Doc 2.2, ver. 1.8 – October 2013

ALMA Cycle 2 Proposer's Guide

www.almascience.org

ALMA, an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile.

User Support:

For further information or to comment on this document, please contact your regional Helpdesk through the ALMA User Portal at **www.almascience.org**. Helpdesk tickets will be redirected automatically to the nearest ALMA Regional Center at ESO, NAOJ or NRAO.

Revision History:

Version	Date	Editors
0.1	August 2013	Gautier Mathys
0.2	August 29, 2013	Gautier Mathys
0.3	September 2, 2013	Gautier Mathys
0.4	September 4, 2013	Gautier Mathys
1.0	October 3, 2013	Gautier Mathys
1.1	October 5, 2013	Gautier Mathys
1.2	October 10, 2013	Gautier Mathys
1.3	October 11, 2013	EU ARC
1.5	October 14, 2013	Paola Andreani
1.6	October 23, 2013	Gautier Mathys
1.7	October 30, 2013	Gautier Mathys
1.8	October 31, 2013	Gautier Mathys

Contributors

Contributors' Logos

In publications, please refer to this document as:
G. Mathys, 2013, ALMA Cycle 2 Proposer's Guide, Version 1.8, ALMA

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1 Executive summary

The Joint ALMA Observatory invites proposals for Early Science observations (Cycle 2) of the Atacama Large Millimeter/submillimeter Array (ALMA). The purpose of Early Science is to deliver scientifically useful results to the astronomy community and to facilitate the ongoing characterization of ALMA systems and instrumentation as the capabilities of the Array continue to grow. Early Science will be conducted on a best-effort basis, with priority given to the completion of the full ALMA capabilities. Nonetheless, Early Science provides an important opportunity for first science from this cutting-edge facility. Early Science will continue until the full capabilities are commissioned.

In Early Science Cycle 2, ALMA will have the following capabilities: thirty-four 12-m antennas for interferometric observations, the Atacama Compact Array (ACA, aka Morita Array) composed of nine 7-m antennas for interferometric observations (7-m Array) and two 12-m antennas for single-dish observations (Total Power Array), receiver bands 3, 4, 6, 7, 8 and 9 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74 and 0.44 mm), array configurations with maximum baselines ranging from ~160 m to ~1.5 km (~1 km for Bands 8 and 9), single-field imaging and mosaics of up to 150 pointings, polarization capabilities, and a set of correlator modes that will allow both continuum and spectral line observations simultaneously. Solar observations will not be available in Cycle 2. Projects requiring detection of extended emission should consider requesting ACA observations..

ALMA Early Science Cycle 2 is expected to span 17 months, beginning June 1, 2014. It is anticipated that about 2000 hours of array time will be available for the highest priority projects, including those transferred from Cycle 1. Users of any professional background, nationality or affiliation may submit a proposal in response to the ALMA Early Science Cycle 2 Call for Proposals. Proposals will be assessed by peer review, and ranked on the basis of scientific merit and potential contribution to the advancement of scientific knowledge. High-frequency observations (upper Band 7 and Bands 8 and 9) will be harder to schedule than low-frequency observations (Bands 3, 4 and 6) due to fewer available hours of favorable weather conditions. A small fraction of proposals may be assigned a priority grade that qualifies them for carry-over to Cycle 3 if they cannot be fully completed by the end of Cycle 2.

ALMA staff will conduct quality assurance on ALMA data, and will provide processed data products through the respective ALMA Regional Centers (ARCs). Principal Investigators (PIs) and observing teams may need to invest their own time and expertise to ensure that the data products are of the appropriate quality and to re-reduce the raw data if the quality is not satisfactory. This may include the need to visit the relevant ARC or ARC node to get help and to assist with quality assurance and potential data re-reduction.

2 Invitation for ALMA Early Science Cycle 2 proposals

The Joint ALMA Observatory (JAO) invites members of the astronomical community to submit proposals for Early Science observations with ALMA. Successful projects are expected to be executed between June 1, 2014 and October 31, 2015. The purpose of Early Science is to deliver scientifically useful data to the astronomical community and to facilitate the ongoing characterization of ALMA systems and instrumentation as the capability of the array continues to grow.

Proposals for ALMA are prepared and submitted using the ALMA Observing Tool (hereafter OT; Section 6.1). The OT is available for download from the ALMA Science Portal (*www.almascience.org*). ALMA Cycle 2 proposal submission will open at:

15:00 UT on October 24, 2013

The Cycle 2 proposal submission deadline is:

15:00 UT on December 5, 2013

It is the proposers' responsibility to convert the UT time of the proposal submission deadline to their local time zone.

Table 1 summarizes the important dates and milestones of Cycle 2. ALMA reserves the right to alter the given dates, should it become necessary to do so.

Date	Milestone
24 October 2013	Release of Cycle 2 Call for Proposals, Observing Tool & supporting documents
24 October 2013	Opening of the Archive for proposal submission
5 December 2013 (15:00 UT)	Proposal submission deadline
April 2014	Announcement of the outcome of the Proposal Review Process
1 June 2014	Start of ALMA Cycle 2 Science Observations
31 October 2015	End of ALMA Cycle 2

Table 1. The ALMA Cycle 2 timeline.

3 Overview

3.1 ALMA

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC), and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan.

ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI), and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction and operation of ALMA.

3.2 *The ALMA telescope on Chajnantor*

At full operational capability, ALMA will be composed of 66 high-precision antennas. Fifty of these antennas will be 12-meter dishes in the 12-m Array, used for sensitive, high-resolution imaging. These will be complemented by the Atacama Compact Array (ACA), composed of twelve closely spaced 7-meter antennas (7-m Array), and four 12-meter antennas for single-dish observations (Total Power Array), to enhance wide-field imaging. The wavelengths covered by ALMA will range from 0.3 mm to 3.6 mm (frequency coverage of 84 GHz to 950 GHz).

The Array is located on the Chajnantor plain of the Chilean Andes, a site that offers the exceptionally dry and clear sky conditions required to operate at millimeter and submillimeter wavelengths. The ALMA antennas, weather stations, the two correlators and their computer interfaces, Local Oscillator generation hardware, timekeeping hardware, and the related Array Real-Time Machine computer are all located at the 5000-meter site referred to as the Array Operations Site (AOS). This site is connected via Gigabit fiber links to the Operation Support Facility (OSF), located at an altitude of 2900 meters, not far from the town of San Pedro de Atacama. Science operations will be conducted from the OSF and coordinated from the JAO Central Office in Santiago.

ALMA is located at **latitude = –23.029°**, **longitude = –67.755°**. Targets as far north as declination +40°, corresponding to a maximum source elevation at Chajnantor of ~25°, can in principle be observed from the ALMA site, but shadowing by adjacent antennas becomes an increasing problem at low elevations. The imaging capability, as well as the time on source, will necessarily be limited for such northern sources, especially at the higher frequencies. Shadowing depends on the antenna configuration. Given the short baselines in the ACA configuration, sources with declinations less than −60° or greater than +20° will be subject to significant shadowing. For the 12-meter array, shadowing becomes significant (> 5 %) in the most compact configuration for sources with declination lower than −75° or higher than +25°. For more details, see the Section 7.2 of the Technical Handbook.

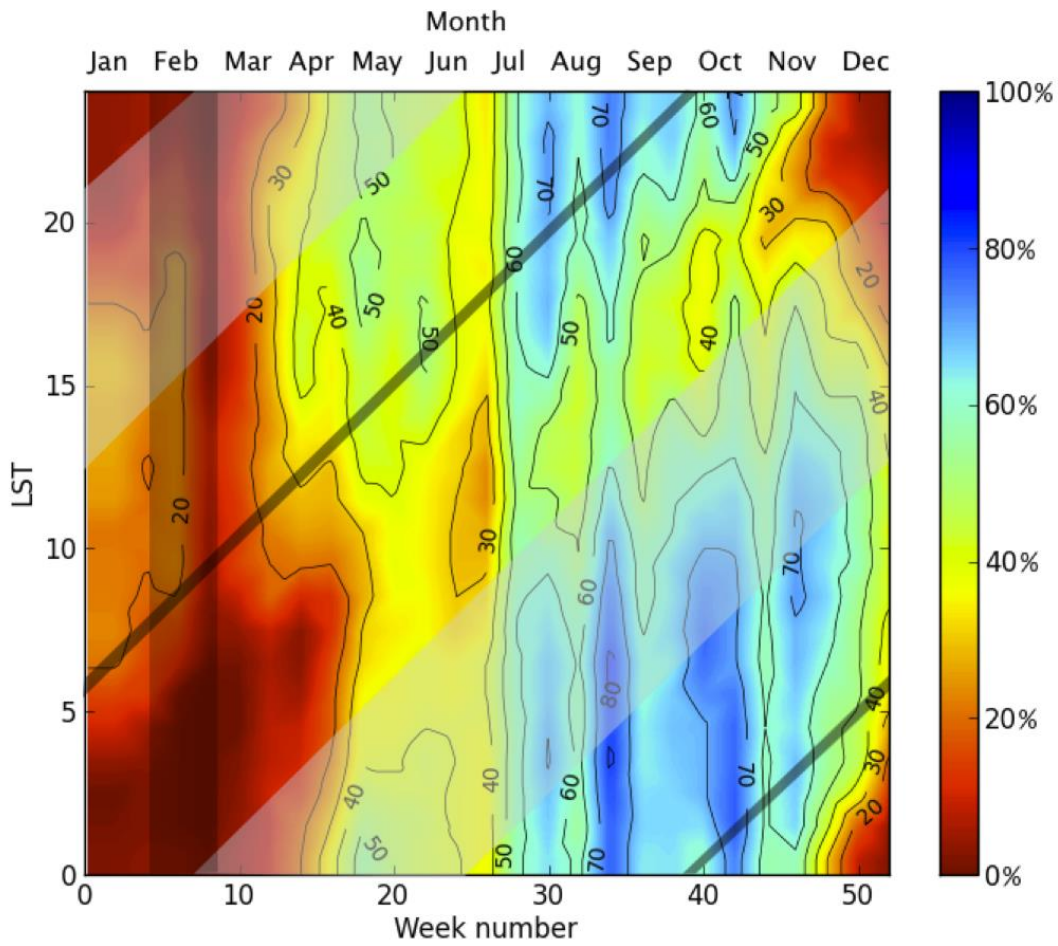

Figure 1. The percentage of time when the Precipitable Water Vapour (PWV) is below 1 mm as a function of Local Sidereal Time (LST) and week number beginning with January 1. Red identifies epochs with very little time available at low PWV and therefore less suitable for high frequency observing, while blue corresponds to epochs with a large fraction of time available at low PWV. The data were obtained with the APEX radiometer over the years 2007-2011 (5 years). The thin dark grey lines show local midnight, and the thick light grey bands show the ALMA engineering time, which normally is unavailable for Early Science observations.

The atmosphere above Chajnantor is one of the best in the world for ground-based observation in the (sub)millimeter wavelength range (Evans et al 2002, ALMA Memo No. 471, available at http://www.alma.cl/almamemos/). However, both the opacity (primarily determined by the amount of Precipitable Water Vapor – PWV) and the phase stability of the atmosphere limit when ALMA can be used at certain frequencies, in particular in the higher-frequency bands and at frequencies near water absorption lines. Both transmission and phase stability follow a yearly cycle (late southern winter is best – see Figures 2 and 4 of Memo 471) and a diurnal cycle (late night and early morning are best – see Figures 3 and 5 of Memo 471). These cycles are illustrated in Figure 1, which shows the fraction of the year when the PWV is below 1 mm. Red and blue colors represent low and high probability of good weather, respectively. Regular weather patterns are subject to both short (daily weather patterns) and longer cycles (years; the El Niño Southern Oscillation may be important). During parts of the year, such as a large fraction of the Altiplanic winter[1] season (January-March), it may be difficult to carry out submillimeter observations. In addition to the transmission and phase stability criteria, low wind speeds and night, or early morning, observing times are required for optimum observing conditions.

