

## **ASAC Report to the ALMA Board**

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### **General considerations**

The ASAC face-to-face meeting was held at JAO in Santiago, Chile, on Feb. 28 + Mar. 1, 2019. 8 committee members were present in person with 4 present via video. In addition, Observatory Director Sean Dougherty, Observatory Scientist Dr. John Carpenter and Deputy Director Dr. Stuartt Corder were present, as well as the three regional Project Scientists (Drs. Daisuke Iono via video, Franciska Kemper and Al Wootten). From JAO, Sergio Martin, Theodoros Nakos, Eric Villard and Nick Whyborn also attended sessions to provide background. ASAC would like to thank JAO for hosting the meeting, and JAO staff, particularly Ann Edmunds for her work in making all the arrangements that allowed the meeting to run smoothly, and Italo Lemus for ensuring that the remote attendees were able to participate fully. ASAC appreciates the timely delivery of all the documentation and presentations for this meeting prior to the meeting itself, which aids in ASAC's preparations and, ideally, gathering of feedback from the regional SACs.

ASAC welcomes new members Anne Dutrey and Mario Tafalla, representing EU. This was Jongsoo Kim's last ASAC meeting and we thank him for his dedicated and thoughtful service to ALMA. The next ASAC face-to-face meeting is currently expected to be held in Sardinia adjacent to the ALMA science meeting there.

John Carpenter presented a summary of recent science highlights, including the release of the protostar disk survey and the nearby-galaxy CO observations. An initial release of the 3mm VLBI data has been made, and it demonstrates the value of ALMA for mm-VLBI.

The Director reported on issues that arose following heavy rain and flooding early in 2019, including a wash-out of the road to the high site that had trapped the functional transporter down at OSF until the road could be repaired. This highlights the fact that assumptions about weather at the site made at the beginning of the project were overly optimistic and are now causing operational problems for the project.

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

*Recommendations:*

- ASAC was impressed with the carefully coordinated planning for introducing new capabilities to be offered in Cycle 7 as well as in future cycles, via the ObsMode process. We strongly endorse these activities and congratulate the Observatory for recent successes in this area.
- Similarly, efforts to increase efficiency (aimed at providing as much as 300 extra hours of observing time per cycle) are endorsed.
- ASAC places a very high importance on offering high frequency observations as standard mode in Cycle 8, or, as a fall-back position, mixed standard/non-standard mode depending on distance to a suitable calibrator.
- ASAC notes the need to fill vacant positions in the DSO group, in order to ensure that science operations continue smoothly.

*Advancement of ALMA capabilities:* ASAC is pleased to see the appropriately measured procedures by which the new capabilities that will be offered each new Cycle are decided upon (ObsMode process). New capabilities offered in Cycle 7, namely long-baseline Band 7 observations, faster standard-mode spectral scans, the new capabilities for solar studies, and more accurate spectral-line linear-polarization measurements, all represent important enhancements to the scientific capabilities. ASAC was also pleased to see the first 3mm VLBI results, and the publication of the first Band 5 result, and congratulates the Observatory on these milestones. Finally, ASAC was happy to see the planning already underway for Cycle 8 and future cycles, and is interested to see how the trials for running observations from JAO rather than OSF work out.

*Observing efficiency:* The ALMA staff have made a detailed analysis of how the array time has been used during Cycle 6, searching for potential ways to improve the observing efficiency. Strategies to reach this goal include identifying problems early by giving priority to pipeline processing data taken immediately after (major) hardware/software changes, improvement of day-time focus modeling, minimizing system restarts, reducing recovery time after snow storms, and more flexibility in the use of engineering time. While the provision of observing time seems to be getting close to its maximum possible value, ASAC is happy to see that the implementation of the above measures could provide an additional 300 hours per cycle for observations. ASAC notes that these additional hours have been taken into account in calculating the number of hours offered in Cycle 7, which is 4300 hours. The possibility of taking advantage of extensive commercial work in the area of queue-building, both in the proposal-acceptance phase and in the observing queue, was mentioned as another possible source of efficiency improvement, and ASAC is eager to see whether this can help further.

