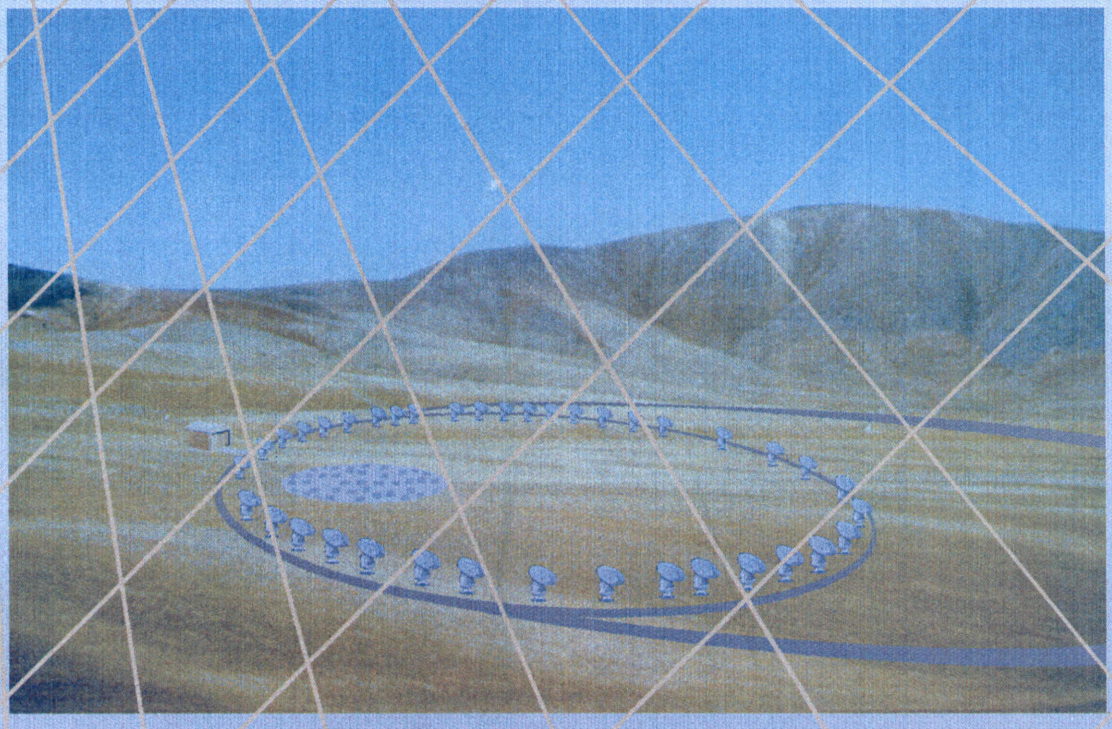
Estimated Site Development Costs of the MMA Project in Chile

Version 2.0

M. A. Gordon
National Radio Astronomy Observatory



NATIONAL RADIO ASTRONOMY OBSERVATORY
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1999-February-24

Summary

This report estimates the cost of building and equipping facilities in Chile needed to operate the MMA. Based on the current model for operations, it describes what is needed for the work locations at the MMA observing site, at the support location near the village of San Pedro de Atacama, within the port city of Antofagasta, and in Santiago.

The objective is to estimate the costs of developing the Chilean sites excluding electronics, cryogenics, control and reduction computers, and antennas. It includes equipment and furnishings for the library, dormitory, kitchen, offices, and shops.

I have included both Spanish and English versions of important correspondence to allow the reader to judge the translations.

The report discusses optional mitigations and embellishments regarding the estimated costs.

It includes a discussion of the purchasing power of US dollars in Chile since 1 October 1991.

Revising these estimates is a continuing process that will continue until the MMA is operating. The reader should note the date of this report because revised versions will appear.

The estimated cost of developing and equipping the four Chilean sites is US$59.9M, exclusive of antennas, electronics, cryogenics, and special-purpose computers. This estimate includes a contingency of 10%.

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1. Introduction

This report presents an estimate for the non-recurring costs of developing and equipping the four sites in Chile needed to operate the MMA. The estimate — Version 1 — is preliminary. It is based upon present assumptions as to the array configuration, the antenna diameters, and the operations model for Chile.

This estimate includes

- the buildings at the MMA site,
- a oxygenation system to enhance the partial pressure of O_2 at the site,
- the antenna pads (concrete foundations),
- the equipment needed to generate, transform, and distribute electrical power at the site,
- the access road from the Paso de Jama highway to the site,
- the intra-site roads used to service and convey antennas,
- the installation of fiberoptic, heliax, and telephone cables between antenna pads and the site buildings,
- a fiberoptic communications link between the MMA site and the OSF,
- the supply and storage of potable water at the site,
- the Operations Support Facility near San Pedro de Atacama including offices, a control room, a library, shops, dormitory rooms, food preparation and serving facilities, a temporary antenna assembly building, a fueling station for vehicles, and recreation facilities,
- the equipment needed to generate, transform, and distribute electrical power at the OSF,
- facilities required to obtain, process, and distribute potable water for the OSF,
- a wastewater treatment and disposal system,
- furnishings and equipment for all buildings including offices, shops, auditorium, library, dormitory, library, and recreation facility,
- assorted vehicles needed to operate the MMA, and
- a temporary camp necessary to house the construction workers.

This estimate does not include

- the antennas,
- electrical grounds (counterpoises) for the antenna pads,
- the electronics installed in the antennas,
- the cryogenics associated with the antennas,
- the electronics used to control the antennas and array,
- the computers associated with controlling the antennas, acquiring data, or processing data,
- the costs of acquiring the right to use land near San Pedro de Atacama, and
- the costs of shipping items from the US to Chile

2.Site Facilities and Furnishings

The requirements for site facilities obtain from a model for operating the MMA in Chile. Operating plans and site facilities are closely related. Changing one affects the other.

The plan for operating the MMA resulted from the best advice that the NRAO could find. Visits to Chile, meetings with past and present directors and employees of observatories operating in Chile, and analyses of the way that the NRAO now operates the 12 Meter Millimeter-wave Telescope, the VLA and the VLBA, formed an initial plan[1] for operating the MMA in Chile. After further discussions among ourselves and with our medical consultant (Prof. John B. West of the UCSD School of Medicine), this plan evolved into the form described in the MMA Project Book[2].

NRAO managers considered operating plans in terms of the specific facilities that would be required to operate the MMA in Chile. These considerations took the form of specific recommendations both from individual managers and from a formal committee chaired by F. N. Owen. The result was a list[3] of building sizes and specifications for which costs could be estimated.

Support of MMA operations will require four locales in Chile, and several in the United States. The instrument itself will be situated on the Llano de Chajnantor, a geologic "bench" at an altitude of 5,000 m (16,500 ft) in the Andes mountains east of the village of San Pedro de Atacama. The Operations Support Facility (OSF) will be located near this village because of its proximity and its lower altitude of 2,450 m (8,040 ft). The local business office probably will be in Antofagasta, a seaport and the capital of Region II of Chile. Finally, a small business office must be located in the capital of Chile, Santiago, to process papers associated with duty-free imports and to maintain contacts with the Chilean government. The NRAO sites in the United States will oversee long-term technical development and offer high-level technical support when necessary.

