European Organisation
for Astronomical
Research in the
Southern Hemisphere

Organisation Européenne
pour des Recherches
Astronomiques
dans l'Hémisphère Austral

Europäische Organisation
für astronomische
Forschung in der
südlichen Hemisphäre

ESO ROUTE SLIP

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Contractor	ARC Nodes
Title	MoU on the ALMA Regional Centre Network

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The European ALMA Regional Centre Network
Memorandum of Understanding
on baseline tasks

1. Scope

This document is a Memorandum of Understanding (MoU) between the ESO ALMA Regional Centre (ARC), the ARC nodes and the Centre of Expertise (CoE). The ARC nodes and CoE are based at the locations given in alphabetic order in the following table, which also lists the regions primarily served by each ARC node.

European ARC node	Host country(ies)	Primary location(s)
Italian	Italy	Bologna
German	Germany	Bonn, Cologne
IRAM	France, Spain, Germany	Grenoble
Allegro Manchester	Netherlands United Kingdom	Leiden Manchester
Czech	Czech Republic	Ondrejov
Onsala	Sweden	Onsala
Centre of Expertise	**Host country(ies)**	**Primary location(s)**
PACE	Portugal	Lisbon

This MoU covers the responsibilities of the ESO ARC (hereafter the Central ARC) in coordinating the activities of the ARC nodes and the Centre of Expertise, as well as the responsibilities of the ARC nodes in the provision of staff effort for all the tasks described in sections 3.1.2, 3.1.3, and 3.1.4.

This MoU may be updated when necessary to document any official changes of the responsibilities between the parties or when any major changes in the ARC node structure occur.

2. The European ALMA Regional Centre

The interface between ALMA and the user community in the ESO Member States is formed by the European ALMA Regional Centre (European ARC), which comprises a cluster of nodes and a centre of expertise (CoE), located throughout the ESO Member States, together with a Central ARC located at the ESO headquarters in Garching. This Central ARC is a department within the ESO ALMA Support Centre (EASC) division.

The European ARC is the point of contact for ALMA users in the ESO Member States throughout the life-cycle of ALMA observing projects: from the moment of proposal preparation through to the data analysis. The Central ARC is responsible for the delivery of data to principal investigators (PIs), the maintenance and development of the ALMA data archive, and the provision of feedback on the software relevant for ALMA science operations.

Fundamental to ALMA's success in the ESO Member States is the high level of user support services provided by the network of ARC nodes. These are required to fully exploit the transformational nature of ALMA and to maximise the scientific return for the community in the ESO Member States. Face-to-face support provided by each of the ARC nodes is open to all users, although it is expected that normally users utilise their nearest ARC node (or the ARC node funded by their own country or organisation). Requests for specialised help may be directed to those ARC nodes with expertise in the relevant subject areas.

The arrangement of geographically distributed nodes outside ESO for science support was recommended by the European Science Advisory Committee (ESAC) and the Science and Technical Committee (STC), and approved by the ESO Council. At the time of writing, seven ARC nodes and a CoE are fully operational within the network. The ARC department head and the ARC network coordinator (both ESO astronomers) as well as the representatives of each node form the ARC Coordinating Committee (ACC). Important decisions within the ARC network are taken by the ACC based on consensus.

Definitions:

- **ARC** - ALMA Regional Centre. There is one ARC at each of the Executives of the ALMA partnership;
- **European ARC** - The European ARC, set up as a network of ARC nodes, the CoE, and the central ARC at ESO, together providing ALMA user support in the ESO Member States and general ALMA operations support;
- **ARC network** - Alternative definition of 'European ARC', used in contexts that emphasise its network character;
- **Central ARC** - The ARC department within the ESO ALMA Support Centre (EASC) division;
- **ARC node** - Independent node within the ARC network, primarily providing user support services to a region;
- **CoE** - Centre of Expertise: temporary status of an independent ALMA support centre, eligible to become an ARC node once certain conditions, described in detail in the document "European ALMA Centres of Expertise: Tasks and Responsibilities" are fulfilled;
- **ACC** - ARC Coordinating Committee consisting of representatives of each node, as well as the ARC Department head and the ARC network coordinator.

3. The European ARC functions and deliverables

The mandate of the European ARC is to provide services to and coordinate user support for astronomers in the ESO Member States. Full face-to-face user support is an agreed service to be provided by each Executive, but in Europe this service is coordinated by the Central ARC and provided by the ARC nodes (see 3.1.2). All ARC services are defined by the ALMA Board and detailed in the ALMA Principles of Operations and the document on operationally critical ARC Services, attached as Annexes 1 and 2 to this MoU. They are under the responsibility of the Executives, and the Central ARC has to ensure that they are delivered in a timely manner and according to quality standards. In addition, each Executive may elect to provide ARC services above and beyond the operationally critical services as defined by the ALMA Board.

It should be made clear that the Central ARC, the ARC nodes and the CoE have several tasks and responsibilities, that extend beyond the obligations of the network. More precisely, ESO has a number of managerial and coordinating responsibilities towards ALMA operations, including Astronomer on Duty shifts, and Subsystem Scientists of a number of subsystems (such as the Observing Tool, the Archive, AQUA and SnooPI). It also has obligations towards the ESO committees, such as reporting to the STC, the ESAC and the Users Committee. The ARC nodes and CoE, on the other hand, all have their own commitments and obligations towards their funding agencies and local communities. All these responsibilities are beyond the scope of the present MoU and are not covered herein.

The European ARC services are distributed among the Central ARC, the ARC nodes and the CoE as specified in section 3.1 below.

3.1. Functions provided by the European ARC network

The European ARC is responsible for the provision of a number of functions towards the community in the ESO Member States and to ALMA operations. Most of these functions are jointly carried out at the Central ARC and at the nodes and CoE. Some of them however, are the responsibility of the Central ARC, while some others have been explicitly delegated by ESO to the ARC nodes and the CoE.

3.1.1. Functions provided primarily by the Central ARC

- **Phase 1 operations**: Preparation of end-user documentation (in particular the call for proposals, proposers guide, etc) and assistance in coordinating the proposal review process;
- **Phase 2 material preparation**: Preparation of the Scheduling Blocks (SBs) for non-standard observing modes and checking of SBs for standard observing modes, to be executed at the telescope;
- **Data delivery:** Delivery of the final raw and pipeline-reduced data to the PIs;
- **Archive operations**: The Central ARC hosts a complete synchronised copy of the ALMA archive and ensures its seamless operation;
- **Science Portal:** Participation in the ALMA Science Portal development and maintenance;

- **Helpdesk:** Handling of Helpdesk queries of all users of the ESO community including questions on data reduction, the OT, or other technical or general matters, as well as the follow up of proposal change requests and requests for extension of proprietary time.