*Standard mode high frequency observations:* ASAC emphasizes the urgency for offering high frequency observations as standard mode in Cycle 8. The high-altitude location of ALMA was partly justified as necessary for making high frequency observations possible, but the community has not yet favored this type of observation. Making at least some high-frequency observations standard will likely encourage

more interest in this mode. In this context, ASAC supports JAO's suggested compromise approach of making standard those observations of targets with nearby calibrators, and non-standard otherwise. Another advantage of making high frequency observations standard mode is that it will indirectly help advance the timetable for introduction of the long-awaited full polarimetric capability (e.g., including circular, mosaicing, and ACA). This is because having too many non-standard observations is a burden to the data reduction teams, so by advancing some more established modes from non-standard to standard, the Observatory can make room for additional capabilities to be rolled out, eventually leading to full polarimetric capability. For all of the above reasons, we expect that standard mode high frequency observations will result in significant improvements in the Observatory's science output.

*Vacant positions in DSO group:* ASAC notes the vacant positions in the DSO group, and urges that high priority be placed on filling these. Otherwise, workforce shortages may jeopardize both the currently very good rate of progress on advancing capabilities as well as the overall success of science operations.

*Cryo system lifetimes:* Maintenance of the cryo systems has been an ongoing issue that threatens ALMA's ability to maintain the promised number of functional antennas. ASAC was informed of steps currently underway to improve the maintenance situation for the cryo systems, and hopes that this will lead to stability for this critical component.

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

*Recommendations:*

- ASAC appreciates JAO's commitment to keep the targeted number of antennas available, and applauds their achievement of usually having many more than the nominal number active.
- ASAC recognizes the efforts undertaken by JAO to recover from the damage caused to the road, the power and communication cables, and buildings due to the heavy rain in January and February.
- ASAC understands that data delivery was delayed due to CASA issues, including the "mosaic" and "1 GB" issues. ASAC reiterates the need to perform rigorous CASA regression tests regularly in order to minimize the possibility of similar problems in the future. ASAC looks forward to a presentation on this issue at the next face-to-face meeting.
- ASAC notes the threat to operations caused by the combination of repairs needed on one transporter, and the damage to the road that has trapped both transporters at OSF. For stable long-term operations at ALMA, proactive solutions that avoid these problems need to be provided, and we acknowledge that there is not likely to be a cheap path forward.
- ASAC would like to see the status of the implementation measures taken to mitigate the impact of the now not-infrequent extreme weather conditions at the site.
- The accumulated QA0 pass time of the 12m array is 16% less than targeted (at the time of the meeting). ASAC acknowledges that this is due to the need to catch up for correlator issues and the recent heavy rains. ASAC encourages JAO to perform more extensive tests of the correlator system before starting a new Cycle.

- ASAC strongly recommends that ALMA announce the cancellation of the Cycle 6 1mm VLBI campaign to the user community as soon as possible. ASAC also strongly encourages ALMA to make it clear that 1mm VLBI will be offered in Cycle 7, as the information on the ALMA website at the time of ASAC's meeting is rather ambiguous. Finally, ASAC recommends that ALMA request a long term plan for high-frequency VLBI from the EHT team that realistically addresses the likelihood of VLBI in Bands 6 and 7 being available in Cycles 7, 8, and 9.

*Data delivery:* Data delivery has been delayed compared with the previous Cycle. The 90% delivery date of pipeline-processed MOUS is 65.9 days, which is more than twice as long as the 30-day goal. ASAC understands that the delay is mostly due to reprocessing of MOUS that have suffered from the CASA mosaicking bug and the "1 GB memory" issue. In the previous ASAC report on the mosaicking issue, ASAC recommended a more rigorous evaluation of the CASA regression tests. ASAC here reiterates the importance of proactive testing of CASA versions for ALMA data processing in order to avoid impacts to data delivery.

