6. OPERATIONS PLAN FOR THE ATACAMA LARGE MILLIMETER ARRAY

6.1 Overview

6.1.1 Operation of the Atacama Large Millimeter Array

ALMA is a joint scientific venture between Europe and North America with participation by the Republic of Chile. The ALMA operation will serve these communities in a way that distributes the burdens and benefits in a mutually agreeable way. The organizational structure for ALMA operations in the bilateral project is derived from the organization of the project for the construction phase and is shown in Figure 6-1. The ALMA Observatory is established by the ALMA Board and staffed and funded by the Executives. The ALMA Observatory is led by the ALMA Director, who reports to the ALMA Board. The main function of the ALMA Observatory is the operations and maintenance of the array at the Array Operations Site (AOS) and the Operations Support Facility (OSF) in Chile.

The necessary scientific interactions of the respective communities with ALMA will occur through Regional Support Centers (RSCs) in a manner to be defined by the ALMA Board. The RSCs are established by the European and North American Executives. Generally, the RSCs will have "core functions" determined by the ALMA Board and managed by the ALMA Director, as well as "additional functions" which may differ among the RSCs and are managed by the Executives. Development of new instrumentation for the array, both hardware and software, is carried out by the Executives, in possible collaboration with other institutes they may choose. New projects to be funded by ALMA Operations are put forward by the ALMA Director after consultation with the user community and the Executives, and they require approval and prioritization by the ALMA Board. Such development projects are conducted in a manner identical to the conduct of the ALMA construction project. Namely, the Executive having task responsibility will assign a project manager who will report to the Executive regarding matters of cost, and he/she will report to the ALMA Director regarding technical scope and schedule.

6.1.2 Guiding Principles of ALMA Operations

When construction of ALMA is completed, the participating nations will have invested more than one half billion dollars in a facility designed and built to answer some of the most important questions of 21st century astrophysics. An ALMA operations plan that enables scientists to realize the enormous potential of ALMA for answering those questions is a fundamental goal of the project. This goal can be achieved with the following principles underlying its operations plan:

(a) The operations plan, just as in construction, embodies the guiding principles of the Bilateral ALMA Agreement (Article 2), namely parity, merit, utilization of existing facilities, and free movement of materials.
(b) The operations plan incorporates structures that maximize the scientific productivity of ALMA by facilitating and encouraging the fullest possible engagement of ALMA user communities, beyond their use of observing time, in

the further development of ALMA. This includes opportunities for technical upgrades and development of new instrumentation and software over the lifetime of the array.

(c) The operations plan should ensure safe, efficient and cost-effective operations of the array, and at the same time ensure delivery of data products of high and consistent quality, which can be used by both experts and non-specialists for scientific analysis.

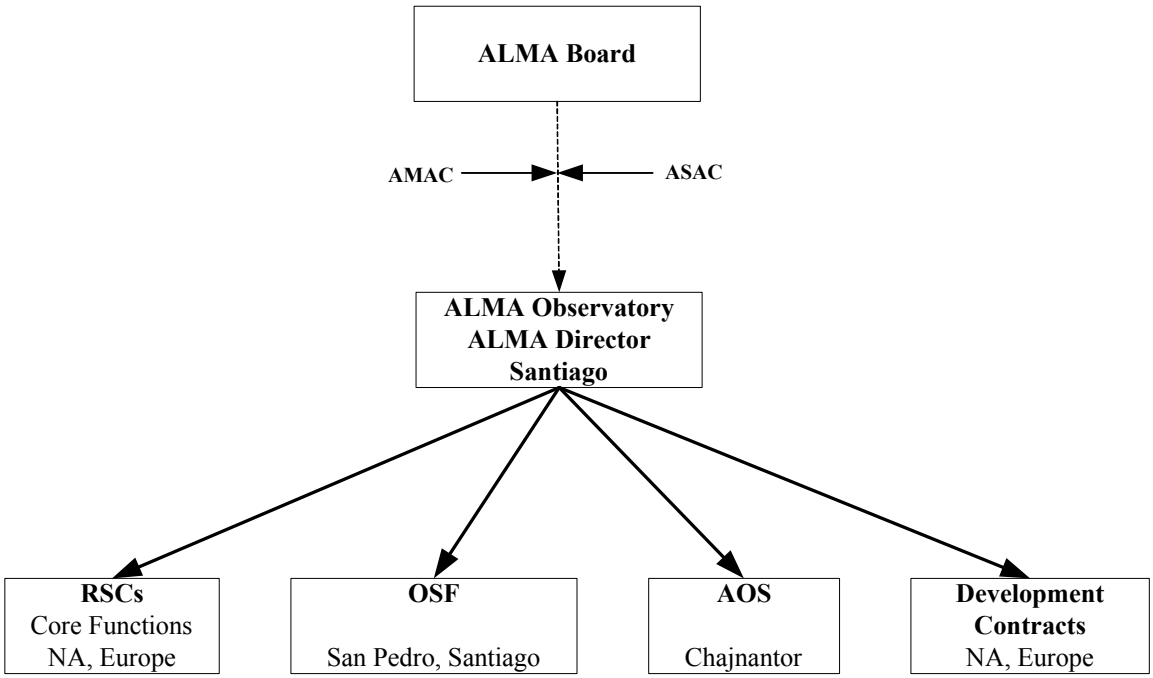

Figure 6-1. ALMA Organization for Operations in the Bilateral Project

These principles have consequences for the joint ALMA operations that are summarized in the following guidelines:

(i) ALMA is a service observing facility, for which the scientific demand will be very high. The astronomer is not normally required to be present when his/her observations are executed.