Table 2 gives the fraction of time in Cycle 2 that is expected to be useful for observing in each band, given the limitations above, excluding complete shutdowns due to excessive wind and to precipitation. This table provides an indication of the limited amount of observing time at the higher frequencies that can be allocated in Cycle 2. However, it should be pointed out that there are large variations within each band. For example, it is as difficult to conduct observations in the upper Band 7 wavelength range as in the central Band 9 wavelength range[2].

ALMA Band	Band 3	Band 4	Band 6	Band 7	Band 8	Band 9
Fraction of time	100%	90%	70%	40%	20%	10%

Table 2. Estimated maximum fraction of observing time suitable for observations in each band in Cycle 2, excluding total weather shutdowns. These estimates are based on 1998-2011 atmospheric transmission statistics from the ALMA Site Characterization and Monitoring program and APEX radiometer in combination with the ALMA Cycle 0 experience from October 2011 to March 2012.

Because of these factors, the actual time to reach a given signal to noise on a target depends on the prevailing conditions when the project is observed. The ALMA OT is designed so that investigators request a given sensitivity to reach a particular Science Goal (see Section 6.1). The OT calculates an estimated execution time to reach the specified sensitivity, based on the radiometer equation, anticipated calibration overheads, the nominal Cycle 2 capabilities (number of antennas, etc.) and default observing conditions (see documentation for the ALMA Sensitivity Calculation in Section 9.2 of the **ALMA Cycle 2 Technical Handbook**). Proposers do not need to anticipate weather conditions when writing their proposals. The Observatory will strive to schedule the observations during appropriate weather conditions.

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3.3 The Joint ALMA Observatory and the ALMA Regional Centers

The Joint ALMA Observatory (JAO) is responsible for the overall leadership and management of construction and operations of ALMA in Chile. The Santiago Central Office (SCO) houses the Director's Office and its associated functional units, as well as astronomers, technicians and administrative staff.

[1] During southern summer, the high-pressure system over the Pacific Ocean weakens and moves southwards, allowing warm humid air from the Amazones to flow over the Andes into northern Chile, causing rain and occasionally snow to fall on the usually dry Altiplano: this phenomenon is known as Altiplanic winter.

[2] To see how the atmospheric transmission varies with frequency, go to http://almascience.org/about-alma/weather/atmosphere-model.

The SCO also hosts the ALMA main archive (referred to in the rest of this document as the Archive). The JAO solicits proposals to observe with ALMA through Calls for Proposals and organizes the peer review of the proposals by science experts. In addition, the JAO schedules all science observations and places the data in the electronically accessible ALMA Archive.

The three ALMA regional partners (Executives) maintain ALMA Regional Centers (ARCs) within their respective region. The ARCs provide the interface between the ALMA project and its user communities. The ARCs are responsible for user support, mainly in the areas of proposal preparation, observation preparation, acquisition of data through the Archive, data reduction, data analysis, delivery of data, visitor support and workshops/schools. Each ARC operates an archive that is a mirror of the SCO main archive. Browsing and data mining are done through the ARC mirror archives.

The East Asian ARC (EA ARC) is based at the National Astronomical Observatory of Japan headquarters in Tokyo. It is operated in collaboration with Academia Sinica Institute of Astronomy and Astrophysics (Taiwan), and supports the astronomy communities of Japan, Taiwan and South Korea.

European researchers are supported by the European ARC (EU ARC). It is organized as a coordinated network of scientific support nodes distributed across Europe. The EU ARC is located at ESO Headquarters in Garching bei München (Germany) and is responsible for all core ARC activities. Additional support is provided by the regional nodes. There are currently seven regional nodes: Bonn-Bochum-Cologne (Germany), Bologna (Italy), Onsala (Sweden), IRAM, Grenoble (France), Allegro, Leiden (The Netherlands), Manchester (United Kingdom) and Ondřejov (Czech Republic).

The North American ARC (NA ARC) is contained within the North American ALMA Science Center (NAASC), based at NRAO headquarters in Charlottesville, VA, USA. It is operated in collaboration with the National Research Council of Canada (Canada) and in collaboration with the Academia Sinica Institute of Astronomy and Astrophysics and the National Science Council of Taiwan (Taiwan), and supports the astronomical communities of North America and Taiwan..

3.4 ALMA proposal eligibility

Users of any professional background, nationality or affiliation may submit ALMA proposals. This includes students, postdoctoral researchers, or non-professionals. Each proposal must identify a single individual who will serve as Principal Investigator (PI). The PI will act as the official contact between ALMA and the proposing team for all correspondence related to the proposal. By submitting a proposal, the PI takes full responsibility for its contents, in particular with regard to the names of the Co-Investigators (Co-Is) and the agreement to act according to the ALMA policies and rules, including the conditions specified in the present Proposer's Guide. He/she also acknowledges and accepts the limitations of the capabilities and the operational restrictions spelled out in the other documents listed in Section 4.2. The PI will be responsible for the scientific and administrative conduct of the project. Proposals shall be submitted only by the PI, not by Co-Is. There is no limit to the number of Co-Is who may appear on a proposal.

All PIs and Co-Is must be registered with the ALMA Science Portal (see Section 4.1).

The main guiding principle in the assignment of observing priorities is to optimize the scientific impact of ALMA. Observing priority assignment will be based on scientific merit, taking into account the expected availability of resources while attempting to ensure that each region receives its share of the time, that is:

- 22.5% for East Asia (EA);
- 33.75% for Europe (EU);
- 33.75% for North America (NA);
- 10% for Chile.

Balancing across regions will be based on the actual execution time of the 12-m Array observations. Successful projects will have their observing time assigned to the region of the PI, which is defined as the region to which the organization that employs the PI belongs, or as the region of residence for unaffiliated PIs. If a PI has access to ALMA through two regions (e.g. due to a joint appointment at organizations in different regions), the PI may select either as his/her affiliation. Users from Taiwan (which is affiliated with both EA and NA) will be able to select either an EA, NA or combined EA/NA affiliation (with 50% of the time accounted to each region) in the OT on a proposal-by-proposal basis.

ALMA proposals may also be submitted by PIs whose affiliation does not lie within any ALMA Executive's region. Such proposals are referred to as "Open Skies" proposals.

ALMA policies prohibit multiple submissions of the same proposal using different Executive affiliations. If such proposals are detected, the first submitted version will be considered and the remaining proposals ignored.

4 Resources

4.1 The ALMA Science Portal

The ALMA Science Portal is the primary access point for science users to ALMA. It is intended to provide a one-stop access gateway to all ALMA web resources, documents and tools relevant to users for proposal preparation, proposal assessment, project tracking, project data access and data retrieval, as well as access to the ALMA Helpdesk (see Section 4.3).

Any user has access to:

- User registration;
- The Call for Proposals and related documents and tools;
- Tables explaining ALMA technical capabilities (sensitivity, frequency coverage, available observing modes, etc.);
- Download of the Observing Tool (OT);
- Helpdesk "knowledgebase" articles listing solutions to common questions and problems;
- Archive access to non-proprietary data ;
- All official ALMA user documentation and some software tools, including the ALMA Sensitivity Calculator, observing simulators, the spectral line database Splatalogue, etc.

In addition, registered users may:

- Submit or be Co-I on ALMA proposals;
- Manage their user profile;
- Access the Project Tracker to monitor the status of the user's scheduled observing projects;

- Submit Helpdesk tickets;
- Access their proprietary data through the science archive.

To ensure full-time availability, there are three instances of the Science Portal, one at each ARC. Users may access any of them via a common entry point, at *http://www.almascience.org.*

The Science Portal also includes links to the local ARC webpages from which users can access local information and specific services of each ARC, such as local visitor and student programs, schools, workshops, and outreach materials and activities.

4.2 Documentation

The following documents are relevant for Early Science and submission of Cycle 2 proposals. All of them can be accessed via the ALMA Science Portal. The Science Portal hosts the Road Map (http://almascience.org/proposing/road-map) that leads users through the successive steps involved in the preparation and submission of an ALMA observing proposal and includes pointers to the relevant documents and sources of additional information.

4.2.1 The Call for Proposals

The **ALMA Cycle 2 Call for Proposals** is published on the Science Portal. It contains a short description of the ALMA capabilities, deadlines and limitations specific to Cycle 2. Full details are available in the documents accompanying the Call for Proposals, which are briefly described below.

The **ALMA Cycle 2 Proposer's Guide** (this document) presents the overall directions and guidelines for proposers, with an overview of the proposal review procedures, of the Cycle 2 capabilities, and of the applicable policies.

The **ALMA Cycle 2 Technical Handbook** describes the more technical aspects of ALMA during Cycle 2, including receiver characteristics, array configurations, available observing modes and correlator setups, and the basis of the OT time estimates.

4.2.2 The Observing Tool documentation

The ALMA Observing Tool (OT) is the proposal preparation and submission (Phase 1) software application; the OT is also used for observation preparation (Phase 2). The OT documentation provides all the basic information required to complete the steps of proposal preparation and submission. It includes:

- The **OT Phase 1 Quickstart Guide**: A guide to proposal preparation for the novice ALMA OT user. It provides an overview of the necessary steps to create an ALMA Observing Proposal.
- The **OT Video Tutorials**: A visual demonstration of proposal preparation and submission with the OT.
- The **OT User Manual**: This manual is intended for all ALMA users, from novices to experienced users. It provides comprehensive information about how to create valid Phase 1 proposals and Phase 2 programs for observing astronomical objects. It is also included as part of the "Help" documentation within the OT application itself.

- The **OT Reference Manual**: This manual provides a more concise explanation for all the fields and menu items in the OT. It is also included as part of the "Help" documentation within the OT application itself.

OT installation requirements are available from the OT trouble-shooting page, which is accessed from the ALMA Science Portal. The known OT issues page lists currently known bugs, their status and possible workarounds.

4.2.3 The ALMA Regional Center Guides

The ARC Guides contain user support details specific to each ALMA regional partner. They are:

- The **East-Asian ARC Guide**;
- The **European ARC Guide**;
- The **North American ARC Guide**.

4.2.4 Proposal preparation utilities

There are two tools to help users to produce simulated images of simple or user-provided science targets.

The first is integrated into **CASA** (Common Astronomy Software Applications), the offline data reduction and analysis tool for ALMA data. CASA includes the tasks "simobserve" and "simanalyze", which generate simulated ALMA data and make images from the simulations. An additional CASA task, "simalma", simplifies the process of combining data from multiple arrays. These CASA tools require configuration files that specify the outlay of ALMA antennas. Files for Cycle 2 configurations are available at the Science Portal. A guide for simulating ALMA observations with CASA is available at *http://casaguides.nrao.edu/index.php?title=Guide_To_Simulating_ALMA_Data*. Additional information on CASA, including hardware requirements and download instructions, is available at *http://casa.nrao.edu*.

The second tool for simulating ALMA observations is the **ALMA Observation Support Tool** (OST). The OST uses a simplified web interface to help users generate ALMA simulations. Users submit jobs to the OST and are notified by email when the simulations are completed. The OST is also described at *http://casaguides.nrao.edu/index.php?title=Guide_To_Simulating_ALMA_Data*, and full documentation is available at *http://almaost.jb.man.ac.uk/help*.

