



# ALMA BOARD

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2022 March 25

## **ALMA Science Advisory Committee (ASAC) Report to the ALMA Board**

Manuel Aravena, Anne Dutrey, Maryvonne Gerin, Meredith Hughes, Stefanie Milam, Alexandra Pope (NA vice-chair), Erik Rosolowsky, Hideo Sagawa, Nami Sakai (EA vice-chair), Kengo Tachihara, Mario Tafalla (chair), and Serena Viti.

### **General considerations**

The ASAC March 2022 face-to-face meeting was organized by JAO and held virtually because of the travel limitations imposed by the covid pandemic. Due to the time difference between the participants, the meeting was split into three sessions of two hours each on March 8-10. The reduced time for both presentations and internal discussion of this and previous virtual meetings has had a significant impact on the range of topics the ASAC has been able to address. We look forward to resuming a presential format when conditions permit.

We welcomed Stefanie Milam, Hideo Sagawa, and Serena Viti as new members of the committee. They replace Stephen White, Kotaro Kohno, and Paul van der Werf, whose generous contributions to the ASAC are gratefully acknowledged.

The meeting included presentations by ALMA director Sean Dougherty, ALMA deputy director Stuartt Corder, Department of Science Operations head Liz Humphreys, Observatory Scientist John Carpenter, Array Performance Group manager Antonio Hales, NA ALMA Program Scientist Crystal Brogan, EU ALMA Program Scientist Ciska Kemper (delivered by Carlos De Breuck from ESO), EA ALMA Program Scientist Daisuke Iono, EASC ALMA Technical Team member Gie Han Tan, and NA ARC manager Anthony Remijan. The meeting was attended (among others) by James Di Francesco as a liaison to the ALMA Board Science Committee and by ESO Director for Science Rob Ivison. The ASAC thanks all the participants for their time and contributions. The material from the presentations, which was kindly provided by JAO in advance of the meeting, has been used to prepare this report. We provide answers to the six ASAC permanent charges and to an ad-hoc charge related to delays in the data delivery by the Large Programs.

**Permanent Charge #1. Assessment of the performance of ALMA scientific capabilities: The ASAC shall indicate what information is required from the Joint ALMA Observatory (JAO) to perform this assessment.**

*Recommendations/issues:*

- ASAC endorses the work on the new capabilities for Cycle 10.
- ASAC supports the investigation of new capabilities for future cycles and stresses the scientific interest of 7m array polarization mosaics and circular polarization observations.
- ASAC appreciates the efforts made to implement an on-line correction of the renormalization issue, and requests to be kept informed of future progress on this issue.

*ObsMode2022.* ASAC appreciates the presentations given by Antonio Hales, the head of the Array Performance Group (APG), which provides the priorities for 2022. These priorities comprise the new Band 1 receivers, the new ACA TP Spectrometer, the possibility of sub-array observations with both 12m and 7m antennas using the Baseline Correlator (BLC), and having an on-line correction of the renormalization issue. The Band 1 receivers are still in commissioning mode, but the APG goal is to offer them in Cycle 10 if enough antennas are equipped with them. The new GPU-based ACA TP Spectrometer was installed in February 2022 and already achieved first light. This important capability shall be ready for Cycle 10 as well. Investigations have started on accelerating the development of subarraying with the BLC to be ready to deal with contingencies related to other technical issues, and this capability is expected to be in the ObsMode for Cycle 11. Additional capabilities for Cycle 10 include high frequency band to band (B2B) observations with the 7m array, complete B2B observations with the 12m array, 4 bit quantization, high data rates, TP spectral scans in Band 8, solar polarization in Band 3, and VLBI. ASAC supports all these new capabilities for Cycle 10.

*Future capabilities.* ASAC was also briefed on the capabilities that are being investigated for later cycles. These include astrometry, 7m array polarization mosaics, improving circular polarization observations, and using the artificial source. ASAC appreciates the work by the APG and recognizes the need to trade off between adding new modes and improving the efficiency and the quality of the existing array observations, which includes commissioning the new systems developed in the ALMA2030 plan. It is unfortunate that the present human resources limit the polarization developments, which are expected to open new lines of research.