The NRAO will need to provide high-quality dormitories and recreation facilities in San Pedro de Atacama. To operate the MMA in Chile, *all* consultants recommend a rotating shift system known in Chile as the "Sistema de Turno" for staffing the operations center and the maintenance of the MMA itself. In Chile all international observatories and most mining operations use the Turno system. It complies with Chilean labor laws. Typically, it consists of one week "on" and

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[1] "Operations of the MMA in Chile," M. A. Gordon, 1 June 1995 (narrowly circulated).

[2] "Site Development," Chapter 16 of the MMA Project Book, M. A. Gordon, 6 October 1998.

[3] "Post-development Operations," Chapter 18 of the MMA Project Book, M. A. Gordon, 6 October 1998.

one week "off" to provide 80 to 88 work hours over a two-week period. Variations are common. A construction project in a remote area east of Iquique operates on a two-week "on" and a 10-day "off" system. Customarily, the employer provides room, board and transportation to and from an urban assembly point.

The OSF will also need to provide housing for families of senior managers required to live in San Pedro de Atacama. Presently, the real estate market of this community is too small to offer enough modern houses. Consequently, our development plan includes construction of five modern houses in a separated location within the OSF compound.

In time there may be additional non-recurring expenses that this document does not address. Similar to the Very Large Array (VLA) in New Mexico, the principal operating center of the MMA may change with time. San Pedro de Atacama is a small village (population 1,000) with few amenities other than those required to support its tourist industry. Few employee families will want to live there for a long term, especially those with school-age children. As the MMA evolves into routine operations, we believe it likely that some aspects of its operations will move to a larger community with more amenities. Such changes could make long-term employment attractive to skilled professionals. The modern fiberoptic telephone network now being installed in Chile should easily facilitate this relocation. Then, the San Pedro de Atacama facilities will become principally a maintenance facility. These changes may require expanded office facilities in, say, Antofagasta, similar to the Array Operations Center (AOC) in Socorro, new Mexico.

3. Methodology for the Cost Estimates

Although an initial estimate[4] for the non-recurring costs of the MMA existed as early as1995, the NRAO needed new estimates reflecting the detail of its most recent plans. This new estimate would also serve as a check on the accuracy of our earlier cost estimates, especially if made by a commercial engineering firm in Chile.

Accordingly we prepared a document describing the scope of the estimating work, spreadsheet pages listing the size and characteristics of each item, and a description of each. This report includes this document in both English and Spanish.

We chose the engineering firm Ocegtel S.A., Ltda., to make the new estimate. Located in Calama, its business involves special engineering projects for mining enterprises in northern Chile where the MMA will be built. This company has considerable experience with high altitude sites. It installed the site-test equipment on the MMA site for both the NRAO and the ESO. Its managing director, Víctor Realini S., has visited the radio interferometer sites of the California Institute of Technology in the Owens Valley, of the University of California in Hat Creek, and of the NRAO on the Plains of San Augustin. We have confidence in the firm's

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[4] "Non-recurring Cost Estimates for the Millimeter Wave Array," M. A. Gordon, 17 March 1995 (narrowly circulated)

judgement, engineering abilities, knowledge of local costs, and interest in seeing the MMA built in Chile.

On 9 November 1998, Eduardo Hardy (MMA managing director for Chile) and I met with Víctor Realini at the Ocegtel offices in Calama, Chile, to review our requirements. We spent approximately eight hours discussing each item in the spreadsheet. Sr. Realini focused our attention on details that we had not considered, thereby making the design for site development more realistic and, we believe, ensuring more accurate cost estimates.

The Ocegtel report arrived in late December. The reference section of this report includes it in both English and Spanish.

Meanwhile, Ellen Bouton (NRAO head librarian), Jeff Kingsley (former site manager for the 12m mm-wave telescope), Pat Lewis (a maintenance supervisor for the VLA), Antonio Perfetto (electronic engineer at NRAO Tucson), Dale Webb (NRAO business manager in Tucson), and I (a former NRAO site director) prepared a list of equipment and furnishings that would be needed for each site in Chile. This list contains furniture for the buildings, books for the library, kitchen equipment, audiovisual equipment, machines and tools for the shops, vehicles, earthmoving machines, electronic test equipment needed to diagnose and maintain the MMA, office equipment, and an initial stocking of shop and office supplies. The reference section of this report contains a listing of this spreadsheet for each site.

We include electric generators and distribution systems for the site and for the OSF. Investigation showed the most appropriate generator for the MMA site to be a natural gas-powered turbine to produce 2MW at that altitude. Natural gas will be available from a new gas line on the periphery of the MMA site. We include a cost summary in the reference section.

The same gas line will pass near San Pedro de Atacama. For the OSF, we plan to use two natural gas-powered reciprocating generators for the OSF, which we've acquired from government surplus. These units are designed for continuous operation and will produce up to 400kW at 50Hz at the 2,425m (7,960ft) altitude of San Pedro de Atacama. Unlike the MMA site, we expect the electrical load at the OSF to vary considerably during construction. Large variations in load is normally a problem for diesel generators, causing "coking" of the engines. We hope that the natural gas fuel should prevent this condition.

4. Estimated Costs of Developing and Equipping Chilean Sites

Summary of Developing and Equipping Costs

Site	*Category*	*Amount (US$)*	*Site Total (US$)*	*Comment*
Antofagasta	Buildings	0		Lease
	Office Equipment	81,292		3k Contingency
	Vehicles	50,000		"New" prices
		Subtotal	131,292	
Llano de Chajnantor	Development	30,717,736		12%
	Turbine Generators	5,755,800		6% Contingency
	Emergency Dormitory	6,400		
	Electronics Test Equipment	1,062,838		Contingency in
	Office Equipment	118,572		5k Contingency
	Safety Equipment	100,000		
	Shop Equipment	190,300		
	Vehicles	1,317,000		"Used" prices
		Subtotal	39,268,646	
San Pedro de Atacama	Development	11,667,908		12%
	Construction Camp and	4,300,000		12%
	Dormitory Furnishings	147,000		
	Electronics Test Equipment	3,267,767		30k Contingency
	Food Service Equipment	102,519		2k Contingency
	Office Equipment	642,344		5k Contingency
	Recreation Equipment	5,000		
	Shop Equipment	222,300		
	Supplies	50,000		
	Vehicles	10,000		
		Subtotal	20,414,838	

Santiago	Building	0		Lease
	Office Equipment	76,622		Some already
	Vehicles	45,000		"New" prices
		Subtotal	121,622	
		Total	$59,936,398	Includes 10%

The numbers in this table do not include the 18% IVA (added value tax), for which I assume that the Chilean government will grant relief as they have done for other international observatories operating in Chile. The column labeled "Comment" lists contingencies where included. The grand total includes a contingency of approximately 10%.

