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Report from the ALMA Scientific Advisory Committee

Face-to-Face meeting, Santiago de Chile

Oct. 13th & 14th 2010

Membership of the ALMA Scientific Advisory Committee

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Executive summary

The ASAC met in Santiago de Chile on October 13th and 14th 2010. Observers from the ASAC also attended the CSV and Science Operations Readiness reviews that took place immediately before the ASAC meeting.

Charge 1 (Early Science readiness)

As expected, a large fraction of the ASAC meeting was devoted to the Project's readiness for Early Science. The ASAC discussion led to a set of recommendations:

- The ASAC considers that Early Science should be presented to the community as strictly a "best effort" enterprise and proposes in this document a series of policies, as an effective definition of "best effort".
- The ASAC strongly urges that only one set of capabilities be offered at the 1st Early Science Call for Proposals, even though the array will be significantly evolving before the next call.
- The ASAC views it as essential that a unified schedule for the path to Early Science be established across the entire project -including at the ARCs- by the end of November 2010.
- The ASAC feels that it should be possible to release the Call for Proposal in the February-March 2011 period and begin Early Science observations before the end of September 2011.

Charge 2 (Call for suggestions for Science Verification)

The ASAC considers this step is critical for the Project and must be used as an end-to-end validation of the software suite and operations procedures, before the first Early Science Call for Proposals is issued. The ASAC suggests renaming this phase 'Astronomical Verification' or 'Science Demonstration' and strongly urges that the ALMA Project should produce a paper on these first results.

Charge 3 (Proposal Review Process)

Although the details of the implementation plan were not discussed during this meeting, the ASAC is worried that the planned workload on the individual ARP and APRC members is too high and may discourage participation. The ASAC recommends flexibility in the implementation of the Proposal Review Process, especially for the 1st Early Science call, to adapt/optimize the process to the actual number of submitted proposals. The ASAC notes that many policies have still to be defined and makes in this document a few preliminary suggestions.

Charge 4 (Progress towards Full Operations)

The ASAC concludes that the project is making good progress towards full operations, and concurs with JAO leadership that completing this process should remain the observatory's top priority in the coming years. The main immediate issues identified by the committee are the reliability of instruments and software (the array is currently experiencing a significant number of system crashes) and the status of the archive software. The committee also flagged a number of other issues – including the poor performances (speed) of CASA.

Introduction

The ASAC met in Santiago de Chile on October 13th and 14th 2010, for the first time in the new ALMA building. Prior to this meeting, many of the committee members visited the ALMA sites (OSF and AOS) and had a detailed tour of the European antenna assembly facility. Observers from the ASAC also attended two reviews that took place immediately before the meeting: the Commissioning and Science Verification review (Oct. 8th & 9th, OSF) and the Science Operations Readiness review (Oct. 11th & 12th, Santiago). The ASAC would like to thank and congratulate the JAO for the smooth organization of these events. ASAC members were uniformly impressed by the progress made at the OSF, AOS, and Santiago sites and are fully confident the Project is making appropriate progress toward the delivery of a superb facility matching the high expectations of the community.

Participation in the CSV and Science Operations reviews was found to be extremely positive and productive, as it allowed the ASAC to have direct access to detailed presentations and key information, which have significantly contributed to our discussions. Should similar reviews be organized in the future, the ASAC would again welcome some of its members being invited as observers.

The ASAC was given four charges by the ALMA Board, which are discussed in turn in this document. Not surprisingly, a large fraction of the meeting and of the committee's discussions was devoted to the first charge, on Early Science readiness.

Finally, the ASAC, in agreement with the Project Scientist, proposes to hold its next meeting (February/March 2011) again in Santiago, as Early Science will certainly be the dominant aspect of this meeting. The second ASAC meeting in 2011 (October) should take place in North America, and the ASAC sees it as an opportunity to visit the NAASC in Charlottesville.

