ALMA BOARD

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ASAC Report to the ALMA Board

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General considerations

There have been some changes to the ASAC membership: Prof. Kotaro Kohno has joined and Dr. Huib van Langevelde has been reappointed, while Dr. Raphael Moreno and Dr. K. Motohara left.

The ASAC Face-to-Face meeting was held at the Joint ALMA Observatory, Santiago, Chile, on February 25th and 26th, 2016, with all the ASAC members present. In addition, the JAO Director, and Observatory Scientist were present, as well as the three regional Project Scientists.

ASAC was extremely happy to receive almost all the presentation files and relevant documents well in advance of the meeting, which made discussions more efficient. We applaud JAO, in particular the Observatory Scientist, for their efforts to making this happen.

ASAC is also pleased to see that ALMA is in general operating smoothly, as described in the Director's report. Despite an explicit plan not to include a discussion of Charge 1 on the agenda, ASAC felt that issues such as execution efficiency have been sufficiently important in the past that observatory performance should always be discussed at some level. For example, based on the material presented it has not been possible to judge whether the observatory is on-track to complete the Cycle 3 program. ASAC appreciated the response to its former report, even if not all of the recommendations were followed - in particular, ASAC strongly encourages the JAO to raise the fraction of A-ranked proposals to 50% in Cycle 5, as was recommended for Cycle 4 in the report.

In addition to the discussion on specific charges, there was also information presented at the meeting regarding two other issues, namely the new ASAC Terms of Reference and the Project Tracker. For the revisions to the Terms of Reference, ASAC only saw a preliminary draft of a small part of the document - and ASAC expects to have the opportunity to comment on the entire document draft before it is finalized. In particular, the lack of an approved ToR significantly impacts the efficiency of ASAC as neither the organization (e.g. chair) nor the relation of ASAC (e.g. reporting, relation to science committee of the board) are settled. Furthermore, ASAC would like to understand its relation to the Science Committee, which is now more formally established. Regarding the new Project Tracker for Principal Investigators (SnooPI), which ASAC has been requesting improvements on for some time, the additional

demonstration was much appreciated by ASAC, as well as the invitation to comment on the functionality of the version of SnooPI currently being tested.

Charge 2: Assessment of the science outcomes from ALMA. Statistics on publications, citations, press releases, web cites, etc. collected by the Executives shall be collated by the JAO, and analyzed by the ASAC.

Recommendations:

- Closely monitor how much the ALMA Archive is used for non-PI science and publications. Strongly encourage the use of standardized acknowledgement texts to facilitate monitoring.

- Survey PIs for reasons behind slow (or lack of) publications. (We understand that such a survey is already ongoing).

- Surveying the greater community on the main hurdles to scientific breakthroughs in (for example) galaxy formation and other areas where ALMA has not yet been transformational enough. Potential hurdles are lack of key proposal modes, observing modes, and analysis tools.

ASAC notes that over the past couple of years ALMA has transformed several fields in astrophysics, including the formation/evolution of protostellar disks and envelopes of evolved stars. There is, however, a feeling that ALMA has yet to be transformational enough for some other fields like HL Tau has been for disk studies; such a field is, for example, galaxy formation even though there have already been important results at high redshift. This might be connected to the lack of large programs, spectral scans, and/or efficient tools to handle large spectral data-cubes in previous cycles. This question needs to be revisited after the completion of Cycle 4 and Cycle 5 (under the assumption that the spectral scan mode becomes available in Cycle 5).

The publication rate and volume follows that of other major ground-based facilities. ASAC looks forward to evaluating the results of an ongoing survey of PIs on possible barriers to publication of ALMA data. The number of publications coming out of the ALMA Archive (i.e., not PI-driven or based on SV data) continues to be very low, and there are growing concerns that the often non-intuitive Archive interface, lack of key meta-data, and the lack of calibrated *uv* data in the Archive are together limiting the potential science return of ALMA.

Charge 3: **Recommendation of ways to maximize ALMA's scientific impact. This includes review of the scientific effectiveness of the Proposal Review Process after each Proposal cycle.**

ASAC discussed ad hoc Charges 6 and 7 as a part of Charge 3 (as reported later in this document).

In addition, as a potential way to maximize ALMA's scientific impact, we discussed the possibility of a new proposal mode, which could be coordinated with other facilities, with JWST as an obvious example. This would be for coordinated observations in general, and not the more specific issue of simultaneous observations at multiple facilities. ASAC encourages JAO to pursue this possibility, and feels that it should be further discussed at a future ASAC meeting.

Charge 4: Reporting on operational or scientific issues raised by the regional SACs and the wider community.

