ALMA BOARD

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

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General considerations

The Spring ASAC meeting of 2023 was held virtually during three two-hour-long sessions on March 15-17. To maximize the discussion time, all presentations were pre-recorded and made available two weeks prior to the meeting. The presenters attended the meeting and answered questions that were posted in advance by the ASAC or that arose during the subsequent discussion. ASAC warmly thanks all the presenters for their work and appreciates the high quality of the material that was prepared for the meeting.

The meeting included presentations by ALMA director Sean Dougherty, Department of Science Operations head Liz Humphreys, Observatory Scientist John Carpenter, NA ALMA Program Scientist Crystal Brogan, EU ALMA Program Scientist María Díaz Trigo, EA ALMA Program Scientist Daisuke Iono, ALMA Archive Scientist Felix Stoehr, and Band 2 Project Manager Pavel Yagoubov. The meeting was also attended (among others) by Toru Yamada as a liaison to the ALMA Board Science Committee. The ASAC thanks all the participants for their time and contributions. The material from the presentations and the content of the meeting discussions have been used to prepare this report, which answers the six ASAC permanent charges. No ad-hoc charges are addressed since none were provided by the ALMA Board.

ASAC notes that while virtual meetings are efficient to discuss relatively simple topics, differences in the time zone of the participants impose time constraints that prevent in-depth discussions of complex matters. For this reason, ASAC supports that some meetings in the future are held in-person. ASAC will work with JAO to deal with the organization of those meetings.

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.

- ASAC supports the Wideband Sensitivity Upgrade (WSU) as the top future scientific capability for ALMA. ASAC also celebrates recent progress toward the implementation of the WSU, including the approval of the new ATAC correlator and the Data Transmission System at the past November Board meeting.

- ASAC is happy to see that despite the disruption caused by the cyber attack a number of important new scientific capabilities will be offered in Cycle 10, including Band 1 observations and the new ACA Spectrometer.

- ASAC agrees on the need to set priorities for future operational activities in view of the current limitations of staff resources. While ASAC agrees with the general order of priorities described in the 7 March 2023 ALMA memo, ASAC regrets that a number of new observing modes that were expected by the community and supported by ASAC will be postponed. ASAC urges ALMA to explain the tight situation to the users so the decision is not seen as indicating a loss of interest in these unimplemented modes.

- ASAC expresses its concerns about the tight resource limitations of ALMA, and requests the Board to take the necessary measures to maintain the high quality of the Observatory performance and to guarantee the success of the WSU implementation.

WSU progress. ASAC was informed that work on the WSU has made good progress since the previous meeting. The WSU underwent a succesful System Requirements Review in mid October and the ALMA Board approved the ATAC correlator and the Data Transmission System projects at the November meeting. The Digitizer project passed a review last February and two working groups have been created to manage and coordinate different aspects of the WSU. In addition, ALMA has made a significant effort to publicize the WSU initiative with a detailed science case posted on astro-ph and numerous presentations at scientific and technical meetings. While a number of risks remain, both technical and human-resource related, ASAC sees very positively the progress so far and congratulates ALMA for it. ASAC would appreciate a fully developed timeline, with all subcomponents being worked in parallel, with risk charts presented to maintain an understanding of challenges and progress being made. ASAC appreciates the constrained resources and acknowledges many are being focused on the WSU, so maintaining an understanding of progress and issues will be critical as the project moves forward.

Cycle 10 capabilities. The cyber attack of 26 October 2022 represented a major disruption in the preparation of the new scientific capabilities to be offered in Cycle 10. The Band 1 Science Verification (SV) observations were delayed and will be carried out over the next few weeks when the number of antennas equipped with Band 1 receivers reaches the number of 20. Although the data from these SV observations will not be released in time for the next call for proposals, ASAC still recommends that the SV observations are carried out and will welcome a report on their results at the next ASAC meeting. ASAC congratulates the Band 1 team for their

work. Additional new capabilities that will be offered in Cycle 10 include solar observations in full polarization in Band 3 (12m array only), phased array observations in Bands 1, 3, 6 and 7 (with ~50 h cap), VLBI in Bands 1, 3, 6, 7 including spectral lines, spectral scans including total power, and 4x4-bit spectral modes in the 12m array. ASAC congratulates ALMA for implementing all these capabilities despite the cyber attack disruption.