3.1.2. Functions provided primarily by the ARC nodes[1]

- **Personalised user support** is one of the cornerstones of the ARC node structure in the ESO Member States. Face-to-face support for proposal preparation and data reduction is the most important task in this context, and it is a task that is explicitly delegated to the ARC nodes by ESO. Face-to-face data reduction support can range from basic assistance in the usage of data reduction tools to advanced support in understanding ALMA data. For standard observing modes, ALMA users can obtain the same level of high quality user support from every node. Every ARC node commits to providing face-to-face support to their local community;
- **Phase 2 participation:** Contact Scientist (CS) assignments are also explicitly included in the functions of the ARC nodes. This service comprises assisting the PIs with the creation and verification of their Phase 2 material;
- **Scientific community development**: Organisation of workshops and schools and any other support and/or educational initiatives for users.

3.1.3. Observatory support provided by the ARC network at large

Quality assurance (QA2) of science data sets consists of verifying that the frequency setup, spatial resolution and continuum and line detection sensitivity requested by the PI have been achieved. According to the Agreement Concerning the Operations of ALMA between NSF, NINS and ESO signed 15 Dec 2015, the ALMA Director is responsible for data quality assurance. However, due to the current and projected very high workload involved in ALMA Operations at the JAO, a large fraction of QA2 is routinely carried out in the three ARCs. In the ESO Member states, ARC nodes and the CoE work in close collaboration with the Central ARC on data reduction and quality assurance of datasets of primarily PIs from the ESO community.

The contribution to this task by ARC nodes and CoE is on a best effort basis. Not all nodes contribute to this task.

3.1.4. Enhanced functions provided jointly by the ARC network at large

ARC nodes and CoE voluntarily and on a best efforts basis provide further services from among those listed below.

- **Additional Phase 1 operations**: Contributing to the updating of technical user documentation and the review of other documents related to the Calls for Proposals;
- **Science Verification (SV) data reduction:** SV data reduction is done collaboratively between JAO and the three ARCs;
- **Advanced data reduction**: Support of large and/or complex datasets requiring non-standard analysis techniques and the utilisation of the advanced algorithms and software developed by the nodes;

[1] The CoE provides only a subset of the functions of an ARC node, as defined in the document "European ALMA Centres of Expertise: Tasks and Responsibilities"

- **Pre-release testing of end-user software subsystems:** In particular the Observing Tool (OT), the offline system (data reduction), the pipeline (automatic data reduction), the archive, the Snooping Project Interface (SnooPI) and the Helpdesk;
- **Participation in commissioning:** Contribution to commissioning of new observing modes, either on-site in Chile or off-site from the ARC network staff home institutes;
- **Storage of advanced data products**: Data reduced at the ARC nodes might be stored at the ARC nodes or in a central archive;
- **QA3 process of PI data:** Problems that are found by the users after data delivery are resolved in collaboration with JAO;
- **Development and maintenance of new software and techniques** and organisation of network-wide meetings to update the other ARC nodes, the CoE and the Central ARC staff with the related progress;
- **Archive research support**: Supporting users from the ESO Member States with the exploitation of the ALMA science archive;
- **Community outreach:** In coordination with the ESO Education and Public Outreach Department, whenever necessary.

Not all ARC nodes and CoE provide all of the above services. Furthermore, additional tasks of the ARC nodes may be the outcomes of continuous discussions among all parties of the European ARC network.

4. The organisation and interaction of the Central ARC and the ARC nodes

4.1. Central ARC responsibility

The Central ARC at ESO is the responsibility of the ARC Department head. In this geographical distribution of ARC nodes and CoE, the Central ARC plays a coordinating role to ensure that it is effective in supporting all parts of the ESO community. The ACC provides descriptions of the tasks of each ARC node/ CoE, and coordinates the activities of the Central ARC and the ARC nodes/ CoE in terms of tasks and expertise areas. Staffing and budget are the responsibility of the individual ARC nodes/ CoE. Communication between the ARC nodes/ CoE is achieved through an interactive web-page (twiki), through monthly teleconferences and yearly face-to-face meetings.

4.2. ARC nodes/CoE responsibilities

Each ARC node and CoE agrees to undertake all actions necessary to carry out their tasks described in this document on a best effort basis. All ARC node and CoE tasks are limited to the boundaries dictated by their respective funding agencies or their governing bodies, and are further subject to potential prioritisation associated with programmes involving local PIs or Co-Is. Each ARC node agrees that within these boundaries highest priority should be given to the top listed tasks stated in section 3.1.2, namely face-to-face user support and Contact Scientist duties.

The ARC nodes representatives are responsible for their respective ARC node's activity and the adherence to this MoU. Each ARC node and CoE reports regularly all relevant

information to the Central ARC and the ARC network, through any of the communication channels mentioned in section 4.1 above. Each ARC node and CoE also agrees to be visited regularly by the ARC Department head and the ARC node coordinator to further ensure efficient information exchange within the European ARC. These visits are scheduled based on the needs and operational constraints of each ARC node to ensure that homogeneous services and user support are provided throughout the network. Each ARC node notifies the Central ARC and the other ARC nodes in a timely manner about any problems that arise with its compliance with this section, and asks for an ACC meeting to find a solution.

The European ARC network staff meets once per year to share information, coordinate support, share documentation and introduce any software developments related to user support. In addition, the ACC has a face-to-face meeting once per year. Both meetings are supported financially by ESO.

5. Funding

Funding for the ARC nodes is sought from their own local funding agencies. Additional funding proposals involving multiple ARC nodes plus the Central ARC (for instance for EU funding for networks) are coordinated by the ACC. The ACC also seeks funding to support travel of ALMA users to the ARC nodes. If required, funding applications are supported by ESO by providing statistics, documents or letters of support.

If an ARC node/CoE cannot obtain the funding from its funding agency or other sources necessary for the tasks assigned to it, it shall immediately inform the ACC, which shall discuss the way forward.

6. Resolution of disputes

Should any dispute arise on any matter relating to the interpretation or the implementation of this MoU, such dispute will be referred to the ACC which will seek to resolve the dispute by mutual agreement.

7. Entry into effect, duration and termination

This MoU supersedes the previous MoU between ESO and the ARC nodes that was signed in 2008. It will become effective upon signature of all ARC nodes, CoE and ESO and will remain in effect until 2020 with automatic extensions of periods of three years each until the end of ALMA operations, unless otherwise agreed upon by all parties. This MoU may be renegotiated at any time when functions are added or redefined or when additional parties are interested in joining the ARC network, by giving a written notice to the other parties, which will be discussed by the ACC.