ASAC is very happy to see that despite the delays mentioned earlier, the Cycle 5 large programs are nearly complete and good progress has been made on the Cycle 6 large programs.

*Transporters and road damage:* ASAC recognizes the issues with transporters (one awaiting parts from Europe in order to carry out a repair, the other trapped at OSF until the road can be repaired). If everything goes according to plan, JAO expects that the move to C43-3 will not be delayed. There is however little available contingency in the schedule if any step is delayed, which will impact the configuration plans. ASAC wishes to emphasize to the Board the seriousness of the potential impact of any future transporter problems on ALMA operations.

*Weather impacts:* There have been major setbacks for science operations due to snow storms last year and rain and wind early this year. Dealing with damage caused by the weather also involves significant costs not anticipated in the budgeting process. ASAC acknowledges that JAO has on-going implementation plans to mitigate the impact of snow. ASAC notes that the likelihood of future heavy rains cannot be ignored, and encourages that similar mitigation plans need to be in place for that eventuality. ASAC would like to hear about the status of progress in this area at the next face-to-face meeting.

*Accumulated QA0 pass time:* The accumulated QA0 pass time of the 12m array is 16% below the targeted time, which is due to the need to reobserve projects affected by the correlator issue, and to bad weather. JAO anticipates that it is unlikely that the QA0 pass time can be caught up during the remaining time in Cycle 6, given the remaining configurations that will be available. ASAC acknowledges that JAO performs testing of the correlator prior to the start of each Cycle, but the correlator problem has impacted operations and ASAC recommends that JAO should do even more extensive tests to avoid these issues.

*Cancellation of 1mm VLBI in Cycle 6:* ASAC was informed that the 1mm VLBI run for Cycle 6 was cancelled in mid-February due to problems with several of the participating telescopes. ASAC strongly

recommends that ALMA announce this cancellation to the user community as soon as possible. ASAC also strongly encourages ALMA to make it clear that 1mm VLBI will be offered in Cycle 7, as the information on the website at the time of the meeting is rather ambiguous. The ALMA Observatory has invested significant resources in implementing high-frequency VLBI, including the recent Band 7 phasing development and spectral line capabilities. ASAC recommends that ALMA request a long-term plan for high-frequency VLBI from the EHT team that realistically addresses the likelihood of VLBI in Bands 6 and 7 being available in Cycles 7, 8, and 9, in order that proposers can prepare accordingly.

**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 congratulates the JAO on delivering data of such high quality, leading to a publication rate that places the Observatory amongst the most productive facilities worldwide.
- ASAC is glad to see that JAO is considering an easing of restrictions on the release and potential scientific usage of EOC test data, and thanks JAO for the opportunity to comment on the policy.
- ASAC requests that publication statistics be made available in tabular form as well as in plots, since they can then be more useful for analysis, e.g., by specific regions and funding agencies.
- ASAC appreciates receiving the publication statistics, but notes that their provision is currently essentially on a voluntary basis. In order to ensure their continued availability and accuracy, we recommend that the board and JAO look into allocating dedicated resources for maintaining publication statistics that include a break-down by mean integration time, band, configuration, project type, capabilities, and other relevant parameters.
- ASAC recommends that a concise statement about the 'recommendation' to re-image the calibrated archive data be placed in a visible location on the archive pages.
- ASAC welcomes the news that there will be a formal review of the ALMA archive during the coming year, and requests that the results of this review be presented to ASAC at the next face-to-face meeting.

*ALMA publications:* ASAC received the annual summaries of publication statistics and archive usage. ASAC continues to be impressed by the large number of publications resulting from ALMA data and that the rate of increase in publications matches that of other high-profile facilities. Furthermore, ASAC is pleased to see the increased usage of the archive. ASAC was interested to see the trend that whereas in earlier years SV data tended to be the major source of publications from archival data, it is now the case that such publications are dominated by archival PI data.