Postponement of new observing modes. ASAC was informed about the recent memorandum on *"Operational activities to be continued and postponed until completion of the WSU parallel deployment and Assembly, Integration, Verification, and Commissioning (AIVC) phases" from 7 March 2023.* This document describes the priorities that have been set for future operational activities in view of the limited resources expected over the next several years as a result of previous constraints and the new needs of the WSU implementation. ASAC agrees with the need of the priorities and with their general order as stated in the memo. ASAC also notes that this will result in the postponement of the implementation of a number of new observing modes that were expected by the community and supported by ASAC, which include enhanced solar capabilities, circular polarization, Band 9/10 single-dish operation, and multi-cycle proposals. ASAC urges ALMA to be open to the community about the tight resource situation and about the need to make painful decisions, so the postponement is not seen as indicating a loss of interest in these unimplemented modes. ASAC also notes that the implementation of multi-cycle observations was recently supported by the Board conditional to a low impact on staff demands, and that this type of proposals remains favored by the community. In addition, ASAC requests that the Board remains vigilant about the tight situation caused by the limited resources of ALMA, and that it takes all necessary measures to maintain the high quality of its performance and to guarantee the success of the WSU implementation.

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 understands the impact of the cyber attack on Cycle 9 efficiency, with ~650 hours behind original target on the 12m array. Efforts to achieve ~3500 hours for Cycle 9 and Cycle 10 readiness are good and encouraged by ASAC. The project completion rate tracking seems to be helpful and ASAC encourages this to be continued.

- ASAC is glad to see that the completion rate of high frequency projects in Cycle 9, while still low, has so far been higher than in previous cycles. This may result from the recent policy changes made to favor high frequency observations. While it is still early in the cycle to conclude that the changes have had a definitive effect, ASAC is encouraged by the results and will welcome a full report at the end of the cycle. ASAC also encourages ALMA to continue exploring possible ways to favor high frequency observations within the limited resources available (e.g., daytime observations).

- ASAC is concerned with the upcoming end of life for the 7m correlator and would like to be informed on the plan/challenges and updated on the progress to transition to the 12m

backends.

Cycle 9 acquisition. Data acquisition for Cycle 9 was trending very favorably for the observatory projected goal of ~4300 hours prior to the cyber attack. Impacts from the attack were notable for science (loss of ~650 hours for 12m), commissioning and Cycle 10 readiness. Mitigation efforts are well constructed and have compensated for some lost time - ASAC commends these efforts on all fronts. Achieving the anticipated ~3500 hours for Cycle 9 is aligned with previous cycles. Project tracking is greatly appreciated and allows for a detailed understanding of observatory time in various manners.

High-frequency observations. The issue of the low completion rate of high-frequency observations, and more generally of observations strongly sensitive to weather conditions, was the topic of an ad-hoc charge in the previous ASAC report. Since then, ALMA has taken a number of measures to favor high-frequency projects. ASAC is glad to see that so far in Cycle 9 the completion rate of Band 9 and Band 10 projects, while remaining at a relatively low level of about 25%, has been higher than in the previous cycle. Although it is too early to tell, this is a good sign, and ASAC encourages ALMA to continue following up closely the completion rate of the high frequency projects, and if resources are available, to continue exploring ways to promote these projects at the telescope (like studying the possibility of day-time observing).

7m Correlator. The 7m correlator is approaching the end of its expected lifetime. Transitioning to the 12m backends will need to happen in the next year and ideally available for Cycle 11. Testing was started for this transition and impacted by the cyber attack. With scheduling impacts being accommodated, it is understood this transition is slightly delayed. ASAC would appreciate a future update on the progress of this transition.

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 believes that the level of publications remains healthy despite having declined slightly in 2022. Whether this decline represents a statistical fluctuation or is a consequence of the 2020 shutdown should be investigated over the next few years.

- ASAC is happy with the publication statistics provided by ALMA, but believes that to properly reflect the scientific effort of the different regions, the publication statistics of each region should be normalized by the size of the astronomical community. Also, knowing the citation rate by region may provide a better understanding of ALMA's regional impact. ASAC kindly requests those statistics.

- ASAC encourages ALMA to investigate the statistics of publications and citations of the

Large Programs. Such information will help understand the effectiveness and impact of the LPs in the ALMA community.