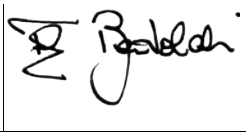
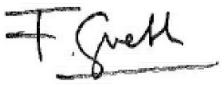
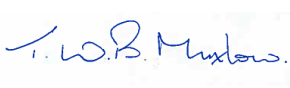
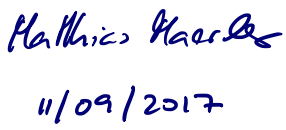
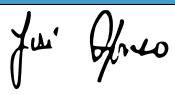
An ARC node/CoE may withdraw from this MoU at any time giving one (1) year´s notice to the other parties. Unless otherwise agreed by the remaining parties, this MoU shall remain in force unchanged among the remaining parties.

8. Annexes

The following Annexes form an integral part of this MoU

ANNEX 1: ALMA Principles of Operations
ANNEX 2: List of Critical Services provided by the ALMA Support Centres, as defined by the ALMA Board

Signatures of ARC node representatives

European ARC node	Representative	Affiliation	Date and Signature
Italian	Jan Brand	Istituto di Radioastronomia Bologna, Istituto Nazionale di Astrofisica	
German	Frank Bertoldi	Argelander Institut für Astronomie, Universität Bonn	
IRAM	Frédéric Gueth	Institut de Radioastronomie Millimétrique	
Allegro	Michiel Hogerheijde	Leiden Observatory	 9-10-2017
Manchester	Tom Muxlow	Jodrell Bank Centre for Astrophysics, Manchester University	 20-08-2017
Czech	Pavel Jachym	Astronomical Institute of the Czech Academy of Sciences	 29/08/2017
Onsala	Matthias Maercker	Onsala Space Observatory	
Centre of Expertise	**Representative**	**Affiliation**	**Date and Signature**
PACE	José Afonso	Institute for Astrophysics and Space Science	 10-10-2017
Central ARC	**Representative**	**Affiliation**	**Date and Signature**
ARC at ESO	Martin Zwaan	European Organisation for Astronomical Research in the Southern Hemisphere	 15 Oct 2017

Signatures of host organisations or funding agencies

European ARC node	Host organisation or funding agency	Date and Signature
Italian	Istituto Nazionale di Astrofisica	
German	Argelander Institut für Astronomie, Universität Bonn and I. Physikalisches Institut, Universität Köln	17.June 2017
IRAM	Institut de Radioastronomie Millimétrique	6th of July 2017
Allegro	Leiden Observatory	9-10-2017
Manchester	Jodrell Bank Centre for Astrophysics, Manchester University	24 August 2017
Czech	Astronomical Institute of the Czech Academy of Sciences	Vladimir Karas 30 August 2017
Onsala	Chalmers University of Technology	26/09/2017
Centre of Expertise	**Affiliation**	**Date and Signature**
PACE	Institute for Astrophysics and Space Science	
Central ARC	**Affiliation**	**Date and Signature**
ARC at ESO	European Organisation for Astronomical Research in the Southern Hemisphere	7.11.2017

Abbreviations

ACC	ARC Coordinating Committee
ALMA	Atacama Large Millimeter/submillimeter Array
ARC	ALMA Regional Centre
CoE	Centre of Expertise
CS	Contact Scientist
EASC	ESO ALMA Support Centre
ESAC	European Science Advisory Committee
ESO	European Organisation for Astronomical Research in the Southern Hemisphere/ European Southern Observatory
JAO	Joint ALMA Observatory
MoU	Memorandum of Understanding
OT	Observing Tool
PI	Principal Investigator
QA	Quality Assurance
SB	Scheduling Block
STC	Science and Technical Committee
SV	Science Verification

ALMA BOARD

ALMA EDM Document	AEDM 2016-029-O_Rev.3
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Subject: ALMA Principles of Operations

AUTHOR(S): AMT and ALMA Director

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Status: Approved by written procedure according to Art. 11 of the Board Rules of Procedure

Atacama
Large
Millimeter /
submillimeter
Array

ALMA Principles of Operations

ALMA-10.00.00.00-0020-A-PLA

2016-05-03

Prepared by:	**Organization Role:**	**Date and Signature:**
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Pierre Cox	ALMA Director	

Change Record

Version	Date	Affected Section(s)	Author	Reason/Initiation/Remarks
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2.0	2015-03-09	ALL	ALL	Revised version after AMT Meeting
3.0	2015-03-16	ALL	ALL	Revised version after internal JAO discussions
4.0	2015-03-24	ALL	ALL	Revised and final version after revision by AMT
5.0	2015-11-24	ALL	ALL	Revisions by P. Roche (Chair of ALMA Board)
6.0	2016-04-13	ALL	ALL	Final revisions after written comments received during Board face-to-face meeting (April 7/8, 2016)
7.0	2016-04-22	ALL	P. Cox	Changes made during approval process by the ALMA Board
8.0	2016-04-28	2.2 2.3	ALMA Board	-Revise the procedure for appointing the JAO key personnel. -Eliminate the relation between the enhanced services and the budget
9.0	2016-05-03	2.3	NAOJ DG TMA	Reordering sentence related to the location and organization of each ASC. Revise wording regarding the services provided by the ASCs.

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1 Introduction

1.1 Purpose

This document provides the overall principles of operations for the Atacama Large Millimeter/sub-millimeter Array (ALMA). Its purpose is to serve as a basis for the documents describing the details of the management and organizational structure for ALMA Operations, including onsite and offsite activities, the implementation plans for each department, groups and teams forming the ALMA project. It forms, together with the ALMA Operations Management Plan, the over-arching documents for the ALMA Operations Plan.

1.2 Description

As stated in Article 2 of the ALMA Trilateral Agreement [AD01], ALMA has been created and is funded by the Parties, ESO, NSF and NINS, and overseen by the ALMA Board, composed of members appointed by the Parties. The Parties have designated ESO, AUI and NAOJ, as their respective entities to carry out tasks required for the commissioning, operations, development and decommissioning of ALMA (ESO, AUI and NAOJ are hereinafter collectively referred to as the "Executives") [AD01]. The Joint ALMA Observatory (JAO), staffed by the Executives and headed by the ALMA Director, provides the unified leadership and management of ALMA Operations. The ALMA Director as Chair of the Director's Council meets with the Executives, to coordinate activities among the Executives and the Joint ALMA Observatory. The necessary scientific and technical interactions and support of the respective regional user communities with ALMA occur through the regional ALMA Support Centers (ASCs) operated and managed by the respective Executives. The ALMA Board utilizes an ALMA Science Advisory Committee (ASAC), a Science Committee, a Personnel Committee, and a Budget Committee, which are subcommittees of the Board and an International Visiting Committee as an advisory body.

