



# ALMA BOARD

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**Subject:** ASAC Report

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## **Report from the ALMA Scientific Advisory Committee**

### ***Face To Face Meeting***

### **CHARLOTTESVILLE**

**September 28<sup>th</sup> & 29<sup>th</sup> 2008**

#### ***Membership of the ALMA Science Advisory Committee***

S. Aalto, J. Afonso, J. Bally, A. Blain (Chair), J. Cernicharo, F. Gueth (Vice chair),  
M. Hogerheijde, K. Johnson, D. Johnstone, K. Kohno (Vice chair), N. Nagar, T. Onishi,  
J. Williams

#### ***In Attendance***

C. Brogan, T. Hasegawa, J. Hibbard, R. Hills, R. Laing, C. Lonsdale, K. Morita, A. Peck,  
L. Testi, T. Wilson, A. Wootten,

### **EXECUTIVE SUMMARY**

The ASAC met in NAASC in Charlottesville September 28<sup>th</sup>/29<sup>th</sup> 2008. Overall, ASAC is pleased to see the progress with the project since we last met face-to-face in January 2008: we are confident that the Project Scientists and their growing team are on track to commission ALMA as a transformational global observatory. The transition to an observatory continues to take shape with the appointment of a permanent director. Our overall level of concern for the readiness of software since the last report has been reduced, and we are especially impressed by the readiness of the CASA tools for commissioning and simulating operations. We report in detail on the five charges sent to ASAC by the ALMA Board in Section III. Our overriding concern is with the schedule, which is currently under extensive review, and we look forward to hearing about the results of November's substantial project-wide software review at our January face-to-face meeting at the OSF. We see that the key project target for the coming six months is the successful operation of a two-element interferometer at the OSF, successfully transferring the experience of the ATF to Chile.

### **I. INTRODUCTION**

This report describes the ALMA Science Advisory Committee (ASAC) face-to-face meeting held in Charlottesville, and is for submission to the Board at its meeting in San Pedro in November 2008. The committee is grateful to Al Wooten for organizing the ASAC meeting and teleconferences, and to the project scientists and project workers in the executives for their help in preparing and presenting documents and reports for our meeting.

The ALMA Board gave ASAC five specific charges, two of which are preliminary and will lead to more substantial reports in spring 2009, after ASAC meets at the OSF in late January 2009. The answers to the charges can be found in Section III.

We start our report with a general overview of the discussions at our meeting, and on additional questions raised about the project during our discussions of the charges. In particular, we note that the Project Team has been providing ASAC with a very useful insight into the status of recent change requests: in our recent telecons the committee has found that this news has given us a clearer view of the status of the project. We then address the specific charges. We would welcome future formal charges from the board that include the matters of concern highlighted in Section II.

## **II. GENERAL DISCUSSION**

II.1 ASAC wholeheartedly supports the current re-scheduling process, and looks forward both to reviewing the results as soon as they emerge, and to assisting the Board in reacting to the results and redefining project milestones.

II.2 ASAC was pleased to see that substantial system components continue to arrive at the OSF, and that progress is being made towards antenna acceptance and integration, including the transfer of trained technical staff from the ATF to Chile.

II.3 The continued effort on developing the local oscillator (LO) photonics design, and the procurement of four baseline systems, coupled with ongoing investigations into alternative LO transmission schemes and systems is sensible, and we consider that this high-risk element in the project is receiving all due attention.

II.4 We recognize that the implementation of correction for atmospheric phase fluctuations due to variations in water vapor content is an essential element in meeting ALMA's science goals. We are pleased to see the release of CASA's imaging simulator, and note that the implementation of realistic phase noise in a simulator would be a useful additional tool to the project. We note that variations in atmospheric temperature both affect the phase errors due to water and cause additional phase fluctuations. We had an interesting discussion about possible radar/sonar techniques for measuring the temperature variations along the line of site. We recommend that the project considers investigating using a test system to evaluate the technology and if possible to build up a database of such measurements ahead of interferometry at the AOS.