- ASAC notes that the delay between data release and publication date has increased systematically over the years, and requests more data to investigate its origin. ASAC recommends to survey the delay not only by cycle, but also by region and with/without Large Program-related data. Since some projects are only partially observed (per Scheduling Blocks or Science Goals), this may also explain some delays. A comparison with other facilities may help to determine whether the increasing delay is unique to ALMA.

- ASAC is very pleased that the preparations for the “ALMA at 10 years” conference are proceeding smoothly, and that the selection of invited speakers has accounted for the diversity of the ALMA community in terms of scientific topic, region, seniority, and gender.

- Since Charge 3 requires ASAC to assess “press releases, web sites, etc,” ASAC would like to be shown some statistics of public outreach activities such as the number of views for web pages, press-releases, or social media messages. To minimize straining the already limited resources of the ALMA staff, this review of outreach activities can be done every several cycles.

2022 Publications. ASAC thanks ALMA for providing publication statistics with a variety of perspectives. ASAC is happy to find that the total number of publications remains healthy in 2022 despite a small decrease with respect to the previous year. The decrease could represent a statistical fluctuation or result from the covid shutdown, and ALMA should continue monitoring the publication statistics to clarify its origin. The statistical data also show that the number of Band-7 publications has decreased, and ASAC would like to see if there is a link between this decrease and the completion rate of the Band-7 observations. Another notable result from the publication's statistics is that the number of publications from China, a non-ALMA country, has significantly increased.

Regional balance. ASAC considers that the current format of the statistics regarding publications by region does not provide an accurate picture of the effort made by each region using ALMA because it ignores the different sizes of the astronomical communities. ASAC recommends that the publication statistics by region are normalized by the size of the relevant community. ASAC is well aware of the difficulty in finding appropriate normalization factors, but encourages ALMA to consider this issue. To further assess the impact of ALMA by region, ASAC recommends determining the citation rates by region (currently only the total citation impact per year is provided). ASAC understands that many projects contain PI and CoIs from several regions, but believes that some improvements can be made to better visualize the use of ALMA by each region.

Publication delay. The publication statistics show that the delay between data release and publication date has increased systematically since Cycle 1. ASAC believes that this is an issue worth investigating, and requests ALMA to look at the delay in more detail, as for example, subdividing the statistics by region, factoring out whether the data belong or not to Large

Programs, or whether the projects have completed their Scheduling Blocks or Science Goals, since incomplete data may be more difficult to publish. ASAC also recommends comparing the delay with that of other facilities to investigate whether such a slowdown is unique to ALMA or represents a common trend among mature observatories.

Publications from Large Programs. ASAC recommends that ALMA investigates the statistics of publications and citations of the Large Programs separately from the normal programs. Over the last several cycles, ALMA has given priority to the LPs in its operations since they are expected to lead to significant scientific results. At the same time, ASAC considers that it is important to maintain an appropriate balance between LPs and normal proposals (see more on this issue in Charge #4). Monitoring the statistics of publications from LPs can help to assess the effectiveness of LPs for the ALMA community.

ALMA Conference. ASAC is very pleased that the preparations for the *"ALMA at 10 years: Past, Present, and Future"* conference are proceeding smoothly. ASAC appreciates having been invited to participate in the SOC, and is happy to see that the selection of invited speakers has been done taking into account the diversity of the ALMA community in terms of scientific topic, region, seniority, and gender. ASAC hopes that this conference will provide a unique opportunity to publicize the exciting achievements and the diversity of ALMA's science.

Outreach activities. ASAC notes that Charge 3 has been traditionally focussed on the analysis of publication statistics although the charge wording includes other aspects more related to outreach activities (press releases and websites). To assess the progress on these activities, ASAC would need additional information, such as statistics of views for web pages, press-releases, or social media messages. ASAC is aware of ALMA's current staff limitations, so it proposes that outreach activities are only reviewed every few cycles.

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.

- ASAC supports the new algorithm in DPR to match the expertise of reviewers and proposals, and is optimistic that it will help reduce previous mismatches. ASAC also supports limiting the number of proposal sets per reviewer. ASAC would like to keep being informed on the outcome of the Cycle 10 call for proposals, especially considering the new features (joint proposals, Band 1 and other new capabilities).