1.3 Scope

This document applies to all the documents related to ALMA Operations. It defines the principles governing the operations of ALMA.

1.4 Applicable documents

The following documents are part of this document to the extent specified herein. If not explicitly stated otherwise, the latest issue of the document is valid.

Appl.	Document Title	ALMA Doc. Number
[AD01]	ALMA Trilateral Agreement – Agreement concerning the Operations of the ALMA by NSF, ESO and NINS	
[AD02]	ALMA Management Agreement – Management Agreement concerning the Operations of the ALMA by AUI, ESO and NAOJ	
[AD03]	ALMA Scientific Specifications and Requirements	ALMA-90.00.00.00-001-A-SPE

1.5 Reference documents

The following documents contain additional information and are referenced in this document.

Ref	Document Title	ALMA Doc. Number
[RD01]	ALMA Operations Management Plan	
[RD02]	ALMA Maintenance Principles	AEDM 2014-027-O (ALMA-02.00.00.01-0003-A-PLA)
[RD03]	Principles for the ALMA Development Program	AEDM 2011-023-O (Rev2)
[RD04]	ALMA Steady and Full Operations	ALMA-00.00.00.00-0121-A-GEN

1.6 Acronyms and Definitions

All acronyms and abbreviations used within this document are given at the ALMA Acronym Finder web page.

2 ALMA Organization Structure

ALMA is a joint scientific venture between Europe, North America and East Asia, in cooperation with the Republic of Chile. ALMA Operations will serve these communities in a way that distributes the burdens and benefits in a mutually agreeable way. The organizational structure for ALMA Operations is derived from the organization of the project that was in place during the construction phase, as revised by the ALMA Trilateral Agreement [AD01] and the ALMA Trilateral Management Agreement [AD02]. The ALMA Governance and Management Structures as well as the Advisory Bodies are displayed in Figs. 2-1, 2-2 and 2-3, respectively. These charts highlight the reporting structure of the JAO, the interactions with the Parties, the Executives, and the different committees (ALMA Board, Director's Council, Advisory Groups, AMT, IXTs and ASCs).