Charge 1 -- The principal item for this meeting is the readiness of the Project to start Early Science and the content and timing of the Call for Proposals. Key issues include: the status and reliability of the infrastructure, hardware and software (including both the real-time aspects and the suite of software for supporting observations) and of the calibration systems and methods; the completeness of AIV, CSV and System Verification tasks; and the preparedness of the user support system, as well as the expectations and needs of the user community. The ASAC will have reports from the CSV Status Review and the Science Operations Readiness Review. (Note that these reviews will be happening immediately before the ASAC meeting so final reports will not be available but members of the ASAC will have participated in those reviews and summaries of the conclusions will be presented.) In addition, reports on the status of construction and of the observatory infrastructure will be presented, along with details of current limitations and developments which relate to the question of which capabilities should be offered at which stage. Further considerations are whether or not the burden of supporting Early Science will delay the completion of the full construction program and, conversely, whether exposure, at this stage, to the problems of providing a service to users will help or hinder the project in achieving its final goals. The ASAC should provide commentary on these topics and make recommendations on how to proceed with the Call for Proposals.

A large fraction of the ASAC meeting and discussions was devoted to the Project's readiness for Early Science (ES). Other aspects directly relevant to ES are also discussed in our responses to Charges 2 and 3. The ASAC discussion led to a set of recommendations, which we have grouped into four different categories, relating to the philosophy, capabilities, mechanics, and timing of ES.

1.1. Philosophy of ES

During the course of our meeting, it became clear that addressing readiness for ES requires a precise definition of the relationship between the project and ES proposers. Given the current construction/commissioning status and the very high priority that should be placed on completion of the full array, the ASAC feels (consistent with JAO sentiment) that **ES should be presented to the community as strictly a "best effort" enterprise**. This approach is the only reasonable option for the project to be able to issue a Call for Proposals within the next months.

- The ASAC prefers the terminology “best effort” over “shared risk”: “best effort” has a more positive connotation and is less vulnerable to misinterpretation than “shared risk.”
- The Call for Proposals should clearly state what will be delivered (both data product and user support) to successful ES proposers, as well as the criteria that

will be used to evaluate proposals during the review process. Given the numerous discussions about ES that have occurred in the community over the last several years, it is crucial that the Project's communication on ES be extremely clear and not allow for any misinterpretation. The role of the ARCs in this context will be instrumental as a vector to circulate information in their communities.

- The Call for Proposals should *not* explicitly encourage particular types of proposing teams ("experts," "teams including experts," "large consortia," etc.), nor should it explicitly discourage particular types of proposing teams. Instead, the goal should be to give prospective proposers a clear enough sense of the realities of the ES that they will be able to adapt their proposal and team organization in appropriate ways.

The ASAC recommends that the following policies be specified in the Call for Proposals, as an effective definition of "best effort":

- PIs will be delivered data that have passed a "slim", or reduced version of QA2¹, but should be prepared to invest significant time in refining the reduction of the data without a guarantee of prompt help from the ARC staff.

By "slim", the ASAC means a version of QA2 that ensures that the global quality of the data is good enough to obtain the requested scientific results, but without the very complete tests planned in the final pipeline. As an example, the data quality might be checked on the continuum or on a single channel map only, but not necessarily on every individual line channel. A more precise definition of QA2 in this context will be needed, and the ASAC would welcome being involved in its definition.

- No projects are guaranteed to be observed. One way to reinforce this message would be for the APRC to award a grade of "B+" rather than "A" to the most highly ranked proposals.
- The JAO, rather than PIs, determine when a project is complete.
- Should the time dedicated to ES come under pressure, the JAO should sacrifice the number of projects rather than the (QA2-level) quality of datasets delivered to the PIs. It is critically important for the success of ES to favor the data quality rather than the number of completed projects.
- Target-of-opportunity (ToO) proposals will be accepted, but only if they can be observed in the default time window designated for ES observations. (See Section 1.3 below for a discussion of this window.)

¹ QA2 is the 2nd level of the data quality assurance, which will eventually be provided by the ALMA science pipeline. During the ES operations, it will be replaced by a manual data reduction performed by the DSO and ARC astronomers.