(ii) ALMA operational activities in Chile are limited to what is required to acquire, certify and archive the scientific data of the scientific teams proposing observations; this includes certain business functions and other activities requiring proximity to the array. For safety reasons, the number of ALMA staff working at the array site at 5000 meters elevation must be kept to an absolute minimum.

(iii) The main interface between the user communities and ALMA is through the Regional Support Centers (RSCs), including proposal handling and support for data reduction and archival research.

(iv) Development work on hardware and software is contracted to the Executives.

6.2 Model for ALMA Operations and Maintenance

6.2.1 Tasks and Deliverables of the ALMA Observatory

The operational tasks of ALMA start with the receipt of proposals for observations from the astronomical community. In accordance with the guidelines enumerated above, it is assumed that the potential users will propose a program of observations to their respective RSCs. Once reviewed and accepted for observation in a manner to be decided by the ALMA Board, the astronomer will provide to the Observatory an observing script that specifies the observational goals in astronomical terms. That is, the astronomer specifies the target object, frequency, spectral resolution, array configuration (if applicable) and the desired on-source integration time, signal-to-noise desired, or the *uv*-coverage needed. It is the task of the ALMA Observatory to deliver to the astronomer, either directly or through the RSCs, the following:

- A proposal preparation package, including a time estimator and a data simulator, which is capable of complete end-to-end simulation of the observations.
- Raw data and real-time calibrated, pipeline-processed, image of the target object.
- Calibrated uv data set including tables of the calibrations that have been applied, and tables of the monitor data, including prevailing metrological conditions, atmospheric transparency measurements and instrumental performance measures.
- Data path to a copy of this same information that has been submitted to the ALMA archive and notification of the proprietary period to that data.
- User support, including an off-line software analysis package for data manipulation, analysis, imaging and presentation aimed at both non-specialists and experienced users.

In order to supply these deliverables to the astronomer, the following functions should be carried out:

- Review the source script and scheduling blocks with the astronomer. The observations may be split into several scheduling blocks which can be carried out at different times. Each script will have a scientific rating and a threshold criterion for "*stringency*" determined by the ALMA Program Committee that need to be met before the program is run.
- Ensure that the array hardware and software at the OSF and AOS is functioning and maintained to specifications.
- Select a sequence of calibration observations that will enable the astronomer to meet his/her goals and that are consistent with the archive policy.
- Conduct pre-observations, if necessary, to select a nearby source for fast-switched phase calibration. Determine the position of that phase calibration source to the precision needed.
- Execute the program observations, including standard pipeline processing of the data.
- Perform a data quality assessment to confirm that the pipeline-generated images are free of corruption resulting from defective instrumentation.
- Transmit all astronomical and monitor data to the astronomer.

- Transmit the raw data, pipeline-processed images and the monitor data to the ALMA archive including with that data a date at which the proprietary period for the astronomer ends.
- Transmit copies of the archive to the RSCs.
- Provide support to the astronomers on issues related to proposal preparation, data reduction and archival research.
- Provide user feedback to the array operations.
- Ensure that array instrumentation and software is regularly upgraded and expanded over the lifetime of the array.

The following section outlines the different locations at which the above functions are carried out. A summary is included in Table 6-1.

Table 6-1. Summary of the Main Functions at the Different Locations

Location		**Main Functions**
AOS		
-Chajnantor :		Antenna re-configuration Instrument module exchange Security of site
OSF		
-San Pedro :		Array scheduling + operations Quick-look reduction Maintenance + repair antennas Maintenance + repair instrumentation Administration, Safety
Central Office		
-Santiago :		Standard pipeline reduction, quality assessment Archive production Business functions Science offices
RSCs		
- NA, Europe	Core:	Proposal handling User support for proposals, data reduction Host of archive copy, archival research support
	Additional:	Advanced software/techniques* Training, summer schools* Financial support users*
Development		
- NA, Europe		New/upgrades instrumentation New/upgrades software Additional functions for RSCs*

* Funded and managed separately by the Executives.

6.2.2 Implementation Plan

Array Operations Site (AOS)—Chajnantor:

ALMA will be operated remotely from the Operations Support Facility (OSF) near San Pedro to minimize the ALMA staff at 5000 m. This leaves on the AOS only those personnel needed to assure the security of the site, those responsible for module exchange —replacing failed instrument modules with functioning spares—and those whose task it is to transport the antennas as needed for array reconfiguration. The array will be designed and built to be modular in character and wherever possible self-diagnosing: each instrument will have provision for an adequate number of monitor points that are reported to the control computer in real time. The AOS will be connected to the OSF by means of a private road for the transportation of the antennas, and a communications highway involving buried optical fibers over which the astronomical data and the instrument monitor data are carried in real time and at high bandwidth. The AOS is further discussed in Section 6.5.