*Renormalization issue.* A working group has been set up to deal with the flux renormalization issue since November 2021. So far, the issue is fixed at the data reduction step for spectral lines but there is no fix for continuum. The proposal is to set an online fix for continuum and continue to correct the spectral lines off line until a more advanced scheme is available for both modes. ASAC appreciates the complexity of the issue and recognizes the effort by the working group. ASAC supports the proposed path to test the procedure for continuum in Q2 2022 with

the perspective of availability for Cycle 10, and at the same time to continue to work on a more complete solution. Given the importance of this issue, ASAC requests to be informed regularly on the progress dealing with it.

**Permanent Charge #2. Assessment of the technical aspects of the ALMA system performance: The ASAC shall indicate what information is required from the JAO to perform this assessment.**

*Recommendations/issues:*

- ASAC praises the ALMA staff for their continued commitment to the functioning of the Observatory despite the difficult conditions imposed by the covid pandemic.
- ASAC celebrates the good start of Cycle 8 (considering the poor December weather).
- ASAC is concerned about the many grade A projects carried over from Cycle 7 and requests further information on their status.
- ASAC remains concerned about the low rate of completion of high-frequency projects and requests a more in-depth discussion of the scheduling policy.
- ASAC understands the reasons for not having a supplemental call in Cycle 9, and requests that users are explicitly encouraged to submit ACA-only proposals. ASAC also recommends analyzing the impact of skipping the supplemental call.
- ASAC is concerned that no spectral-line VLBI observations will be carried out in Cycle 9 due to a lack of ALMA-related GMVA submissions. ASAC requests JAO to continue making additional efforts to inform the community of the need for a GMVA submission in advance, and to follow this issue in future cycles.

ASAC praises the ALMA staff for their continued commitment to the functioning of the Observatory despite the difficult conditions imposed by the covid pandemic.

*Cycle 8 start.* ASAC also appreciates the good start of Cycle 8 observations with a large number of antennas used by science operations, and the continuation of operations after the February shutdown. A shortfall of about 300 hours on the 12m array and about 170 hours on the 7m array has been accumulated due to some technical issues and especially bad weather (52% downtime in December). The QA0 Pass Time numbers are starting to approach those of previous (pre-covid) cycles, which is an impressive achievement given the remaining limitations imposed by the pandemic.

*Data processing.* ASAC is also glad to hear that the data processing has recovered from dealing with the normalization issue thanks to pipeline development and a new workflow strategy. For pipeline-processed data, the target of delivering 90% of the data within 30 days has been achieved, and the milestone of having 90% of the data load performed at the JAO has been reached. These are all very good news.

*Cycle 7 projects.* Given the significant fraction of uncompleted Cycle 7 projects, ASAC wants to confirm that the remaining Grade A projects are being carried over, and requests additional information on these projects in the next face to face meeting.

*High frequency observations.* As reported by JAO, the observing rate at high frequencies is notably low, and this seems to be partly related to the policy of project execution under special weather conditions. ASAC considers that observations at high frequency are unique to the ALMA site, and therefore they should be considered important and have priority if weather conditions permit. ASAC understands that a long-term weather study has been started, and that a climatologist has been hired. In order to assess the status of the high frequency observations and maximize their success rate, ASAC requests further discussions about the prioritization policy under given atmospheric conditions and proposal rankings.

*Supplemental calls.* ASAC understands the large workload to JAO imposed by having a supplemental call, and thus endorses not having one during Cycle 9. Since eliminating this call represents a significant change in policy with respect to previous cycles, ASAC requests that JAO explicitly encourages the submission of ACA standalone proposals during the main call for Cycle 9. ASAC also recommends analyzing the impact of skipping the supplemental call, and would like to re-discuss the issue in the next meeting to assess whether the call should be brought back in Cycle 10.

*VLBI.* ASAC is concerned that no VLBI spectral line projects have been proposed for Cycle 9. This may have occurred because people did not realize that an observing proposal had to be submitted to the Global mm-VLBI Array (GMVA) by its February deadline, despite several communications to that effect by ALMA and GMVA. ASAC requests JAO to continue making an effort to inform the community of the need for GMVA submission in February, and to keep track of this issue in future cycles.