1.2 Capabilities of ES

The ASAC was presented with a matrix describing ALMA's evolving capabilities (Phases A/B/C/D), which was very useful for structuring discussion of the first proposal call(s). **The ASAC strongly urges that only one set of capabilities be offered in any given call.** Having a call that includes two sets of capabilities would make the whole process extremely complex for the Project as well as for the proposers, for little scientific gain. The ASAC therefore favors the idea of having the first two calls follow each other in close succession, possibly 9 months apart.

For the first ES Call for Proposals, the ASAC considers the basic capabilities (16 antennas, 4 bands, 750 m baselines) as scientifically appealing and realistically achievable on the proposed time scale. Among the more advanced capabilities that were discussed, the committee recommends that **mosaicing** and to a lesser extent polarization be prioritized over single-dish observations. Single-dish observing depends on software that will not be deployed until R8.1, is unlikely to yield high-fidelity images of complex sources before the advent of the ACA, and removes an antenna from the main array that could be important for preserving the sensitivity and uv coverage of ES datasets.

The ASAC also recommends that "mixed" correlator modes (allowing **simultaneous observations of line and continuum emission** from Galactic sources) be assigned a higher priority than given in the current plan. If it is not possible to include these in the initial ES Call for Proposals, mitigation measures might include the early rollout of (already tested) intermediate-resolution/bandwidth correlator modes, and the highlighting in the Call of strategies (e.g., interleaving) for combining line and continuum observations within a single scheduling block.

1.3 Mechanics of ES

The ASAC emphasizes that ensuring **adequate uv coverage should have extremely high priority in the strategy for scheduling ES programs.** Because of the limited number of antennas, the total integration time cannot be used as the only criterion for scheduling and deciding whether a program is completed or not. Good uv coverage is essential to allow for high fidelity imaging.

The ASAC endorses the scheme that was outlined in response to committee questions: **the default mode of operation assigns ES a fixed block of time each day** (e.g., 12-8 am) and reserves the rest for CSV. Adjustments should be possible in periods when smooth operations will be impossible (e.g., during major software releases, when CSV will take the bulk of the time) or easy (e.g., between releases, when ES can claim a larger share). This approach ensures CSV access to the array on a daily basis, facilitating progress towards inauguration, and makes it possible to sequence ES observations in multi-hour blocks that deliver sufficient uv coverage to each program.

1.4 Timing of ES

The ASAC views it as essential that a **unified schedule for the path to ES be established across the entire project** -including at the ARCs- **by the end of November 2010**, and that the basic parameters of the Call for Proposals be drafted well before its planned release, so that the CIPT, the DSO and the ARCs have adequate time for testing and preparing software and documentation. Ordinarily, it might seem unnecessary to endorse the importance of a unified schedule, but it emerged at our meeting that different parts of the project have been working with different planned dates for the first Call release (December 1, 2010 vs. February 1, 2011) since August. This bifurcation is an indication that vertical communication within the project needs to improve.

Lateral communication within the project also needs to be strengthened. The interface between CSV and DSO – i.e., CSV's exit strategy for commissioning and DSO's exact needs for supporting ES – is not at present clear. These comments do not pertain to communication at a personal level, which remains excellent, but reflect rather the degree to which different groups have focused exclusively on their respective core missions.

The ASAC views February 1, 2011 as a reasonable baseline date for the Call for Proposals release. We understand the Science Operations Readiness Review panel's preliminary conclusions as reflecting a feeling that the Project is not quite ready for a February 1st release. Considering our own optimistic view of how the project is progressing, **the ASAC feels that it should be possible to release the Call for Proposals in the February-March 2011 period and begin ES observations before the end of September 2011.**

Charge 2 -- Issuing the Call for Suggestions for Science Verifications targets has been postponed several times. It is now proposed to do this as soon as possible after the reviews and the ASAC meeting, in order to take advantage of the improved perspective that will have been gained. The ASAC should advise on the content of that call.