Operations Support Facility (OSF):

San Pedro: The main function of the OSF near San Pedro is the operation of the array and the acquisition of the astronomical data based on the proposal scheduling blocks. This includes responsibility for the calibration sequence, dynamic scheduling and execution of the observations, and a quick-look processing and inspection of the data. Another important function is the maintenance and repair of instrumentation and antennas. The location of the OSF is discussed in the ALMA construction project plan, and includes residential facilities for staff at the OSF and AOS, and offices for administration, safety and health. The personnel at the OSF and AOS will work turno shifts.

Central Office:

Santiago: The standard pipeline data reduction and data quality assessment is done largely at the Central Office in Santiago. All astronomical and monitor data and pipeline-produced images, once checked, are transmitted to the joint ALMA archive, with copies sent to the RSCs, to be distributed to the users. The Santiago facility will contain offices for the staff astronomers to pursue their personal research as well. The Santiago office is also the natural location for all those business and administrative functions not directly related to the operation and maintenance of the array, and is the functional node for nearly all governmental relations, contracting and import/export administration. Santiago provides a living environment (schools, medical care, shopping, partner employment) that will aid retention of those members of the ALMA professional staff who are hired from abroad and who will be working turno shifts in San Pedro/Chajnantor. The Central Office is further discussed in Sections 6.4, 6.5, and 6.6.

Regional Support Centers (RSCs)—North America and Europe

The first and last steps in the sequence of functions described in Section 6.2.1 are carried out at the RSCs in North America and Europe in a manner to be defined by the ALMA Board. The RSC core functions may include proposal handling and support to the astronomer for proposal preparation, data reduction beyond the standard pipeline data products and archival research. They may also provide user feedback on the array performance to the OSF and on the need for improvements, upgrades and future developments of hardware and software to the ALMA Director. Each RSC will host a copy of the ALMA archive or have a fast link to it. At the discretion of the respective Executive, a RSC may choose to add other functions which are not under the control of the ALMA Observatory, including advanced software beyond the nominal operations, development of new interferometric data handling techniques, support for special projects, additional training, and financial support for ALMA research. The RSCs are further described in Section 6.4.

Development—Executives in North America, Europe

The Executives are responsible, at the request of the ALMA Observatory, for providing upgrades to existing instrumentation and development of new instrumentation for ALMA. The Executives will carry out these responsibilities in the same manner as the Construction Project, and with the affiliated institutes they deem most appropriate for the task. Such developments may range from hardware aspects (receiver upgrades, new receiver bands, second generation correlator, ...) to software improvements (operations, data simulator, off-line analysis package, ...). Development is discussed further in Section 6.8.

6.3 Functional Organization of the ALMA Observatory

The ALMA Observatory is established by the ALMA Board and staffed and funded by the Executives. It is led by the ALMA Director and its top-level organizational view is shown in Figure 6-2. Figures 6-3 thru 6-5 in the following sections show the organizations of the three major sub-elements. The senior management shown in Figure 6-2, specifically the ALMA Director and the three Deputy Directors, are all appointed by the ALMA Board and report to the ALMA Board. The ALMA Director will have the responsibilities and authorities as stated in the Bilateral ALMA Agreement. The remainder of the staff are to be hired in Chile by an organization established by the ALMA Board, or they are employees of the Executives assigned to ALMA. All such people are managed by, and report to, the ALMA Director.

In addition, the Executives will establish the ALMA RSCs, whose primary task is scientific support to their respective communities in their respective countries. Each RSC will have its own manager, who reports to the ALMA Director for the core functionalities of the RSCs (see Sections 6.2 and 6.4), and to their respective Executive for the additional functionalities.

Development of new instrumentation and software, as defined by the ALMA project and funded by the ALMA Board, is the responsibility of the Executives at the request of the

ALMA Observatory. Each project will be led by a manager, who reports to the ALMA Director for matters of scope and schedule, and to his/her Executive regarding matters of cost.

