

Recommended Location of the ALMA Operations Support Facility: The Direct Link Option

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Abstract

We recommend that the baseline plan for ALMA construction and operations be changed in a way that moves the Operations Support Facility (OSF) from the immediate vicinity of the village of San Pedro de Atacama to a location 15-20 kilometers east of San Pedro and south of the Paso de Jama. Further, we recommend that the ALMA project construct a private road from the OSF to the Array Operating Site (AOS) on the llano de Chajnantor that would serve as the prime access for the movement of ALMA staff and equipment between the OSF and the AOS. This private road should be capable of handling antenna transport suitable for the needs of ALMA in both the construction and operation phases of the project. Such a road would provide an OSF-AOS *direct link* that would minimize our dependence on public roads and utilities. The motivation for this recommendation, its effect on the baseline plan, and the next steps needed to determine its feasibility are described.

1. Background

The baseline plan for ALMA operations is set forth in Chapter 18 of the ALMA Construction Project Book. Briefly, the plan is informed by the following considerations:

- ALMA is a “joint venture” of the European Southern Observatory (ESO) and Associated Universities, Inc./National Radio Astronomy Observatory (AUI/NRAO) which represent the European and North American partners in ALMA respectively;
- Interaction with the scientific communities of ALMA users in Europe and North America will be the responsibility of ESO and AUI/NRAO;
- ALMA operations in Chile will conduct and support the ALMA science program as specified by ESO and AUI/NRAO; this program will be run as a “remote operation”, with the scientist/user (usually) not present in Chile;
- ALMA operations in Chile will have the responsibility to operate and maintain the ALMA observing facility;
- ALMA will operate as a full-time research facility for which the scientific demand will be very high;
- ALMA operations must insure that the instrumental “downtime” does not exceed the level achieved on major research telescopes elsewhere;
- It is the desire of the ALMA partners to minimize the size of the operating staff, and to maximize the task effectiveness of that staff.

The last three considerations noted above require that the task of maintaining the considerable instrumentation and software that is part of ALMA be done with high efficiency. The baseline ALMA operations plan addresses this need by recognizing that

the operations and maintenance staff will not be able to work as effectively at the elevation of the AOS (5000 meters above sea level) as they could at lower elevation simply as a consequence of the rarified air at the AOS. For this reason, the baseline plan is to move the array operations staff, and the maintenance staff, from the AOS to an office and laboratory complex built at lower elevation but still in the immediate vicinity of the AOS. This complex is called the Operations Support Facility (OSF); the baseline plan locates the OSF near the village of San Pedro de Atacama. Administrative support for the AOS and the OSF will be provided by the ALMA business office; it will be located in Santiago.

The majority of the staff assigned to the OSF will work turno shifts (8 days on followed by 6 days off is a common rotation). The employees will likely reside in Santiago or elsewhere in Chile. Few, we expect, will choose to live permanently in San Pedro. Thus residence facilities will to be provided at the OSF. Employee transport to the OSF worksite, and personal amenities at the OSF needed to attract and retain a talented and effective workforce are primary operational requirements.

2. Baseline Location of the OSF

In the ALMA Construction Project Book, the OSF is to be located near, but not in, San Pedro. Being in San Pedro is not an option. 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. On the other hand, being near San Pedro has the following advantages:

- It is near public transport; employees could arrive and depart by bus for Calama, Antofagasta and other places in Chile;
- It is near restaurants, hotels and some limited shopping;
- It is near emergency medical care and police security.

The baseline model emphasizes these attractions but it recognizes that ALMA should not depend on San Pedro for utilities (potable water, electrical power, sewage, telephone); all these services we will have to provide privately for our own needs at the OSF.

In the construction phase, the antennas will be erected by the antenna contractor at the OSF and, once accepted by the project, they will be carried to the AOS making use of the Paso de Jama (the road from San Pedro to Argentina). In order to reach the AOS it will be necessary for us to build a road of approximately 20 km that connects the AOS with the Paso de Jama on the western side of Cerro Toco. (In the interest of safety, the road on the eastern side of Cerro Chajnantor also will be improved.) While the antennas are in transit on the Paso de Jama traffic on that road will be interrupted. The width of the antenna base, loaded on any kind of a transport vehicle, will require most of the width of the double-lane Paso de Jama. Moving at 10 km per hour, the road will be blocked for 4 hours each time an antenna is taken to the AOS. To do this on 64 occasions over the course of 6 years, at times that can be scheduled in advance, is not regarded as an excessive imposition.

The distance from San Pedro to the AOS along the Paso de Jama and then along a western access road is approximately 55-60 km. Forty kilometers of this distance is on the Paso de Jama itself.

3. The Direct Link Option for the OSF Location

The direct link option for the location of the OSF proposes that the OSF be located 15-20 km east of San Pedro and south of the Paso de Jama. This location would be in undeveloped, public (“fiscal”) land administered by Bienes Nacionales. This option arises both from a recognition of potential difficulties with the baseline plan, and from recognition of operational advantages offered uniquely by the alternative direct link option.