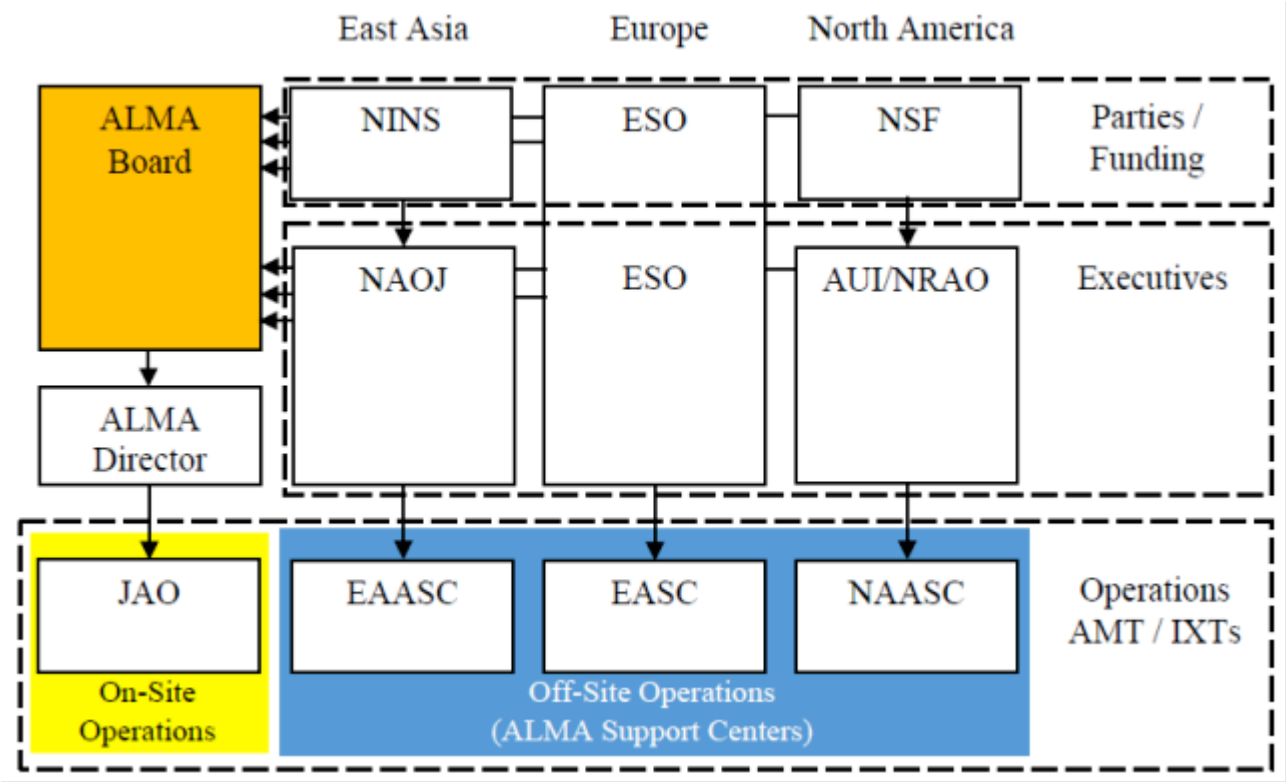

Figure 2.1: ALMA Governance Structure

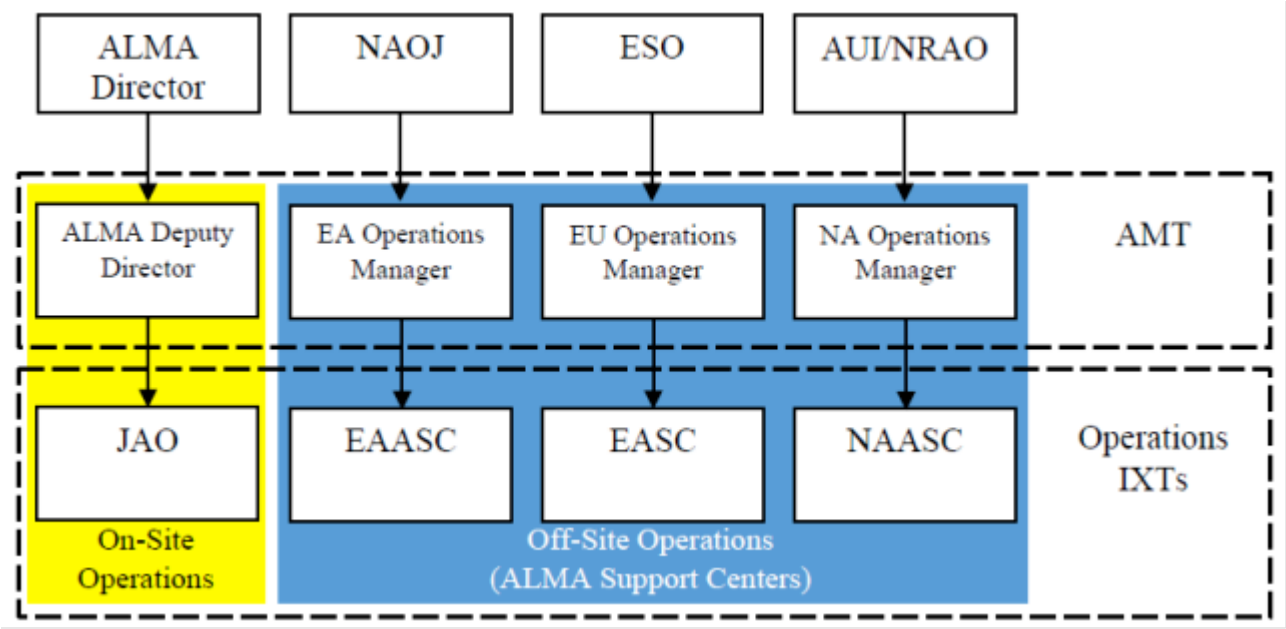

Figure 2.2: ALMA Management Structure

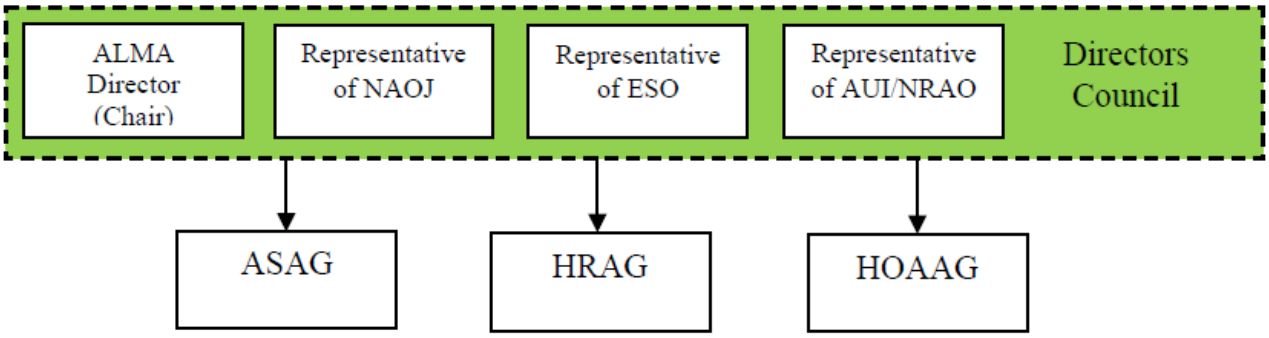

Figure 2.3: ALMA Advisory Bodies

2.1 ALMA Governance

ALMA is funded by the three Parties: ESO, NSF and NINS. The Parties will share the costs and contributions for ALMA Operations according to the following Shares of Contributions: NSF (37.5%), ESO (37.5%) and NINS (25%) as described in the ALMA Trilateral Agreement [AD01].

The ALMA governing body is the Board, which is the primary forum for interactions among, and decisions of the Parties to the ALMA Trilateral Agreement [AD01], with the ultimate approval authority remaining with the Parties. The Board shall ensure that Operations are carried out jointly in accordance with the terms and provisions of the ALMA Trilateral Agreement.

The Board shall be composed of representatives of the Parties and include twelve (12) members. NSF and ESO shall each appoint four members and NINS shall appoint three members to the Board. Additionally, the Parties invite Chile to appoint one member to the Board. The members

appointed to the Board are expected to cover astronomical, technical and managerial expertise relevant to ALMA.

All decisions of the Board shall be consistent with the ALMA Trilateral Agreement [AD01] and with the governing laws, regulations of the Parties and the Executives and their contractual obligations therein. Any decision by the Board that may impinge upon the legal, budgetary or similar competences of the Executives shall be taken only after the recommendation of the Director´s Council.

2.2 The Joint ALMA Observatory

The Joint ALMA Observatory is headed by the ALMA Director and is comprised of such staff as is required for Operations in Chile. The staff will be employed by the Executives (the designated administrative organizations: ESO, AUI/NRAO and NINS/NAOJ).

The ALMA Director shall be responsible for managing and directing all JAO staff regardless of their employer. The ALMA Director is responsible for establishing end-to-end operational priorities and schedules, subject to the review and approval of the ALMA Board.

The ALMA Director, in consultation with the Executives, develops the yearly Operations Budgets for approval and out-year Budget Planning for adoption by the ALMA Board. Direct budgetary control on a day-to-day basis for the onsite operations budget remains with the ALMA Director.

The primary function of the JAO is the operations and maintenance of the array at the Array Operations Site (AOS) and the Operations Support Facility (OSF). The JAO shall also maintain the Santiago Central Office (SCO) to facilitate administrative and operational tasks that need not be done at the OSF, e.g. data pipeline processing.

The JAO Staff is responsible for the day-to-day operations of the JAO. Governance of the JAO, i.e. policy decision making, remains the purview of the Executives and the ALMA Board.

The following assumptions are adopted for the day-to-day operations in Chile:

- Due to the remote nature of the OSF and AOS, it is assumed that most staff will work in rotating shifts (*Sistema de Turno*), which is a commercial staffing system that complies with Chilean labor laws. Work arrangements include a range of possible schedules, such as 5+2 (five days on, two days off) and 8+6 (eight days on, six days off).
- For each staff member working at the OSF (and AOS), the ALMA Director shall provide room and board at the OSF and transportation to and from pre-established pickup points.

The ALMA Director's Office (ADO) is the focal point for operations management of the JAO. The ALMA Director leads the JAO and reports to the ALMA Board. The ALMA Director shall have the responsibilities and authorities stated in the ALMA Trilateral Agreement [AD01]. The ALMA Board appoints the ALMA Director and, in concurrence with the ALMA Director, all personnel designated by the Board as Key Personnel.

