

**Report of the December 15-16, 1998 Review of the Millimeter Array Project
Submitted to the National Science Foundation**

by

The Millimeter Array Oversight Committee

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INTRODUCTION

The NSF and the NRAO are to be commended on the progress they have achieved since our last review in developing an international partnership to carry out this great advance in millimeter wavelength science. It is also evident that this progress has been achieved in parallel with the vigorous and timely execution of the MMA Design and Development activities.

Our last report stated that the "MMA will be a wonderfully powerful instrument" and we urged that it be built and exploited. We also commented on the embryonic possibility of an international partnership, with the following perspective:

"If the scenario hinted in the Feasibility Study were to be achieved, the scientific community would get more science than might be achieved deploying the separate resources of each partner. The whole could exceed the sum of the parts and this is worth the effort by the NSF and NRAO to revise the project plan for MMA. Given this prospect, the NSF and NRAO should vigorously pursue the negotiation with potential partners with a view to a definite agreement by the middle of 1999. These negotiations will require give and take and should be driven primarily by the goal to achieve the best outcome for millimeter wavelength science." Recognizing that the path to partnership will need to be pursued in parallel with the MMA Design and Development phase activities for a solely US project, we wrote:

"However, the process of achieving foreign partnership should not be cause for delay of any aspect of the standalone MMA project, including detailed planning even at this stage. The planning is needed for several reasons: NRAO needs to know the scope and complication of both the D&D and construction phases. This baseline can form the basis of any negotiations between NRAO and foreign partners. With such a detailed plan, the decision points that can guide the development of foreign partnership can be formulated and the consequences (delays, etc.) of different MMA configurations can then be assessed. NRAO also needs this plan to assure that it is able to proceed without a partner, if necessary --- it is needed to assure the NSF that the project is viable."

The NRAO and the NSF have moved forward to fulfill the hopes contained in our recommendations. We reaffirm our previous advice and encourage this continuing effort.

Despite even the most attentive management efforts to freeze the MMA technical baseline, cost and schedule, we note that the definition of the MMA systems and the development of the international partnership may require adjustments in the baseline. This may lead to some schedule, cost and technical baseline changes before the end of the Design and Development phase. If such adjustments result from a real international partnership and an improved capability in millimeter wavelength science, this may yield a more successful scientific outcome for NSF's and NRAO's sponsorship of the MMA Project.

Our report uses the NSF Charge to structure our additional response.

MMAOC CHARGE

Meeting of December 15-16, 1998

At its third meeting the MMAOC is requested to consider the following issues: Based on the Memorandum of Understanding establishing a European consortium to carry out a program to parallel NRAO's MMA design and development efforts, as well as on other information presented at this meeting:

*** Does the MMAOC have comments or recommendations regarding the general process of obtaining partners for the MMA project?**

The Memorandum of Understanding (MOU) establishes a European Coordination Committee (ECC) to guide the combined European development plans. This ECC also provides a point of contact for discussion and negotiation. The MMAOC finds this MOU, and the establishment of the ECC, encouraging. We feel that this provides a good basis to continue the process and supports an optimistic view that partnership will occur.

The MMAOC applauds the European effort defined by the MOU and we also applaud the NRAO for its efforts to lay the foundation for this progress. We also note the NSF's very positive role and we encourage the NSF to continue to exercise this leadership.

Both the NSF and NRAO should proceed to develop the emerging partnership with vigor.

The MMAOC also notes that, in the future, the international partnership may expand.

*** Does the Committee have specific comments or recommendations on the steps taken and proposed to be taken by NRAO in order to accommodate the antenna procurement process to the interests of its prospective European partners?**

The MMAOC agrees with the NRAO that the antenna procurement process should not be delayed by the desire to await the outcome of the discussions with the Europeans. It is of the utmost importance to the timely accomplishment of the goals of the D&D program that this procurement proceed within the D&D schedule plan.

However, the Europeans have placed high priority on the additional extragalactic scientific reach supported by adopting a 12 meter diameter antenna design. The MMA project has assumed a 10 meter diameter. The NRAO has prudently asked its own Millimeter Array Advisory Committee (MAC) to review the implications of adopting a 12 meter diameter. The MAC has responded that the MMA scientific goals can be accomplished with either diameter.

Given that the MMA goals are preserved with either diameter, and recognizing that a 12 meter diameter is considered important for the additional scientific interests expressed by the Europeans, the MMAOC recommends that the MMA antenna procurement schedule be preserved by promptly commencing the procurement of a final design and antenna prototype with the 12 meter diameter. We prefer this to any strategy that contemplates modifying a 10 meter design after commencing the procurement and in response to partnership negotiations.

The 12 meter design may facilitate operational simplicity since, for constant collecting area in the array, fewer units need to be operated. This operational simplicity may result in lower total life-cycle costs, offsetting the possibly higher up front production costs for the antennas. The D&D phase antenna procurement, however, may be more costly. The MMAOC feels that this would be justified by the promise of a superior antenna unit as the basic building block for the full project.

Should the NRAO accept this recommendation (discussion during the meeting indicate that this recommendation is being favorably considered), we urge immediate incorporation of the larger diameter into the Request for Proposal (RFP) documentation package. We further urge release of a draft RFP to prospective bidders and incorporation of the bidder comments in the final RFP package. The MMAOC feels that the combined draft RFP-comment-final RFP-proposal-evaluation cycle can be held to approximately the same total duration, preserving the MMA planned award date for the prototype antenna procurement.