Splatalogue is a database containing frequencies of atomic and molecular transitions emitting in the radio through submillimeter wavelength range. This database is used by the ALMA OT for spectral line selection. To learn more about it, see the Splatalogue QuickStart Guide on the Science Portal.

Atmospheric Transmission at Chajnantor can be reviewed with the atmosphere-model tool, which allows the user to model the atmospheric transmission as a function of frequency and amount of precipitable water vapor. The output is a plot of the transmission fraction as a function of frequency. Up to six different water vapor contents can be selected.

4.2.5 Other documents

Observing with ALMA: A Primer for Early Science is a brief introduction to ALMA observing, to (sub)millimeter terminology, and to interferometric techniques, which should prove useful for investigators who are new to radio astronomy. Several example science projects illustrating the Cycle 2 capabilities are also provided.

The **ALMA Memo Series** is a series of technical reports regarding various aspects of the ALMA project development and construction.

4.3 The ALMA Helpdesk

The ALMA Helpdesk is accessed from the ALMA Science Portal or directly at *http://help.almascience.org*. Submitted tickets are directed to support staff at one of the ARCs, who are available to answer any question relating to ALMA, including ALMA policies, capabilities, documentation, proposal preparation, the OT, Splatalogue, CASA, etc. Users may also request information on workshops, tutorials, or about visiting an ARC or ARC node for assistance with data reduction and analysis. Users must be registered at the ALMA Science Portal to submit a Helpdesk ticket. As a rule, ALMA staff aims to answer Helpdesk tickets within two working days.

The Helpdesk includes a "knowledgebase feature", which is a database of answered questions or "articles" on all aspects of ALMA and is also available to unauthenticated users. Users should search the knowledgebase to find answers to common queries without submitting a Helpdesk ticket. Matching knowledgebase articles are automatically suggested to users as they type in a query.

5 Cycle 2 general information and policies

5.1 Introduction and policies

Cycle 2 will have a duration of 17 months. It is expected to start on June 1, 2014 and finish on October 31, 2015.

The ALMA capabilities during Cycle 2 will be limited compared to those of the completed array. The time available after engineering activities will be shared between observations and execution of tasks associated with optimization and further development of the Array. About 2000 hours of 12-m Array time are available for Cycle 2. They will be allocated to the highest priority Cycle 2 projects and the highest priority projects transferred from Cycle 1. Science observations will be executed by ALMA operations staff, taking into account (in rough order of priority): the weather conditions, the configuration of the array, target elevation and other practical constraints, the projects' assigned priority group, and executive balance. All other things being equal, the project with the highest scientific rank will be observed.

Cycle 2 observations will be scheduled during blocks of about 10 days, with 16 hours daily of observing time, mainly during nighttime. All Cycle 2 Early Science observing will be conducted on a best effort basis.

ALMA staff will conduct quality assurance on ALMA data, and will provide processed data products through the respective ARCs. However, it cannot be guaranteed that the characterization and quality of the data and data reduction will meet the standards expected when ALMA becomes fully operational. Experience in radio (in particular, millimeter) interferometry, though not considered by the review panels, will be an advantage in working with ALMA Early Science data products, particularly for projects that include Band 9 or ACA components. PIs and observing teams should anticipate the need to invest their own time and expertise to assure the quality of the provided data products and to re-reduce the raw data if the quality of the data products is not satisfactory. This may include the need to visit the relevant ARC or ARC node to get help and to assist with quality assurance and potential data re-reduction.

A small fraction of Cycle 2 proposals may be assigned a priority grade that qualifies them for carry-over to Cycle 3 if they cannot be fully completed by end of the cycle (see Section 7.1).

5.2 Summary of Cycle 2 capabilities and limitations

The Cycle 2 capabilities are described in Appendix A. In summary they are:

- Thirty-four 12-m antennas in the 12-m Array, and nine 7-m antennas (for short baselines) and two 12-m antennas (for making single-dish maps) in the Atacama Compact Array (ACA);
- Receiver bands 3 (wavelength range: 2.6–3.6 mm), 4 (1.8–2.4 mm), 6 (1.1–1.4 mm), 7 (0.80–1.09 mm), 8 (0.60–0.78 mm), and 9 (0.42–0.50 mm);
- Both single field interferometry and mosaics;
- Spectral--line observations with all Arrays (except Band 9 with the TP Array) and continuum observations with the 12-m Array and the 7-m Array;
- Polarization (on-axis, continuum, selected frequencies in Bands 3, 6 and 7, no ACA, no mosaics);
- Mixed correlator modes (both high and low frequency resolution in the same observation);
- Baselines up to 1 km for Bands 8 and 9 (angular resolution of 0.09” at 650 GHz);
- Baselines up to 1.5 km for Bands 3, 4, 6, and 7 (angular resolution of 0.13” at 345 GHz);
- The maximum observing time per proposal, as estimated by the OT, is 100 hours.

ACA observations are only available to complement 12-m Array observations, and are restricted to projects requiring detection of extended emission.

As much as one-third of the 12-m Array time will be available for observations that require both the 12-m Array and the ACA (which can be operated concurrently). This fraction is based on the expectation that 2000 hours of ACA will be available for Cycle 2 science observing, and the fact that for Cycle 2 the OT allocates four times as much time on the TP Array and two times as much on the 7-m Array as is needed for the corresponding 12-m Array observations (see Appendix Section A.4). Proposers should note that, due to this restriction, it is possible that a proposal ranking high enough to be schedulable within the 2000 hours of available 12-m Array time may fall below the cutoff for the available ACA time, and therefore will not be scheduled on either array. This situation did not occur in Cycle 1, however, since the requested number of ACA hours was smaller than that available. Note that observers cannot apply to use the ACA separately from the 12-m Array.

Note that the 12-m Array time and the ACA time are computed separately. The ACA time estimate is based on the TP Array time if TP observations are requested, or on the 7-m Array time otherwise (see Appendix Section A.5). The 100-hour proposal limit applies to the sum of the 12-m Array time and of the ACA time. The total observing time is reported by the OT on the summary page. Observers who request an amount of observing time different from that estimated by the OT (see Section 6.3) must still adhere to the 100 hour maximum.

For each Science Goal (see Section 6.1), users will specify a desired angular resolution and the source Largest Angular Structure. Acceptable values span the ranges available from the Cycle 2 configurations (see Section A.3 in Appendix A). ALMA operations staff will aim to obtain the requested resolution using observations from either a single 12-m Array configuration, or a pair of such configurations (one compact, the other extended). The time of year and time spent in each configuration will be planned to meet the scientific demand as much as possible given the anticipated weather conditions (Figure 1). The scientific demand will be based on the number of Science Goals requesting a given set of angular resolutions, sensitivities, and Largest Angular Structures that have to be recovered.

5.3 Proposal types

Standard, Target of Opportunity (ToO) and Director Discretionary Time (DDT) Proposals will be accepted for Cycle 2. The review process of Standard and ToO Proposals is described in Section 7.[3]

5.3.1 Standard Proposals

Standard Proposals deal with observations that can be fully specified by the regular proposal submission deadline, and whose estimated execution time does not exceed 100 hours. Most proposals belong to this type.

Standard Proposals may involve time-critical, multiple-epoch observations, and continuous monitoring of a target over a fixed time interval (rather than to achieve a given sensitivity), but their execution is restricted to the time slots reserved for Cycle 2 science observations. Therefore proposals with an execution time tolerance of less than 2 weeks cannot be guaranteed and may be rejected on technical grounds, even though they validate in the OT. This should not prevent observations of recurring phenomena with predictable times (such as, say, maximum elongations of planetary satellites), as long as their occurrences are spread over a sufficiently wide fraction of the Cycle 2 observing period and as long as the number of epochs that need to be observed remains relatively small with respect to the total number of suitable epochs across the Cycle (i.e., there are several possible time slots for each observation). Any special timing constraints (e.g. observations that once started need to be continued for a set amount of time or executed with a fixed cadence) must be fully justified.

5.3.2 ToO Proposals

ToO Proposals should be submitted to observe targets that can be anticipated but not specified in detail. Like Standard Proposals, these proposals must be submitted by the Cycle 2 proposal deadline. While the target list may be left unspecified, observing modes and sensitivity requests must be specified in detail for ToO observations. Associated with these observations there must be a clear indication of the number of triggers needed to reach the science goals of the proposal, what the trigger will be for the actual observation to be performed, and the necessary reaction time for scheduling the observation after it is triggered.

Highest priority ToO proposals will be executed during the time reserved for Cycle 2 Science Observations, and as a rule, engineering activities and activities associated with the optimization and

[3] For DDT Proposals, see http://www.almascience.org/proposing/ddt-proposals.

further development of the Array will not be interrupted to carry out ToO observations. Restrictions on triggering time are given in Section A9.

During Cycle 2, PIs will trigger observations from accepted ToO Proposals through a web form available at the ALMA Science Portal.

5.3.3 DDT Proposals

DDT Proposals may be submitted at any time during Cycle 2, for implementation during this cycle. They must be submitted using a special version of the Observing Tool, available from the Science Portal after the start of Cycle 2 observing. They must belong to one of the following categories:

- Proposals requiring the immediate observation of a sudden and *unexpected* astronomical event ("immediate" should be understood as within a period of 2 weeks following their approval: the same time tolerance restriction applies to DDT Proposals as to Standard and ToO Proposals);

- Proposals requesting observations on a highly competitive scientific topic, motivated by developments that have taken place after the regular proposal submission deadline;

- Proposals asking for follow-up observations of a program recently conducted with ALMA or any other observing facility, where a quick implementation is expected to provide breakthrough results.

DDT Proposals will be approved for execution by the ALMA Director, based on the advice of a small Standing Review Committee, with members from the JAO and the four regions, appointed by the Executive Directors and Chile. In exceptional cases, the ALMA Director may approve projects that would benefit from a very rapid response, and inform the Standing Committee of this decision within 24 hours (but note the time tolerance restriction for Cycle 2 specified above). The science assessment of DDT Proposals will be based on the same criteria as for Standard and ToO Proposals (see Sect. 7.1).

Given the limited amount of time available in Cycle 2 and the expected heavy oversubscription of this time by standard proposals, DDT Proposals are likely to be approved only if their science case is exceptionally strong, especially if they are not related to the observation of a sudden and unexpected astronomical event.

In Cycle 2, a maximum of 5% of the total time available for observations may be dedicated to the execution of DDT projects.

5.4 Science categories

Cycle 2 proposals will be assigned to one of five science categories:

1. Cosmology and the high redshift universe
2. Galaxies and galactic nuclei
3. ISM, star formation and astrochemistry
4. Circumstellar disks, exoplanets and the solar system
5. Stellar evolution and the Sun

Category information is used to distribute the proposals for review to the most qualified assessors. The proposers select the category to which their proposal is assigned, but this selection may be modified by the JAO if another category is judged to better describe the science of the proposal.

Cycle 2 proposers must further specify the area of investigation to which their project pertains by selecting in the OT at least one and at most two keywords from the list in Appendix C.

6 Proposal preparation and submission: Phase 1

6.1 The Observing Tool

The ALMA Observing Tool is used for proposal preparation and submission ("Phase 1") and later for detailed planning of observations on the telescope ("Phase 2"). The OT is a Java-based application (client) that resides and runs on the user's computer and interacts with the ALMA Archive and other databases over the Internet. Anyone can download and use the OT, but only registered ALMA users are able to submit or be Co-Is on ALMA proposals. Users should consult the OT trouble-shooting page for system requirements and the list of known OT issues (cf. Section 4.2.2).