Recommendations:

- The Implementation document for mm VLBI should be made public well before the Cycle 4 deadline.
- It is important to ensure that VLBI expertise is represented on the panel(s) that review the VLBI proposals, and that the panels get sufficient technical information. It is also important to ensure that the evaluation of the proposals to the VLBI networks is transparent and fair.
- ASAC agrees that the AVCC can be responsible for the final scheduling of VLBI proposals, while acknowledging the potential conflict of interest issue.
- ASAC has repeatedly highlighted the need for a duplication checking tool. It must be ready for Cycle 5 (if the board policy should be obeyed).
- JAO should be ready to handle a potentially large number of Large Programs in Cycle 4.

ASAC members surveyed operational and scientific issues raised by the regional SACs in advance of the Face-to-Face meeting, and summarized items to be discussed at the meeting, e.g., mmVLBI, duplication checking tool, and review process of large programs. We also briefly touched on issues of combining ALMA data from multiple arrays, as well as the need for guidance for novice users.

mm VLBI

ASAC was informed about recent progress in preparing for the participation of ALMA in VLBI observations. There was considerable interest in 3-mm observations through the GMVA call earlier in February. Preparations have been ongoing for the 1-mm call, with the pre-announcement coming out during the course of the ASAC meeting. ASAC was extremely pleased to have access to the 18Feb2016 version of the "Implementation Plan", along with other documents, since it helped us to focus on the important issues. ASAC feels strongly that a final version of this document should be publicly available well before the deadline, because it will help proposing teams to understand the operational, technical and organizational constraints (and its availability would surely have helped 3-mm GMVA proposers).

ASAC expressed concern about whether the proposal review panels will have sufficient expertise to evaluate the VLBI proposals. Providing technical assessments to the panels will be very helpful, and the panel chairs should be given explicit instructions for how to deal with issues that are VLBI-specific. Because the proposals will be reviewed by the VLBI networks first, ASAC advices that the panels should perform an ALMA-based review that is blind to the outcome from the network reviews, but this information should definitely be available before the final rankings are made – in particular the APRC should use this information in order to avoid ranking proposals that were not scheduled by the VLBI networks.

With respect to the 1-mm network that is still being defined, ASAC was happy to hear that NRAO will handle the proposals. However, there are still some concerns regarding the review

process. Since the agreed principle is that ALMA VLBI should be open to any user, a consequence is that the 1-mm VLBI network review must be done by an independent expert panel. ASAC agreed that the responsibilities for discussing which projects should be scheduled can be with the AVCC, while acknowledging that there is a potential for conflict of interest on the AVCC. In addition ASAC suggests that the operational responsibility on taking go/no-go decisions for dynamic scheduling should not lie with a single person.

Other issues

ASAC notes that it has been asking for years for a duplication checking tool to be available for proposers. This should therefore be considered as a policy item of the highest priority for implementation for Cycle 5. One definite piece of progress is that there is now an agreed document discussing the definition of what is meant by duplication. ASAC understands that the first version of such a tool does not need to be perfect, and that full functionality could follow in later cycles. To give specific examples: if RMS is not available in the archive, then one should be able to at least provide a rough estimate using integration time and number of antennas; and it would be good to combine scheduling blocks in the query output, even if one still has to carry out the search manually.

ASAC asked for reassurance that the review process will be able to deal with large programs (LPs), especially given the possibility that there might be many of them. Specific issues that should be considered ahead of the process include the different balance in LPs between science areas, the instructions that will be given to the ARPC, and how to deal with the conflicts that will inevitably arise for some ARPC members. JAO should be prepared to react quickly to assess whether any changes need to be made, as soon as the number and distribution of LPs is known.

ASAC encourages more effort to be made in order to make it easier to combine data from different arrays, including TP data. We remind the JAO that delivering combined data is a goal.

ASAC suggests that there is a need for a guide (or video walkthrough perhaps) for novice users on how to start with the data processing workflow.

Charge 5: Provision of advice on the scientific priorities of the ALMA Development Program, and particularly on new projects that are proposed.

Recommendations:

- ASAC strongly recommends to involve external experts into the Development Working Group from the very beginning, to develop a vision that challenges the advancement and development of new technologies, but can be sufficiently adjusted to enable a seamless and efficient transition to the next generation ALMA.
- ASAC was particularly impressed by progress made in the framework of the Solar Observing study.
- ASAC is also pleased to see that the ALMA Band 5 receiver project is making excellent progress.