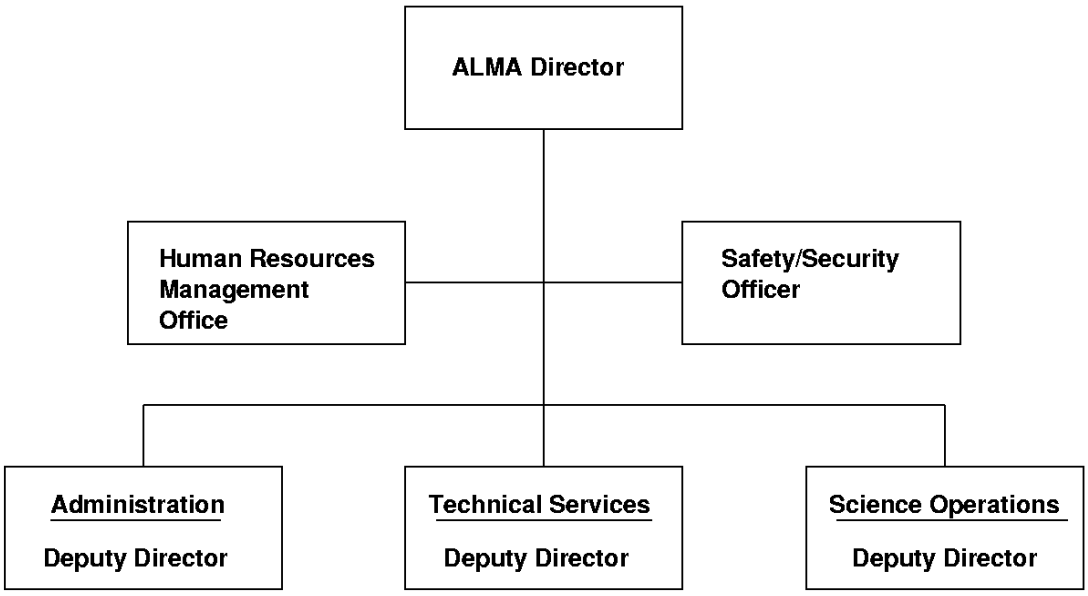

Figure 6-2. ALMA Operational Structure

6.4 Science Operations

6.4.1 The Overall Science Operations Concept

Flexible (dynamic) scheduling is essential for ALMA, and this defines the overall science operations concept. The necessity for flexible scheduling arises because millimeter and especially submillimeter observations are critically dependent on atmospheric conditions. The capability of ALMA to make instantaneous images in continuum and spectral lines opens new possibilities in this respect: a given observation can be split into several shorter ones to optimize the use of the best atmospheric conditions.

Flexible scheduling implies service observing, and this brings several other advantages. Short projects, which may be commonplace with ALMA, can be handled easily in this framework, as well as "target of opportunity" observations of unpredictable phenomena. Service observing also facilitates the long-term monitoring and consistent calibration of the array. Service observing has been used for years at radio arrays and is the default mode of operation for the current millimeter/submillimeter interferometers. Another major objective for ALMA science operations is to make the millimeter and submillimeter Universe accessible to a wide range of astronomers, particularly those who are not specialists in this area. Therefore the input from the astronomer should be focused on scientific objectives rather than technical aspects, and the default output to the astronomer should be reliable images that can be readily used for scientific analysis. This objective also implies service observing. The ALMA Observatory will be responsible for the quality of the data products and delivery to the ALMA archive.

To assure that the major objectives are met and that the archived data and pipeline-produced images are of a high and consistent quality, a complete and comprehensive end-to-end data management plan will be implemented for ALMA. Such complete data management systems are currently also in use or being developed at other facilities, including the ESO-VLT and NRAO-VLA. In the following, the different steps in the entire observing process are described in more detail.

6.4.2. Proposal and Observation Preparation

The proposal submission (Phase I) and observation preparation (Phase II) will be done electronically. The Phase I proposal form will contain the scientific case and will be used largely for scientific evaluation, but it will also have enough information for an initial assessment of technical feasibility, done largely automatically by the data simulator.

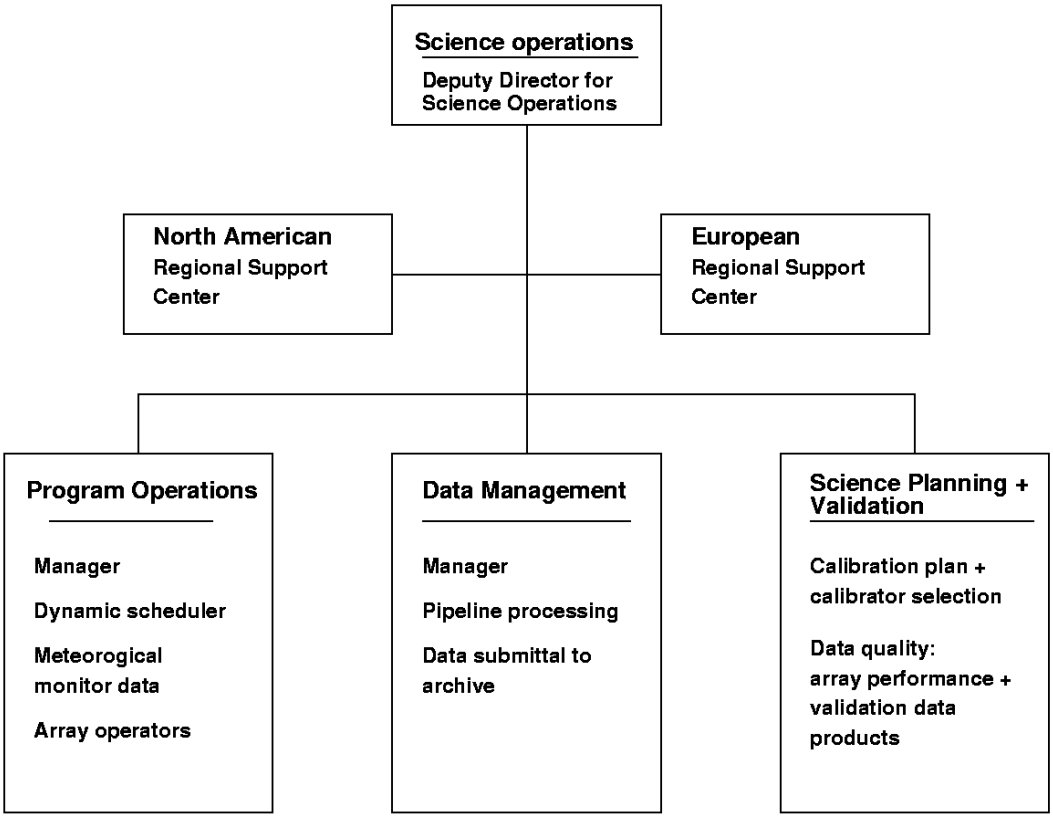

Figure 6-3. Organization of ALMA Science Operation

The scientific Phase I proposals will be peer-reviewed in the manner to be decided by the ALMA Board. A prioritization of approved proposals will be used by the dynamic scheduler at the OSF to select proposals to be run in a particular period of time.