Transport of the antennas from the OSF to the AOS along the Paso de Jama presents a problem that was not recognized at the time the baseline plan for the OSF location was determined. That problem is weight. The weight of one of the prototype ALMA antennas being built now is approximately 40 metric tons. The antenna transporter being designed has a similar or somewhat greater weight. Together, the combined weight on the 4 transporter wheels far exceeds the carrying capacity of the Paso de Jama. Therefore, in order to carry the antenna along the Paso de Jama a “low boy” type tractor-trailer vehicle will be needed that can distribute the antenna weight on many wheels. Once this vehicle carrying an antenna reaches the turnoff onto the ALMA road to the AOS, the antenna would be transferred to the ALMA antenna transporter for the last 15-20 km to the AOS itself. Antenna transport from the OSF to the AOS becomes a process more complicated than one would have liked.

In contrast, the direct link option locates the OSF south of the Paso de Jama and does not require the use of that international highway to access the AOS. Instead, a road is built to ALMA specifications for the approximately 30 km needed to connect the OSF to the AOS. This road need not be paved with asphalt, it can be salt-stabilized as is common in the Atacama region of Chile, and built to the width needed to carry antennas on the ALMA transporter. No additional transport vehicle is necessary. Moreover, the existence of the “direct link” opens additional options. In particular, we have the option to do all antenna maintenance at the OSF—we simply transport the antennas down to the OSF whenever major maintenance is scheduled (e.g. painting, mechanical replacements etc). The lower elevation of the OSF, compared to the AOS, allows the antenna maintenance staff to work with higher efficiency and without the need for supplemental oxygen. One could consider even doing maintenance on the antenna front end electronics system by transporting the entire antenna down to the OSF; this option is not available were the OSF to be located near San Pedro.

In the direct link option the OSF is, of course, closer to the AOS than is the case were it to be located near San Pedro. With the OSF-AOS distance in the case of the direct link being approximately 30 km rather than 55-60 km as is the case for the San Pedro option, the exchange of staff and equipment between OSF and AOS occurs more quickly and with less operational disruption. The shorter distance also creates a safer environment for

those working on the AOS: employees or others experiencing altitude problems can be evacuated to lower elevation more quickly.

4. Comparison of the Direct Link Option to the Baseline Plan

The baseline plan for the location of the OSF emphasized the need to provide a work environment for the ALMA staff that facilitated access to off-duty amenities. Foremost among these was access to places for socialization and the interaction with people who are not focused on ALMA operational tasks. It is also more convenient to connect with public transport for employees needing to do so if the OSF is in or near San Pedro.

The direct link option for the location of the OSF emphasizes efficiency in the work environment. It provides better staff access between the OSF and the AOS that has efficiency and safety advantages. It provides options for the operations and maintenance of the array antennas and instrumentation that are not available with the baseline plan. However, it does so by defining the OSF as an “ALMA complex” that is not near any other site of community activity or diversion.

Nearly all of the requirements on the civil works necessary for the OSF in either the baseline plan or in the direct link option are identical. In particular, the need for the ALMA Project to provide for the electrical power, water, sewage and communications is not affected by the choice. Nor is the magnitude of the task of providing these utilities greatly affected by the choice.

Road construction is a clear difference between the two possible OSF locations. The direct link model will require roads to be built that are at least 10 km longer than is the case for the baseline plan. A total of 20 km is needed for the baseline plan to connect the Paso de Jama to the AOS; a total of 30 km, or more, is needed for the direct link option. There are possibilities for cost savings that could offset, partially, the additional road cost in the direct link option. In particular, it will likely be necessary to build only one antenna assembly building in the direct link model, as opposed to the two in the baseline plan (one at the OSF and the other on the AOS).

5. Recommended Course of Action

It is our conclusion that the advantages of the Direct Link Option for the efficiency of ALMA operation outweigh the disadvantages of locating the OSF distant from an established community. We believe that it should be possible to shuttle off-duty people to and from San Pedro for recreational activities in a way that they would find satisfactory. In doing so we also believe that we can make the work environment superior in the direct link option.

The feasibility of the direct link option depends on several factors for which we have only limited information. Among these are the following:

- Is there a location for the OSF at an altitude between 2700m and 3000m from which it is possible to reach the AOS by a road that does not cross a major quebrada?
- Is it possible to reach that OSF location from the Paso de Jama, or the “old” routing of the Paso de Jama, without encountering major difficulty from the quebradas?
- Is the land at the location so identified available to us, in principal, from Bienes Nacionales?
- Is the land needed for the road connecting OSF to AOS also available?
- What is estimate for road costs?
- What is the plan, and what are the costs, associated with providing electrical power to the OSF?
- What is the plan, and what are the costs, associated with providing the OSF with water? Is there water (potable or other) on the AOS? Can that water be piped to the potential OSF location?

We propose to address these issues, quantitatively where required, and update this recommendation in 4 months time.