ASAC feels that there would be value in having the publication statistics made available in tabular form as well as in the form of figures, particularly the publication statistics for regions and/or countries. Additionally, when showing the statistics per country it would be helpful to see this for the regions as well. Funding and science agencies within different ALMA member countries are likely to be interested to see these breakdowns.

ASAC also sees value in further break-down of some of the statistics by different aspects, e.g. cycle, capabilities, band, configuration, [mean] integration time, and project type (large vs normal). However, ASAC understood that currently the resources for compiling the statistics are limited. Furthermore, the accuracy of the statistics was discussed as the statistics are presently compiled based on the ALMA project code without regard to the overall observations acquired, e.g., if multiple bands were observed, but data from only one band was published. ASAC encourages that this be looked into further and recommends that the Board, the Observatory and partners review what statistics should be provided and what resources they are willing to allocate to this purpose. It is recognised that the statistics are important for several stakeholders; for ASAC specifically, good quality statistics are important when, e.g., evaluating concrete questions such as the demand for and value of the high-frequency bands.

*Archive usage:* There is recognition that imaging capabilities have improved considerably since the early years of ALMA data processing, and that image data cubes in the archive are generally not optimal for science. With the increased usage of the archive, ASAC recommends that a clear statement be given in a highly visible location that reminds archive data users to be cautious of blindly adopting the archive imaging products (the recommendation for re-imaging is currently embedded in “Readme” files).

ASAC notes the plans for the development of the archive and the planned archive review, but very little detail was available at the meeting. Improving the archive capabilities is significant for ALMA’s scientific impact. In this context it is important to pay attention to the increased number of downloads from the archive and the high ratio of downloads of data products vs. raw data, e.g. the mean of science product downloads increased from 4 to 6.5 (i.e. by 60%) in the last year alone. ASAC would like to be informed of the results of the review and any development plans at the next face-to-face meeting.

*EOC and test data usage:* The community is aware that significant test data are obtained through the EOC activities and the question arises whether these will become available for the public as well. ASAC is informed that there is currently a policy being drafted regarding the release of test data for scientific usage. ASAC supports the ability to publish such data by JAO staff, in order that they can see direct benefit from the extensive efforts that they put into commissioning new capabilities, and strongly supports provision of an easier path for making such data publicly available where appropriate. This can only enhance the scientific productivity of ALMA. ASAC would appreciate the ability to comment on the policy when ready.<sup>1</sup> It is important that the data release policy be fair both to JAO staff and to the community in general: specifically, while easing the steps to public release, the policy should also recognize the need to make sure that the community does not feel that it is being “scooped” on major results, e.g., ALMA staff publishing test data from a single object should not raise such concern in most cases whereas publication of a survey from test data likely would.

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<sup>1</sup> JAO made the draft policy available to ASAC immediately after the face-to-face meeting and ASAC has subsequently provided comments. In general ASAC was strongly in favor of the new policy.

**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:*

- ASAC supports the changes to the review process being implemented for Cycle 7, including obscuring PI identification and increasing the number of review panels in order to reduce the workload of each reviewer.
- ASAC appreciates the Observatory's effort to check the font size to ensure a fair assessment process.
- ASAC expressed some concern about the fact that it is planned that only 18 out of 25 panel chairs will participate in the discussion of large programs, and discussed this with JAO.
- ASAC strongly supports the plan to poll all PIs of the Cycle 7 ACA supplemental call to assess how acceptable the DPR process is (from both PI and reviewer perspectives). For a fair comparison of the PIs' satisfaction with the outcome from the DPR process and the panel review of a regular call, ASAC advises JAO to develop a plan on how this can be achieved given that no users' survey is planned for Cycle 7.
- It is worth hearing how many new PIs joined from the Cycle 7 ACA supplemental call and how this differs from other calls. This will serve as one of the metrics of the effect of the DPR system.