During proposal preparation, the OT is used to specify the details of the proposed observations. The user uploads the Science Justification as a single PDF file through the OT interface. The user also expresses intended scientific goals as a series of specialized OT constructs called Science Goals, and then specifies target coordinates and mapping field parameters, line frequencies and correlator bandwidths, desired sensitivities, etc. As of Cycle 2, the Technical Justification (see Section 6.3), which in previous cycles was included in the uploaded PDF together with the Science Justification, must be entered in the OT on a per Science Goal basis. The OT interprets the user's inputs to establish which resources (e.g., configurations of antennas) are required, and to make an estimate of how much observing time (including calibration and observing overheads) is needed.

In simple cases, a single Science Goal may encompass the entire scientific purpose of a proposal. However, due to various restrictions, multiple Science Goals will often be necessary. For example, multiple sources can only go into the same Science Goal if they share the same performance requirements (resolution, sensitivity, etc.) and observing frequencies, and are close enough on the sky that they can share the same phase calibrator. The OT will warn the user if the settings do not conform to the various restrictions, and will note parameter choices that require extra technical justification. Details of the various restrictions that are enforced by the OT are given in Appendix A.

The OT allows users to design observations according to Cycle 2 capabilities. Visual editors show target positions and mapping regions, and spectral editors display the available frequency range against the backdrop of the atmospheric opacity. While a proposal is being prepared, it can be exported to and recalled from the local disk. Once the proposal is validated within the OT, it can be submitted to the ALMA Archive. Note that the proposal can be resubmitted by the Principal Investigator as many times as needed before the proposal deadline. This does not apply for DDT proposals, for which the first submission is final. Resubmitted proposals overwrite previous versions.

6.2 General guidelines for writing a proposal

ALMA Cycle 2 proposals must be written in English and include the following sections:

1. Science case;
2. Figures, tables and references (optional);
3. A brief statement on the likely potential for publicity (e.g. images, press releases etc.) arising from the proposed scientific observations.

These sections shall be submitted as a single PDF document. **The total length of this document is limited to 4 pages** (A4 or US Letter format), with a font size no smaller than 11 points. Proposers are free to adjust the length of the various proposal sections within this overall length limit. The recommended breakdown is 2 pages for the science case and 2 pages for figures, tables, references and publicity statement. Figures and tables may be interleaved with the science case, so that e.g. figures appear close to the location in the text where references are made to them. Although the Technical Justification for each Science Goal is entered in the OT, any figure required for it still needs to be placed in the Science Justification PDF document. Users are encouraged to use the LaTeX template developed by ALMA for preparation of their proposals.

A file size limit of 20 MB will be enforced at submission. Accordingly, extremely large or complex figures may not be acceptable. Proposals must be self-contained. Their assessment will be based solely on their explicit contents, to the exclusion of external references such as personal webpages. Reference can be made to published papers (including astro-ph preprints), as per standard practice in the scientific literature. Consultation of those references should not, however, be required for understanding the proposal.

6.2.1 Science case

Each proposal must describe the astronomical importance of the proposed project and include a clear statement of its immediate observing goals. Since the proposal review panels will be encouraged to consider favorably proposals that best demonstrate and exploit the advertised ALMA Early Science Cycle 2 capabilities, producing scientifically worthwhile results from relatively short observations (averaging a few hours), the science case should address this aspect. Additionally, it should explain how the expected intensity of the target source(s) was estimated and justify the Signal-to-Noise (S/N) ratio required to achieve the scientific objectives of the project as well as, when appropriate, the size of the target sample.

Proposers can simulate ALMA observations using different array components and configurations (see Section 4.2.4). Simulations are not required. However, if they are discussed in a proposal to justify any technical aspects of an observation, their results (i.e., images and simulation details) should be included in the science case and in the relevant Technical Justification.

Proposers should keep in mind that the topical ALMA Review Panels span a wide range of scientific areas. Therefore, proposals should be written for an expert, but broad-based, astronomy audience.

6.2.2 Figures, tables, and references

Figures, tables, and references that support the science case and the Technical Justification may be included. Figure captions, tables and references may be listed in 10-point font and, together with the science case, they must fit within the overall 4-page length and 20 MB size limits of the PDF proposal.

6.2.3 Opportunities for public promotion of ALMA

Opportunities for public and media interest in ALMA science will be very important during Early Science Cycle 2. Proposers are requested to consider the potential media appeal of proposed observations, with regard to scientific content and/or the quality of the visuals that could be produced. Each proposal must include a brief statement on the likely potential for publicity arising from the proposed scientific observations. The statement must fit within the overall 4-page limit of the PDF proposal. This information will not be used in the assessment of the proposal, which will be based solely on scientific merit and technical feasibility.

In the event that a Cycle 2 proposal is successful and is selected for publicity activities, the ALMA Education and Public Outreach (EPO) team will work with the PI to develop materials for presentation to the media and the public (e.g. press releases), including support in the preparation of visuals if relevant. EPO may ask for cooperation on the scientific content and for the PI to be available for possible interviews. Furthermore, the PI will be asked to agree to inform the ALMA EPO team if he/she is planning a press release or similar media interaction (for example through the PI's own institution's press office). ALMA requests that PIs do this at the start of the process, to allow for sufficient time to assess the news story and provide assistance to PIs as appropriate. The contact e-mail address for all liaison with the ALMA EPO team is *alma-epo-ipt@alma.cl*.

6.3 Technical justification

An important, mandatory, part of each proposal is the Technical Justification, which starting from Cycle 2 is entered directly into the OT via a designated Technical Justification pane for each Science Goal instead of being included in the attached Science Justification PDF (any figures associated with the Technical Justification must however still be included in the Science Justification PDF file). The Technical Justification pane shows the relevant parameters entered by the PI in other parts of the Science Goal, as well as a number of derived quantities such as signal-to-noise ratio and dynamic range. The Technical Justification is entered in a free-format text box and should fully justify the technical aspects of the requested observations, with particular attention paid to those parameters that most directly affect the Science Goal time estimate. The text is limited to 4000 characters per Science Goal and should address the following aspects:

- Sensitivity: relevant parameters to discuss here include the source flux, angular size, width of the spectral lines, desired spectral resolution/channel width and significance (i.e., signal-to-noise ratio). PIs should be aware that the sensitivity returned by the ALMA Sensitivity Calculator may not always be achievable. For instance, this can occur when the field of view contains a very bright source. Similarly, bright lines in the spectra can also make it very difficult to achieve a theoretical rms, as can a crowded spectrum or faint lines sitting on top of bright continua. Low or very high signal-to-noise ratios must be justified.
- Imaging: if science targets are to be mapped, the most important consideration will be whether the imaging algorithms are able to reconstruct the various source components. The *uv*-coverage for Cycle 2 is such that even snapshot images will be able to produce good maps of most sources. In the rare instances this is not the case (e.g. a very complex but bright source), the OT's sensitivity-based time estimate can be overridden, but this must be explicitly justified. PIs should make sure that the source fits within the inner 1/3 of the primary beam (field of view), or alternatively discuss the effects of the sensitivity loss towards the beam edges. Finally, overriding the OT recommendation concerning the use of the ACA must be justified.

- Correlator setup: the requested correlator setup, including the total bandwidth, spectral resolution, and spectral window placement should be justified. Additional details of the correlator setup are automatically defined by the OT in Phase 2 (based on the Phase 1 request) and will not normally need to be adjusted. In rare instances though this might be necessary. Examples include requiring a smoothing function other than Hanning or a very short integration time. Such requirements should be justified.
- Calibration: By default, ALMA observations will contain observations of sources necessary to calibrate the flux scale, bandpass and the relative gains of each antenna. For a small fraction of projects, e.g. those requiring a high spectral dynamic range, it might be necessary to perform additional calibrations and/or to use specific sources. Requests for user-defined calibrators must be justified.
- Bandpass accuracy: Projects that intend to observe spectral features that cover a significant fraction of a spw, and/or study spectral features with small contrast with respect to a strong continuum are affected by the bandpass accuracy. It has been determined that, for Cycle 2, projects that require spectral response accuracies per observation execution of up to 1000 for ALMA Bands 3,4,6 and 500 for Bands 7, 8 and 9 are feasible. Requests for higher accuracies may be the grounds for rejection of the proposal (see section A8.1)
- Scheduling/time constraints: most ALMA projects are not time constrained i.e. they will be dynamically scheduled when the source is at sufficient altitude above the horizon and the atmospheric conditions are appropriate for the wavelength being observed. However, some projects may have time constraints. The OT currently has the ability to capture specific time intervals, multiple epochs as well as one or more monitoring visits. In the latter case, the OT's sensitivity-based time estimate is overridden by the combined length of the monitoring visits specified. Any time constraints requested must be justified.
- Data rate: the maximum data rate is 60 MB/s, with an expected average of 6 MB/s. Spectral setups that result in a data rate that is more than twice the expected average of 6 MB/s must be justified.
- Special constraints on standard observing modes: these include requests for observations whose overheads are very high (> 30% of the total requested time), very short observations (less than 2 minutes on-source time) and lengthy observations (continuous target observations for more than 40 minutes). If such requests are done, they must be justified.

Any non-standard choices regarding the technical setup of the Science Goal (including those specifically mentioned above) will be explicitly listed above the Technical Justification text box and must be carefully justified.

In addition, PIs should avoid the following requests/mistakes, which will lead to proposal rejection on technical grounds:

- Underestimation of the required observing time by more than a factor of 2 due to mistakes in the input parameters
- Smoothing of the data to resolutions that are comparable to those of a 12-m single-dish telescope.
- Technical Justifications based on data unavailable at the time of writing the proposal
- Omission of ALMA simulations that are integral to the justification of the observing requirements (see Section 6.2.1).

- Proposals that require continuous observations at frequencies that require very good weather conditions (best quartile) for more than 2 hours will be rejected on technical feasibility grounds.

Before the final submission, PIs should double check that the parameters described in the Technical Justification text boxes agree with those entered into the OT numerical fields and are consistent with the advertised Cycle 2 capabilities, as detailed in Appendix A. If users have any questions about the Technical Justification, they should consult the ALMA Helpdesk. Additional considerations for ALMA Early Science observing are included in the ALMA Early Science Primer.

6.4 Proposal validation and submission

All proposals must validate in the OT (via the use of the "Validate" option under the "File" menu item) before they can be submitted. If a proposal fails to validate, the non-validating parts will be listed in the "Feedback" pane, and clicking on each message will direct the user to the corresponding error.

Upon submission, the PDF file containing the science case (Section 6.2) together with the observing specifications entered into the OT are electronically transmitted to the ALMA Archive. PIs should save the proposal as a local file on their computer after submitting it ("Save" or "Save as" option under the "File" menu item), so as to leave open the possibility of resubmitting it with the same project code (see below) until the deadline. A detailed PDF summary of the entire proposal may also be generated and saved locally by the user (see option listed under the "Tool" menu item).

Submission of Standard and ToO Proposals will be available from 15:00 UT on October 24, 2013.

The proposal submission deadline is:

15:00 UT on December 5, 2013

The proposal submission deadline is firm. Proposals received after the deadline will not be considered. It is the PI's responsibility to convert the UT time of the proposal submission deadline to his/her local time zone.