**Permanent Charge #3. Assessment of the science outcomes from ALMA: Statistics on publications, citations, press releases, web sites, etc. collected by the Executives shall be collated by the JAO, and analyzed by the ASAC.**

*Recommendations/issues:*

- ASAC is happy to see that 2021 has set a new record in the number of ALMA publications, and that the slight decreasing trend seen in 2020 (likely due to the pandemic) has been reversed.
- Overall, ALMA publications continue to grow at a rate comparable to that of facilities like HST VLT, and XMM at a similar point in their lifetime, confirming the quality of ALMA's scientific output and the productivity of its users.
- ASAC recommends to continue closely monitoring the publication statistics to quantify the effect of the year-long shutdown.

*2021 publications.* ASAC recognizes the significant effort made by the staff to collect a variety of statistical indicators of publications using ALMA data. These indicators provide a very complete view of the scientific impact of ALMA as a function of science category, region, and receiver band, and make it possible to monitor the evolution of this impact over the years. The data from 2020 showed for the first time a year-to-year drop in the number of publications, a result that was attributed to the covid lockdowns and was the cause of some concern. Happily, the new 2021 data shows that this trend has not only been reversed, but that 2021 has set a new record of ALMA publications. ASAC celebrates this result.

*Comparison with other facilities.* Another notable result from the publication statistics is that ALMA is keeping a level of yearly publications that is comparable to that of other major facilities such as HST, VLT, and XMM at a similar point in their lifetime. This is a clear indication of the large scientific impact of the instrument and the high level of interest from the observing community.

*Effects of 2020 shutdown.* While the publication statistics for 2020 and 2021 show only a limited loss of productivity of ALMA due to the covid pandemic, it is likely that data from future years will qualify this impression. The median delay between release and publication of ALMA data is slightly larger than 30 months, so the effects of the year-long shutdown of ALMA are likely to impact the level of publication over the next three years. ASAC recommends to closely monitor the publication statistics over this period to assess the full impact of the instrument shutdown. The results of this monitoring may be of interest when planning future shutdowns, as the one that may be needed during the bandwidth and correlator upgrade.

**Permanent Charge #4. Recommendations of ways to maximize ALMA's scientific impact: This includes review of the scientific effectiveness of the Proposal Review Process after each Proposal cycle.**

*Recommendations/issues:*

- ASAC applauds the detailed analysis of systematics carried out with data from the Cycle 8 proposal review process, and the publication of two dedicated papers. This effort puts ALMA at the forefront of using and understanding the systematics of DPR.
- ASAC is concerned about a persistent bias against proposals written by EA authors, and requests JAO to continue investigating its presence and its roots. ASAC also requests that future analysis of proposal systematics include EA authors.
- ASAC notes that the primary concerns from proposers in the Cycle 8 PI survey were the quality of some reviewer comments and high dispersions in the ranks. While ASAC

supports the measures that JAO plans to introduce in Cycle 9 to mitigate these issues, it is concerned that they may not be enough. ASAC requests that JAO continue to explore alternative measures, such as implementing a some type of anonymous feedback between reviewers (Stage 3).

- ASAC is also concerned that the DPR system may be damaging minority research fields because they are reviewed by a majority of non experts. This problem may also be ameliorated by implementing a Stage 3 and by improving the algorithms that match reviewers and proposals
- Given the standing issues with the DPR system, ASAC requests an in-depth analysis of the Cycle 9 results, and offers itself to help JAO analyze the data to uncover hidden biases.

*Implementation of DPR.* The technical implementation by JAO of the combined dual-anonymous (DA)-distributed peer review (DPR) process in Cycle 8 has been very successful. JAO, in addition, has carried out a very detailed analysis of DA-DPR and its systematics using the results from Cycle 8 and feedback from both PIs and reviewers. The results of this analysis are presented in two manuscripts that have been recently submitted for publication in PASP (one of them already accepted: Carpenter et al. 2022, arXiv:2203.11334). ASAC applauds this level of transparency that puts ALMA at the forefront of institutes using DA-DPR, and which provides unique insights into the workings and possible systematics of this new proposal review system.