ASAC received the presentation by JAO Director Pierre Cox on the role of the newly formed ALMA Development Working Group (the WG hereafter). The WG was established to develop a science-driven vision for medium (~5 years) to longer term (5–15 years) ALMA Development Programs, consistent with the overarching scientific and technical themes of the ALMA2030 document.

ASAC was pleased to see that the ALMA2030 document is regarded as a basis for the work of the WG, as it gives a coherent vision across the Executives on the future direction and priorities of the ALMA science and technology program, based on the needs and interests of the ALMA community. While the committee endorses the position of the JAO Director on the necessity to keep the WG as small as possible, it strongly recommends the involvement of external experts from the very beginning of the process, to develop a vision that challenges the advancement and development of new technologies, while adjusting itself sufficiently to enable a seamless and efficient transition to the next generation ALMA. The JAO Director should include such expertise into the WG in the way deemed most appropriate. It is anticipated that a first draft of the WG document will be completed by November 2016, and that the final version will be presented to the ALMA board by April 2017. ASAC welcomes the opportunity to comment on the document prior to its submission to the Board.

ASAC was provided with progress reports on the status of the Development Programs from each Executive. In particular:

1. ASAC was particularly impressed by progress made in the framework of the Solar Observing study. The committee was excited to see the ALMA Band 9 (TP) images obtained in Dec 2015 of the solar chromosphere and congratulates all groups involved in the Solar Observing Campaign for this great achievement. The committee is pleased to see Solar Observing in the interferometric and SD modes now being offered for Cycle 4.

2. ASAC is also pleased to see that the ALMA Band 5 receiver project is making excellent progress and is on track to be offered in Cycle 5. The committee fully endorses the general plan for the science verification of ALMA Band 5.

ASAC also endorses the idea to focus the Development Calls on the priority development paths outlined in the ALMA2030 plan, and supports the overall bottom-up procedure for the new EU/NA Calls for Development Programs and for the EA Workshop for Development Studies 2016. The committee encourages the Executives to evaluate the possibility of taking a federated approach for some programs to maximize the prospects for developing breakthrough scientific capabilities and technologies with the next generation development programs.

Charge 6: The ALMA Project is developing a 5-year plan for operations and development that will be used to develop a long-term budget. The JAO and the IST shall produce a list of potential enhancements covering hardware, software, and new observing capabilities. The ASAC should advise the Board on the highest priorities over this time period that will maximize the scientific impact of ALMA.

Recommendations:

- ASAC recommends the following items as high priority for the ALMA 5 year plan:
    - increase overall observing efficiency (including long-term and dynamic scheduling, pipeline usage for most modes), specifically:
        - on-source efficiency (optimizing calibration scheme, e.g. for spectral scans)
        - general time efficiency gains
    - finish polarization commissioning
    - rapid data reduction: project completion, system health tracking
    - combined array mode: significant gains in sensitivity, effective integration and image fidelity
    - 3- and 4-bit quantization: significant (~10%) gain in sensitivity
- ASAC reiterates that spectral scans, 90-deg phase switching, and an artificial beacon remain high priority items.

ASAC repeats that the implementation of the duplication tool is key to ensure that the proposers (and the observatory itself) can easily follow the ALMA Board policy on duplications. We do not include it in the list here because it is not an "upgrade" priority.

ASAC discussed the documents "Potential ALMA Enhancements over the next 5 years" (version 4) to construct a prioritized list. ASAC classified suggested upgrades into "high", "medium", and "low" priority. In general, ASAC continues to recommend high priority for items that generally improve the efficiency (including timely delivery of high quality data and more access to observing time). In particular, ASAC reiterates the importance of completing commissioning and offering efficient spectral scanning, which will benefit both the astrochemistry and high-z communities. We also anticipate that 90-deg phase switching will be implemented in the correlator to enable efficient sideband separation in bands 9 and 10, as well as the artificial beacon for improved polarization calibration.

Below we recommend a number of high and medium priority improvements that yield either increased productivity for the array or have scientific promise. We favor improvements with the largest impact, either because they will benefit a large community of users, or because we have identified particular science cases that offer the potential for breakthroughs.