Because the governance, legal, technical, financial, safety or reputational risks of ALMA Operations are ultimately borne by each Executive, there may arise instances when an Executive cannot accept a decision of the ALMA Director. In these cases, the Executive will collaborate with

the JAO, and as required, with the other Executives, to seek an acceptable alternative. Each Executive agrees not to impose unnecessarily its right to require an alternative course of action and shall do so only in cases where it judges the risk to be unacceptably large.

In response to the ALMA Director's requirements, the Executives hire the necessary staff as required for Operations in Chile. The JAO staff shall be composed of International and Local Staff. All JAO staff that has functional duties that do not require a daily presence at the OSF will be co-located in Santiago de Chile at the Central Office. Each member of the JAO will be employed by one of the Executives. International Staff Members (ISM) and Local Staff Members (LSM) are employees of the individual Executives assigned to ALMA and working under the contractual terms and conditions established by the relevant Executive, but reporting to JAO division heads. The Executives control the promotions and career paths of ISM and LSM employees, upon recommendation by the appropriate JAO Department Heads. Local Staff Members are hired in Chile on behalf of the JAO by the NSF Executive under the contractual terms and conditions established by that organization and in accordance with the Chilean Labor Law, and work under the management of the JAO Department's Heads and Managers. The JAO steers the promotions and career paths of the LSM employees, under the control of the Legal Employer (the NSF Executive). Contract Staff Members are provided by local service providers under contract to one of the Executives; the Contract Staff Members work under the contractual terms and conditions established by the provider, as amended by the service contract between the relevant Executive and the provider.

All JAO employees in Chile are managed by, and report to, the ALMA Director, either directly or indirectly.

The ALMA Advisory Groups, which are defined by the Director's Council or by the ALMA Trilateral Management Agreement [AD02], include Safety, Human Resources and Heads of Administration (see Section 2.5). Those Advisory Groups are shown to be ASAG, HRAG and HAAG in Figure 2.3.

2.2.1 Safety Organization

The safety of ALMA staff and equipment is paramount. It is imperative that a comprehensive safety management system and oversight following international standards be in place and regularly reviewed and updated.

The Joint ALMA Observatory is one of the most technologically complex astronomical complexes in the world, operating at the highest altitude ever for a facility of this magnitude. The diverse and complex environment of the ALMA operations with two sites that are both at high altitude, contributes to a potentially hazardous work environment that warrants special attention and scrutiny.

Implementation of the ALMA safety strategy is one of the responsibilities of the ALMA Director, who is charged to provide the resources in the form of manpower and financial support to ensure the site safety and security requirements are implemented, executed, and reported to the ALMA Board and the Executives. The Safety Manager, who reports directly to the ALMA Director, is appointed to support the ALMA Director in the implementation of the Safety Program.

In order to support the ALMA Director in the execution of the safety responsibilities, the ALMA Safety Advisory Group (ASAG), which is a group established by the Director's Council according to the ALMA Trilateral Agreement [AD01] and replaces the previous ALMA Safety Advisory Committee, monitors and provides guidance to the ALMA Director for the ALMA Health, Safety, Security and Environment (HSSE) Program.

Subject to the approval of the ALMA Director, the Safety Manager shall implement AOS safety policies, according to the current regulations, including requirement & procedures related to the level and kind of activity allowed both at day and at night. Procedures shall be implemented for regular medical certification before authorization for AOS work.

Various close monitoring practices shall also be implemented, such as check-in/check-out for those working at the AOS and practices, equipment tag-out practices, and procedures to ensure that no one can work alone under any circumstances.

At all times, sufficient vehicles (including an ambulance) should be available at the AOS in case of emergency or evacuation. Following recent regulations, the presence of a paramedic team is required at the AOS to provide assistance when needed at all times.

2.2.2 Environmental Issues

The Joint ALMA Observatory operations shall be compliant with all Chilean environmental regulations, as well as international standards as they apply to the OSF and AOS sites. Consistent with the spirit of this requirement, the Joint ALMA Observatory will remain mindful of the unique and high environmental, cultural and historical value, as well as sheer natural beauty, of the OSF and AOS sites. Efforts will be taken to minimize the physical impact of the Joint ALMA Observatory in its environs by, e.g. keeping the footprints of facilities as small as possible consistent with safe and efficient operations, driving on graded roads only, walking on graded paths for everyday activity, choosing the most environmentally-friendly power generation process whenever possible, exercising proper care with waste disposal, etc. Additionally, ALMA will retain environmental consulting services to maintain compliance with the requirements and specifications of the environmental impact statement. This will require visits twice a year of an archeologist and biologist, to monitor the fauna and flora.

The Safety Manager shall be responsible for developing, implementing, and/or maintaining an environmental protection plan; once in place, the Safety Manager shall monitor compliance with this plan.

ALMA shall operate a Spectrum Management Office to deal with issues related to and take measures to maintain the ALMA radio quiet zone.

2.3 Regional ALMA Support Centers

All interactions (observing proposal and data related, scientific, technical, etc.) between the regional communities and ALMA will occur through three regional ALMA Support Centers (ASCs) established operated and managed by the Executives. The ASC is the body responsible for the execution of the ensemble of activities related to ALMA operations on behalf of one of the ALMA

Executives. This may or may not include services at various distributed centers throughout the relevant region for a specific Executive. Typically these services are related to science operations, science activities, computing, engineering, development, and education & public outreach.

The location and internal organization of each ASC is the responsibility of its managing Executive.

The Regional ALMA Support Centers will provide a package of operationally critically services to ALMA Operations in Chile and their respective user communities, to be defined by the Board. Each ASC may also provide additional, enhanced services as deemed desirable by the managing Executive.

Each ASC shall have a regional Operations Manager as the Head of the respective ASC. As is true for all ASC employees, the regional Operations Manager is hired by and reports to the respective Executive. The regional Operations Manager is responsible for providing Board-approved operational deliverables to the JAO and the Regional ALMA User Community, in accordance with the detailed requirements and schedule established by the ALMA Director or his Delegates.

The organization of the JAO and its relationship to the ASCs provides the necessary centralized decision-making and direction required to manage a distributed operations structure. On the other hand, the risks in ALMA operations are borne by the Executives.

The ASCs, in possible collaboration with other institutes, manage the development of new instrumentation for ALMA, both hardware and software. The ALMA development shall be carried out according to the Principles for the ALMA Development Program [RD03].