*Bias against EA authors.* ASAC is especially happy to see that the new review process is free from biases in the ranking of the proposals due to gender and expertise level, likely due to its DA character. The JAO analysis, however, shows that proposals from EA authors are systematically ranked lower than proposals from NA and EU authors. This bias was already present in the panel results from previous cycles, and the current implementation of DA-DPR has not been able to correct for it. While the JAO analysis has detected the bias, it has not been able to identify its cause, so further work on this issue is required. ASAC is concerned about the presence of this bias, and requests that it is further investigated, especially using data from the upcoming Cycle 9. ASAC also notices the absence of EA authors in the paper that studies the bias, and requests that future analysis of proposal biases involve EA authors.

*DPR issues.* While the transition from panel to DA-DPR is out of the question, ASAC is concerned that the current implementation of DPR has introduced some new issues that require attention. The PI survey from Cycle 8 showed that the two primary concerns from proposers were the quality of some reviewer comments and high dispersions in the ranks. These two issues may affect the credibility of DPR, so they need to be addressed in future cycles. JAO has already proposed some changes for Cycle 9, which include requiring that the reviewer comments have at least 200 characters, extending the Stage 2 period from one to two weeks, and improving the materials available for reviewer training. ASAC supports these measures, but is concerned that they may not be enough. The underlying problem seems to be the lack of

feedback between reviewers, which in the panel system allows to correct misunderstandings through discussion, and in cases of minority research fields, allows for a local expert to educate fellow panelists. ASAC understands that recreating these interactions in DPR is not trivial, but encourages JAO to continue exploring additional measures, such as implementing a Stage 3, in which reviewers can interact anonymously with fellow reviewers to correct misunderstandings.

*Effect on minority research fields.* Another issue of concern with the current DPR system is the possibility that it may put some minority research fields at a disadvantage, and as a result, it may decrease the diversity of science carried out with ALMA. The lack of successful pulsar proposals in Cycle 8 (despite the implementation of the new pulsar observing mode) is a possible example, although the small number of pulsar proposals makes it difficult to reach a solid conclusion. The reason minority research fields could be at a disadvantage is that their proposals will likely be rated by a majority of non experts, and without a panel discussion, the proposals may be rejected for the wrong reasons. Again, implementing reviewer interaction via Stage 3 may help alleviate the issue. An additional measure would be to use better algorithms to match proposals and reviewers, so that these minority proposals are always reviewed by the best possible experts.

In view of the number of issues that still surround DPR, ASAC requests that JAO continues carrying out the same type of in-depth analysis of possible systematics with the Cycle 9 results. ASAC offers itself to further discuss with JAO alternative ways to analyze the outcome of the review process, and to search for hidden systematics. Given the high oversubscription rate of the previous cycle, which caused most proposals to be rejected, it is critical to maintain the trust from the community in the review process.

**Permanent Charge #5. Reporting on operational or scientific issues raised by the wider community as communicated by the three regional Science Advisory Committees (ANASAC, ESAC and EASAC).**

*Recommendations/issues:*

- ASAC is disappointed that medium-sized proposals have been moved to DPR in Cycle 9. ASAC worries that this decision may put these underrepresented proposals at a disadvantage against shorter proposals, contradicting previous efforts to promote them.
- ASAC feels that achieving a proper balance between small, medium, and large proposals is an important issue that needs to be addressed. Changes in the Calls for Proposals over the years may have sent contradictory messages to the community, and a more consistent policy seems to be needed. This issue has many stakeholders, and ASAC will be happy to contribute to the discussion

*Medium-size proposals.* The increase in the submission and success rate of proposals requesting moderate amounts of time (25-50 hours: “medium-sized proposals”) has been a long-standing goal for ALMA, since they have been traditionally underrepresented in previous cycles. In Cycle 8, these proposals were reviewed by a panel system (APRC), in contrast with shorter proposals, which underwent DPR. This difference in the review method was seen as a way of encouraging the submission of medium and large proposals, and seems to have worked well. For this reason, ASAC is disappointed to see that the review of medium-sized proposals has been changed to DPR for Cycle 9. While ASAC understands that the decision was made because the APRC of Cycle 8 was overwhelmed by the large number of Large Programs (as promptly explained to ASAC by James Di Francesco in his email on 11 January), ASAC is concerned that moving the medium-sized proposals to DPR will put them at risk. These proposals will now compete with much shorter proposals, and they will be reviewed by a majority of researchers who are themselves authors of much shorter proposals. ASAC feels that the decision to send medium-sized proposals to DPR sends the wrong message to a community that was previously encouraged to submit this type of proposals.