The ASAC highly recommends that a few 'Verification' projects be observed in the near future. These initial observations will become a showcase data set for the community to use while preparing for Early Science. Even more importantly, **this end-to-end test should be used by the Project as a validation of the software suite and of operations procedures, before the first ES Call for Proposals is issued.**

The ASAC is concerned that the term 'Science Verification' may imply a very specific type of observation to many in the community, as it has been widely used in other contexts (e.g. VLT, Herschel) to describe the final validation of an instrument before its opening to the community. In the specific ALMA situation, the array will continue to evolve and improve after these preliminary astronomical observations (the most obvious difference being the number of antennas). **The ASAC therefore suggests that the Project renames this phase:** suggested names are 'Astronomical Verification' or 'Science Demonstration'.

Most importantly, the observations undertaken should not be designed to provide new science results but rather should test the ability of the telescope to reproduce known results. Once the data have been made public, however, there may indeed be new science results, which the community will uncover and publish. The ASAC strongly urges that the ALMA Project, led by the Project Scientist and the CSV team (and likely even more broadly), should produce a paper on these first results (i.e. 'ALMA works') and that this paper should be submitted at the same time that the demonstration data sets are made public. Future work with these data would then refer to that initial paper, which would also provide recognition for the CSV team.

The ASAC agrees with the Project Scientist that the general astronomical community should be invited to suggest possible targets through an open call. This will help ensure that a large set of astronomical targets is acquired and may engage the ALMA community. The ASAC suggests that the ARCs play a central role in communicating this call most effectively to their respective communities. The ASAC advises that the workload associated with this Call remain as 'light' as possible, especially for the CSV team and therefore recommends a very simple call be issued.

Given the importance of this step in demonstrating the ability of ALMA to perform Early Science, the ASAC recommends that the process be initiated as soon as possible. The committee also suggests that one or several similar processes of astronomical verification of the array functionality be performed in the future, when significant milestones in the ALMA deployment have been reached.

Charge 3 -- The document Principles of ALMA Proposal Review Process has been approved by the Board. ASAC should review progress on the implementation of these principles and provide comments to the Board.

The ASAC did not receive a presentation on the implementation of the Proposal Review Process during the meeting - however a draft copy of the document was distributed. Obvious and important progress has been made in the development, deployment, and testing of the necessary software tools, as evidenced by the recent end-to-end tests performed by the DSO. The committee was also pleased to learn that a list of possible scientific assessors had already been compiled and that the process of contacting them was about to start.

The committee's immediate concern with the current draft plan is that the **workload on the individual ARP and APRC members is too high and may discourage participation**. It is not realistic to ask people to review more than 120 proposals and attend a 7-days meeting in Chile (i.e., requiring a 10-days trip for most of the participants). Solutions to mitigate this overload include:

- Fewer voting assessors per proposal (e.g. 6 assessors instead of 9), so as to assign fewer than 80 proposals per ARP member.
- Triage of proposals based on initial ratings (with possible resurrection during the face-to-face meeting), so that the number of proposals effectively discussed is reduced. The proportion of 'triaged' proposals should depend on the oversubscription rate.
- Fewer meeting days: ideally 2.5 days for the ARP members plus one or two additional days for the APRC members.

The ASAC recommends **flexibility in the implementation** of the Proposal Review Process (meeting length, triage, number of proposals per assessors, etc.) to adapt/optimize the process to the actual number of submitted proposals and oversubscription. This is felt to be especially important for the 1st Early Science call, as the number of proposals is difficult to predict. Feedback from the ES review process will be important for establishing the final procedures for ALMA full operations.

The Science Operations Readiness Review that took place before the ASAC meeting made it clear that there are a large number of **policies and implementations still to be decided** before ALMA is ready to start Early Science. The ASAC understands that a meeting will be held early November to begin the process of finalizing these issues and suggests that the ASAC also be engaged directly in this process. The ASAC did have several preliminary suggestions:

- Proposals submitted through the OT before a deadline should be allowed to be modified and resubmitted up to the deadline. This is common practice at many other facilities and is well appreciated by the community.
- There should be a balanced approach to allowing small changes to a proposal between phase 1 and phase 2. Those changes that are optimizing the scientific

output of the observations (e.g. better knowledge of the source coordinates or velocity) should be allowed in a semi-automatic way.