A Standard or ToO proposal can be submitted and resubmitted until the submission deadline. Modifications of submitted proposals will not be permitted after the deadline. Co-Is can retrieve proposals from the Archive both before and after the deadline, but only the PI can submit (or resubmit) a proposal. To ensure that the load on the server does not affect its performance close to proposal submission deadline, users should refrain from unnecessarily retrieving proposals from the Archive between 0:00 and 15:00 UT on December 5, 2013.

If successfully submitted, a proposal receives a unique code adhering to a standard format. The format of the proposal code is as follows: YYYY.C.NNNNN.T. Here, "YYYY" denotes the year, "C" is the cycle ID, "NNNNN" is a five-digit running number and "T" denotes the proposal type. For example, the code 2013.1.00156.S indicates a Standard proposal which is the 156th ALMA proposal submitted for the regular cycle in 2013. To allow for later re-submission, *it is essential that, after submitting a proposal, users save a copy of it to their local disk, complete with the proposal submission code*.

Cycle 2 DDT Proposals may be submitted throughout the Cycle, from 1 June 2014 to 31 October 2015. Like Standard and ToO Proposals, they must include a full science case and a detailed Technical Justification. DDT proposal submission is final; DDT proposals cannot be resubmitted.

To update a previously submitted proposal, users should modify that saved, post-submission copy, to ensure that the same submission code is used. *Attempts to update a previously submitted proposal using the local copy without a code should always be avoided, as this will result in a new (duplicate) submission that will be assigned a new code.*

Users wishing to create a new proposal based on a previous one as a template should make sure to take as starting point a local copy without a code, so as to avoid overwriting their original proposal in the Archive.

A Helpdesk ticket should be submitted to withdraw a proposal after a code has been assigned.

7 The ALMA Proposal Review Process

7.1 Description

ALMA proposals will be subject to peer review. The policies and procedures for this process are summarized below.

Standard and ToO proposals[4] will be reviewed by the ALMA Proposal Review Committee (APRC) and the ALMA Review Panels (ARP). There will be at least one ARP per science category, comprising experts in the range of scientific topics covered by this category. The primary criterion for selection of the ARP members (Science Assessors) will be scientific competence. ARP membership will ensure appropriate representation of the ALMA regions.

Proposals will be assessed on the basis of the overall scientific merit of the proposed investigation and its potential contribution to the advancement of scientific knowledge. Projects having the potential of delivering scientifically worthwhile results from relatively short observations will be favorably considered.

To keep the workload of the panels to a manageable level, science assessments will take place in two stages. For Stage 1 review, each proposal will be assigned to four members of one of the ARPs of its science category, who will each give it a score and provide a brief written assessment. The individual assessor's scores will be combined to compute a mean preliminary score, which will be used to build a Stage 1 ranked list of all proposals. The top ~70% will proceed to Stage 2, as well as any proposals for which the standard deviation of the individual Stage 1 scores exceeds a given threshold.

Proposals proceeding to Stage 2 will be subject to Technical Assessment before the panel meetings. Technical Assessment is carried out by a selected group of JAO and ARC experts. Technical assessments will be performed according to criteria reflecting the technical justification requirements described in Section 6.3.

All ARPs will meet face-to-face to discuss the proposals that proceed to Stage 2. Following its discussion, each proposal will be assigned a single, final ARP score by secret vote. It may be complemented by additional ARP recommendations such as when two or more proposals involve duplication of Science Goals (see Section 7.2.2).

[4] For DDT Proposals, see http://www.almascience.org/proposing/ddt-proposals.

The APRC, consisting of the ARP Chairs and of a non-ARP member APRC Chair will meet face-to-face immediately after the ARP meetings to prepare a single ranked list of all proposals after reviewing all ARP recommendations. Particular attention will be paid to the recommendations for treatment of duplicated Science Goals. A subset of the highest ranked proposals will be assigned Grade A by the APRC. They will be eligible for carry-over to Cycle 3 if they cannot be completed by the end of Cycle 2. In Cycle 2, the estimated execution time of Grade A proposals will not exceed 10% of the available science time for each region.

Science Assessors will be advised against de-scoping proposals, except for cases where a fraction of their Science Goals duplicate those of a higher ranked project. For more details see Section 7.2.3.

Based on the APRC recommendations, the JAO will assign execution priorities, for communication to proposers. Grades A and B will be assigned to the top-ranked proposals of each region until their cumulative execution time exceeds the respective regional share of the available science time for the cycle, taking into account the technical feasibility of the proposals, the limitations on availability of specific configurations (e.g., Atacama Compact Array), and observability constraints. Selected proposals further down the ranking will be assigned Grade C. They will be used as "fillers" so as to optimize the distribution of the projects eligible for execution in the multi-dimensional observation parameter space, to ensure that the observing queue is populated at all times throughout the cycle, even when weather conditions are not optimal. Grade C projects will be added to the observing programme until the cumulative execution time for each region exceeds 1.5 times the regional share of the available science time. Grade C projects will be observed only if the conditions do not allow any of the Grade A or B projects to be executed. The remaining proposals are very unlikely to be observed and may be considered unsuccessful.

The final decision about proposal selection rests with the Directors Council. The JAO will prepare the final recommendation to the Directors Council, based on the APRC ranked list, and taking into account scheduling considerations. After its approval by the Directors Council, the outcome of the Proposal Review Process will be communicated to the PIs of all valid submitted proposals. The notifications will include the following information:

- A statement of the ratio between the total amount of estimated time that would be required to carry out all submitted proposals and the anticipated available observing time over the cycle (that is, the array oversubscription factor);
- The overall ranking of the proposal, as one of the following options: first decile, second decile, 20-40% band, 40-70% band, or bottom 30% of the ranking;
- The elegibility of the proposal for execution and the probability of completion of the project, in the form of one of the following "priority grades":
    - **A:** the proposal was assigned the highest priority of execution. If it is not completed by the end of Cycle 2, its execution will continue in Cycle 3.
    - **B:** the proposal was assigned the highest priority of execution. However it will not be carried over to future cycles, even if it is not completed by the end of Cycle 2.
    - **C:** the proposal is in the group of filler projects, which will be observed only if the conditions do not allow any higher priority project to be executed.
    - **U:** the proposal is highly unlikely to be scheduled. Phase 2 Scheduling Blocks will not be prepared for it (see Section 8).
    - **I:** the proposal was rejected because it is deemed technically infeasible with the Cycle 2 capabilities.
    - **O:** the proposal will not be observed because of duplication with a higher-ranked project.

- A consensus report, that is, the feedback of the Science Assessors about the strengths and the weaknesses of the proposal;
- A technical feasibility note for those proposals that have been subject to technical assessment and deemed infeasible or affected by technical feasibility issues.

Note that priority grade A, B, C and U are assigned on the basis of proposal ranking, factoring in regional share constraints and consideration of the distribution of the approved projects in terms of array configuration, LST, bands (hence observing conditons), etc. Thus there is no simple, one-to-one match between the overall ranking of a proposal and its priority grade.

7.2 Proposal Review Process policies

7.2.1 Confidentiality

For proposals assigned priority grade A or B, the project code, the proposal title and abstract, the name and region of the PI, and the names of the Co-Is will be made public soon after PIs are informed of the outcome of the proposal review process. For proposals assigned priority grade C the corresponding information will be made public as soon as the first data are archived. The corresponding information for proposals that are unlikely to be scheduled or deemed infeasible, as well as the scientific and technical justifications of all proposals, remain confidential.

Since proposals assigned priority grade A have a high probability of being completed, their proposal metadata (e.g. source coordinates, frequency setups) will also be made public. For proposals assigned priority grades B and C, the corresponding information will be made public only when the data are archived.

7.2.2 Duplication

A high-level principle of ALMA is that identical data should not be taken twice unless scientifically necessary. The term “Duplication” is used to refer to projects that may potentially replicate the data or results obtained in another proposal.

In Cycle 2, potential duplication of proposals may occur when more than one team applies to observe the same targets in the same observing mode (frequency, angular resolution, area, depth, etc). Duplications will be assessed at the Science Goal level; that is, a Science Goal will be considered a duplication of another Science Goal only if the observations are judged to be scientifically equivalent.

Observations are considered duplicates if all the following conditions are met:

1. Target field location:

    a. For single-field interferometry, the map reference positions coincide within the primary beam (Half-Power Beam Width), or

    b. For mosaic observations, the fields of the two Science Goals (defined as the Half-Power Beam Widths) overlap by more than 50% of the size of the smaller one.

2. The values of the highest angular resolution for the two considered Science Goals differ by a factor of less than 2.

3. Spectral windows:

a. Each spectral window of one Science Goal overlaps with a spectral window of the other by more than 50% of the narrower one (TDM mode), or

b. At least 50% of the spectral lines to be observed in the Science Goal including the smaller number of lines overlap the lines of the other Science Goal (FDM mode).

4. The difference of spectral resolution between overlapping spectral windows (as defined above) is less than a factor of 2.

5. The difference in the requested rms (rms noise values in Jy for continuum observations and in K for line observations at the same velocity resolution and the same angular resolution) within each pair of matching spectral windows is less than a factor of 2.

If one proposed observation is less sensitive than a second observation and if it meets the area and spectral overlap criteria above, it will also be considered a duplicate since the science objective of the poorer sensitivity program can be achieved using the deeper observation.

Similar criteria will be applied to proposed observations that have poorer angular or spectral resolution than another proposal, provided that the higher resolution observation can achieve all the science requirements of the lower resolution observation, including sensitivity on the desired spectral resolution and angular scales.

Note that, for targets undergoing non-periodic or non-semi-periodic variations, observations at different epochs do not represent potential duplications.

In case of potential duplications, the relevant proposals shall be directly compared with each other, so as to ensure that their relative ranks shall duly reflect their respective scientific merits. The science assessors will determine if the considered duplicate proposals are mutually exclusive or if it would be scientifically meaningful for more than one to be approved. The final verdict will be rendered by the APRC.

Observations done in ALMA Cycle 1 projects will constitute potential duplications for Cycle 2 proposals if the above conditions are fulfilled.

The Science Justification of a Cycle 2 proposal involving partial or full duplication of Science Goals of an approved Cycle 1 project belonging to the same proposing group (either with highest priority or as filler) must include an explicit statement about the considered duplication(s). The proposers must specify if the duplicating observations need to be repeated in Cycle 2 even if they have been successfully completed by the end of Cycle 1. Such repetition, if deemed necessary, must be scientifically justified.

Proposers of a high-priority Cycle 1 project who have agreed to transfer it to Cycle 2 if incomplete by the end of Cycle 1, are not allowed to request observations duplicating this project in a Cycle 2 proposal.

Cycle 2 proposals involving partial or full duplication of the Science Goals of an archived or transferred Cycle 1 project may be rejected or descoped by the review panel (see below). A list of the metadata from Cycle 1 proposals designated for transfer into Cycle 2 will be posted to the Science Portal so that Cycle 2 PIs can avoid duplicating these observations.

7.2.3 Descoping

The ARPs and the APRC may recommend the descoping of a project but will be strongly advised against it. Descoping of projects shall only arise as a result of the review process and will be made only for compelling scientific and/or technical reasons. These include cases of partially duplicated observations of completed or transferred Cycle 1 proposals, or of a more highly ranked proposal.

Descoping rulings will be communicated to the PIs as part of the APRC feedback report. They will include:

- A clear and rigorous description of the reasons for the descoping decision;
- A detailed description of the specific manner in which the intended descoping should be implemented; number and, if needed, identification of the targets to be omitted; observing modes or configurations not to be used, etc.

ToO proposals may be descoped, for example, by setting an upper limit to the number of events that may be observed in the period, and/or on the number of times observations (at different epochs) of these events may be triggered over the period.