The astronomers of successful proposals interact in Phase II with the RSCs to produce scheduling blocks (SBs) which contain the detailed technical specifications of the observing program and which will be provided to the OSF in Chile. The SBs will contain all the necessary information to define an observation, including the information required to prioritize observations based on the science ratings and the stringency conditions.

6.4.3 Array Observations

The data base of scheduling blocks (SBs) will provide the basis for the actual sequence of observations performed by ALMA at the OSF near San Pedro. The first step is to determine and review the sequence of calibration observations and assure that it is adequate for the astronomer to meet his/her goals and is consistent with the archive policy. During the actual observations, the SBs will be prioritized in real time by an automatic dynamic scheduler at the OSF, in accordance with a variety of factors, including science rating, configuration requirements, source position, "stringency" (e.g., atmospheric conditions and phase stability) and hardware status.

Observations are carried out 24 hr per day, except during planned maintenance and instrumental downtime or when weather conditions prevent acquisition of scientifically useful data. The observations are carried out by a team of array operators and support scientists who work in shifts.

In addition to the standard flexible scheduling service observing mode, other possibilities may exist for various special cases. Eavesdropping, in which the astronomer monitors the observations in real time, and preset "breakpoints" in the program are planned capabilities in accord with the recommendations of the ASAC.

Pipeline data processing will be an essential element of ALMA operation. The pipelines will support calibration and quick look data reduction, and provide calibrated images for science analysis. For calibration, the pipeline will apply all phase and amplitude calibration data, including the results from the water vapor radiometers; it will apply passband calibrations to spectral line observations and any other meteorological information as may be provided (such as measurements with an FTS). Phase and amplitude calibration results will be fed back to the scheduler and operator as the observing progresses. Whenever the calibration data identify hardware problems, a status report will be logged at system level for maintenance purposes, and made available to both the operator and dynamic scheduler, with the relevant information also submitted for incorporation into the ALMA archive.

The quick-look pipeline will keep up-to-date calibration data as new data are taken, including antenna and baseline-based amplitude and phase. It will apply calibration data to the science data on-the-fly to monitor the incoming data for an initial assessment of the quality (e.g., does the calibrator have the expected flux? is a strong line detected where expected?), and to produce early science results (current spectrum, quick-look images) when requested (e.g., after breakpoints).

6.4.4 Post-Processing, Quality Assessment and Archiving

For standard observing modes, the science data pipeline will operate in fully automated mode. The products will be calibrated images. The science data pipeline will be run at the Central Office where a data quality assessment will also be made by a support astronomer. It is the vision that support astronomers rotate between the OSF in San Pedro and the Central Office in Santiago, and that with time, experience and increased automation, an optimum division of tasks between Santiago and San Pedro will be found. It is essential that this task is carried out by a single team to ensure homogenous, consistent reduction and calibration of the data and uniform data quality.

All the data previously obtained since the project started will be available for processing. This means raw data and calibration data obtained in different array configurations, including total power data for measurements of zero and short spacings. Another algorithm may be used if it has been specifically requested by the user. The information on the data quality and array performance will be fed back to the array observations at the OSF-San Pedro on a daily basis. Feedback on array performance and calibration strategies will also be given regularly to the RSCs.

The raw and calibration data, all monitor data, and the standard pipeline-produced calibrated images will be delivered to the archive. A copy of the entire archive will be hosted at each RSC for further processing and analysis. Each Executive will receive a copy of all the data taken by ALMA. The data should be made available promptly to the users.

6.4.5 Data Analysis Support and Archival Research

Once the data have been shipped to the user in Europe, North America, Chile or elsewhere, the loop has been closed and the observation process is complete. However, there are three further important elements in the system—data analysis support, archival research and user feedback. In many cases where the observation was a straightforward image and the default or requested pipeline processing was adequate, no further interaction will be required. There will also be cases, however, where the astronomer has questions on the standard pipeline products and may want to try a different reduction scheme, or special programs where a variety of algorithms will be required to extract the science from the data. This support will be provided by the RSCs with core services ranging from simple advice, to provision of appropriate data analysis documents and products (which could be standard pipeline or off-line data processing software packages), to in-depth assistance for users who require it. The software packages are developed by the Executives and the affiliated institutes the Executives may choose to involve. It is also the core function of the RSCs to provide user feedback to the OSF in Chile, both electronically and through regular visits to Chile.

The proprietary period for science data will be as decided by the ALMA Board, after which they will be made publicly available in the archive. For complex projects, such as surveys or projects requiring many configurations, it may be appropriate for the proprietary period to start once all the data have been collected. Phase and flux calibrator data, on the other hand, will be made public immediately.

A copy of the complete archive will be maintained by the RSCs in Europe and North America. The archive will include raw data, calibration data and the images produced by the standard pipeline. They will also include header information such as all user input, scientific case from the proposal, observing scripts as used, the observation descriptors, relevant environmental data, the monitor data, relevant fault logs, and the pipeline reduction scripts. Except for the most complex programs, the images could also be re-generated on-the-fly with the latest version of the standard pipeline using the reduction script and the visibilities extracted from the archive. The archives will be accessed through the Archive Search Tool. Assistance in the use of the archive will be provided by the respective RSCs. The RSCs plan to interact with the Virtual Observatory to make the ALMA archive available to the world-wide community after the proprietary periods for the data have expired.