- More important changes may be allowed but should go through a particular acceptance process within the DSO.

Finally, while a large project like ALMA will undoubtedly find that any particular deadline date is problematic, the ASAC suggests that September 1st presents significant barriers for astronomers in some regions. We suggest the JAO should have the flexibility to change the deadline to whatever date best accommodates the needs of all regions.

Charge 4 -- Although the immediate question of readiness for Early Science will be dominant at this meeting, the ASAC should nonetheless also pay attention to the broader picture of the progress of the Project towards Full Operation and for its further development, and bring any concerns to the notice of the Board, particularly in the areas of scientific commissioning, software development and implementation and user support.

The ASAC concludes that the project is making good progress towards full operations, and concurs with JAO leadership that completing this process **should remain the observatory's top priority in the coming years**. The “best effort” nature of ES should also be used to reinforce this message and channel the pressure from the community.

From the presentations made during the CSV review, the Science Operations Readiness review, and the ASAC meeting itself, we have identified a number of potential threats to full operations. The project is well aware of all of them, and with the exception of the archive (see below) has been proactive in addressing them. Following the language of the charge, we group these concerns in different categories.

4.1 Scientific commissioning

Progress on assembly, integration, verification, and commissioning tasks over the last six months has been good; in particular, the ASAC applauds the restructuring of the CSV group into focused teams and views this organization as worth continuing. The most significant problem facing the project is the **reliability of the instruments and software**: the array is experiencing a significant number of system crashes, whose frequency needs urgently to be reduced to allow for smooth Early Science and later Full operations.

Single-point failure risks at this point appear to be associated with the lack of particular equipment, notably a spare holography receiver at the OSF, and a transmitter/polarization calibration unit at the AOS. The ASAC recommends procurement of these items by the project.

The most significant schedule risks are due - as has been clear for some time - to the deliveries of frontends from the FEIC's (in the near term) and AEM antennas (in the long term). With respect to the latter, while initial optical pointing results for the first AEM antenna have been positive, holography and testing of the metrology system had not begun as of our meeting, making it difficult to assess the projected acceptance date of March 2011. Additional unknowns are the number of weeks that will be required for AIV to process the first AEM antenna, and how severely the delivery schedule will be affected by the shortage of pads on the AEM contractor's site at the OSF. At a lower level of urgency, the ASAC notes the uncertain prospects for the nutator (whose absence can be mitigated by use of alternate, but less efficient single-dish observing modes) as an additional area of concern.

4.2 Software

The most immediate software threat to full operations, and indeed to the efficient use of AIV and CSV staff time, is the **limited functionality of the archive query tools**. Currently, AIV and CSV scientists have to manually log all commands to record when data are injected into the archive and later edit scripts (executed at the command line) to query the archive. General multi-parameter queries to the archive require specific SQL and XML knowledge, that only one CSV scientist currently possesses. By any standard, this is not a secure and acceptable operation mode, not to mention the significant loss of the AIV and CSV teams' time spent on such basic work. The same issue was already flagged in an ASAC report one year ago. While we welcome the recent change in management of the archive group, seeing a presentation at the Science Operations Readiness review promising multi-parameter query functionality (for external users) by October 2012 was not reassuring. The ASAC therefore makes the following recommendations to the Computing IPT:

- Multi-parameter queries to the archive, even if not optimally fast or efficient, should be made available to the AIV and CSV teams *as soon as possible* (January 2011 suggests itself as an opportunity).
- Fast, efficient multi-parameter queries to the archive should be made available to the community through the User Portal no later than the release of the second Call for Proposals - conservatively, by November 2011.

The ASAC encourages the Computing IPT to make the necessary resources available to the archive group so that these goals can be achieved.

Beyond the archive, the ASAC noted **several additional software-related challenges** for full operations:

- The ability for correlator and other control software to handle large numbers of antennas and correlator channels. Some problems with the current data rate have been reported.
- The performance (reliability and latency) of the real-time software. (See previous section 4.1)
- The performance (speed) of CASA, which continues to be an issue. It has and will have an impact not only on the efficiency of CSV and DSO efforts but also on the public image of ALMA across the community. The ASAC again urges the project to pay a special attention to this issue.