8 Preparation & submission of observations: Phase 2

Once a project has been approved for scheduling, the project passes into Phase 2. At this stage, the project is assigned an ALMA Contact Scientist at the associated ARC or ARC node. This Contact Scientist initiates contact with the PI, establishes a preparation timeline and subsequently acts as the primary channel of communication between the project PI and the ALMA Observatory as a whole.

An initial draft version of the observing instructions (i.e. the actual Scheduling Blocks, or SBs) is created by ALMA staff, based on the information originally submitted in the proposal. Any modifications to the submitted proposal mandated as a result of the proposal review process or necessitated by technical considerations are incorporated.

These draft SBs are then presented to the PI by the Contact Scientist. At this point, the Contact Scientist will explain the actual expected execution behavior of the SBs, and may provide additional explanatory material as appropriate. Any other details requiring further clarification or possible modification are also discussed at this juncture. Communication with the Contact Scientist happens through the ALMA Helpdesk. This ensures that all such discussions are well documented and completed in a timely manner.

Necessary changes to the project may also be implemented at this stage, at the discretion of the Contact Scientist, consisting only of minor changes that do not impact the science scope or increase the total execution time. Examples of these might include (i) a change in a target position that is no more than half the primary beam size, (ii) a change in the target frequency for spectral line observations that is no more than 20% of the width of the original spectral window specified (as long as no additional diagnostic spectral lines would be measured as a result of the change), and (iii) other trivial changes, such as changing the velocity reference frame from LSR to Heliocentric. Any change that is more significant than these examples must be filed through the Helpdesk as a fully justified formal change request (see Section 8.1), and is generally discouraged.

Once a final version of the Phase 2 program has been agreed to be ready for execution by both the Contact Scientist and the PI, the project is admitted to the ALMA observing queue to await actual execution at the telescope. PIs may track the status of their SBs through the Project Tracker (PT), accessible from the ALMA Science Portal.

8.1 Changes to submitted projects

Changes to a submitted project prior to the completion of the review process will not be permitted. Changes to a project accepted for admission to the ALMA observing queue, unless minor (see above), will not normally be permitted. However, should a PI wish to request a change to a project (e.g. to correct a mistake in a field source list, or in response to later additional information obtained that may seriously affect the scientific case of the project), this will be done via a standard change request form accessed from the Helpdesk. Such change requests must include a very clear description of the proposed change along with a clear, substantive justification for the change. All such change requests will be considered by the Observatory on a case-by-case basis. Approved changes will be implemented by ARC staff, in consultation with the PI.

8.2 Project withdrawals, completion and carry-overs

Should a PI wish to withdraw his/her project before completion for some reason, then a Helpdesk ticket should be filed to this effect, and no further observations will be performed for that project.

If they are not completed by the end of the cycle, Cycle 2 projects assigned priority grade A will be carried over to Cycle 3. All other projects, whether completed or not, will end at the conclusion of Cycle 2 and will not be carried over to Cycle 3.

9 Data processing and data delivery

Each Science Goal consists of one or more ObsUnitSet (OUS), which includes of one or more Scheduling Blocks (SB) that will be executed as many times as needed to reach the defined sensitivity. Once the requisite number of successful executions of an OUS has been obtained, the resulting data will be processed by ALMA staff. This involves calibration and flagging of the visibilities, and imaging enough of the data to validate that the calibration has been successful, that it has obtained the requested sensitivity, and contains no gross instrumental artifacts or calibration defects. The data are assessed using Observatory-defined metrics as part of the “Quality Assurance level 2” (QA2 – see Chapter 11 of the ALMA Technical Handbook), which are summarized in a QA2 report.

The data are made available to the PI through the ARC with which the PI is registered. The data are transferred by network transfer (preferred method) or by shipping of hard disks (by special request). The data package will include at a minimum the processing log files, data processing script, QA2 report, a README file and the imaging products. The raw data are available upon request.

By default, data obtained as part of an ALMA science program are subject to a proprietary period of 12 months, starting for each data package when the ARC sends the notification to the PI that the data are available.

10 ALMA Cycle 2 checklist

1. Read the summary of ALMA Cycle 2 capabilities (Appendix A).
2. Both (sub)millimeter astronomy experts and novices are encouraged to download and read *Observing with ALMA: A Primer for Early Science*. **This document, and all Cycle 2 documentation, is available through *http://www.almascience.org*.**
3. Create an ALMA account by registering on the Science Portal (*http://www.almascience.org*), if you do not already have one. This step is necessary to submit proposals and Helpdesk tickets, and to access proprietary data (note that access to the Helpdesk knowledgebase does not require registration).
4. Download the Observing Tool (OT) from the link provided on the Science Portal (under "Documents and Tools") and install it on your computer.
5. Download and read the *OT Quickstart Guide*.
6. Start up the OT and select "Create new Proposal".
7. Select the correct Proposal Type (either **Standard** or **Target Of Opportunity**).
8. Note the evaluation criteria listed in Section 7.1 of this Guide.
9. Prepare your observing proposal according to the Cycle 2 capabilities described in Appendix A and the guidelines listed in Section 6.2 of this Guide. The Science Case and supporting documents should be attached as a PDF document of 4 pages or less and no more than 20 MB.
10. Compare the observation setup printed as part of the OT proposal summary PDF file and make sure all quantities agree with what is used in the written Technical Justification panes (sensitivities, bandwidths, reference frequencies, spectral resolutions, highest angular resolution, Largest Angular Structure, etc.).
11. Follow the steps described in Section 6.4 to electronically submit your proposal, cover sheet, and Science Goals. Note that you can resubmit the proposal as many times as you like before the proposal deadline (**December 5, 2013, at 15:00 UT**). Be sure to only resubmit your previously submitted and locally saved copy with the correct proposal code.
12. Submit your proposal well before the deadline to avoid unnecessary last-minute problems. If you experience difficulties when trying to submit your proposal just prior to the deadline, immediately contact the ALMA Project through Proposal Submission Emergencies, a Helpdesk department available for the 36 hours before the proposal deadline.

Appendix A ALMA Cycle 2 capabilities

In the Observing Tool (OT) an observing proposal is specified in terms of Science Goals. A single Science Goal (SG) is constrained to include one set of observational parameters that apply to all sources included in that goal. This includes a single angular resolution, sensitivity, Largest Angular Structure (LAS), and receiver band. For Cycle 2, there is no restriction on the number of Science Goals per proposal.

A.1 Antennas

All proposers should assume that observations in Cycle 2 will have available thirty-four 12-m antennas in the 12-m main array (hereafter 12-m Array), and that the Atacama Compact Array (ACA, also called the Morita Array) will have available nine 7-m antennas (for short baselines; hereafter 7-m Array) and two 12-m antennas (for single-dish observations; hereafter the Total Power or TP Array). The ACA is used for short baseline interferometry and single-dish observations, and will only be offered to complement observations with the 12-m Array, and not as a stand-alone capability. The use of the TP Array is limited to spectral line observations in Bands 3–8, to the exclusion of continuum observations and no spectral line observations using Band 9.

It may be that, due to problems with the equipment or other reasons, the number of antennas available will sometimes be less than these numbers. In that case the ALMA support staff will endeavor to schedule observations that they believe will not be seriously affected by having a slightly smaller number of antennas. The integration times or *uv* coverage might be increased to compensate where that is practical.

A.2 Receivers

Bands 3, 4, 6, 7, 8 and 9 will be available on all antennas. However, observations with Bands 8 and 9 will only be offered for configurations up to ~1 km (see Section A.3). For all bands both linear parallel-hand polarizations of the astronomical signals (XX, YY) are received and processed separately (dual polarization).

The heterodyne receivers multiply the incoming sky signals with a signal from a Local Oscillator (LO) in order to down-convert the signal to an Intermediate Frequency (IF) range, which is more practical to digitize. This results in two 4 GHz-wide Sidebands (per parallel polarization) which are equidistant in frequency from the LO signal. There are two types of receivers: dual-sideband (2SB), where the upper and lower sidebands are separated in the receiver and then processed separately, and double-sideband (DSB), where the sidebands are super-imposed coming out of the receiver but may be separated in later processing.

The frequency ranges and receiver types are shown in Table A 1.

Table A 1. Properties of ALMA Cycle 2 Receiver Bands

Band	Frequency range[1] (GHz)	Wavelength Range (mm)	IF range (GHz)	Type
3	84 – 116	3.6 – 2.6	4 – 8	2SB
4	125 – 163	2.4 – 1.8	4 – 8	2SB
6	211 – 275	1.4 – 1.1	5 – 10	2SB
7	275 – 373	1.1 – 0.80	4 – 8	2SB
8	385 – 500	0.78 – 0.60	4 – 8	2SB
9	602 – 720	0.50 – 0.42	4 – 12	DSB

Notes for Table A 1:

1. These are the nominal frequency ranges for continuum observations. Observations of spectral lines that are within about 0.2 GHz of a band edge are not possible at present in Frequency Division Mode (FDM, see section A.6.1), because of the responses of the spectral edge filters implemented in the correlators.

Although up to three receiver bands will be available at any time, the capability to rapidly switch between them within the same Science Goal (except for the purposes of data calibration) is not offered in Cycle 2.

Water Vapor Radiometer (WVR) measurements to correct for errors due to fluctuations in atmospheric water vapor will be available for all 12-m antennas. These corrections will be applied when it improves the phase coherence. No WVRs will be installed on the ACA 7-m antennas and users should assume that in Cycle 2 no WVR corrections will be applied to 7-m Array observations.

A.2.1. Band 9 considerations

For Band 9 observations, additional uncertainties will affect the data. Since the sidebands can be only separated reliably in interferometric observations, single-dish Band 9 spectral line observations with the TP Array will not be offered in Cycle 2. Also, owing to the complexity of the atmospheric absorption in Band 9, calibration will be compromised (this also applies to Band 8 and the high frequency end of Band 7). Band 9 ACA 7-m Array observations are more compromised than Band 9 12-m Array observations, since the lack of WVR means that rapid atmospheric phase correction will not be available, and the smaller collecting area will limit the network of available calibrators; in particular bright calibrators will be sparse at these high frequencies. All of these factors will affect imaging at Band 9 during Cycle 2 and will in particular limit the achievable dynamic range with the ACA 7-m Array. Spectral dynamic ranges up to 500 are offered for this Band in Cycle 2 (see Section A.8.1 for details).

A.3 12-m Array configurations

The antennas of the Cycle 2 12-m Array can be staged into distinct configurations intended to smoothly transition from the most compact (with maximum baselines of ~160 m) up to the most extended (maximum baselines of ~1.5 km, offered for Bands 3, 4, 6 and 7; and ~1 km for Bands 8 and 9). Seven configurations have been defined to represent the possible distribution of 34 antennas over this range of maximum baselines. The detailed properties of these configurations are given in Chapter 7 of the Cycle 2 Technical Handbook.

For all observations, the relevant parameters used by the OT in deciding the required array components for the representative frequencies of a given project are: (1) the Maximum Recoverable Scale (MRS) that can be imaged without the need for the ACA (defined by the shortest baseline of the most compact 12-m Array configuration); (2) the coarsest angular resolution obtainable with the 12-m Array (defined by twice the resolution of the most compact 12-m Array configuration to avoid significant loss of sensitivity); and (3) the finest angular resolution obtainable (defined by the longest baseline of the most extended 12-m Array configuration). These quantities are given in Table A 2. Sources with a user-specified LAS larger than the Maximum Recoverable Scale listed in this table will require the addition of ACA observations. Observations with a requested angular resolution either coarser or finer than the values listed in Table A 2 (scaled to the appropriate frequency) are not allowed. Values that are inconsistent with any Cycle 2 limitations for the above parameters will result in a warning or a validation error in the OT.