The Executives may choose to add other functionalities to the RSCs (e.g., development of new interferometric data techniques, support for special surveys, interferometer schools and training, user funding, ...) from their own resources outside the ALMA Operations budget. The RSCs should be operated with an international and collaborative spirit, and some of the additional functionalities (e.g., advanced software) should be coordinated between the various RSCs.

6.4.6 Phase-in of Science Operations During Construction

When sufficient science capability is available, science operations will start—some years before completion of the full array. Initially, experienced millimeter astronomers will be asked to join in the commissioning activities, with the expectation that they would provide important technical feedback on the facility and operations. This will be followed as soon as possible by a period of early science operations in which the general community will be invited to apply for some fraction of the observing time with the partial array. This will also be a period when observations relevant to the long-term operation of ALMA will be made (e.g., surveys for calibration sources) and first-look surveys which illustrate the capabilities of the array.

Thus, many elements of the operational setup must be in place from the outset and early operations staff is needed when the hardware arrives on Chajnantor. Initially, individual observations will be longer (fewer baselines), with a lower data rate and fewer users than after completion.

6.5 Technical Services

6.5.1 Operating ALMA at the AOS-Chajnantor

Overall concept. The environmental factors will impose severe constraints on the working conditions at Chajnantor. This leads to the decision of establishing the Operations Support Facility (OSF) at a lower elevation where the observatory control center and a large fraction of the technical services are to be located. The OSF is also the place where all the activities at the AOS are programmed and monitored on a real-time basis.

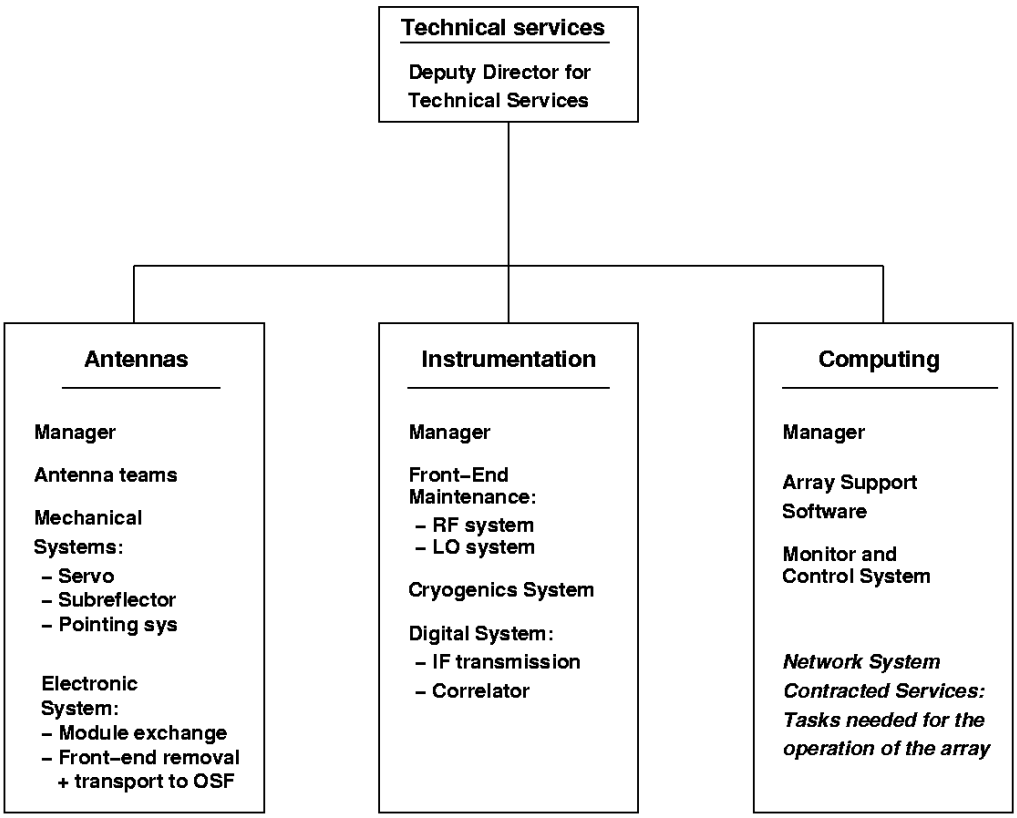

Figure 6-4. Organization of ALMA Array Operations

The aim is not only to minimize the number of staff at the AOS, but also to limit the number of the different crews operating at the high site. Essentially, only the antenna transport teams should be present on a daily basis at the AOS. When we speak of antennas here, we mean the antennas including all of the equipment and instrumentation installed on the antenna—most particularly the front-end equipment. Therefore, all the support functions at Chajnantor for the antennas, including the exchange of the instrumentation modules, would be integrated under a single group belonging to the antenna group.

Safety integration at the AOS. Safety is an essential component of the ALMA operations. It is of crucial importance at Chajnantor. The safety procedures have to be fully integrated into the activities of the antenna teams. Their work checklists have to include all the safety requirements.