2.4 ALMA Management Teams

The ALMA Management Team (AMT) shall be composed of the Operations Managers from three regional ASCs and the ALMA Deputy Director from the JAO. The Chair of the AMT will be the ALMA Deputy Director. Significant coordination between the JAO and the ASCs is required to provide effective support to the operations and development. To this end, each major area of operations or support shall form an ALMA Integrated Team (IXT), tasked with executing this coordination, as described in the ALMA Operations Management Plan [RD01]. The ALMA Integrated Teams are composed of members from all three ASCs and the JAO whose primary functional duties are concerned with core operational aspects of ALMA requiring coordination and interaction between and among the ASCs and the JAO.

2.5 ALMA Advisory Bodies

The Director's Council is a subsidiary body established by the ALMA Trilateral Agreement as a forum to discuss and coordinate activities among the Executives and the Joint ALMA Observatory and to identify and resolve policy implementation matters consistent with the policies set forth by the Board. The Director's Council shall be composed of the ALMA Director as Chair and one representative of each Executive as approved by the respective Parties. The Director´s Council supports the ALMA Director to ensure that ALMA Operations are carried out in accordance with the obligations of the Parties, the rules applicable to the Executives and the policies set forth by the Board. In particular, the Director´s Council shall recommend the long term budget plan for adoption

by the Board for planning purposes, and shall recommend to the Board for approval the Budget, the principles of the ALMA proposal review process, and the high level policies regarding the mid and long term perspectives of ALMA. The Director's Council shall also recommend to the Board scientific, technical and administrative policies required to achieve the agreed goals; the manner in which Operations will be carried out; the principles for the coordination of operational processes among the Executives and the Joint ALMA Observatory; the policies and procedures for the allocation of Observing Time, data rights, proprietary time, data storage, archiving, access, and subsequent use by the astronomical community; and general policies, guiding principles and all other significant matters concerning ALMA Operations.

The ALMA Science Advisory Committee (ASAC), who reports to the ALMA Board, will provide regular scientific and technical advice. The ASAC's advice will also be considered when the Board needs to make decisions regarding prioritization of tasks and resources, including the ALMA Development Program. The ALMA Board, in consultation with the ALMA Director, will define the terms of reference of the ASAC and appoints its members. Additionally, each Executive shall maintain regional science advisory bodies to channel scientific and technical input into the ASAC and the ASCs.

3 Fundamental Goals of ALMA Operations

The prime goal of ALMA Operations is to facilitate the scientifically efficient use of the Joint ALMA Observatory (JAO), consistent with operating safely at a high altitude (5000 meters) site in a cost effective manner and with as small as possible impact on the unique environment in and around the ALMA sites in Northern Chile. To this end, operations modes will be developed and implemented that allow the antennas, instruments, data flow and infrastructure to work together in a fully coordinated fashion and to adapt quickly to the prevailing atmospheric conditions. The ALMA Operations shall be designed to minimize the global overhead for target selection, antenna pointing, target acquisition, instrument set-up, data collecting and storage, and quick-look quality of control.

The ALMA Level One Primary Science Requirements [AD03] are:

- Detect emission from the CO molecule, atomic or ionized Carbon towards a galaxy of Milky Way luminosity at a redshift of 3 in less than 24 hours integration.
- The ability to image the gas kinematics in protostars and protoplanetary disks around young Sun-like stars at a distance of 150 parsecs, enabling one to study their physical, chemical and magnetic field structures and to detect the gaps created by planets undergoing formation in the disks.
- Provide precise imaging at an angular resolution better that 0.1". Here 'precise' means that the ratio of the most intense to the weakest feature in the image can reach 1000.

The Mission Statement of ALMA is as follows:

ALMA collects and delivers high-quality data sets to the scientific community by operating, maintaining and further developing a state-of-the-art observatory to explore the universe in the millimeter/sub-millimeter wavelength range.

To this effect, ALMA will:

- *Provide a stable operating interferometer*
- *Maximize the availability of the array*
- *Make the operations user-friendly to facilitate science by the broad community*

The ALMA interferometer includes the 12-meter Array of fifty (50) 12-meter dishes, which can be reconfigured with baselines ranging from 15 m to 16 km, along with the Atacama Compact Array (ACA) or Morita Array with four (4) 12-meter dishes with the ability to measure total power and twelve (12) 7-meter dishes. All telescopes will be equipped with at least the seven (7) receivers bands provided by the construction project (by 2017 an eighth band will be available). The array shall allow multiple simultaneous sub-arrays in order to increase capabilities and improve operational activities.

Highly qualified staff will operate the array in order to provide a stable operating interferometer, maximize the availability of the array, and maintain high scientific performance.

ALMA operations include activities at the Array Operations Site (AOS) and Operations Support Facility (OSF) near San Pedro de Atacama and Toconao in Northern Chile, the Santiago Central Office (SCO) in Santiago de Chile, and three regional ALMA Support Centers (ASCs) established

by the Executives – Europe, North America and East Asia. These ASCs include the user and science support, technical support, particularly in the areas of hardware and software development and maintenance, and development studies and projects. The Executives manage and operate the ALMA Support Centers (ASCs).

Most of the maintenance work will be done in Chile, except when there is a need for specific skills or equipment that are not available at the JAO, according to the ALMA Maintenance Principles [RD02].

To optimize the match between varying atmospheric conditions and science observations, ALMA will be operated almost exclusively in service observing mode, in which observatory staff execute observations based on pre-determined execution sequences defined after interaction between ALMA staff and the Principal Investigator (PI) of the proposal. Observations will be executed via a dynamic scheduling process designed to maximize the overall scientific return, the goal will be to execute the observations with the highest scientific priority that matches the current atmospheric conditions and array configuration. All other things being equal, programs closer to completion shall be given priority.

There will be a single proposal review process for ALMA to assign the observing time of the ALMA Partners and Chile, through a regular annual proposal submission, in order to optimize the scientific impact of ALMA. The ALMA Director is responsible to the Board for implementation of the ALMA time allocation process, and the details are described in the Principles of ALMA Proposal Review Process. The Joint ALMA Observatory (JAO) through the regional ALMA Support Centers (ASCs) will issue the call for proposals once per year.

An international Proposal Review Committee shall review the ALMA proposals with the goal of optimizing the science impact of ALMA; therefore proposal prioritization will be according to scientific merit, while assuring each region receives the observing time of 33.75% in North America, 33.75% in Europe, 22.5% in East Asia and 10% in Chile according to the following Shares of Contributions: NSF (37.5%), ESO (37.5%) and NINS (25%) as described in the ALMA Trilateral Agreement [AD01].

Observations preparation will follow a Phase 1/Phase 2 process. During Phase 1, observation proposals will be created using software tools provided by ALMA and submitted for scientific and technical review. Approved Phase 1 proposals will be submitted to Phase 2 where all observations will be specified as Scheduling Blocks (SBs).