4.3 User support

The ASAC considers the current ARC deployment and plans as very satisfactory, although somewhat different models have been adopted in the three ARCs. As for software, experience gleaned through the initial Early Science observations will be extremely valuable in building knowledge of users' real needs and the corresponding

burden on DSO and ARC staff.

4.4 Development

The ASAC notes that regionally-based calls for development studies are proceeding apace in Europe and North America. The ASAC endorses the project's support for a nascent cross-partner effort to develop a software correlator that could be used for VLBI.

These studies will lead to very strong proposals for future developments/construction. The ASAC suggests that the Project define as soon as possible a detailed mechanism for soliciting (full) development proposals from the community when the development line in the operation budget becomes significant. The ASAC stresses again the necessity to have one single comprehensive plan for ALMA and the three Executives.

4.5 Other

An additional issue of concern for full operations is the retention of skilled AIV/CSV staff members in operations positions, in order to avoid losing the very valuable expertise acquired during the AIV and CSV phases. Securing and protecting enough time to allow JAO astronomers to do science is also a key element to preserve the attractiveness of these positions in the long term.

The supply of reliable power at the AOS with the current, temporary system, along with the transition to the permanent power system, remains of course another long-term concern. The ASAC also notes that it has not been briefed on project-wide outreach to the general public, an important activity for ensuring the long-term support of the observatory, and asks for a presentation on this area at its next meeting.

Other ASAC activities which are not formal charges from the Board.

5. Community sounding on expectations for early science, and ALMA information resources for the general community.

6. ASAC will continue to look for ways in which ALMA construction and operations might be more environmentally friendly, especially in terms of energy use (without compromising science).

ASAC stresses that ALMA's capability to carry out scientific observations is not decoupled from the long-term availability of reliable and affordable power. While the currently planned 'island-mode' diesel-powered electricity generation is a sensible solution in the current context, ASAC identifies two potential risks. (1) An increase in the market price of fossil fuels negatively and strongly impacts the ALMA operations budget, and market fluctuations add an associated uncertainty in the operations budget. (2) Negative publicity regarding the carbon footprint of the project can adversely affect the public's support for the ALMA budget, and ultimately the long-term support from funding agencies. ASAC applauds the project's recognition of both the economic and public-relations issues associated with power generation. The choice of multifuel generators, which can run on cleaner and cheaper LPG or LNG compared to the currently used diesel fuel, reflects the awareness of both issues. So, too, do the requirements for low energy use in the call for design proposals for the OSF residencia, where the value of the intention exceeds the modest energy savings.

ASAC recommends that the Project actively pursue ways to increase the efficiency of power generation at the site. The step that can be taken most straightforwardly in this respect, albeit at non-negligible cost, is to supplement the initial generator with a heat exchanger (comprising a combined cycle power plant) for an immediate 30% increase in efficiency. ASAC also recommends that the ALMA Project keep an open eye to including alternative energy sources such as wind or solar energy at the site as an addition to the currently planned power generation system.

ASAC recognizes that one of the fundamental obstacles for such changes is the initial capital investment. However, there may be multiple options for meeting this expense, including (but not limited to) partnerships with providers, philanthropic organizations, or funds for infrastructure development within the ALMA project. Some of these solutions may be "unorthodox" in the strict organization of ALMA as a partnership between three executives, but ASAC feels that such considerations do not outweigh the significant positive impact of increasing the energy efficiency and sustainability of ALMA.

ASAC suggests that a Board/JAO working group be established to investigate potential energy alternatives, and to define the terms under which a contribution to capital investment from outside the project could be used to enhance the efficiency of ALMA's power generation. In addition, recognizing the impact its own travel has on the project's carbon footprint, ASAC will explore the possibility of using a "video conferencing from the ARCs" format for one of its upcoming "face to face" meetings – in part as a dry run for a more stripped-down version of an ALMA proposal review meeting.