II.5 The ASAC was pleased to hear that the surface accuracy specification of the 7-m ACA antennas during daytime is set to remain at 20 microns, following the discussion of a change request to relax the requirement to 25 microns. We view access to ACA baselines for high-frequency observations when low-opacity conditions continue after dawn as a potentially important way to improve the efficiency of operations of the joint array.

II.6 The challenging performance specification of the band-3 receiver was only barely met by prototypes, after extensive searching for excellent matching in components. This has led to a change request to increase the specified noise temperature across the whole of band 3. We note that this leads to a reduction in sensitivity by 7-8% in the middle of the band, but to improved performance as compared with the original specifications at the ends of the band. The more uniform performance leads to a science gain for spectroscopy of HCN and redshifted CO emission from the requested change. The change request describes a target for the performance averaged over both sidebands and polarizations. ASAC recommends pushing back on the request to specify that each delivered receiver should meet the new requirement in both polarizations, as this would maximize the uniformity and depth of polarization observations. Furthermore, we would encourage the project to continue any possible mixer development work that could yield improved devices for inclusion in frontends produced later in the manufacturing run. As a workhorse band that can be operated in most weather conditions, we consider that a relatively small expenditure now which might make the full array significantly faster in this band would be well justified.

II.7 After our meeting in January 2008, ASAC supported an investigation to reoptimize the configuration of the array on baselines from 5-10 km to provide better  $uv$  coverage. This was a timely discussion owing to the imminent detailed design of the network of roads, pads and fiber runs at the site. The simulations that have been carried out indicate that the  $uv$  coverage can be improved by adding about 10 pads and moving several others, but that the improvement to the quality of the final maps is only significant in circumstances that will be encountered rather rarely, i.e. observations with very high signal-to-noise ratio at high angular resolution. Given that the costs of these changes are substantial, and that the design of the layout of roads and optical fiber trenches has been completed, we do not recommend making this change. We do however suggest that redundant cables are buried, to allow for future expansion without any retrenching back to the core, thus reducing the cost of any future decision to increase the number of pads, and removing any risk of damaging existing cables.

II.8 The design and site preparation of the central core has proved more complex than anticipated: the initial plan for a three-tiered terraced core included inter-level steps that were too high, and would lead to shadowing of antennas. ASAC was pleased to hear that an alternative plan to install the initial interferometer baselines on the simpler ACA foundation is viable, thus allowing more time to redesign and construct the more complex central core foundations without delaying AIV/CSV.

II.9 The committee discussed the status of the planned six Band-5 receivers; while this appears to be a modest issue in commissioning, it could impact operational efficiency if the locations of the small minority of antennas equipped with these receivers have to be chosen specially. Equipping ALMA with band-5 receivers is an issue under consideration by the development working group. However, plans for the integration of the expected six receivers should be drawn up.

II.10 NRAO director Fred Lo talked with ASAC during our visit to Charlottesville. We understand that he is leading reactivated discussions of a board subcommittee to consider the ongoing issue of time allocation for ALMA. ASAC remains committed to helping the Board to understand the impact of the time allocation policy on the science output of ALMA.

### **III. RESPONSE TO BOARD CHARGES**

**III.1) ASAC should continue to monitor and assess the readiness of ALMA software, in particular to review the outcome of software CDR number 6 and the ongoing work on detailing the software requirements for Early Science. These topics should be covered in the ASAC's written report for the Board's November 2008 meeting.**

ASAC was pleased to hear that the functionality, stability and number of users of the offline reduction package CASA has continued to improve, and would like to congratulate members of the project team on this success. We note the success of recent releases, and support the decision to change the schedule for the release of new versions to every six months from every three months, thus providing more substantial and internally-consistent updates. We are pleased to see that high-performance computing requirements for reducing data from the full array are being worked on by the CASA team, but remain concerned that the effort being applied to these longer-term developments should not distract from making ready the more modest software that is needed more imminently to support commissioning and early science. The ongoing lack of a replacement for Joe McMullin as CASA Group Supervisor continues to reduce the efficiency of oversight and the assignment of scientific priorities within the CASA project. We urge the Board to continue to push for this position to be filled urgently, or to seek a suitable reorganization of responsibilities within the project to recover this capability.