ALMA Operations shall ensure that appropriate calibration data are acquired for all ALMA science data. A calibration plan shall provide information about the nature of calibration data, frequency of calibration acquisition, accuracy goals of calibration, and application of calibration data for processing science data. The JAO shall maintain up-to-date calibration of the array and shall track the stability of the calibration to monitor the array performance with time. ALMA shall implement a data quality assurance process to ensure that observations are performed under the appropriate atmospheric conditions and system configuration, that system performance fell within the expected range during the observations, and that the calibrations meet the published accuracy requirements.

By the time of Full Operations [RD04], the fundamental data product of ALMA shall be calibrated, de-convolved images. In addition, astronomers shall receive the appropriate calibration data necessary to re-process the data. Raw data shall be made available to astronomers through the

ALMA Archive. A data pipeline processing system shall be implemented to process science and calibration data, to support the ALMA data quality assurance program, and to produce the images. ALMA shall provide the off-line software necessary to re-process the data.

The backbone of ALMA Science Data Flow will be the ALMA Archive, a distributed system with archives at the OSF, SCO, and ASCs. The OSF/SCO archives will be tightly bound by a high-bandwidth Internet connection link and specified to handle an appropriate sustained data rate. The ARCs will have copies of the SCO archive but synchronization will not occur in real-time.

ALMA observations will be systematically archived along with calibration data, processed images, and those engineering and environmental data required for subsequent engineering and scientific analysis. All the data that are necessary for scientific analysis, including calibration data and processed images, will be distributed to the PI. Those data shall be accessible to the worldwide community after the expiration of a proprietary period of 12 months from the delivery of the final data products to the PI. The ALMA Director may grant extensions to this period upon justified request.

In summary, ALMA shall provide an array operating efficiently and conducting programs according to their scientific priority and matched to prevailing conditions. This requires:

- Effective preventive and corrective maintenance;
- System performance monitoring and trending for timely detection of problems;
- Astronomer friendly interfaces, tools, and documentation for observation planning and execution;
- Reproducible and quantitative ALMA data products;
- Standard calibrations for standard modes;
- Data processing tools to assess quickly data quality and extract accurate, quantitative results;
- A Science Archive that allows data trend analysis as well as data re-use.

To achieve these demanding goals, ALMA has implemented the following processes:

- Phase 1 Proposal Generation: Call for Proposals; Proposal Submission, Review & Scheduling, User Support & Notification;
- Phase 2 Program Generation: User Support, Scheduling Block creation, Submission & Validation;
- Observation Execution: System Calibration, Site Conditions Monitoring, Quick-Look Quality Assurance, Dynamic Scheduling and Scheduling Block Execution;
- Maintenance: Preventive & Corrective Maintenance, Performance Trending, Fault Correction, Array Re-Configuration;
- Archive & Pipeline Operations: Archive Maintenance (Science & Engineering Data), Detailed Quality Assurance, Data Product generation & Delivery;
- Science Research Archive: Web-Based, Virtual Observatory Compliant Interface to Public Data, Project-Independent search & Retrieve Tools.

ALMA BOARD

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Subject: List of Critical Services provided by the ALMA Support Centers: Annex to the ALMA Principles of Operations

AUTHOR(S): AMT

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List of Critical Services

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I. Introduction

"Regional ALMA Support Center(s)" or "Regional ASC", as defined by the ALMA Agreement, means the regional organizations established, operated and managed by the respective Executives to carry out Offsite Operations Activities. "Offsite Operations Activities", as defined by the ALMA Agreement, means support services, including **maintenance** and **development**, performed outside the JAO and organizing and maintaining the **interface between the corresponding regional user community and the JAO**, including **user support services** and **public outreach and education activities**.

This document details the services that the ALMA Board considers to be critical to the successful operations of the ALMA observatory irrespective of region and, therefore, considered part of the Executives contribution to the ALMA Operations Budget.

The list below does not exclude that the Executives decide to provide enhanced services in the benefit of ALMA Operations.

This list shall be reviewed periodically by the ALMA Board, depending on the ALMA Long-term budget planning, the optimization of the resources and the evolution of ALMA Operations.

II. Critical Services provided by the Regional ALMA Support Centers (ASCs)

1. Maintenance Support Services

a) **Hardware Maintenance**

1. Technical support with diagnostics and/or reviews
2. Provide technical advice and review of proposals to modify maintenance approaches
3. Corrective maintenance
4. Maintain technical documentation up to date
5. Provide plans to deal with obsolescence

b) **Software Maintenance**

1. Preventive, Corrective, Adaptive and Perfective maintenance
2. Further development on deliverables
    a. Completion of features requiring operation expertise
    b. Internally funded features
    c. Externally funded features
3. Contribute to software integration and testing effort led by JAO
4. Software fault tracking (troubleshooting, analysis, and diagnosis)

2. Development

1. Developments of equipment and infrastructure (including improvements, upgrades, retrofits, and completions) to enhance the new science capabilities and to strengthen the steady-state operations.

3. User Support Services

a) **Science Operations**

1. Pre-release testing of End-user Software Subsystems (Observing Tool, CASA, Science Archive, Science Portal, SnoopI, and pipeline)
2. Science Software Requirement tracking
3. Software Prioritization
4. Preparation of End-user Documentation
5. Call for Proposal
6. Proposal submission support
7. Proposal Review support
    a. Proposal Logistic Support
8. Scheduling Block Support
    a. Scheduling Block Preparation for non-standard observing modes
    b. PI-generated SB checking
9. Astronomer on Duty Support
10. Data Reduction and Quality Assurance 2 (only for early operations)
11. Improvements to Data Reduction (including providing requirements, testing, feedback and training)
12. Data Packaging and Delivery
13. Quality Assurance 3 (multi-tier quality assurance program to monitoring both short-term and long-term system performance)
14. Data Reprocessing as agreed
15. Helpdesk Support
16. User face-to-face support
17. Feedback from user community

b) **Support Computing Facilities**

1. Maintain and operate the ALMA science archive
2. Software operations and computing infrastructure support for ALMA software deployed at the regional ASC

4. Interface with User Community

1. Scientific support and input to the ALMA Development Program
2. High-level input to the ALMA Science Program via the ALMA Program Scientists and the science advisory structure
3. Stimulation and monitoring the scientific use and productivity of ALMA
4. Obtain and advise upon community input to ALMA

5. Public Outreach and Education Activities

1. Coordination of planning for ALMA education and public outreach activities worldwide