Other activities at the AOS. The antenna teams will not handle any infrastructure maintenance or domestic functions (cleaning, provision of supplies, etc.) at the array site. The infrastructure maintenance will be provided by the Facility Group stationed at the OSF. This group will go to the AOS for emergency cases and for scheduled maintenance (roads, buildings, power supply, etc.). They will not be on site on a daily basis.

6.5.2 Operating ALMA at the OSF-San Pedro

Overall concept. The OSF will be the focal place for the ALMA operations in Chile. The plan is to locate this facility at an elevation where the staff can work efficiently in a comfortable environment. The array will be remote-controlled from the OSF, and the main facilities for the technical support will be established there. Consequently, the OSF will include operations, maintenance and residential facilities. It will also provide the infrastructure for assembling antennas and outfitting them with receivers during the construction phase of ALMA.

Planning and monitoring of the tasks to be performed at the high site will also be provided from the OSF. The goal is not only to minimize the presence of the people at the high site, but also to supervise and control the activities at the array site to ensure efficiency and safety.

The OSF will be linked to the array site with a communications highway and with a direct road connection. It should be stressed that the OSF and the array site represent a fully integrated unit, from the functional, managerial and social point of view.

Location of the OSF. The ALMA project plan is to locate the OSF near, but not in, the village of San Pedro de Atacama. San Pedro is a historic village that is a popular tourist attraction owing to its historic and cultural significance. The OSF is not congruous with this particular appeal. Being not too distant from San Pedro, however, has the advantages of being near public transport, restaurants, hotels, some limited shopping, emergency medical care and police security. ALMA will not depend on San Pedro for utilities (potable water, electrical power, sewage); all these services will have to be provided privately for ALMA's own needs at the OSF.

The location selected for the OSF is about 15 km east of San Pedro and south of the Paso de Jama. From this location a restricted-use road will be built connecting the AOS to the OSF in a straight line that can be used not only to transport the assembled antennas to the AOS without using the public highway, but also to return the antennas to the OSF for repair and maintenance. The direct link provides increased staff efficiency and safety at the expense of moving the OSF further from the amenities provided by San Pedro.

Scope of activities for the technical services. The technical services include the Antenna Group, the Instrumentation Group and the Computer Group. Only the latter will rely extensively on contracted services, while the first two groups will be staffed by ALMA employees as their activities are highly specialized and represent a vital component of the project core operation.

Antenna Group

a) Antenna teams
The scope of the activities of the antenna teams working at the array site is described in Section 6.5.1. These teams are complemented by continuous, on-line, support from the OSF where the planning, scheduling and monitoring of their tasks is established.

b) Antenna engineering services
The antenna arriving from the array site will be earmarked either for repair or overhaul. The repair work request will originate from the antenna teams. Prior to any antenna removal decision, a joint assessment of the failure will be established between the teams and engineering services. The regular overhaul scheme will be scheduled by the antenna engineering services, based on major servicing and realignment of each antenna every five years.

Instrumentation Group

This group will be required to maintain a broad spectrum of equipment, both at the front-end and back-end side of the instrumentation chain. RF, LO, digital electronics, and cryogenic specialists will have to be included in the group.

a) Front end and LO support
In ALMA, antenna front ends are designed in a modular manner. The receiver band cartridges are built as separate units, which can be tested, and serviced, individually. Modularity and reliability should ease the maintenance efforts for the OSF engineers and technicians. Servicing will, therefore, basically consist of receiver cartridge tests and repair, and their insertion into the dewar. The RF support will also include the servicing of the water vapor monitors. The team specializing in the IF area will maintain the digitizing units and the fiber transmission equipment.

b) Back end support
The second segment of technical support will deal with all the electronic equipment at the back end, including the IF transmission system and first LO. Most of the equipment consists of solid state electronic components with very high reliability.

Computing and Software Group

Most of the efforts of the computing group at the OSF at San Pedro and in Santiago will focus on the integration of new software packages and updated versions of existing packages. Little software development is planned to take place in Chile. The software packages originate from the Executives and those affiliated institutes the Executives may choose to involve. The team will have to provide feedback information to those sources and manage the integration of the updates on site. This implies a close collaboration with the Executives where the software is developed. The ALMA Observatory will have the overall responsibility for assuring that the software packages are developed according to common specifications.

The software team will also manage the networking and computer hardware maintenance for which contracted services will be used (computer peripheral exchanges, cabling, etc.).

6.6 Administration/Facilities

The scope of activities for Administration covers the functions necessary to provide an efficient support to the scientific and technical operations of ALMA:

- Administrative services;

- Logistics/general services;
- Facilities for the infrastructure support.