Given the danger that medium-sized proposals may suffer from their move to DPR, ASAC requests that JAO considers future alternative measures to protect them. One option could be to have medium-sized proposals have their own allocation, so they are ranked separately from the small proposals in a way similar as done by HST.

*ALMA science portfolio.* The discussion of how to review medium-size proposals connects with a larger issue that has been present in ASAC discussions over the years, and that remains unsolved: the proper balance between small, medium, and large proposals. ASAC understands that this is a complex issue with important implications in the type of science done with ALMA and the type of community that benefits from ALMA time. Small proposals tend to favor independent work by younger researchers and small research groups, while Large Programs tend to favor the lines of work of more consolidated researchers and larger groups. Striking a proper and consistent balance between these different approaches is critical to maximizing the diversity of science carried out with ALMA, and ASAC feels that a more conscious effort to define this balance should be made. It is sometimes said that the time allocation simply reflects the requests from the community, but the comparison is often misleading, since an accepted Large Program is effectively ranked Grade A and given priority in the queue among other Grade A programs, while an accepted small or medium program may be ranked A, B, or C, and not given such priority in the queue. In addition, the community clearly reacts to what the Call for Proposals encourages, as seen from the submissions in Cycle 8. ASAC feels that a discussion of these issues has become an urgent need. It clearly involves multiple stakeholders, and ASAC will be happy to contribute its part.

**Permanent Charge #6. Assessment of the scientific impacts of the ALMA Development Program, and particularly of new projects that are proposed.**

*Recommendations/issues:*

- ASAC notes the importance of the overall Wideband Sensitivity Upgrade for achieving the goals of ALMA2030 and endorses the process laid out in the presentations to ASAC. The improvements are scientifically compelling and as users ourselves ASAC is excited for these new capabilities.
- This Wideband Sensitivity Upgrade plan requires significant coordination between the regions and strong centralized management to support the detailed timelines of individual projects. The committee felt that ASAC should be consulted regularly when important decisions are made that affect the users such as prioritizing one band over another or scheduling shutdown periods.
- ASAC strongly endorses the correlator upgrade proposal and was pleased to see a robust proposal that doubled the available bandwidth and dramatically improved the number of channels available, all while spanning ALMA's broad frequency coverage from Bands 1 to 10.
- ASAC is excited about full signal chain improvements being planned which are crucial for the success of the new correlator.
- ASAC strongly endorses the development project proposal of "ALMA 2030 Digitization to Correlation Path Prototyping and System Demonstration". This 2-year project proposal aims at demonstrating the required improvement in the digitization and correlation path, which ASAC considers as a supportive project for realizing the ALMA 2030 architecture.
- ASAC noted several new challenges that will come along with the Wideband Sensitivity Upgrade plan including increased data rates (for the project and for PIs), management (between projects led by different regions), and maintaining the archive (related to increased data rate). While ALMA is aware of these challenges, ASAC recommends discussing the challenges from the increased data rate with the community now so the users are able to prepare accordingly.

*Wideband Sensitivity Upgrade.* ASAC was given updates from the three regional development groups on all ongoing development activities in addition to several detailed presentations on the wideband sensitivity upgrade, the next generation correlator and the new digitizer. The Wideband Sensitivity Upgrade provides more bandwidth per band, more correlated bandwidth (full spectral resolution over the full band) and faster mapping speed enabling a wide variety of new science. ASAC commends JAO for working together to set requirements for the various

upgrade components to allow the regions to quickly develop proposals and establishing the *JAO development team* and *integrated development teams* to coordinate the different projects.

*Regional development studies.* The regional Development studies and projects continue to demonstrate impressive technical advances, many of which will find application in the 2030 upgrades, while others will improve the analysis resources available to ALMA observers or enable an easier use of the ALMA science archive. ASAC commends the Observatory for the continuing success of these efforts. ASAC is excited to hear Band 1 will be ready for Cycle 10. It is unfortunate that the new OT is delayed. ASAC hopes the staffing problems can be resolved so that the OT can be made available for Cycle 11.