For the Chilean construction, Ocegtel has assumed an exchange rate of C$475 to US$1 which is slightly more favorable for dollars than today's rate of C$465 to US$1 but perhaps appropriate for construction beginning in the year 2001. All values refer to 1998 US$; that is, there is no correction for changes in the purchasing power of US or Chilean currencies over the period ending with the commencement of construction.

5. Contingency

A contingency is an important part of any cost estimate. Ocetel's estimates for developing the site include contingencies of 12%. Solar Turbine's estimate arrived without a contingency. There we added a 6% contingency on the total to reflect the considerable uncertainties in the shipping and installation of the turbines; we regard the turbine prices themselves to be firm quotations on the date of their estimate. Lists of furnishing and equipment include amounts for "unspecified items." We calculated the overall contingency by adding up the *dollar* uncertainty for each entry and dividing that by the total cost. The result is a 10% contingency on the total.

Will 10% be enough? The estimates contain some elasticity. Unlike technical components of the MMA like antennas, electronics and software, the items considered here are widely available in the commercial marketplace. Substitutions of lower cost items is possible. Furthermore, the cost of technical devices tends to decrease with time -- although consumers seem to correspondingly increase the performance expected from these devices.. Finally, the level of detail in the list of furnishings and equipment should reduce the chances of our forgetting something.

6 . Possible Mitigations and Embellishments

The architecture and quality of the buildings affect costs considerably. Except for the dormitory building, all buildings will be pre-fabricated to reduce on-site construction costs and to maximize quality. Such construction is standard for remote areas in Chile and has the advantage of being resistant to earthquakes. The construction manager of the ESO Very Large Telescope on Cerro Paranal advised us to seek bids from US companies for pre-fabricated structures as well as from Chilean companies. Because labor rates are high in Region II, US companies may be able to deliver prefabricated structures including freight more cheaply than Chilean companies.

There is a trade off between the quality and the long-term maintenance of buildings. We asked Ocegtel (and, through them, their architectural consultants) to consider only high-quality buildings that would need little maintenance over the nominal 30-yr lifetime of the MMA. This cost/benefit issue significantly affects the non-recurring costs of the project.

Chilean electrical code requires that underground high-voltage lines be protected by a concrete cover over the trench. Unlike Chile, US code allows direct burial provided that a warning tape is installed a foot or so above the cable. Because Ocegtel's estimates assume installation according to Chilean code, obtaining an exemption could reduce construction costs significantly.

The recommendation of Ocegtel is to install the fiber-optic cable connecting the MMA site with the OSF inside PVC conduit with inspection boxes at appropriate intervals. Simple direct burial could save money at expense of facilitating later maintenance.

It may be cost-effective to replace the proposed liquid oxygenation system with "molecular sieve" units. Installation of the liquid O_2 design is inexpensive but its operation is not. The molecular sieve system extracts oxygen from nitrogen by passing ambient air through a "sieve" and ducts the oxygen to an appropriate location. Preliminary investigation shows that the molecular sieve units provided by say, AirSep Corporation, may cost slightly more to install but that the operations savings over liquid oxygen could be enormous.

The office furniture selected for the cost estimates is the basic line from the Steelcase Corporation at General Services Administration (GSA) prices[5]. These pieces have excellent durability, and Steelcase operates in many countries. The Federal Supply Services -- a division of GSA -- offers good, "no-name" furniture at even lower prices.

Some savings will result from transferring equipment from the NRAO 12 Meter Telescope to Chile. The Tucson location is equipped with test equipment and parts used to support observing

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[5] "GSA prices" refers to commercial products with pre-approved prices available to federal agencies. Pre-approval means that federal buyers do not need competitive bids. In other words, these prices have been already negotiated.

equipment up to 300GHz. The availability of this equipment will depend upon the role of Arizona Operations after the MMA is operating.

Savings will result from the NRAO obtaining surplus government equipment when possible. Heavy-duty trucks, cranes, and earth-moving equipment are available on the surplus equipment lists. Our experience is that these offerings should be inspected carefully before transfer because expensive repairs may be required to make the equipment reliable.

To integrate MMA personnel into the community of San Pedro de Atacama and to provide an opportunity for these employees to withdraw completely from the work area at the day's end, the MMA may prefer to locate the five managerial houses away from the OSF compound into the village itself. Buying adequate land for these houses would add to the non-recurring costs. However, Ocegtel notes this choice might bring protests from the local amerind community, as occurred with the construction of the new Hotel Explora in 1998.

Finally, we have undoubtedly omitted some items required for operations -- although we have included unspecified allowances. With time, we'll add these to our list and change the estimates accordingly.