High priority:

- ***Observing efficiency***: ASAC feels that improving the ***scheduling*** (long-term for season planning and proposal ranking and acceptance, and dynamic for day-to-day operations) and usability of calibration/imaging pipelines for most modes should result in higher efficiencies (in terms of delivering data that passes QA2 and complies

with the applicant's requirements in terms of resolution and depth) - see charge 7 as well. ASAC recommends the following specific items:

- Improve on-source efficiency: decrease calibration overheads (especially for ***spectral line scans***). For certain applications the adopted calibration scheme seems excessive (e.g., too much passband calibration for some extragalactic observations), and a ***flexibility/optimization of the calibration scheme*** (based on information provided by the PI) may achieve significant efficiency gains (e.g., line detection experiments in sources without continuum usually only require a first order polynominal correction that is generally achievable with a short passband observation). While this extra-safe calibration policy might have enhanced (or guaranteed) the archival quality of the observations in early cycles, we believe with the experience gained in Early Science it is now time to revisit the calibration scheme to ensure that very valuable telescope time is not spent on calibration beyond the requirements of the original science program.
- General time efficiency gains, which should be defined by taking into account their payoff in terms of net time gain. This also includes pushing efficient ***day-time observing*** for as wide a range of frequencies as feasible.

- ***Polarization:*** Implementation of wide-field polarization and circular polarization will complete the original science requirements of ALMA and enable magnetic field studies. This is a long awaited capability.

- ***Rapid data reduction***: Currently ALMA waits for all data in a science goal to be acquired before reduction takes place. Reducing data on an observing block basis will allow for the immediate detection of observations not meeting the PI's specifications and thus re-observations while the array is still in the correct configuration, increasing the efficiency of observations. An additional benefit would be a more thorough check on the system stability and timely identification of issues that can impact data quality.

- ***Combined array mode***: Fully correlating the 12-m array with the 7-m antennas and the TP antennas will increase significantly the sensitivity of the array (15%-20%), leading to at least 30% reduction in effective integration time. This mode will also provide improved image fidelity, and would help in calibrating the 7-m antennas. Implementing this should be a very high priority.

- ***3- and 4-bit quantization***: This represents a 10% gain in sensitivity, leading to ~20% gains in effective integration time. Pretty much every observation taken by ALMA would benefit from both this improvement and the combined array mode in the previous bullet.

<u>*Medium priority*</u>:

- ***Limitations to the spectral resolution/data rates***: Data rate limitations (as we understand, mostly related to the archive) regularly force PIs to reduce the spectral resolution of the observations. This is unfortunate, because it degrades the richness of

the archive. We recommend the observatory works to remove these limitations, which we understand are not fundamental.

- ***Archive improvements:*** There are important limitations of the current archive model. These limitations will have an increasingly negative impact on the long-term productivity of the observatory. Working at increasing the richness and the ability to mine the archive is clearly important. Within this general theme, ASAC specifically identifies as an obstacle that needs to be addressed the ***current sparseness in meta-data*** (which is one of the obstacles in implementing a duplication check). We also ***continue to be concerned about the long-term viability*** of the current archive model, where the user must rely on calibration scripts that are CASA-version specific to produce the calibrated *uv* data: direct access to calibrated data within the archive seems more sensible. Although we recognize that this may constitute a significant increase in the volume of data to be stored, we think it a wise investment for a robust archive that needs to last for many decades. If data volume is the barrier, data compression options should be investigated.

- ***Science sub-arrays:*** This capability would potentially allow for simultaneous multi-band or multi-source observations. A unique scientific application would be the study of variability across bands for rapidly variable sources (e.g., SgrA*, variable stars). For science that requires very short integrations with the full array, it may also provide a way to reduce overheads.

- ***Total power continuum:*** The ability to accurately measure dust continuum over large spatial scales is an important scientific capability for Galactic and a few nearby galaxy observations, which provides complementary spectral energy distribution measurement capability with far-infrared data. The option of using a single dish with a continuum camera to acquire it is not appropriate in many cases: contamination by line emission renders those measurements useless in sources such as hot cores and galaxy centers. Attaining the stability necessary to perform accurate continuum measurements in a heterodyne system is not trivial, but it has been designed into ALMA (e.g., TP nutators).

- ***On-the-fly (OTF) interferometry:*** ALMA is currently limited in its speed and fidelity performance for imaging large mosaic areas. We think OTF interferometer should offer a better way to achieve large, uniform mosaics. This application is particularly important for Galactic science, and some of the nearest galaxies (e.g., the Magellanic Clouds).

- ***T_{sys} in FDM mode:*** In bands with complex atmosphere the ALMA calibration is limited by the current measurement of system temperature in wide channels. Commissioning this capability will make it possible for ALMA to achieve its original calibration goals.

ASAC recommends assigning low priority to the following list of items, based on their smaller science impact.

Low priority:

- Phased ACA
- Total power antennas: bands 9 and 10, frequency-switching
- Band cycling
- Additional proposal categories, as listed in the document mentioned at the beginning
- ACA dynamic sub-arrays for calibration
- Multi-resolution correlator modes
- Fast accumulation

Charge 7: The JAO should provide the ASAC an overview on how observations of grade A/B/C proposals are prioritized for execution on the telescope, and summarize the completion rate of science goals and projects in Cycle 1/2. The ASAC should advise if the current scheduling procedure is optimal for the overall science output from ALMA, or if the procedure should be modified for Cycle 4.