*Digitization proposal.* ASAC was presented with a development project proposal of "ALMA 2030 Digitization to Correlation Path Prototyping and System Demonstration". This proposal follows several successful ESO ALMA development studies, and now aims at demonstrating the improvement in the digitization and correlation path which are both required for the wideband system upgrade. The proposal is comprehensive with well-formed milestones within 2 years. ASAC endorses this proposal.

*Correlator proposal.* ASAC congratulates the team for the new correlator proposal, which includes important adaptations to fit with the receiver bandwidth specification. The expected capabilities will clearly enable revolutionary projects that will benefit from the exquisite sensitivity of ALMA receivers and the flexibility and spectral resolution offered by the new correlator. ASAC is supportive of the staged approach of building the 2x bandwidth correlator first and then the 4x through a possible EA expansion project that leverages the engineering investment from the first phase. ASAC suggests that when the correlator construction schedule is known, JAO should have detailed discussions with ASAC and the broader community about the plans for installation to minimize the burden of the shutdown period.

*Data processing.* ASAC discussed that the high data rate expected from this correlator may require modifying the data processing strategy. ASAC would like to understand what computing resources will be needed for processing observations with the new correlator and where these resources will be located. JAO mentioned they are doing a study now to quantify the data rates anticipated. ASAC looks forward to seeing the results of this study. The increased data rate not only affects the pipeline but also the analysis that users perform on their data, and this upcoming data rate challenge should be discussed with the community.

**Ad-hoc Charge.** The ASAC is charged to identify for the April 2022 board meeting what level of observatory and ARC support is needed to ensure the success of Large Programs, including timely delivery of higher-level data products to the ALMA community. Polling the PIs of more recent LPs is recommended to determine what roadblocks they have faced in completing their projects.

*Recommendations/issues:*

- ASAC is not able to fully address this Charge at this point and requests further data. Specifically, ASAC requests the completion of the survey to PIs/co-PIs about bottlenecks in delivering survey data. ASAC requests timely provision of survey responses to the committee.
- ASAC recommends ARCs create a summary of support that has been provided on a per-LP basis for further discussion of this Charge.
- ASAC recommends archive development to make future LP products readily visible in the Archive.

*ARC support.* ASAC recognizes that many of the LPs have had challenges in delivering higher-level data products to the observatory within the nominal 12 month timescale after the data for an LP is fully delivered. ASAC was provided with a summary of Large Program support resources from the ARCs and the survey of LP PIs from 2020. The community clearly responded to the request for more LP proposals in Cycle 8 and more LPs were approved. With more time allocated to LPs, ASAC agrees that identifying any systematic issues facing LPs is important. ASAC also recognizes the ARC support provided to LP teams as being at an appropriate level and of high quality. In particular, the committee notes the success of ARCs at providing data space and processing for LPs, and the highly constructive relationships between the Contact Scientists, P2G team members, and the LP teams.

At this point, ASAC and JAO have not identified unifying reasons why most programs have not returned higher-level data products on the expected timescale. There are several factors that have been identified in individual project delays, including work delays from the COVID-19 pandemic and the identification of concerns with how the data were collected. ASAC recognizes that LPs provide unparalleled scrutiny of ALMA data leading to identification of issues (e.g., the renormalization issue) and subsequent improvements to observatory operations. In this sense, the committee prioritizes delivering high quality, well vetted data products over timely delivery when the two factors are in tension. The committee also recognizes that the data processing and scientific challenges vary substantially between LPs.

*PI survey.* The committee approved of the survey to be submitted to LP PIs/co-PIs specifically inquiring about roadblocks that they encountered in processing the data. The committee looks forward to seeing the results of the survey of PIs as soon as they are available. Survey input will

be invaluable in evaluating this Charge. In addition, ASAC recommends ARCs create a summary of support that has been provided on a per-LP basis for further discussion of this Charge.

ASAC supports having multi-cycle observing proposals, especially as this may allow for new types of science (monitoring campaigns), and allow more flexibility in scheduling LPs vs PI science. While it seems unlikely to be the primary bottleneck in LP delivery delays, the committee also applauds efforts at creating a smoother channel for ingest of higher level data products into the ALMA archive. ASAC strongly supports archiving community-contributed data products from LPs and recommends archive development to make future LP products readily visible in the Archive.