7. Purchasing Power of US Dollars in Chile

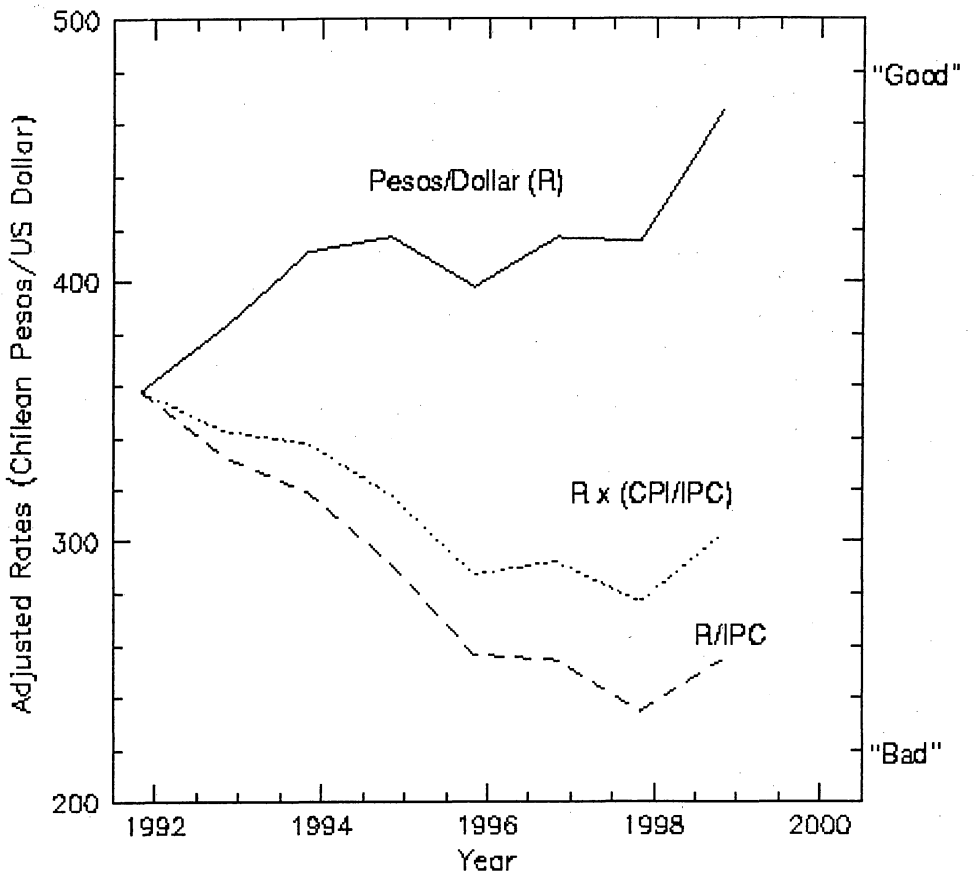

Figure 1 Purchasing Power of US dollars in Chile

The figure above shows the change in the purchasing power of the US dollar in Chile relative to 1 October 1991. The solid curve shows the number of Chilean pesos purchased per US dollar from 1 October 1991 through 1 October 1998. This exchange rate (R), known as the Dolar Informal, generally increased over this period. Dividing R by the Chilean Consumer Price Index (Indice de Precio de Consumador or IPC) corrects for the inflation of the peso, producing the dashed curve. This curve shows that, while the purchasing power of the dollar in Chile decreased significantly since 1991, it has generally stabilized over the past 1.5 years.

The middle curve corrects for US inflation as well by using the seasonally adjusted CPI for urban areas. It shows what 1992 dollars would have purchased in Chile over the succeeding years. The difference between the two lower curves shows the effect of *US inflation* alone since 1 October 1991. The difference is academic, of course, because the MMA will not have the luxury of using 1992 dollars for construction.

Three additional points need to be made:

First, the models used to calculate the consumer price indices in the US and in Chile apply to household spending and may not track the *industrial* spending that we need.

Second, the Dolar Informal (R) — the solid curve — tracks the price in US dollars that currency traders were willing to pay for Chilean pesos. This price involves many factors such as the trade balance between the US and Chile, the amount of currency reserves in each country, speculation regarding economic growth, etc. It also includes the relative price inflations in both countries to an unknown extent. Therefore, the analyses of inflation plotted above are indicative rather than mathematically rigorous in an economics sense.

Third, it is almost impossible to predict the buying power of US dollars in Chile. Glen Blevins, the Business Manager of Associated Universities for Research in Astronomy (AURA) has tried unsuccessfully for many years. The forces affecting the Dolar Informal exchange rate are too complex to analyze because, ultimately, they reflect the personal judgement of the currency traders themselves.

We conclude that the buying power of US dollars in Chile appears have been stabilized over the last year and a half. We hope that the situation will continue.

A. Estimate of the Costs of the Civil Works of the MMA Telescope

[General translation by M. A. Gordon]

Calama, 19 December 1998
OCEG. 167/98/

Gentlemen
National Radio Astronomy Observatory
949 North Cherry Avenue
Campus Building 65
Tucson, Arizona

Attention: Mr. Mark A. Gordon

Reference: Estimation of the costs of civil works for the MMA radio telescope

Dear sirs:

We are attaching for your consideration the result of a study requested by your company regarding the estimated costs of construction of civil works, of architecture and operational facilities, and of necessities for the construction of the MMA radio telescope on the Chajnantor site and for operational support in the vicinity of San Pedro de Atacama, Region II, Chile.

We have tried to reflect in our evaluation in the most realistic way, based on our experience as a company for civil works and industrial development, those costs that will be significantly affected by the location with respect to the town, and to the altitude and climate of the locale.

Considering the preliminary data delivered to you regarding the size of the project, we have estimated that all of the work evaluated here would be possible to realize in a period of 24 months. Moreover, all the costs that we have estimated have been considered from this perspective. We believe all of our views are contained in the attached report. However, we declare that we are at your disposal to respond to and to clarify any question that may arise or some other aspect that may be necessary.

Hoping that this study fully satisfies your requirements, yours faithfully,

for OCEGTEL S.A.

[signature]

Víctor Realini Saldaña,
Managing Director

Estimated costs for the Civil Works of the MMA Telescope

1.- Works at the MMA Site on Llano de Chajnantor

1.1.- Improvement of the access road.-
We have recommended a 7m wide roadbed for circulation that in the initial period will be open across slopes and curves and, later, will be outfitted with a sub-base of selected materials 20cm thick in accord with the Chilean Code for Highways. This price includes guard rails, necessary road signs, and design.

1.2.- Project shack.-
This is treated as a temporary installation that will be used during the construction of the observatory. We recommended using an ocean shipping container or some kind of modular construction that would be appropriate for support in the local climate including acclimatization systems and oxygen enrichment. This building would include office furniture.

We recommend the purchase of this installation since renting for this location could be very expensive and the building may have important residual value.

1.3.- Electric generator.-
We recommended the purchase of a 10kVA generator set that would be used during the construction period., at least for the reasons mentioned earlier. This set would contained in a small enclosure for protection from the climatic elements. Our estimate includes fuel for 24 months.

1.4.- Emergency dormitory.-
We recommended a modular construction with bathroom and acclimatization and oxygen enrichment systems. This dormitory would be built in conjunction with the project shack and connected to the generator set. This estimate includes equipping the dormitory.

For using the bathroom, we recommend a portable septic tank that could be removed when it's full. Also, we recommend a water tank of 500 liters for kitchen and bathroom that would be filled daily.

1.5.- On-site roads.-
We have considered the construction of 20km of 7m wide roads to link the 145 antenna pads. Considering the weight that would carried by these roads, we recommend the road-bed follow the natural contours of the site because correcting the slopes and curves to accommodate these heavy loads would be difficult. Over this strip we would place a cap of compacted material 20cm thick

in accordance with the Chilean Code for Roads. Over this cap, we would put a double coating of asphalt.

This design is based upon the consideration that the site gets snow that could soften the roadbed and impair the movement of heavy loads.

1.6.- Antenna foundations.-
We have considered the construction of 145 antenna pads in a single stage, each containing approximately $45m^3$ of reinforced concrete.

For the construction of each antenna, we recommend a preliminary study of the soil mechanics of each pad and a design according to the individual characteristics of that pad location.

The reinforced concrete should utilize high strength H30 concrete and incorporate air to resist cyclical freezing. In the study we have recommended the preparation of the reinforced concrete at the site from a dry mixture carried to the site in a "big bag." At the site, we would install only a mixing plant. The concrete would be transported to each location by cement-mixer trucks. We have selected this procedure on the recommendation made by the Ready Mix company specialists after evaluating the problem of producing concrete at the site, and because of the shortage of aggregate at the site and at San Pedro de Atacama that would comply with the Chilean Codes for Concrete.

Reinforced concrete.-
The steel we consider for reinforcing the concrete complies with the Chilean Code for Steel for reinforced concrete.

The forms to be used will be prefabricated type that complies with the resistance and waterproof conditions necessary for this type of structure.