*Cycle 7 proposal review:* ASAC reviewed the changes planned for the regular Cycle 7 review process. In particular, it supports the changes aimed at reducing potential biases (randomizing the investigator list and asking that the proposal be written to make it difficult to identify the PI in the Science Justification) and looks forward to seeing how this affects review outcomes. Further the checks on font size will ensure a fairer assessment process. ASAC discussed the plan to have only 18 out of the 25 panel chairs participate in the review of large programs. John Carpenter explained that it was felt that having all 25 chairs take part would be unwieldy, and that the 18 participating would probably be chosen with experience in mind (although balance by region, gender and topic must also be considered). While ASAC agrees that having too many people participate in the large-program review will be inefficient, there remains some concern within the committee as to how the community will perceive this, and how the excluded chairs will feel about it.

*Cycle 7 ACA supplemental call:* ASAC is strongly in favor of the planned survey of the PIs/reviewers' experience with the distributed peer review (DPR) process. ASAC is concerned that there is currently no clear plan for comparing PIs' relative satisfaction with the DPR review process compared to the APRC panel process, as no users' survey for Cycle 7 is foreseen and the data from the last users' survey after the Cycle 6 review is likely not sufficient for a direct comparison. Further, it cautions that it should be kept in mind that the supplemental call selects only rank C proposals which might be very different to the ones discussed in the regular Cycle 7 call where the 12m main array is offered. For the evaluation of the DPR process, ASAC is looking forward to see a rigorous statistical analysis of the ranking and outcome. In addition, it is worth investigating how many new PIs (including the fraction of students) participate in the Cycle 7 ACA supplemental call and how this number differs from other calls. Finally, ASAC is still in

favour of a side-by-side comparison of the DPR process and the panel review process -- either as part of the Cycle 7 ACA supplemental call or in Cycle 8.

*Large Programs:* ASAC appreciates that the Observatory is adding an explicit statement in the Proposer's Guide that in the management plan available computing resources should be discussed.

**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).**

No new issues were raised for this topic that are not covered elsewhere in the report.

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

*Recommendations:*

- ASAC endorses the proposed metric to balance broader receiver bandwidth against better receiver temperature, but the metric may need to be fine-tuned to the specific receiver band to which it is being applied. This fine-tuning should take into account the balance, for that particular band, between continuum/multi-tuning projects versus deep spectral-line/single-tuning projects.
- ASAC recommends that ALMA consider reviewing the current specifications for receiver noise, as they were set many years ago.
- ASAC recommends that the project publish an updated schedule for both the construction and the installation of the Band 1 receivers as soon as possible, in view of the delays in this project and public interest.
- ASAC strongly recommends that the new Observing Tool that is under development must have some kind of off-line mode so that it can be used when an internet connection is not available.
- ASAC recommends that the Observatory work towards storage of calibrated *uv*-data in the ALMA archive. In the short term, this could include calibrated data produced by the ARI-L project.
- ASAC recommends that data products delivered by the Large Programs should be stored in the ALMA archive rather than on a separate site.

ASAC was very pleased to see the exciting new technology development work that was highlighted in the reports from the three regions. The work on new mixers is especially impressive. ASAC congratulates the Observatory on completing the integrated alarm system. ASAC is pleased to learn of the success of the ALMA Phasing Project at Band 7. ASAC compliments the Observatory on setting up the system requirements project team with a focus on the front-end and digitizer systems and looks forward to seeing their report.

*Metric for receiver bandwidth versus system temperature:* The ASAC discussed the proposed metric to balance broader receiver bandwidths against better receiver temperatures, to be applied to future receiver

projects. ASAC finds that the proposed metric is reasonable when there is a rough balance between continuum and spectral-line projects, but that the metric should be fine-tuned to the specific receiver band to which it is being applied. This fine-tuning should take into account the balance, for that particular band, between continuum/multi-tuning projects versus deep single-tuning projects. In this analysis, recent experience with ALMA in the band or a nearby band should be used. For the specific case of the Band 2 receiver, ASAC feels that the scientific mix in Band 3 from recent cycles would be appropriate.