We saw a brief demonstration of the Observing Tool (OT) from Leonardo Testi, who was running the OT on his laptop, and received an informal verbal report by Robert Laing about the testing of the control software at the ATF. There appears to have been substantial progress in these areas. We look forward to a much more thorough analysis of these issues in January 2009. In particular, the experience of extended operation of the control software on real hardware at ATF has provided the development team with the valuable chance to improve the system. Progress in total-power operation has included the demonstration of large-field mapping, and a final campaign is planned to address software latency prior to the closure of ATF. This experience emphasizes that minimizing the delay between the closure of ATF and the establishment of 2-element interferometry at OSF is crucial.

We understand that before ASAC meets again in January, Alison Peck and Lars-Ake Nyman will have set up the procedures for testing and accepting the software for ALMA commissioning and operation at OSF. In addition, the project is holding a substantial ALMA-wide software review in November. We look forward to reviewing the status of the system in January, when we hope to see the state of the commissioning program directly at the OSF.

ASAC emphasizes that our concerns about CASA from previous reports have been largely satisfied. While we will continue to take an interest in the progress of CASA, it seems more important to concentrate our efforts at present on reviewing the readiness of the online software components - control software and the OT - for activities throughout the project, that is from component acceptance and testing, to science commissioning and then early and full operations. Following the forthcoming reviews, we look forward to reporting on these aspects of the system in March 2009. We remain concerned that there could be a potential disconnect between the software needs of the changing project, and the effort being expended by the software development teams.

The board specifically charged ASAC to report on the outcome of Software CDR-6. In light of the forthcoming November software review, and following informal discussions between the ASAC chair and Richard Hills that revealed the very specific, technical and fine-grained nature of the material presented at Software CDR-6, ASAC has decided to defer comment on issues involved in CDR-6 until March 2009.

Software remains an urgent concern. ASAC believes that the current ongoing reviews are necessary in order to evaluate the state of software development that could impact science readiness, and that the overall leadership of the project is aware of and reacting to these dynamic issues with all due diligence.

**III.2) ASAC should continue to review AIV/CSV activities and to recommend necessary and desirable changes. Any significant new issues in this area should also be included in the report for the November 2008 meeting, but the Board expects a more detailed examination of these topics after the ASAC meeting in Chile in early 2009.**

The ASAC wholeheartedly supports the project scientists' plan to merge the AIV and CSV processes, with priority for staff time and effort being given to AIV tasks until interferometry has been demonstrated at AOS, and thereafter being transferred to CSV.

Progress made with software testing at the ATF implies that the need for establishing 2-element interferometry at OSF is urgent, and should proceed with the minimum delay after the closedown of ATF. The project scientists have elevated the priority of 2-element interferometry as compared with single-antenna testing in current plans.

There has been general progress with recruitment; however, we continue to view that the availability of numbers of high-quality AIV/CSV astronomers remains a key issue for the schedule and success of the project, and encourage the project and executives to continue to take whatever steps are necessary to attract suitable staff. The possibility of combining University and ESO/NRAO fellowships with years split between service at JAO and back in a research environment in the executives is something that we recommend trying.

ASAC is concerned that modifications to the structure of the new buildings at the OSF that are currently underway to accommodate commissioning should be implemented in a way to minimize any delays to the AIV/CSV process. In particular, we note that the full specifications for thermal stability and durability of the connections between antenna pads and correlator, which are necessary for successful operation of the full ALMA array at AOS, are likely to be overkill for the purposes of acceptance testing at OSF.

