy may have to progress with a phasing in the production stream from one antenna to perhaps 3 and then to perhaps 8, followed by series production. The bidding vendors should play a strong role in defining this progression as they are responsible for the production at the lowest cost. ALMA will need to exercise considerable insight to the production engineering aspects of the task in order to maintain appropriate responsibility, approval and oversight.

There are predictions of cost increases in this area. Attention must be paid to a design to cost strategy and scope contingency, as ALMA is starting with a relatively small contingency pool for such a complex project.

- **The procurement of the front end elements;**

During our earlier reviews, the AMAC urged that steps be taken to move the front end production planning from in house effort to an industrial series production effort. Considerable progress has been made by the ALMA team towards this goal and we urge that thorough attention be paid to system and production engineering and to industrialization of the front-end production. This will require increasing the effort and expertise within ALMA to production matters, in a field that has succeeded so far by in house production of small numbers of highly specialized technology.

There are predictions of cost increases in this area. Attention must be paid to a design to cost strategy and scope contingency, as ALMA is starting with a relatively small contingency pool for such a complex project.

- **The preliminary safety plan;**

The preliminary safety plan is thorough and represents a good start on safety planning in this large, multi-institutional project. The plan addresses the safety organization, responsibilities and operating safety procedures. It does not address hazard analysis of the system or subsystems, mitigation of identified hazards with a hierarchical methodology for addressing hazards through design, training or procedures or aspects of system safety. The AMAC was assured that these are addressed in the design requirements. At a future review the AMAC would like to see a presentation on system safety.

- **Are there issues to which the project should pay special attention in negotiations with Japan for their entrance into the project?**

The installation of the Mitsubishi antenna in New Mexico and the participation of Japanese observers are signs of the serious nature of the Japanese overture to join ALMA. The ALMA Board is taking a measured and appropriate course in negotiating with the Japanese for their participation. All parties are mindful of the singular opportunity to expand the scientific impact of the ALMA project and the example that a successful tri-lateral ALMA would set. The AMAC continues to advise that the bi-lateral ALMA proceed without delay or hesitation on its program plan while negotiations are carried out. The goal of achieving Japanese participation without delay or disruption to the bi-lateral ALMA is the recommended approach.

■ **Are there other issues that the AMAC considers relevant?**

Within the system engineering, the AMAC recommends that ALMA carry out a reliability, maintainability, availability analysis in order to identify significant failure modes. This should be carried out before significant production begins.

Finally, the AMAC notes that the ALMA team has achieved a great deal during the previous year and they are on track to realize the ALMA project.

AMAC GENERAL CHARGE

The ALMA Management Committee (AMAC) will provide advice on those major issues presented to the AMAC by the ALMA Board regarding the technical program, cost, and management of the ALMA project. The AMAC will be kept informed of progress and developments in the project through periodic reports and briefings provided by the Joint ALMA Office (JAO), and will normally meet at least twice a year. Reports of AMAC deliberations will be made in writing to the ALMA Board by the Chairperson of the AMAC following each Committee meeting, on a schedule specified in advance by the Board.

Charge for the Meeting of 24-25 March 2003, Socorro NM

Based on the written materials and presentations made at this meeting, the AMAC is requested to evaluate:

- The overall status of the ALMA project, including its organization, management, and progress relative to previously-planned schedule milestones and budget. Are there significant management or project weaknesses which require attention or changes?
- The status of Phase I activities related to prototype antenna procurement.
- The first year of Phase 2 Project Plan activities with particular reference to
- the ALMA Project Plan;
- the ALMA WBS, division of tasks, and schedule; and
- Operations Planning.

The AMAC is also requested to address the following:

- The production antenna procurement strategy;
- The procurement of the front end elements;
- The preliminary safety plan;
- Are there issues to which the project should pay special attention in negotiations with Japan for their entrance into the project?
- Are there other issues that the AMAC considers relevant?

Please deliver your written report to the ALMA Board by April 25, 2003.

Meeting #3 of the ALMA Management Advisory Committee

**Array Operations Center and Very Large Array Site, Socorro, NM
24-25 March 2003**

Draft Agenda (March 10, 2003)

Monday, 24 March 2003 (Array Operations Center)

- 8:00 Executive Session (AMAC plus ALMA Board representatives)
- 9:00 Welcome and Introductions
- 9:05 Charge to the AMAC
- 9:10 Status of Project Report of the Board
 - Government approvals and funding status
 - Governance and ALMA Agreement
 - Japan status
 - Chile status
- 9:45 Executive Session
- 10:00 Break
- 10:15 Report of Project
 - Overview and Introduction (Director and Project Manager)
 - Summary of Scope & Scientific Requirements
 - Review of Management Plan & Changes
- Overview of WBS, Division of Tasks, Schedule
- 11:00 Performance of Project (templates for each WBS, showing key data)
- 11:45 Executive Session , including status of JAO Personnel Search (with Board representatives and Director)
- 12:30 Lunch
- 13:30 Executive Project Managers' Reports
 - European Project Manager
 - North American Project Manager
- 14:00 Selected IPT Reports:
 - Front End
 - Computing
- 15:00 Break
- 15:15 Selected IPT Reports (continued)
 - Systems Engineering
 - Site Development
 - Report of Joint Safety Committee
- 16:30 Executive Session
- 17:30 Wrap-up and adjourn
- 19:00 Group Dinner in Socorro

Tuesday, 25 March 2003 (Array Operations Center)

- 7:45 Executive Session
- 8:45 Depart AOC for VLA Site
- 10:00 Antenna Status
 - Overview
 - Vertex Antenna Status
- 11:00 Tour of Antenna Test Facility

Demonstration of Vertex Antenna Operations
 Tour and Inspection of Vertex Antenna
 Tour and Inspection of AEC and MELCO antennas
 12:30 (Working) Lunch
 13:30 Antenna Status (continued):
 AEC antenna status
 Antenna evaluation process
 Antenna procurement strategy
 ATF Software

 15:30 Break
 15:45 Correlator status
 16:00 Executive Session
 16:45 Exit Discussions with JAO Staff
 17:15 Depart for Socorro (time approximate)
 19:00 Dinner