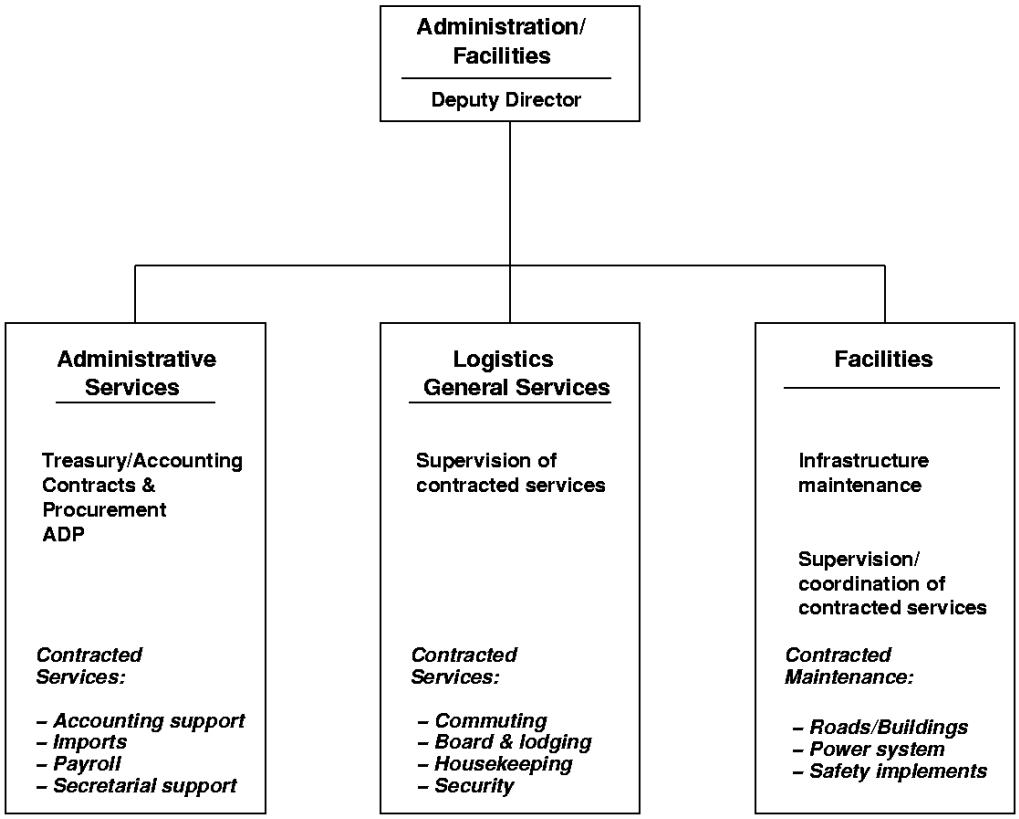

Figure 6-5. Organization of ALMA Administration

6.6.1 Administrative Services

Budget and accounting. Accounting and budgeting will support the ALMA activities in Chile, in the frame of the financial rules and procedures to be developed for the project. It includes accounting of the assets, billing services, insurance, the administration of the budget information according to the WBS for the in-house users and feedback to the regional centers abroad. It does not include the overall financial and budgetary management between the ALMA partners. The local accounting service will be largely automated and rely on contractors for the detailed development.

Contracts and procurement. This service will establish the contracts according to the ALMA policies and procedures, including price inquiries, calls for tenders, and assessment of the offers. Procurement for the supplies according to the purchase requests from internal users is another essential function of the service. This requires a close coordination with the users requirements and objectives, therefore the service must operate in close collaboration with the technical and scientific teams at the OSF.

Human resources management. This is the domain of the Head of Personnel who will report directly to the ALMA Director, to ensure an active development of staffing according to requirements of the ALMA technical and operational services. The staff concerns should be properly addressed, in view of the particular conditions and environment of the ALMA Observatory. The Head of Personnel and the assistants will also be responsible for harmonizing the staff regulations and procedures to ensure a coherent policy across the organization.

6.6.2 Logistics --- General Services

Logistics and General Services provide the following support:

- Staff commuting (OSF/Array Site, OSF/home station);
- Board & Lodging – Travel agency;
- Housekeeping;
- Security.

All of these services will be subcontracted.

6.6.3 Facilities

The Facilities Group will provide the support for the ALMA infrastructure, both at the OSF and the array site. Its scope of activities include:

- Supply and distribution of the power network;
- Maintenance of the roads;
- Maintenance of the buildings;
- Maintenance of the outdoor safety implements.

The group will focus on the supervision and coordination of the contracted support in the area of civil engineering and electrical installations (not including the power installation at the antenna and ancillary instrumentation). It is the group's responsibility to develop the working programs, maintenance schedules and, thereafter, to monitor and commission the execution phase. Last, but not least, the contractor compliance with the safety regulations is under their responsibility. While functionally detached from the antenna teams, their activities are to be coordinated closely with the team leaders. As already mentioned in the case of the antenna teams, the decision processes and the task scheduling are to be managed and administrated from the OSF.

6.7 Education and Public Outreach

The ALMA education and public outreach activities are described in Section 1 of this Project Plan.

6.8 Continuing Technical Upgrades and Development

Continuing technical upgrades and development of new capabilities will be required to maintain ALMA as the state-of-the-art facility for millimeter/submillimeter astronomy over the course of its projected life of up to 50 years. In particular, the rapid progress of electronic technology should make new hardware components and subsystems offering

improved performance and higher reliability available for insertion into ALMA on much shorter time scales. Equally important, advances in software and computing should also offer improved performance and reliability that translate into more capability and reduced costs of operation.

Development projects are the responsibility of the Executives. The normal procedure is that the ALMA Director, in consultation with the user community and Executives, will put forward proposals to the ALMA Board for upgrade and development projects. The ALMA Board then decides on the projects, prioritizes them, assigns values and assigns responsibility to one (or both) of the Executives. Thereafter, development projects are conducted in a manner identical to the conduct of the ALMA construction project. Namely, the Executive having task responsibility will assign a project manager who will report to the Executive regarding matters of cost, and he/she will report to the ALMA Director regarding technical scope and schedule.