Noting that this strategy is a positive and preemptive accommodation to the European position, the MMAOC encourages the NRAO to involve the prospective European partners in reviewing and evaluating the antenna procurement.

*** Does the Committee have comments regarding NRAO's other plans for managing the impact of a potential European partnership?**

First and foremost, we encourage the NRAO to proceed with all activities in the MMA D&D phase without delays motivated by the partnership process. The planned schedule must be maintained. The NRAO should, then, continue to proceed with the partnership process in parallel.

We encourage the NSF to continue the process begun in the September meetings in Europe and we hope that this process can occur as rapidly as possible.

We reaffirm our previous recommendation that the goal should be a definite agreement by the middle of 1999.

*** Does the Committee have comments on the possible international partnership models presented at this meeting?**

We have been exposed to the NRAO/NSF preliminary ideas for organizational models to accommodate partnership and we urge the NRAO/NSF to continue towards the planned discussions with the Europeans.

*** Based on the information presented at this meeting, does the MMAOC have comments on the NRAO's technical progress for MMA design and development efforts?**

The meeting included a set of summary and status presentations on the technical subsystems. This was a useful update and offered the MMAOC the chance to meet some of the technical task leaders. Progress is

being made in all areas. One notable milestone, the scheduled December 1998 selection of a digital FIR filter or an analog BBC option for the correlator appears to be ripe for a decision on schedule. The MMA project indicated that both MMA, and the MAC, will favor the digital option. This promises significant technical advantages, with a cost comparable to a surface mount analog version. This choice is a promising indicator that MMA management is working towards achieving its intermediate program technical milestones.

At the next MMAOC meeting, the OC looks forward to a presentation of the MMA computing requirements and the status of the choice of computing standards.

It is very important for all of the technical tasks in MMA to be paced by their schedules and measured by accomplishment of planned milestones. The development of the technical task schedules originates at the task level with the leadership of the task. The combined schedule is integrated and adopted at the project level. It is very important that the combined schedule be adopted, in turn, by the technical task leaders, and used faithfully in the day to day management of the technical work. In future technical subsystem presentations to the MMAOC, it will be useful for each technical presentation to incorporate a common format that includes, for example, the design requirements, the baseline definition with any configuration changes that have been approved, or are considered, the description of the technical progress, comparison of progress against the subsystem cost and schedule, and discussion of significant risks and developments. In addition to contributing to a more efficient review, this format demonstrates that the baseline plan has been adopted and used by the technical task teams.

Please provide a critique of MMA project planning and organization, as proposed by NRAO in the Millimeter Array Management Plan (Version 2.0), the Millimeter Array Project Book (Version 2.0), and as described at this meeting. In doing so, please provide answers to the following questions:

*** Does the MMAOC believe that the proposed management plan and work breakdown structure will lead to the successful completion of the MMA project's design and development goals?**

The MMAOC recognizes considerable progress in the development of the Management Plan and in the planning of the schedule, WBS, and in the development of the Project Book.

The Project Book has advanced but could be brought more into conformity with the WBS and provide a clearer baseline definition. We urge continued development in this direction during the D&D phase.

These planning tools can be used as the basis for successful execution of the MMA design and development. There were some inconsistencies in the documentation and the MMA management was aware of these and planned to address the integrated consistency by the early 1999 delivery of the full WBS, cost estimate and schedule.

Planned development of the Preliminary Cost Estimate on April 30, 1999 is an extremely important milestone towards which the MMA team is working. Towards the goal of defining an accurate cost estimate and a predictable project plan, we urge the NRAO to continue their commendable progress to deliver a comprehensive cost estimate as planned in the spring, and to continue progress towards applying the project management tools described in the draft management plan.

Beginning with the next MMAOC meeting, the OC would like to see the reports of MMA project performance at the review expanded to include performance against milestones and earned value against the baseline.

*** Are there issues which have been incompletely treated or omitted from the Management Plan or Project Book?**

The Configuration Management section of the Management Plan should include a provision for triggering consideration of a number of changes that individually fall below the chosen change control thresholds, but cumulatively exceed the thresholds. The Project Manager, and the Division Heads, should be explicitly able to collect a number of small changes into a change control decision normally reserved for large, individual changes. This provides a means of explicitly controlling configuration, cost and schedule creep by incremental changes.

*** Is the proposed management structure matched to the project's goals?**

The proposed management structure is well matched to the challenges of the MMA design and development phase. The team appears to have effective communication mechanisms in place for exercising the structure in a project divided over several widely separated sites. It will be a challenge to maintain the intense communication. The role of system engineering has been elevated appropriately in the organization, following our earlier recommendation.

*** Has NRAO responded satisfactorily to the MMAOC's previous recommendations?**

The NRAO provided a written, point-by-point response to our recommendations. They have responded satisfactorily, completing action on many of the recommendations, with significant continuing progress in all other areas.

*** Are there any other management issues which the MMAOC deems relevant?**

Given the high priority in holding to the MMA schedule, and the promise contained in the emerging partnership for better science, the NSF, AUI, and NRAO will have to concurrently manage the MMA Project and the smooth merging of the combined project. This is a great challenge with a high scientific payoff. NSF, AUI and NRAO will have to simultaneously exercise the focused resolution intrinsic to project management, and the disruption and distraction of the evolving merger with flexibility and a clear vision of the ultimate goals.

*** Are there any other issues which the MMAOC deems relevant?**

The current agreement with the Chilean government provides for use of the land at the Chilean site for a period of five years. Given the long term life cycle of the MMA facilities in Chile, steps should be taken to extend the period of performance of the agreement.