Table A 2. Maximum Recoverable Scale[1] and Coarsest and Finest Angular Resolutions[1] for the Cycle 2 12-m Array configurations

Frequency (GHz)	Maximum Recoverable Scale[2,3,4] with no ACA (arcsec)	Coarsest allowed angular resolution[2,3,5] (arcsec)	Finest achievable angular resolution[2,3,6] (arcsec)
100	25	7.5	0.41
150	17	5.0	0.27
230	11	3.3	0.18
345	7.2	2.2	0.12
460	5.4	1.6	0.12
650	3.8	1.2	0.09

Notes for Table A 2:

1. See Chapter 7 of the Technical Handbook for relevant equations and detailed considerations.
2. Computation for source at zenith. For sources transiting at lower elevations, the projected baselines will decrease proportionally to sin(ELEVATION), so that the North-South angular measures in the table will increase proportionally to $\sin^{-1}$(ELEVATION).
3. All angular measures scale inversely with observed sky frequency.
4. “Maximum Recoverable Scale” is the largest angular structure that can be observed effectively. It is defined by the shortest baseline of the most compact 12-m Array configuration (14 meters).
5. Coarsest allowed angular resolution is twice the resolution of the most compact 12-m Array configuration (maximum baseline of 166 meters).
6. Finest achievable angular resolution is defined by the resolution of the most extended 12-m Array configuration (~1.5 km for Bands 3-7, and ~1 km for Bands 8 & 9), assuming uniform weighting.

A.4 ACA

The ACA in Cycle 2 is composed of nine 7-m antennas for the 7-m Array and two 12-m antennas for the TP Array. Two 7-m Array configurations will be offered in Cycle 2, one compact for regular observations and another with significantly less antennas packed close together for observations of objects that transit at low elevations. Both configurations render similar performances, and the decision on which to use for a given project is at the discretion of the Observatory. For more on the ACA see Chapter 7 of the Cycle 2 Technical Handbook.

The TP Array is used to recover, at low angular resolution, all the angular scale information up to the size of the mapped areas. For Cycle 2, the TP Array can only be used for spectral line observations (not continuum) in Bands 3–8. No TP Array Band 9 observations are offered for this cycle. This means that angular scales greater than those listed in Table A 3 cannot be recovered for any observations in Band 9, or for continuum observations in any band. For projects that require both 7-m Array and TP Array, observations will be carried out in parallel as much as possible to optimize the use of the ACA.

Table A 3. Maximum Recoverable Scales for ACA 7-m observations

Frequency (GHz)	Maximum Recoverable Scale[1,2,3] with 7-m Array (arcsec)
100	42
150	28
230	18
345	12
460	9.1
650	6.4

Notes for Table A 3:

1. Computation for source at zenith. For sources transiting at lower elevations, the projected baselines will decrease proportionally to sin(ELEVATION), so that the North-South angular measures in the table will increase proportionally to $\sin^{-1}$(ELEVATION).
2. All angular measures scale inversely with observed sky frequency.
3. "Maximum Recoverable Scale" is the largest angular structure that can be observed effectively. It is defined by the shortest baseline of the 7-m Array (8.9 meters). See Chapter 7 of the Technical Handbook for details.

Observations with the 12-m Array and the ACA will be conducted independently, and the data from the different arrays will be calibrated separately and combined during data reduction.

A.5 Time estimates for multi-configuration observations

Images that obtain a high fidelity over a broad range of angular scales require observations taken with a continuous range of antenna baseline separations. The user-requested angular resolution (θ) determines the most extended 12-m configuration that is needed (up to the "finest allowed angular resolution" listed in Table A 2), and the user-requested sensitivity plus calibration requirements determine the amount of observing time needed in this configuration ($\Delta t_{extended}$). For point sources, only a single configuration is sufficient to reach the user-requested resolution. For non-point sources, the OT uses the user-provided LAS and angular resolution to determine all the array components needed. Interested users should refer to Chapter 7 of the Cycle 2 Technical Handbook for a table of the array combinations needed to recover various angular scale ranges.

For the purposes of proposal preparation, the time needed for the different array components (including calibrations), referenced to the time needed in the most extended 12-m configuration, has been defined as $4\Delta t_{extended}$ for the TP Array, $2\Delta t_{extended}$ for the 7-m Array and $0.5\Delta t_{extended}$ for a more compact 12-m Array configuration (if needed).

The **total** time required by a proposal is estimated in the OT by adding the expected observing times for both the 12-m Array and the ACA. For Cycle 2, this total time must be less than 100 hours. Table A 4 lists the total **observing** time estimates for the different array combination possibilities offered in Cycle 2. For this computation the fact that 7-m Array and TP Array observations will be done, as much as possible, in parallel has been taken into account, i.e. the ACA time is the TP Array time if this array is used or otherwise the 7-m Array time. Please note that there are two project execution queues, one for the 12-m Array and one for the ACA. Therefore, the time available for Cycle 2 observations is about 2000 hours for the 12-m Array and the same for the ACA. The time accrued by a proposal using the 12-m Array and the ACA will therefore be charged to the two queues separately, as per the time requirements estimated by the OT for each array.

Table A 4. Total Time multiplication factors for multi-array observations

Array Components needed (based on θ and LAS)	**Total Time estimate**
Single 12-m Array configuration	1.0 $\Delta t_{extended}$
Two 12-m Array configurations	1.5 $\Delta t_{extended}$
Single 12-m Array configuration and 7-m Array	3.0 $\Delta t_{extended}$
Two 12-m Array configurations and 7-m Array	3.5 $\Delta t_{extended}$
One 12-m Array configuration and 7-m Array and TP Array (spectral line, Bands <9)	5.0 $\Delta t_{extended}$
Two 12-m Array configurations and 7-m Array and TP Array (spectral line, Bands <9)	5.5 $\Delta t_{extended}$

The fixed time ratios adopted in Table A 4 were selected to get good imaging performance between the different array components (see Chapter 7 of the Cycle 2 Technical Handbook for more details). However, given the many fewer baselines in the 7-m Array compared to the 12-m Array, good imaging may not be obtainable with short observations (estimated ACA times of less than ~1 hour). If, because of this issue, users want to request longer 7-m Array observations, a detailed request must be added to the Technical Justification.

Based on the LAS, the OT will advise whether the ACA is needed for a given project. If the user chooses not to follow this recommendation, it must be explained in the Technical Justification.

A.6 Spectral capabilities

A.6.1. *Spectral windows, bandwidths and resolutions*

The ALMA IF system provides up to four basebands (per parallel polarization) that can be independently placed within the two receiver sidebands. For 2SB receivers (Bands 3–8 – see Table A 1), the number of basebands that can be placed within a sideband is 0, 1, 2, or 4. For DSB receivers (Band 9), any number of basebands (up to 4) is acceptable.

The 12-m Array uses the 64-input Correlator, while the 7-m and TP Arrays use the 16-input ACA Correlator. Both correlators offer the same spectral set-ups. They operate in two main modes: **Time Division Mode (TDM)** and **Frequency Division Mode (FDM)**. TDM provides modest spectral resolution and produces a relatively compact data set. It is used for continuum observations or for spectral line observations that do not require high spectral resolution. FDM gives high spectral resolution and produces much larger data sets. It is used for observations of spectral lines in all sources except when coarse spectral resolution is sufficient. Six FDM set-ups with different bandwidths and spectral resolutions are available (see Table A 5).

For each baseband, the correlator resources can be divided across a set of spectral "windows" (spw) that can be used simultaneously and positioned independently. For Cycle 2 up to four spectral windows per baseband are allowed. A fraction of the correlator resources are assigned to each spectral window, which sets the number of channels and bandwidth of the spectral window. The sum of the correlator resources spread across all spectral windows must be less than or equal to one.

The correlator can be set to provide between 128 and 3840 channels within each spw, and the fraction of correlator resources that are assigned to each spw sets the number of channels and the bandwidth available within it.

Cycle 2 allows the data to be pre-smoothed in the correlator by averaging (or binning) spectral channels in powers of 2. This allows one to reduce the data rate without increasing the sampling integration time (see Chapter 4 of the Cycle 2 Technical Handbook for more information). In Cycle 2, the maximum data rate is 60 MB/s, with the expected average of 6 MB/s. If the spectral setup ends up with a data rate that is more than twice the expected average of 6 MB/s, the user will need to technically justify this.

Different correlator modes can be specified for each baseband, but all spws within a given baseband must use the same correlator mode. For example, a high-resolution FDM mode can be used for spectral line observations in one baseband (with up to 4 differently placed FDM spectral windows), while the other three basebands can be used for continuum observations using the low-resolution TDM mode. And while each spw within a baseband must use the same correlator mode, they can each be assigned a different fraction of the correlator resources and each use a different spectral averaging factor, providing a broad range of simultaneously observed spectral resolutions and bandwidths. Spectral windows can overlap in frequency, although the total continuum bandwidth for calculating the sensitivity is set by the total independent continuum bandwidth.

Table A 5. Properties of ALMA Cycle 2 Correlator Modes, dual-polarization operation[1,2]

Bandwidth[3] (MHz)	Channel spacing[4] (MHz)	Spectral Resolution[4] (MHz)	Number of channels	Correlator mode
2000[3]	15.6	31.2	128[3]	TDM
1875	0.488	0.976	3840	FDM
938	0.244	0.488	3840	FDM
469	0.122	0.244	3840	FDM
234	0.061	0.122	3840	FDM
117	0.0305	0.061	3840	FDM
58.6	0.0153	0.0305	3840	FDM

Notes for Table A 5:

1. These are the figures for each spectral window and for each polarization, using the full correlator resources and no on-line spectral binning.
2. Single-polarization modes are also available, which gives twice the number of channels per spw, and half the channel spacing of the above table.
3. The "Bandwidth" given here is the width of the spectrum processed by the digital correlator. The usable bandwidth in all modes is limited to a maximum of about 1875 MHz by the anti-aliasing filter, which is ahead of the digitizer in the signal path. For TDM modes, the anti-aliasing filter also limits the total bandwidth to about 1875 MHz and the number of channels to about 120.
4. The "Channel Spacing" is the separation between data points in the output spectrum. The spectral resolution – i.e., the FWHM of the spectral response function – is larger than this by a factor that depends on the "window function" that is applied to the data in order to control the ringing in the spectrum. For the default function – the "Hanning" window –

this factor is 2. See the Technical Handbook for full details.

5.

A.6.2. Polarization

For Cycle 2, on top of the dual polarizations (XX, YY) and single polarization modes (XX), observations to measure the full intrinsic polarization (XY, YX) of sources will also be offered for TDM observations in Bands 3, 6 and 7, with some restrictions. Please note that only linear polarization has been commissioned. While PIs will receive data which will allow them to generate circular polarization data, the quality and/or accuracy of that data at this time is not assured, and such data should not be used for scientific purposes.

When a **Dual Polarization** setup is used, separate spectra are obtained for each linear parallel-hand polarization of the input signal. This will give two largely independent estimates of the source spectrum that can be combined to improve sensitivity.

In **Single Polarization** mode, only a single input polarization (XX) is analyzed. For a given resolution, this provide √2 worse sensitivity than the Dual Polarization case, but one can use either a factor two more bandwidth for the same spectral resolution or a factor of two better spectral resolution for the same bandwidth. Single polarization should therefore be used in cases where having a large number of spectral channels is more important than having the best sensitivity.