In an evaluation, moreover, we include the cost of a geo-technical study with regard to materials and samples required for testing.

1.7.- Power Grid
We consider this grid to convey electricity from the generator building to the specific consumption points: antenna pads, control building, antenna assembly building, and warehouse.

We envision transmission at 50Hz and voltages of 13.2kV, 380V, and 220V in accordance with the Chilean Electrical Code.

We consider installing switchgear with five circuits and a general power circuit breaker panel with five circuits at 13.2 kV: one circuit for the control building, one circuit for the antenna workshop, one circuit for the small configuration of antennas, and one circuit for the large configuration of antennas [This concept may have come from the illustration on our web page – MAG]

25. Generator building to control building:
Supply circuit to run in buried 4", high impact, PVC pipe for strength and a control circuit in 2" pipe covered with an H5 concrete cap, following the Chilean Code with an inspection chamber at intervals prescribed by the Code. At the entrance of the control building we will install a transformer from 13.2kVa to 380/220V and a circuit breaker panel for power and lighting with three circuits: one for control, one for offices, and one for lighting.

26. Generator building to antenna assembly building and warehouse:
In the same manner a power circuit will leave the generator building running in a 4" PVC pipe and a control circuit running in a 2" pipe protected by a cap of H5 concrete, following the Chilean Code and with inspection chambers at distances specified by the Chilean Code. At the entrance to the antenna assembly building will be installed a substation to transform 13.2kVA to 380/220V and a circuit breaker panel with two circuits: one for the antenna workshop and one for the warehouse building.

27. Generator building to the small array:
In the same manner a power circuit will leave the generator building running in a 4" PVC pipe and a control circuit running in a 2" pipe protected by a cap of H5 concrete with inspection chambers at distances specified by the code. We consider a substation at each antenna pad to transform from 13.2 kVA to 380/220V.

28. Generator building to large array:
In this case we have considered an installation with the same characteristics as for the small array but divided into two sub-circuits each serving half of the antenna pads of the large array.

1.8.- Substation transformers.-
In this item we consider the substations that will be installed at each antenna pad. These will consist of 20kW transformers installed with their structure above ground anchored to the concrete pad of each antenna and with a connection panel for 380 and 220V.

1.9.- Installation of continuous use generator.-
Considering the information supplied to us about the two turbines that will come in enclosures, we consider mounting these enclosures on a concrete pad and in both cases we will construct a metal building with steel sheathing and polyurethane thermal insulation of [density] 40kg/m^3. At one end there will be the valves that control the gas pipes to the turbines. At the other end, will be the distribution panel for the electric power. Also, we will cover the enclosures with a sloping roof to prevent an accumulation of snow on them.

1.10.- Infra-foundation network.-
This is the fiber-optic network that will connect the control building with the antenna pads. The network consists of fiber-optic cable (Andrew 6 core, armored, model 242981-6) and 23mm heliax cable (Andrew FSJ4-50B). The cables will be installed in two 6" PVC conduits, in a trench covered with a concrete protective cap described earlier as stipulated by code. We considered inspection boxes at 100m intervals, that will be made from precast concrete, of 1m x 1m x 1m.

The scope of this part includes the supplying and mounting of the network with all of our activities including the placing in service and measuring the appropriate parameters, for in the case of optical fiber we have also considered the complete installation of the fiber (case and jumpers).

1.11.- Antenna assembly building
This will be a shed-type building 15m deep by 30m long with a covering of approximately 560m^2 and a height of 20m. This will be a metal structure covered with metal sheets with polyurethane thermal insulation of [density] 40kg/m^3, with walls like the roof, sealed so that the acclimatization and oxygenation systems will be efficient. This building will be equipped with a traveling crane with a capacity of 50 tonnes.

We have considered a floor of 20cm reinforced concrete to cover the 560m^2 interior and an apron 15m by 15m to facilitate access to the building.

The size of the electric service of the building will provide illumination and power outlets at voltages of 380 and 220V.

The price includes design, structural calculations, supply and erection of the structure, materials and parts that make the building.

1.12.- Warehouse
This will be a building of metal structure covered with metal sheathing with polyurethane thermal insulation of [density] 40kg/m^3, similar to the antenna building but 5m deep and 15m wide and 3m in height and with a sloping roof to

prevent snow accumulation. This building would not contain an oxygen enrichment nor an acclimatization system

The floor will be 12cm reinforced concrete.

We have included metal shelving and a small shop.

1.13.- Control building.-
This will be a building of 1,400m^2 of which 700m^2 is intended for the control room and the remainder will be for offices, a library, lunch room, kitchenette, lavatories for men and women, emergency dormitory, and the entrance hall. In addition, we consider systems for heating, air-conditioning, and oxygen enrichment.

The calculation for the heating and cooling systems for the control room that you have given us indicates that we ought to remove 150kW of heat produced by the digital correlator. We have not considered the cost of providing instrumentation to control relative humidity in the room for the digital correlator. It would cost approximately an additional US$60k.

Also, we have evaluated the cost of radio frequency protection for the outsides of the control room area. This isolation would consist of copper sheets 0.3mm thick.

The construction of this building would include foundations and floors of reinforced concrete. The walls would consist of self-supporting panels, fabricated from zinc-coated steel sheets with a baked prepainted finish 0.6mm thick, with a core of injected polyurethane of [density] 40kg/m^3, (with no Freon 11), of thickness 110mm and finished in accordance with the use of each area. The panels would be firmly secured by an assembly system of male-female mechanical connectors driven by eccentrics incorporated in the edges.

We have considered antistatic flooring for the control room area, ceramic tiles for the access hall, lavatories, kitchen, lunch room, and carpet for the library and dormitory.

1.14.- Telephone connection.-
We have considered the telephone connection from the control building at the MMA site to the operations support center in San Pedro de Atacama. This connection will have two options, the prices of which we include as part of a proposal that can be selected by NRAO:

a) Microwave link: This system consist of two E1 circuits that can be used back to back with a capacity of 2 M bytes/s and 30 telephone channels

each, repeater towers 30m high equipped with repeaters and battery banks; equipped with solar panels, a solution suggested by Entel Chile specialists in this area.

b) Fiber-optic connection: This system would be composed of Andrew 6 FO direct-burial model 242981-6, inspection boxes, and fiber-optic connection interfaces.

We recommend this network use the fiber-optic network described for the transmission of data (point 1.16). This system was also evaluated and suggested by Entel Chile.

1.15.- Telephone system.-

We have considered a telephone system installed in the control building with 176 stations of which 145 correspond to the antenna pads and the rest for offices and other dependencies. Of these stations 32 are multiline and 22 are conventional. We have taken account of the need to transmit data, that is to say, there are no digitally multiplexed lines. The installation of these multiple pair lines will be in buried high impact PVC and with inspection boxes according to codes.

The telephone system does not include purchase of telephone lines [service connections to the outside world] from the Chilean Telephone Company (CTC).