- ASAC continues to strongly encourage the observatory to keep improving the algorithms that support DPR, for instance by making sets of proposals include only similar topics, whenever possible. This will help the reviewers to rank proposals in the fairest possible way. It may also reduce repetition of similar topics and increase the diversity of science.

- ASAC reiterates the urgent need to keep improving stage 2 in order to increase the quality of the proposal evaluation and the reviewer comments.

- ASAC would like to review statistics to determine whether the number of successful

proposals toward the same targets has increased after the implementation DPR, potentially indicating a loss of diversity.

- ASAC remains concerned about the impact of Large Programs on the diversity of the science portfolio of ALMA. Since only a few LPs have delivered data and the current set of publication statistics does not examine LPs, ASAC requests a charge to evaluate the scientific impact of programs of different sizes with a focus on the balance between Small and Large Programs.

Preparation of Cycle 10 review process. ASAC welcomes the proposed changes made to the DPR process, in particular, improving the algorithm used to assign proposals will reduce the number of proposals assigned outside the principal areas of reviewer expertise. Limiting the number of proposal sets per PI to five is welcome and is an appropriate response to the finding that the quality of comments decreased when a too large number of proposals is evaluated by the same reviewer. ASAC also suggests revisiting the list of keywords to determine if they are still sufficient, and would be happy to help with the revision if deemed useful by the observatory. ASAC would like to keep being informed of the outcome of the cycle 10 review process, especially given the new features that are being implemented in this cycle (joint proposals with other facilities, Band 1 receiver, VLBI, etc.).

Stage 2. ASAC reiterates the importance of Stage 2 since this is the only moment where the different reviewers see all opinions about a given proposal, thus mimicking the discussion in a panel review process. Improving Stage 2 by, e.g., allowing reviewers to flag or react to comments from other reviewers (either positively or negatively) would be beneficial. ASAC also proposes to set some mechanism that can encourage reviewers to effectively participate in stage 2 and that compels reviewers to modify their comments if found incorrect or in mismatch with the proposed rank.

DPR and science diversity. ASAC is concerned that DPR may be impacting on the diversity of the science done with ALMA. A review panel usually compares and rates a large number of proposals with similar goals (e.g., same source, same molecules but with different frequency, similar purpose, etc.) and may strive to award time to a diversity of topics. DPR reviewers, on the other hand, have a very limited view of the pool of proposals that is restricted to their ten assignments. For this reason, ASAC suggests comparing the diversity of proposal aims and scientific targets accepted before and after the implementation of DPR. ASAC notes that the text similarity algorithm used in Archive Queries could potentially be useful here. It may also be interesting to check the overlap of sources and possibly members in successive proposals with those of Large Programs.

ALMA science portfolio and scientific priorities. ASAC reiterates the importance of considering ALMA's broader scientific portfolio and believes that the observatory should consider more metrics than proposal pressure and simple bulk publication statistics in guiding the science of the observatory. While publication and impact factors are clearly important, the scientific portfolio of the observatory should also consider balancing time across other dimensions. For example, the resulting division of time between normal and large programs affects the engagement of the broader ALMA community. Only a few large programs have delivered data

for the community and several have yet to publish any results, representing a significant opportunity cost to the community. Expressly ensuring that small research communities (e.g., pulsars or solar users) have access to the observatory allows ALMA to establish a broader impact across astrophysics. Similarly, high-risk proposals should have a specifically identified channel for access to the telescope for high scientific gains. Finally, the scientific portfolio of the observatory should identify clear opportunities to train the next generation of millimeter-wave astronomers. While the current scientific selection process for the observatory addresses each of these in part, ASAC believes that ALMA should define its priorities in these different areas and use this to refine the proposal review process.

Given these concerns, ASAC wishes to specifically examine the relative science impact of the different types of proposals. For this purpose, ASAC requests a charge to make this evaluation and return recommendations to the Board. The evaluation would examine the current statistics about Large vs. normal programs: is there a difference in their completion rate (when correcting for the difference in A, B and C grades)? Does the balance between program types depend on the scientific categories? Publication and data use statistics separating Large and normal programs (see Charge 3) would be most useful.

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).