Full Polarization continuum measurements will be offered in Cycle 2 only for 12-m Array observations in Bands 3, 6 and 7. Sources must be centered and have a user-specified Largest Angular Structure that is less than one-third of the 12-m Array primary beam at the frequency of the planned observations. Observations shall be single-field, but measurements of individual sources within a 10-degree area on the sky are possible (one field per source; see below). The continuum polarization measurements are offered only for specific frequency settings, as detailed in Table A 6.

Table A 6. Fixed frequencies for Polarization Observations[1]

Band	SPW1 (GHz)	SPW2 (GHz)	LO1 (GHz)	SPW3 (GHz)	SPW4 (GHz)
3	90.5	92.5	97.5	102.5	104.5
6	224.0	226.0	233.0	240.0	242.0
7	336.5	338.5	343.5	348.5	350.5

Notes for Table A 6:

1. Fixed central frequencies for four TDM spectral windows, each of width 1.875 GHz, and the corresponding LO1 setting. Frequencies were chosen to optimize spectral performance, and they are centered in known low noise and low instrumental polarization tunings of the receivers.

It should be noted that full polarization observations require sufficient parallactic angle coverage for calibration (about 3 hours). Science Goals with properties that lead to a total observing time estimate that is less than 3 hours will have the time estimate set to 3 hours to ensure sufficient parallactic angle coverage is obtained.

A.7 Source restrictions

Sources can be designated by a fixed RA and Dec, or can include moving targets (including the planets, their moons, asteroids and comets). Observations of the Sun, however, are not supported in Cycle 2.

Sources are selected in one of two ways: by specifying a single rectangular field, or by specifying one or more source positions, with or without offsets. Each involves some restrictions. The total number of positions in a Science Goal (SG) must be less than or equal to 150 and all must lie within 10 degrees of each other. Pointings with the ACA, if used, do not count against the 150 pointing Science Goal limit.

A.7.1. Single rectangular field

A rectangular field (also referred to as a mosaic) is specified by a field center, the length, width and orientation of the field, and a single spacing between the pointing centers. Observations are conducted using the “mosaic” observing mode. This repeatedly cycles through all the pointings in the mosaic so that the imaging characteristics across the map are similar.

One rectangular field is allowed per Science Goal. A single mosaic can have up to 150 pointings and must be done in a single frequency set-up. If ACA observations are requested as part of a mosaic, then a corresponding 7-m Array mosaic will also be observed. If these are spectral line observations, the full mosaic area can also be covered by the TP Array using On-The-Fly mapping.

The OT will set up a uniform mosaic pattern based on a user-specified pointing separation, and will calculate the time to reach the required sensitivity considering any overlap. Non-Nyquist spatial samplings are allowed (up to HPBW/√2), where HPBW is the angular size of the half-power width of the Gaussian primary beam of a single 12-m antenna, at the frequency of the observations. Sparser samplings must be justified in the proposal. If the position separations are not too large, then the interferometric data are combined in post-processing to produce a single image. Mosaics in different Science Goals will not be combined during post-processing.

A.7.2. Individual pointings

If a user does not wish to specify a rectangular field, they may include in a single Science Goal a mixture of sources and offsets, provided that:

1. They are not separated by more than 10 degrees on the sky;
2. They can be observed with one spectral setup (relative placement and properties of spectral windows);
3. They can be observed with no more than five separate frequency settings that all fall within the same receiver band;
4. The sum over all sources, offsets, and frequency settings is less than or equal to 150.

For more widely spaced targets, such as wide-area surveys, additional SGs may be used for sources separated by more than 10 degrees.

Offsets can be specified for all sources within a Science Goal, but the 150 pointing limit applies. If ACA observations are requested for the Science Goal, then the corresponding ACA observations will be obtained for each source. Sets of offsets are designated either as a “Custom Mosaic” or a “Pointing Pattern”. The former are observed using the “mosaic” observing mode and can be separated by no more than HPBW/√2). The interferometric data will be combined in post-processing to produce a single image.

The later are not observed as mosaics, do not have a separation constraint (apart from the 10-degree separation limit of a Science Goal), and will not be combined to produce a single image.

For offsets, the OT does not consider the effect of overlapping pointings; users must take this into account when specifying the required sensitivity.

A.7.3. Spectral scan mode

Proposers who wish to carry out spectral surveys or redshift searches can do so using the "Spectral Scan" option in the OT to automatically set up a set of contiguous spectral windows to cover a specified frequency range, provided that:

1. All targets are separated by less than 10 degrees on the sky;
2. Angular resolution and LAS are computed for the Representative Frequency of each SG;
3. No more than 5 frequency tunings are used, all in the same band;
4. Only one pointing per target (no mosaics or offsets allowed);
5. The sum, for all targets, of the number of separate tunings required per target does not exceed 150 (i.e., the maximum number of targets, for 5 tuning for all targets in a SG, is 30);
6. Only 12-m Array observations are required (the ACA is not offered for this mode).

A.8 Calibration

Absolute amplitude calibration will be based on observations of objects of known flux, principally solar system objects. It is expected that the accuracy of the absolute amplitude calibration relative to these objects will be better than 5% for Bands 3 and 4. Calibration in the higher frequency bands is likely to be less accurate. The goal is for it to be better than 10% in Bands 6 and 7. Calibration at Bands 8 and 9 will be challenging even at the 20% level owing to the high atmospheric opacity, particularly so for Band 9 Total Power observations due to the Double-Sideband nature of the receiver (see Section A.2).

The ALMA Observatory has adopted a set of strategies to achieve good calibration of the data (see Chapter 10 of the Cycle 2 Technical Handbook). Requests for changes in these strategies will only be granted in exceptional circumstances and must be fully justified by the requester. Some flexibility exists in choosing the actual calibrator sources. The default option is automatic calibrator selection by the system at observing time. If users opt for providing their own calibrators, justification will be needed. This may result in decreased observing efficiency and/or calibration accuracy.

A.8.1. Bandpass accuracy

The detailed shape of the spectral response of the arrays during observations depends on many factors. This shape particularly affects projects that intend to observe spectral features that cover a significant fraction of a spw, and/or study spectral features with small contrast with respect to a strong continuum. It has been determined that, for Cycle 2, projects that require spectral response accuracies (i.e., the desired signal-to-noise ratio per spectral resolution element), per observation execution, of up to 1000 for ALMA Bands 3,4,6 and 500 for Bands 7, 8 and 9 are feasible. Requests for higher accuracies may be the grounds for rejection of the proposal.

A.9 ToO and time-constrained observations

Observations of ToO, monitoring and time-constrained projects will be offered in Cycle 2 with a few restrictions:

- Observations must be done in only one 12-m Array configuration; time constraints cannot be imposed with the ACA;
- Monitoring projects that require observation windows spaced by less than two weeks are unlikely to be fully observed;
- ToO projects that require observations within two weeks of contact with the ALMA observatory cannot be guaranteed.

Appendix B Acronyms and abbreviations

ACA	Atacama Compact Array
ALMA	Atacama Large Millimeter/Submillimeter Array
AOS	Array Operations Site
APEX	ALMA Pathfinder EXperiment
ARC	ALMA Regional Center
ARP	ALMA Review Panel
APRC	ALMA Proposal Review Committee
AS	Academia Sinica
AUI	Associated Universities, Inc.
CASA	Common Astronomy Software Applications
Co-I	Co-investigator
DDT	Director Discretionary Time
EA ARC	East Asian ALMA Regional Center
EPO	Education and Public Outreach
ESO	European Southern Observatory
EU ARC	European ALMA Regional Center
FOV	Field Of View
JAO	Joint ALMA Observatory
LAS	Largest Angular Structure
LST	Local Sidereal Time
MRS	Maximum Recoverable Scale
NA ARC	North American ALMA Regional Center
NAASC	North American ALMA Science Center
NAOJ	National Astronomical Observatory of Japan
NINS	National Institutes of Natural Sciences
NRAO	National Radio Astronomy Observatory
NRC	National Research Council of Canada
NSC	National Science Council of Taiwan
NSF	National Science Foundation
OSF	Operation Support Facility
OST	Observation Support Tool
OT	Observing Tool
PDF	Portable Document Format
PI	Principal Investigator
PWV	Precipitable Water Vapor
SB	Scheduling Block
SCO	Santiago Central Office
SG	Science Goal
spw	Spectral window
ToO	Target of Opportunity
TP	Total Power
WVR	Water Vapor Radiometer

Appendix C Science keywords

The list below presents for each science category the keywords that can be used in the OT to further specify the scientific area of the proposal. **Proposers must select at least one and at most two keywords.**

Category 1 – Cosmology and the high redshift universe

a. Lyman Alpha Emitters/Blobs (LAE/LAB)
b. Lyman Break Galaxies (LBG)
c. Starburst galaxies
d. Sub-mm Galaxies (SMG)
e. High-z Active Galactic Nuclei (AGN)
f. Gravitational lenses
g. Damped Lyman Alpha (DLA) systems
h. Cosmic Microwave Background (CMB)/Sunyaev-Zel'dovich Effect (SZE)
i. Galaxy structure & evolution
j. Gamma Ray Bursts (GRB)
k. Galaxy Clusters

Category 2 – Galaxies and galactic nuclei

a. Starbursts, star formation
b. Active Galactic Nuclei (AGN)/Quasars (QSO)
c. Spiral galaxies
d. Merging and interacting galaxies
e. Surveys of galaxies
f. Outflows, jets, feedback
g. Early-type galaxies
h. Galaxy groups and clusters
i. Galaxy chemistry
j. Galactic centres/nuclei
k. Dwarf/metal-poor galaxies
l. Luminous and Ultra-Luminous Infra-Red Galaxies (LIRG & ULIRG)
m. Giant Molecular Clouds (GMC) properties

Category 3 – ISM, star formation and astrochemistry

a. Outflows, jets and ionized winds
b. High-mass star formation
c. Intermediate-mass star formation
d. Low-mass star formation
e. Pre-stellar cores, Infra-Red Dark Clouds (IRDC)
f. Astrochemistry
g. Inter-Stellar Medium (ISM)/Molecular clouds
h. Photon-Dominated Regions (PDR)/X-Ray Dominated Regions (XDR)
i. HII regions
j. Magellanic Clouds

Category 4 – Circumstellar disks, exoplanets and the solar system

a. Debris disks
b. Disks around low-mass stars
c. Disks around high-mass stars
d. Exoplanets
e. Solar system: Comets
f. Solar system: Planetary atmospheres
g. Solar system: Planetary surfaces
h. Solar system: Trans-Neptunian Objects (TNOs)
i. Solar system: Asteroids

Category 5 – Stellar evolution and the Sun

a. The Sun
b. Main sequence stars
c. Asymptotic Giant Branch (AGB) stars
d. Post-AGB stars
e. Hypergiants
f. Evolved stars: Shaping/physical structure
g. Evolved stars: Chemistry
h. Cataclysmic stars
i. Luminous Blue Variables (LBV)
j. White dwarfs
k. Brown dwarfs
l. Supernovae (SN) ejecta
m. Pulsars and neutron stars
n. Black holes
o. Transients

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership of Europe, North America and East Asia in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere (ESO), in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and in East Asia by the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Academia Sinica (AS) in Taiwan. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI) and on behalf of East Asia by the National Astronomical Observatory of Japan (NAOJ). The Joint ALMA Observatory (JAO) provides the unified leadership and management of the construction, commissioning and operation of ALMA.