1.16.- Fiber-optic network.-

This network consists entirely of the linking of the MMA site on Chajnantor with the OSF site in San Pedro de Atacama by installing fiber-optic cable (Andrew 6FO direct-burial, model 242981-6). This cable will be installed in underground conduits of high impact PVC and with inspection boxes at distances established by the codes.

The price includes supplying and installing the cable, the conduit, the terminals, joints and inspection boxes, the excavation of the trenches, the filling, and the cap of H5 concrete to protect the circuit.

1.17.- Water service station.-

Considering that there will not be very many people working at the site, we estimated that it will be adequate to install a single septic tank and leaching field connected to the control building and the antenna workshop by sewage pipes.

A cost analysis of this system includes the sewage pipes.

1.18.- Potable water system.-
Considering everything, we estimate that it won't be justified to install a water purification plant. Moreover, we have considered the installation of a metal storage tank with thermal insulation for potable water. At the exit of the tank will be installed a pressure system that will deliver pressurized water to the sanitary facilities in the control building and the antenna building. We recommend that this tank be filled with water supplied from San Pedro de Atacama.

We have included the supply lines for potable water.

1.19.- Valve for reducing gas pressure.-
We understand that Gas Atacama will have installed a 6" pipe and cutoff valve in a specified location. As part of this, independent of the location where it's installed, we recommend a the installation of a pressure reduction valve in the line supplying the turbine generators.

1.20.- Gas line.-
We have considered the underground installation of a 6" gas pipe and length 1,000m, including anti-corrosion protection. We have not included cathodic protection on the advice of the Bonatti company, experts in installing gas pipes.

In soliciting the evaluation we indicated that this line would be no more than 100m from the generator building, a distance that we believe is too short for [cathodic erosion] to occur.

1.21.- Control building for continuous-use generator.-
In item 1.9 we describe that this building could function, basically, by using the turbine enclosures and the construction of two rooms abutting them; one for the array of gas entrance valves and the other for the equipment distributing the electric energy.

1.22.- Surfacing the access road.-
This item will consist of the road sub-base described in item 1.1 – and eventual covering with a cap of hot asphalt 5 cm thick.

2.- Works at the OSF site in San Pedro de Atacama.-

2.1.- Security wall
We have considered that the site will be 200 by 200m next to the international highway between Chile and Argentina. As the suggestion that the design of the access be visually attractive, the architects of V&V Arquitectos have given us a plan for the space that includes a large parabolic wall at the access constructed of plastered concrete blocks and pillars and concrete beams. The sides and back of

the site will be closed with semitransparent webs of adobe and metallic screen with metal pillars.-

2.2.- Main building.-
Consistent with the development plan from the architects is a main building next to and joined with the parabolic access wall. This will be a building of 1,441m^2 divided into:

entrance hall and reception area	36m^2
50 offices of 8m^2 each	400m^2
laboratory	400m^2
library	60m^2
100 person auditorium	120m^2
meeting rooms	25m^2
50 person dining room	90m^2
kitchen	30m^2
lavatories	40m^2
structures and circulation	240m^2

We have considered a prefabricated building with excellent finish, compatible with the location, with a good acclimatization system, and with excellent thermal and acoustic qualities.

The interior floors will be: carpets in the library, offices, and meeting rooms, and ceramic tiles in the access hall, corridors, dining room, kitchen, and lavatories.

The estimates include the architectural fees and the engineering costs for all specialties.

2.3.- Transformer station.-
From the information given us about the characteristics of the turbines that will arrive in enclosures, we considered installing these enclosures over a concrete floor and constructing an each end a metal structure with metallic sheathing. At one end will be the valves that control the gas supply and at the other end the switch panel for the distribution of electric power.

This generator building will be built in a far northern location of the site away from the installations of the dormitories, offices, and family houses.

2.4- Power network.-
Considering that the generator building will be in a northern sector of the site, the power lines will supply different buildings from this location in a manner that is described:

- in a distribution room electrical equipment and a transformer from 13.2kV to 380/220V.
- subterranean busses from the generator building to the treatment plant for potable water in high-impact PVC conduit and inspection boxes following the Chilean code.
- subterranean busses from the generator building to the sewage treatment plant in high-impact PVC conduit and inspection boxes following the Chilean code.
- subterranean busses from the generator building to the main building where a distribution panel will route power to the following buildings: dormitories, recreation, shops, warehouses, control room, and exterior lights and sports installations.
- above-ground lines from the generator building to the water well, made with 8.5m concrete poles and bare copper wires because this well would be located about 6km from the generator building.
- above-ground lines from the generator building to the antenna assembly building, made with 8.5m concrete poles and bare copper wires because this building is situated 1,000m from the OSF site and would be a temporary construction.

2.5.- Gas pipeline.-
We have considered the subterranean installation of a 5,000m-long 6" gas pipe , including anti-corrosion protection. We have included cathodic protection considering the station and the transformer.

2.6.- Generator building.-
As described in item 2.3, the generators would be mounted on a concrete pad and the gas connections and power distribution would be located in metal rooms built on the sides.

2.7.- Telephone system.-
We have considered a telephone exchange installed in the main building with 120 extensions that would be distributed through the building. These would permit data transfer from each telephone, in the same way the extensions at the MMA site would be reachable through this system. We consider a digital telephone center, 8 telephones would be multiline and 112 conventional. The system would consist of a maximum of 136 stations with an E1 line [larger than T1, the US equivalent]. The installation of the multiple pair lines would be in a buried, high-impact PVC conduit with inspection boxes according to code.

This telephone system does not include the purchase of telephone lines from the Chilean Telephone Company (CTC).

2.8.- Water well.-
We have considered drilling a well 180m deep, encased and equipped with a pump to retrieve the water.

It has been assumed that the plan is to drill at a location 6km from the location of the OSF.

2.9.- Treatment plant for sewage.-
In the far northeast of the enclosed area will be located a sewage treatment plant AGUASIN model LA-180, an active mud type with extended aeration. This plant was recommended by the company Aguas Industrias, Ltda. [AGUASIN] for treating sewage generated by a total of 100 persons considering a contribution of 160 l/person/day of sewage, an average daily flow of 16,000L/day. The plant specification considers an elevation less than 3,000 meters above mean sea level, maximum average daily flow of 16,100L/day, maximum hourly flow of 4,000L/hr, DBO5 2.9 to 4.0 kg/day and design temperature of sewage 15C. The exit water will have the following characteristics: DBO5 less than $30g/m^3$, SST 105C less than $30g/m^3$, fecal colliform less than 1,000NMP/100ml, and generated mud volume 700L in 30 to 40 days. This plant includes a mechanical air pump including its parts, mechanisms and accessories such as a $35m^3$ processing tank, dispensing pumps for sodium hypochlorite, submergible centrifugal pumps, electric power panel, control analyzers for chlorine, manifold, and electrical cables and conduits.