ASAC has two additional comments on the metric. (1) It would be interesting to quantify what penalty is paid in the extreme cases, e.g., how much more observing time does a single-tuning spectral-line project require due to the higher receiver temperature associated with a large-bandwidth receiver? (2) The team should consider whether some types of scientific studies are enabled by a particular choice, such as extremely faint but scientifically important spectral lines by low receiver noise, or wider bandwidth facilitating more archival science.

ASAC recommends that ALMA consider reviewing the current specifications for receiver noise, as they were set many years ago. For example, stricter noise specifications may now be appropriate at the higher frequencies. For Bands 1 and 2, ASAC notes that it is impossible to meet the original requirements, as the contribution of the optics to receiver temperature was not fully recognized when these requirements were written. So for these two bands, more relaxed requirements may be more appropriate.

*Band 1 receiver project:* ASAC heard that work continues on construction of the Band 1 receivers. Noting the community interest in Band 1 expressed at the workshop on October 2017, ASAC would like to see an updated schedule for both the construction and the installation of the Band 1 receivers published as soon as possible. The fact that the Band 1 installation has been a stop-start process does not give the community confidence in ALMA's ability to deliver all the promised new capabilities, and for the Band 1 team to demonstrate that they can keep to a schedule would provide reassurance.

*Correlator upgrade project (CUP-1):* ASAC was notified of a 6-month delay in the CUP-1 project and understands that this will affect the timing of the proposed commissioning plan, which was originally scheduled to overlap with the Cycle 10 February shutdown. ASAC looks forward to being consulted on the plans and schedule for the revised commissioning plan.

*Development of a new Observing Tool (OT):* ASAC was interested to hear of plans for development of a new observing tool. However, ASAC was extremely concerned to hear that the design as planned required a continuous connection to the internet in order for PIs to work on a proposal. ASAC feels strongly that the new OT must have some kind of off-line mode, as it would be unacceptable if a proposal under development could not be worked on without an internet connection. At a minimum, the ability to export the full proposal as a PDF is required; ideally, the ability to read in and make edits to the *.aot* file offline, even with reduced capabilities, is extremely helpful for less-experienced PIs such as students. This capability also provides robustness against temporary loss of internet connection at home or at work.

*ARI-L project:* ASAC was pleased to hear that data processing in the ARI-L project will start very shortly. ASAC is very pleased to hear that ARI-L will produce and store calibrated *uv*-data for at least 70% of

Cycle 2-4 projects. However, ASAC notes that it would be best if these calibrated visibility datasets could be stored in the archive rather than on a separate website (see next point). ASAC also recommends that individual elements of the ARI-L products (e.g. an image cube for a particular spectral window) should ideally be downloadable from the archive, as this will likely increase their usage.

*Calibrated uv-data in archive:* ASAC feels that storage of calibrated *uv*-data in the ALMA archive is an important resource for the community and would enhance the scientific productivity of ALMA. Such storage is particularly important because old versions of CASA, currently needed to reprocess older data, may not be accessible forever (e.g. the migration from Python 2 to Python 3 is a particular concern). ASAC is pleased to hear that the ALMA computing team is carrying out a costing exercise to understand what would be required to store all the calibrated *uv*-data in the ALMA archive and looks forward to seeing the results of this exercise.

*Large Program products in the ALMA archive:* ASAC feels strongly that the best long-term storage solution for the products delivered by large programs is the ALMA archive. However, ASAC heard that there has been some difficulty in implementing this due to resistance from large-program PIs, at least partly due to the archive requirement that the uid identifier be added to every product file name in order for ingestion to be possible. ASAC asks the Observatory to continue to look into solutions to enable such storage in the archive. ASAC heard that the ISOpT is working on a document with guidelines for Large Program PIs on deliverable data products and looks forward to seeing this document.