- The three regional Science Advisory Committees (SACs) continue to report significant user dissatisfaction with the DPR process. Commonly raised issues include: (1) feedback that is not useful, difficult to interpret, inaccurate, and/or inconsistent with the proposal outcome, (2) poor expertise matching, especially for minority fields, (3) ineffective/underutilized Stage 2. ASAC notes that the slow rate and small impact of the tweaks that ALMA has been making to the DPR process are out of step with the rate at which the community is getting disaffected with the process. ASAC strongly encourages the observatory to prioritize experimentation and modification of DPR in response to user feedback. ASAC also requests that satisfaction surveys attempt to obtain a more detailed picture of the PI's views on ratings and comments.

- The regional SACs, especially ESAC, encourage ALMA to respond explicitly and publicly to the concerns raised in the letter submitted by the solar community.

- While EASAC confirms that the WSU is a key strategic priority for ALMA, and understands the need to consider trade-offs in the development plans because of limited resources, it has strong concerns about the postponement of several important capabilities: (1) Polarization improvements beyond Band 1 and 2 commissioning since polarization science cases are still an unexplored domain, and have a huge discovery potential; (2) Band 9 and 10 single-dish operation since this is an important mode for observations of the interstellar medium and star formation.

- All regional SACs express their concern that despite ALMA being a global flagship scientific facility, it seems to be working in a consistently and concerningly resource-limited state. This imposes an enormous pressure on the observatory staff,

and ASAC is concerned about the resulting delays, descoping, and phasing out of scientific activities that are broadly considered critical for innovation by the user community (examples include, but are not limited to, multicycle/monitoring proposals, work on the ngOT, new polarization capabilities, etc). All SACs ask the Board to ensure that ALMA has all the resources it needs to continue innovating while minimizing pressure on observatory staff.

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

- ASAC strongly endorses the Band 2 wide-band receiver development project. ASAC was happy to see the preliminary measurements of performance of this first wide band receiver.
- ASAC continues to be supportive of all the ongoing studies and projects, and commends the regional executives for developing an exciting set of future capabilities.
- ASAC expresses strong support for continued development of the ALMA archive. ASAC recognizes the excellent work completed by the ALMA archive subsystem group in development to date. The committee strongly recommends that the Archive group conduct a survey of the full ALMA community to inform priorities for future development.
- ASAC remains concerned about the development of the Next Generation Observing Tool and would like to see a full update and status report at its Fall meeting.

Band 2 receiver. ASAC reviewed the Band 2 receiver development project and strongly supports its continuing progress through its design reviews. The Committee was pleased to see that the initial performance tests show the receiver meets most specifications while maintaining the broad bandwidth expected as a vital component for wideband sensitivity.

Regional development studies and projects. ASAC reviewed the ongoing development studies and projects taking place in the three regions. In general, ASAC continues to be supportive of all the ongoing ALMA development efforts and commends the regional executives for developing an exciting set of future capabilities. Much of the ALMA development efforts are becoming focused on the WSU (See Charge 1), and ASAC is pleased to see the developments in projects to support the WSU such as the Agilex design study (NA) are encouraging. ASAC also supports other ongoing initiatives showing excellent promise for improving ALMA observing efficiency (e.g., variable speed compressors from NA efforts), calibration (Artificial calibration sources from EA), and data analysis tools (beam shaping and imaging reconstruction from EU, spectral regridding from NA) as well as setting path for next generation receivers (all executives).

ALMA Archive. ASAC is broadly supportive of the good work done by the ALMA Archive group in reaching a “version 1.0” stage and is pleased with the substantial and continuous progress being made in archive development. The archive is essential for maintaining ALMA’s legacy and

the Archive group has created an easy to use portal, which sets the standard in the field. The Committee was also pleased to see ESO funding for more archive development beyond the basic subsystem support provided through the Observatory structure. As the Archive group moves toward future development, ASAC advises that the Archive group survey the ALMA user community to prioritize feature development. Of the proposed future developments in the presentation, ASAC in particular strongly supports pipeline processing of the current archive so that calibrated imaging-ready measurement sets can be delivered to archive users.

Next generation Observing Tool. ASAC remains concerned about the progress of the ngOT development and is optimistic that returning the project to ESO will resume active development for future work. ASAC has not had a substantial report on ngOT progress and current development plans, and requests a report on development status and plans at the Fall meeting. ASAC expresses concern that the ngOT would suffer further delays from being required to meet constantly changing development targets since it is now being developed in parallel with the WSU capacity.