Recommendations:

- ASAC supports the development and implementation of a procedure to assign the final grade for projects not only by the scientific ranking but also by considering the scheduling feasibility.
- The likelihood that all science goals of each project will be accomplished should be taken into account in the assignment of final grades.
- Project completion should be included in the selection criteria for execution on the telescope in future cycles.

ASAC received the presentation on "Charge 7: Scheduling and completing projects", by the ALMA Observatory Scientist. The presentation summarized the results of Cycle 2 and addressed the following issues: (1) the current procedure for assignment of Grades A/B/C and its limitations; (2) the procedure for selecting scheduling blocks (SBs) to be executed on the array; and (3) the criteria for QA2-pass and the stale data policy. ASAC considers that the plan presented for the development of tools for a flexible observing schedule seems adequate to optimize the scientific return of ALMA.

ASAC discussed in detail the procedures for assigning the final grades after ARPC evaluation and for selecting SBs to be executed for Cycle 4. Grades should be assigned so that they lead to maximum science returns and provide a clear perspective on execution probability to proposers. The role of science assessors in the APR is to evaluate the scientific value of each project on the assumption that all its science goals are achieved. To deal with projects in a consistent manner, the likelihood of completion of each project should be taken into account in any subsequent stage, e.g., in assignment of final grades or in selecting an SB during execution.

Based on the above consideration, ASAC makes the following specific additional recommendations:

1. Assignment of final grades

- ASAC supports the development and implementation of a procedure to assign the final grade for projects not only by the scientific ranking but also by considering the scheduling feasibility, estimated from the array configuration schedule and the statistics on weather conditions. The likelihood that all science goals of each project will be accomplished should be taken into account in the assignment of final grades A/B/C. Grade A should be awarded only when the project is feasible to be *fully* observed in the next two cycles.

- To give the observatory more flexibility in the execution of projects, ASAC supports the idea that the OT for Cycle 5 should provide the option to include a range of angular resolutions for which the science objectives could be achieved.

2. Selection of scheduling blocks to be executed

- ASAC was informed about the overall procedure, as well as the criteria applied and different factors considered for the selection of the SBs to be executed on the telescope. Project completion should be included in the selection criteria for execution on the telescope in future cycles. ASAC liked the general idea of the scheduling priority being "tapered" as the project becomes completed and will be happy to discuss specific weighting factors when there are statistics for how completion works in practice. The scheduling of the SBs should evolve from manual in Cycle 4 to dynamical and automatic in Cycle 5 and beyond.

In addition to the above recommendations, ASAC endorses the policy on releasing "stale data" for Cycle 3. This should be a tentative measure before the introduction of a new procedure for grades assignment in which scheduling feasibility is taken into account.

Charge 8: One of the roles of the ALMA Observatory Scientist is to improve the scientific environment at the JAO. The JAO will present long-term plans to the ASAC regarding steps to improve the scientific environment at the observatory, for both the JAO staff and JAO visitors. The ASAC should provide guidance on the proposed plans, particularly from the perspective of the community that may be interested in visiting the JAO.

Recommendations:

- Quantify how much of a real problem is the current scientific productivity. It is unclear if this is mainly a matter of a perception of JAO not being a fertile environment, since some staff are very productive while others are not. ASAC would like to see more quantitative metrics about whether staff members are able to realize their contractually obligated science fractions, as well as publication rates for JAO staff compared to staff at the ARCs.

- Promote JAO leadership in research through evaluations. In order to make a more specific recommendation, the ASAC would require more information on the evaluation of JAO staff. It seems, however, that science is not in general being used as an evaluation criterion. In the case of ESO staff, a minimum level of scientific productivity is required for promotion. There does not seem to be an incentive for science productivity through rewards in the evaluation process.

- Tackle the geography problem with several medium-length (~1 month) visits to the ARCs.

- Advertise more widely the possibility of visits to the JAO by researchers.

- Implement JAO PhD fellowships for joint supervisions with universities in Chile, and encourage students to come to the JAO, through the use of summer schools or summer research programs.

ASAC welcomes the efforts by JAO to improve their scientific productivity, and sympathizes with their concern for a better scientific life. The proposed plan seems a good approach, in particular for preserving the science time of JAO staff.

Implementing a policy to allow staff to publish technical data will additionally provide more visibility to the community and help establish expertise. ASAC would like to hear an update on the efforts to make the increased science chatter sustainable.