**Ad-hoc Charge #1. The ASAC should identify the main science cases that would require joint observing proposals between ALMA and other facilities, especially JWST.**

*Recommendations:*

- ASAC has identified a number of science use cases where joint observations clearly enhance the scientific return from both observatories, e.g., high-redshift galaxies, protoplanetary disks, transients and solar system objects.
- ASAC feels that programs that require simultaneous (e.g., solar system objects) or near-simultaneous (e.g., protoplanetary disk chemistry, transient such as GRBs or neutron-star mergers) observations should be given preference. ALMA observations of JWST targets that do not require simultaneity will remain possible after JWST ceases observing.
- ASAC discussed what fraction of time is appropriate for joint proposals: 5% appears to be a typical number for similar existing arrangements.
- ASAC recognizes the difficulties of implementing joint proposals, worsened by the combination of ALMA's configuration schedule and JWST's limited viewing range at any given time. A number of practical issues will need to be addressed before implementing such a joint proposal framework.

ASAC held further extensive discussions on this issue. ASAC recognizes the importance of taking advantage of JWST given its relatively short lifetime (nominally 5 years, of which 6 months will likely coincide with ALMA downtime for the CUP upgrade). The committee notes that 3 of the 4 top-level JWST science goals overlap with high-priority science for ALMA. High-redshift galaxies are an obvious

area of synergy, particularly between the MIR capabilities of JWST and the high-frequency capabilities of ALMA for probing their spectral energy distributions. In fact, some of the deep fields, like GOODS-S (which includes the Hubble Ultra Deep Field) and Hubble Frontier Fields, are scheduled to be observed using JWST via GTO and/or ERS programs, and these fields have already been intensively observed using ALMA to maximize the scientific returns by e.g., identifying unique distant galaxies which shall be followed-up by JWST. Investigating the stellar components of gravitationally-lensed high(est)-redshift galaxies with ALMA detections of metal lines (e.g., the [CII] 158  $\mu\text{m}$  and [OIII] 88  $\mu\text{m}$  lines) and/or dust emission is another compelling case. Similarly, observations of proto-planetary and circumstellar disks will benefit from data taken with both JWST and ALMA.

To these general considerations, we add the following specific examples of use cases:

- Time-critical events and sources, which include multi-wavelength follow-ups of (long- and short-) gamma-ray bursts, (typical and super-luminous) supernovae, AGNs, and tidal disruption events. Some of these cases may not require exactly simultaneous observations. ToO proposals will generally be needed for such unscheduled events, while others will require joint DDT proposals.
- Electromagnetic-wave follow-ups of gravitational-wave (GW) sources discovered with LIGO, VIRGO, and other near-future GW detectors, will also benefit from simultaneous observations using both ALMA and JWST, for such events where localization can be determined.
- The young stars that host proto-planetary disks often exhibit vigorous stellar activity, and there is increasing evidence that variable X-ray fluxes, for example, can affect chemistry and disk evolution, particularly in the inner disk. It is important to understand what impact this may have on planet formation, since it affects disk temperatures, structure, ionization levels and composition. Both time-variable illumination of the disk by a changing stellar spectrum and accretion nonuniformity can be traced by molecules such as  $\text{HCO}^+$ ,  $\text{H}_2\text{O}$  and  $\text{C}_2\text{H}_2$ . This is a compelling science case that would require synchronized ALMA (favoring outer-disk chemistry), JWST (for inner disk diagnostics such as  $\text{H}_2\text{O}$  and  $\text{C}_2\text{H}_2$ ), and ideally Chandra spectroscopy, since the light travel-time across the inner  $\sim 50$ -au-scale disk is only  $\sim 7$  hours.
- Solar system objects will require coordinated simultaneous measurements using both observatories since most targets are rotating with timescales of order days or less, and features (e.g., dust on Mars, outgassing by comets) are often time-variable as well.
- Near-simultaneous ALMA and JWST observations of exoplanets and exoplanetary systems will allow us to obtain a full picture of the circumstellar dynamics, and of the drag forces exerted on forming or growing planets. JWST will be sensitive to thermal radiation in the mid-infrared, while ALMA resolves cooler dust or dust structures comprised of larger dust grains, which are more indicative of dynamical perturbations by unseen planets, and thus the two observatories are very complementary for the science.