**III.3) The ALMA Board has charged the Project to draw up a long-term ALMA Development Plan in consultation with the international astronomy community. The plan should set out the scientific context for transformational science with ALMA in the next two decades, in the era of for example JWST, ELTs and SKA, and recommend developments necessary to achieve this vision. The ALMA Board views this plan as having a high strategic priority, and is coordinating its development across the entire ALMA partnership. The process of generating the ALMA Development Plan should be led by the JAO Project Scientist and the ASAC (with support from the Executives). The first stage will involve an examination of the scientific drivers by a team of astronomers, chosen to be representative of the broad astronomy community that is expected to use ALMA. It is therefore important that the proposed team include people with a broad perspective and expertise at wavelengths outside the range that will be observed by ALMA as well as people with experience of mm-wave interferometry and instrumental development. This team should take time to work with the community, e.g. by sounding their own 'networks' and holding local discussions, before making a first-order draft of potential long term developments, grouping them in high, medium and low scientific priority, and identifying the ones which require long-lead technical developments. The ASAC should review and comment on the report (again with members taking soundings through their networks) before submitting it to the Board. The Board would like to receive a progress report on this at its November 2008 meeting and, if possible, the full report by March 2009. The Board suggests that it would not be appropriate to hold a large community workshop devoted to this topic, but recommends that discussion sessions be planned as part of other workshops (e.g. at one of the annual ALMA-oriented science workshops, or at more general meetings on future astronomical facilities). It is anticipated that a larger-scale activity will follow after the start of Early Science.**

The regional SACS, ASAC and the development working group have all been generating ideas and science drivers for development planning. In addition, the September 2008 NAASC workshop in Charlottesville that immediately preceded the ASAC face-to-face meeting included an extra follow-on session on ALMA development. A significant fraction of the participants at the NAASC workshop delayed their departure from Charlottesville to contribute to the discussion. This was a very successful format, and ASAC encourages its members and the ALMA project staff to engage the organizers of forthcoming scientific meetings to facilitate further such discussions. ASAC also compiled a list of names of leaders in the field who could help the project to further the next stage of the development plan.

The report from the working group, as a starting point for the process was reviewed by the ASAC following our face-to-face meeting and is submitted to the Board independently of this report. *(Secretary's note: for convenience, the working group's progress report is attached*

to this one.) ASAC notes that the preparation of the report/white paper on ALMA that will be submitted to the Decadal Review process organized by the US National Academies will be the responsibility of ANASAC, whose members share a more direct knowledge of the process of planning in the US community than the ASAC.

**III.4) The ASAC should review the plans for provision of ALMA Regional Centers and report to the Board's March 2009 meeting.**

We received updates on progress with recruitment and activities at all three ARCs. The board charged us with making a more substantial report in March 2009. We note that the ASAC face-to-face meeting at the OSF will follow directly after a meeting of the executives' ARC leaders in Chile. ASAC would like to hear in January about the readiness of the ARCs for early science, especially from a project-wide level. We would appreciate hearing from head of science operations, Lars-Ake Nyman, about the functionality of all three ARCs working together. ASAC appreciates that each regional ARC is required to deliver different services to its community; however, we would prefer to focus on the overall performance of the ARCs within the project, and leave the details of the provision of these regional services to the scrutiny of EASAC, ESAC and ANASAC.

**III.5) Noting that 2009 is the International year of Astronomy, the ASAC should examine the Project's activities in the area of outreach, both to the general public and to the astronomical community, and make suggestions as to how they and the ALMA Project could enhance these activities.**

ASAC received a report from NAASC's new EPO staff member (and former STScI staff member) John Stoke, and heard about planning for the International Year of Astronomy (IYA). ASAC is committed to raising the profile of ALMA EPO, and looks forward to continuing to working with EPO efforts throughout the project. We are confident that the level of public interest in IYA will outclass that in the current 'International Year of the Potato'.<sup>1</sup>

Outreach to improve and unify ALMA's websites for both public and astronomers would be a valuable goal for the year. The lack of consistent information and the difficulty of finding documents and information on ALMA on the web makes it difficult for ASAC members to find key references, and is hindering astronomers from the non-mm community from getting better knowledge about ALMA. Better information resources would also allow more and better outreach and communication to the public, by better engaging the large number of effective communicators already at work in the professional astronomical community.