2.10.- Water distribution system.-
The water distributed system considers the water main from the well 6km away to the treatment plant and the pipes that carry the water to the different buildings, houses, and other destinations within the compound including a storage tank for treated water from the treatment plant for potable water.

2.11.- Treatment plant for potable water.-
In the extreme northwestern part of the compound will be located a potable water treatment plant of the reverse osmosis type capable of treating water with a salinity of 200ppm, an operational temperature of 10C, and a supply flow of 1,532 L/hr and a recovery percentage of 50%. This plant includes a sand filter, a dispensing pump, and inverse osmosis equipment, all of which recommended by the firm Aguas Industriales Ltda [AGUASIN]. They specialize in this area.

No building has been considered for this installation.

2.12.- Parking area.-
Following the architect's concepts a short access street will exist that will connect the parking area with the parabolic wall described earlier. This system of street

and parking area comprises 1,000m^2 of asphalt surface 5cm thick confined by concrete curbs and sills.

2.13.- Fueling station.-
We have considered the installation of two 20m^3 tanks: one for gasoline and the other for diesel that will go into the ground and form part of an island where the dispensing pumps will be installed, following the suggestion of the Copec company specializing in this area.

In the price we have considered the design of this station and the inspections and certificates of authorized service as is the case of SEC, which is the office that must authorize the said installation.

2.14.- Dormitories.-
This will be a building with an access hall and reception area of 40m^2 and 40 rooms divided into: 20 rooms with two beds and a bath within 480m^2, 5 rooms with a double bed and bath within 100m^2, and 15 rooms with a single bed within 180m^2.

Forming part of this hostel will be an area for service and functioning consisting of a kitchen of 122m^2, a dining room for 50% of the guest within 40m^2, a laundry within 10m^2, and a living room of 90m^2.

This complex will be constructed in masonry as requested, with stucco walls for the exterior and interior and carpeted floors in the dormitory and hall, and ceramic tiles for the kitchen, dining room, and laundry.

In the price we have considered the installation of electric lighting and outlets and the installation of an acclimatization system.

This hostel building will form a complex of the recreation area defined by the architects to be acoustically isolated from the sleeping area.

We have not considered the furnishing of these facilities.

2.15.- Antenna assembly building.-
This will be a shed 15m deep by 15m wide to cover approximately 225m^2 and height 20m. This will be a metal structure covered with metal sheathing, both the walls and the roof. This shed will be equipped with a traveling crane with a capacity of 50 tonnes.

We have considered a floor of reinforced concrete 20cm thick to cover the 225m^2 interior and a hard access area of 15m by 15m to facilitate access to the shed.

The size of the electric installation in the shed will support lighting circuits and outlets circuits of 380 and 220V.

This shed, because of zoning regulations of San Pedro de Atacama, cannot be constructed on the OSF site. Therefore, we have considered construction 1,000m to the east of the OSF at the edge of the international highway from Chile to Argentina.

This [price] includes a cost analysis of engineering and designing the structure and the civil works.

2.16.- Workshops.-
We have considered a metal structure formed from pre-painted steel sheathing 250m^2 in area and a height of 3m to the shoulder of the frame [minimum interior height]. The interior will be a floor of reinforced concrete 12cm thick.

2.17.- Group of houses.-
The request from the NRAO was that these houses be located within the town of San Pedro de Atacama but there are difficulties obtaining a site that would permit construction of five houses within a pleasant area. An alternative site might have complications arising from old remaining sentiments of the indigenous inhabitants. Therefore, we do not recommend this location.

Therefore the architects in their plan for utilizing the designated four hectares [9.9 acres] have defined an area for the construction of these houses in such a manner that they will maintain their independence with respect to the work and hostel areas but, at the same time, allow access to open-air areas.

We have evaluated this alternative considering prefabricated houses with very good acoustic and thermal characteristics and with an excellent level of finish, including kitchen equipment (furniture [cabinets], kitchen, electric range) and laundry (automatic washer and dryer). Also, we have considered some square meters of exterior sidewalks around the house, a small yard , and native trees.

2.18.- Warehouse.-
We have considered a metal structure lined with pre-painted steel 375m^2 in area and 3m high to the shoulder of the frame [minimum interior height]. The interior will have a floor of reinforced concrete 12cm thick.

This building is part of the connected buildings that we will construct in the OSF site and located in a sector defined by the architects for work, connected to the shop.

2.19.- Swimming pool.-
According to the general proposal made by the architects, an open-air recreation area will exist where a swimming pool would be constructed on reinforced concrete and lined with ceramic tiles of size 25m long by 12m wide and one meter deep at the shallowest end and two meters deep at the deepest end. Also, we have considered concrete walks around the perimeter of the pool, a pergola [a structure of open rafters to break the light], and a barbecue.

2.20.- Control building.-
This is the building similar to that to be constructed on the MMA site, that is to say, to have 750m^2 of area for the installation of equipment and all walls protected by copper sheets 0.3mm thick and equipped with air conditioning that will maintain a temperature between 20 [68] and 25C [77F].

The building will be prefabricated and mounted above a reinforced concrete floor 12cm thick.

2.21.- Recreation building.-
This will consist of a building composed of an exercise room or gymnasium, sitting rooms, television rooms, lecture rooms, club room [card playing], kitchenette, and a multiple use area for, for example, pool tables, everything within an area of 750m^2.

This building will be prefabricated with materials that guarantee [good] thermal and acoustic characteristics and a durability appropriate for a 30-year lifetime. It will be erected over a concrete floor 12cm thick and will have only one level.

2.22.- Tennis court.-
We have considered a tennis court with an asphalt surface and enclosed by a fence of metal pillars and metal screening to keep the balls from escaping and for protection from wind.

2.23.- Soccer field.-
We believe that the best recommendation is to build a multiple use field, that is to say, where one could play basketball, volley ball, and baby soccer [common in Chile], and not a soccer field of full dimensions and that covering the field [presumably with concrete or grass or astroturf] would be very expensive and would be vulnerable to contamination [by blowing sand].

Therefore, we have considered a multipurpose area of concrete 12cm thick and with the equipment needed to play basketball, volleyball, and baby soccer and protected by a fence of metal pillars and metal screen.

2.24.- Exterior works.-
The development plan of the architects includes circulation areas for sidewalks, steps, small patios that would be constructed of concrete and flagstones. It would include a lighting system for these spaces.

3. General observations:-

3.1.- Engineering and quality control: This study includes the costs of the detailed engineering of everything we have evaluated and the mechanical tests of the soil for the design of the antenna pads, foundations, and road construction. Also, it includes the costs of tests of materials and the certificates required by code.

3.2.- Architecture: The building costs include the architectural costs and the costs of building permits needed by the government.

3.3.- Water well: In this case we have evaluated only the construction of a well without the costs needed to pay for the water rights, easements, purchase of the land where water is discovered, and exploration costs.