ASAC notes that there are also exciting ALMA-JWST synergy projects in the research fields of star formation, nearby galaxies, evolved stars, etc, etc. In order to keep the report at a reasonable length, ASAC is not elaborating on these as well.

Given the limited amount of time likely to be available for joint proposals, ASAC discussed whether it is appropriate to limit the scope of the joint proposal program, but decided against such a restriction.

However, ASAC feels that programs that require simultaneous (e.g., solar system objects) or near-simultaneous (e.g., protoplanetary disk chemistry, transients such as GRBs or neutron-star mergers) observations should be given preference for joint observing if the Board proceeds with that endeavour, since ALMA observations of JWST targets that do not require simultaneity will remain possible after JWST ceases observing.

ASAC also discussed a number of practical issues that will need to be addressed in implementing a joint proposal framework. There will be significant difficulties in scheduling and executing joint proposals that require simultaneous data thanks to the combination of ALMA's configuration schedule, ALMA weather and JWST's limited viewing range at any given time<sup>2</sup>. ALMA's configuration schedule is driven by the need to reconcile seasonal weather conditions, types of science that prefer particular configurations or bands, and the LST ranges of likely targets. Another issue for the joint proposal discussion is the expected fraction of time to be allocated to joint proposals. A typical number for other joint-proposal arrangements is ~5% of the observing time, just as many observatories appear to use ~5% of the observing time for DDT proposals and similar arrangements. Depending on the most popular science for joint proposals, one could end up with a situation where joint proposals could dominate the available time in one configuration.

ASAC reiterates that students and postdocs, in particular, will benefit from the certainty involved in having research that required both telescopes approved in a single proposal. Having such a joint proposal will also urge ALMA users to think more about how to exploit unique JWST capabilities.

### **ASAC feedback to the International Visiting Committee**

ASAC acknowledges the importance of providing a regular independent assessment of the ALMA project by an external international visiting committee (IVC), and welcomes the opportunity to provide input. The IVC has requested specific feedback on their Charges #1 (status of ALMA as compared to its original, level-one science goals), #3 (consistency of performance goals for the next 5 years with the mission of the Observatory) and #5 (appropriateness of the ALMA Development Vision to maintain ALMA as the state-of-the-art and world leading facility for mm/submm astronomy). ASAC has identified responsibilities and has set a rough timeline for preparing its response to the Visiting Committee on the three questions raised. On the same note, ASAC members will be glad to participate in the external committee visits at the different regional centers.

ASAC has already at hand the ALMA roadmap for 2030, which will allow it to address Charge #5. However, to produce a meaningful report and provide feedback on Charge #3 by April 26, ASAC requires access to the document listing the performance goals for the next 5 years (to be provided by the ALMA Deputy Director), hopefully no later than May 1.

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<sup>2</sup> In order to stay protected by the Sun shield, JWST can point at any given time in a 360° annulus covering solar elongations between 85° and 135°.

One point, mentioned earlier, that ASAC feels should be given weight by the Visiting Committee is the fact that the original assumption of all-year-round excellent weather conditions at the ALMA site does not accord with reality. Extreme weather conditions have now had a clear effect on ALMA operations for several successive years, and this impacts the Observatory's ability to meet all of its initial goals on the timeline and budget originally anticipated.