ASAC supports ongoing efforts to improve information resources within the project. ASAC continues to see advantages in having the JAO maintain an efficient and proactive EPO team in Santiago, both to provide a consistent message from the Director of the Observatory, and to provide a common set of information and resources to the EPO teams within the different executives that can then be tailored to match outreach efforts in their own communities.

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<sup>1</sup> ASAC in no way intends to understate the importance of the world tackling hunger and food cost inflation. However, we're not sure that IYP has been a success in raising the international profile of these issues in 2008.

## JAO Response to the ASAC Report

Item II.4. Use of Radar/Sonar sensing of the atmosphere. We will investigate what the capabilities and limitations of this technique are and whether it has the possibility doing either a direct correction for the dry component or improving the correction for the water.

Item II 6. Band 3 Noise Temperature. We have had intensive discussions about this within the Project. Amongst other aspects we investigated the issue of balancing the performance of the channels to optimize polarization performance. It turns out that this is a quadratic effect – e.g. having two channels where one is 10% better than the mean and the other 10% worse produces only a ~0.5% loss of accuracy in measuring the Stokes' parameters. We therefore concluded that it is more important to optimize the average noise temperature of the entire front-end rather than laying the emphasis on balancing the noise temperatures. It was also estimated that insisting that both polarizations meeting the requirements individually would reduce the yield of useable devices from 25% to 15%, which would produce substantial delays in delivery. We have therefore agreed to new specifications for the cartridges as originally proposed, i.e. <37K average at LO = 104GHz, and <41K average at all other LO frequencies, in place of 37K over 80% of the band and 61K over the remaining 20%. These figures are still at least as good as those being achieved at these frequencies by any other receiver developers. As far as the cartridge is concerned this still provides the originally specified performance for continuum observations at 104GHz (where the atmospheric transmission is good) and gives substantially better sensitivity for spectral line observations at frequencies around 86 and 115GHz which are near the band edges.

This does not, however, include the losses due to the warm optics. For the present the requirement on the additional noise due to these has been set at 2K. The measurements continue to indicate that there is a larger excess than this and this remains under investigation. There will also be noise added by the membrane that separates the front-end from the external environment and it remains to be determined whether we can replace the current rather thick Goretex material, which has relatively poor performance at this frequency, with a much thinner one.

Finally on this topic, the Project has agreed to work with UVA on producing more and, if possible, better wafers to ensure that there are sufficient to cover the full production run of Band 3 cartridges and to make sure that the performance is as good as possible.

Item II 7. Configurations. Additional fibres have been included in the layout to allow extra pads to be added at intermediate baselines and also for some extension to longer baselines.

Charge 1: Software. The External Review has now taken place. The verbal feed-back was positive in that the panel did not see any show-stoppers in the software design and development. The panel did however have many detailed comments and there will no doubt be a number of significant recommendations in their report.

Charge 2. AIV/CSV. We are already moving into the technical building at the OSF. A revised plan for the use of lab space has been agreed which will keep the delays to a minimum.

Schedule and Milestones. The Board discussed this topic in detail. The ASAC is requested to comment on the attached revised set of milestones. This should be discussed at the next telecon. Meanwhile work on a revised schedule is still going on. The initial reappraisal, taking account of known delays in deliveries and including a realistic contingency, indicated a date for the start of Early Science of Oct 2011, which is too late. We are therefore reworking the plan to see what work-arounds can be put in place to avoid the delays caused by late deliveries. We hope that the commissioning and therefore early science can be brought forward by several months. The ASAC will be kept informed.