3.4.- Oxygen enrichment: We believe it important to deliver in detail the characteristics of the oxygen enrichment system given that the monthly operations costs appear to us to be significant, which we have added into Items 1.23 and 1.24 in a special form.

Later [in this document], we include a study made by the company Indura S.A. who has installed this system at Chilean mines operating above 4,000m above sea level. Perhaps the monthly consumption and costs would justify the installation of a small oxygen production plant possibly available in the U.S.A. and which investment would be justified over the life of the [MMA] project

3.5.- Telephone connection between the MMA site and the OSF: We include in the list of evaluation items two alternative connections, one a microwave connection and the other a fiber optic connection.

The fiber-optic connection evaluated here has no relation to the fiber-optics in item 1.16 that we consider to be solely for the transmission of data. Utilization of this route for communications depends upon the NRAO [preference].

3.6.- Camp for the first stage of construction: Considering that this is an evaluation of the things needed to construct an observatory with a complete support infrastructure, we believe it is appropriate to suggest that whoever builds [the observatory] ought to have -- or to live in -- a construction camp. Therefore, we have included in the list of items in the proposal an item that refers to this camp.

In evaluating this cost we have considered the experience that we have had with large mining projects developed in this region and have consulted a company highly experienced in setting up this kind of construction camp.

We have considered the option of arranging the camp compound in the following way: Setting up and taking down the [camp] modules at the site and living quarters to comprise a kitchen and canteen for 300 persons, dormitories for 50 professional people and 250 dormitory rooms for workers, recreation and entertainment building and 50 offices for different functions.

We have calculated the cost of this camp beyond the base estimate necessary to build the project in 24 months.

3.7.- Catering and housing: Similarly we have used our experience with respect to the form in which the catering and housing is managed in large projects. Standard procedure is to contract with companies that specialize in the catering and maintenance of construction camps that worry about the preparation and supply of food and of hygienic facilities and of changing the linen in the dormitory rooms. For these services the companies charge on the order of US$15 per person per day. Using this amount and multiplying by 300 persons, we estimate the average cost of support over 24 months for the first stage of construction.

3.8.- Indirect costs and general expenses: The execution of this project requires personnel for management, administration and support. Therefore, we include the cost of an organization capable of administrating and conducting this work, the indirect equipment needed for operations, and the costs of implementing, communications, and necessary paperwork. We do not include the finance costs for the investment required for construction and administration of this work, nor required insurance [or bonds].

When we refer to the organizational structure and its equipment, we do not include the organization or the infrastructure required for oversight, in this case the NRAO.

3.9.- Contingency: In the prices we have included a contingency factor that will load the construction by 12% above the total of direct and indirect costs, a usual margin for this kind of contracts.

3.10.- Exchange rate: We have considered in our study an exchange rate of 475 Chilean pesos to 1 US dollar.

3.11 Budget estimate: The net total indicated in the estimate should also include 18% IVA (value-added tax) that must be paid for contracted services.

The value shown corresponds to US dollars.

Feasibility Observatory MMA Chajnantor
1
San Pedro de Atacama

Item	Component	Unit	Quantity	Unit Price (US$)	Total (US$)
01.	MMA Site at Cerro Chajnantor				
01.01	Improvement of access route (12km of asphalt road)	global	1	440,932	440,932
01.02	Construction shack	global	1	31,347	31,347
01.03	Electric generator for shack	global	1	83,255	83,255
01.04	Emergency dormitory	global	1	27,910	27,910
01.05	On-site roads	per km	20	87,645	1,752,900
01.06	Antenna foundations (pads)	per unit	145	49,042	7,111,090
01.07	Power network (excluding generators)	global	1	3,774,988	3,774,988
01.08	Transformer substations	per unit	145	17,407	2,524,015
01.09	Installation of continuous use generator	global	1	10,505	10,505
01.10	Intra-foundation fiber-optic network	global	1	2,659,595	2,659,595
01.11	Antenna maintenance building	global	1	2,797,745	2,797,745
01.12	Warehouse	global	1	132,439	132,439
01.13	Control building	global	1	1,713,253	1,713,253
01.14	Telephone connection, fiber-optic option (MMA to OSF)	global	1	714,277	714,277
01.14.1	Telephone connection, microwave option (MMA to OSF)	global	1	122,795	122,795
01.15	Telephone system	global	1	1,432,758	1,432,758
01.16	Fiber-optic network (data transmission)	global	1	3,637,544	3,637,544
01.17	Waste water system	global	1	35,502	35,502
01.18	Potable water system	global	1	17,523	17,523
01.19	Valve for reducing gas pressure	global	1	44,879	44,879
01.20	Gas line	global	1	321,882	321,882
01.21	Control building for continuous-use generator	global	1	207,998	207,998
01.22	Finishing the access road	global	1	1,023,513	1,023,513
01.23	Oxygen enrichment system (antenna building, control building, offices, dormitories, et al.)	global	1	99,466	99,466
01.24	Operations of the oxygen enrichment system	per month	1	122,420	122,420

Feasibility Observatory MMA Chajnantor
San Pedro de Atacama

Item	Component	Unit	Quantity	Unit Price (US$)	Total(US$)
02	Operations Support Facility (OSF)				
02.01	Security wall	per meter	800	274	219,200
02.02	Main building	global	1	1,570,244	1,570,244
02.03	Transformer station	global	1	184,276	184,276
02.04	Power network	global	1	660,580	660,580
02.05	Gas pipeline	global	1	1,612,019	1,612,019
02.06	Generator building	global	1	1,292	1,292
02.07	Telephone system	global	1	174,144	174,144
02.08	Water well	global	1	141,109	141,109
02.09	Treatment plant for sewage	global	1	111,938	111,938
02.10	Water distribution system	global	1	358,641	358,641
02.11	Treatment plant for potable water	global	1	52,838	52,838
02.12	Parking area	global	1	34,678	34,678
02.13	Fueling station	global	1	53,176	53,176
02.14	Dormitories	global	1	1,318,487	1,318,487
02.15	Antenna assembly building (temporary)	global	1	966,182	966,182
02.16	Shops	global	1	189,748	189,748
02.17	Houses	global	5	192,219	961,095
02.18	Warehouse	global	1	247,050	247,050
02.19	Swimming pool	global	1	188,146	188,146
02.20	Control building	global	1	865,089	865,089
02.21	Recreation building	global	1	865,089	865,089
02.22	Tennis court	global	1	26,736	26,736
02.23	Soccer field (multipurpose)	global	1	41,278	41,278
02.24	Exterior works	global	1	98,770	98,770
02.25	Heating and cooling system (not discussed)	global	1	642,676	642,676

Item	Component	Unit	Quantity	Unit Price (US$)	Total(US$)
03.	Construction camp and support				
03.06	Construction camp	global	1	1,060,000	1,060,000
03.07	Catering and housekeeping (over two years)	per person	300	10,800	3,240,000
				Grand Total (net)	46,808,439

For OCEGTEL S. A.

[signature]

Víctor Realini Saldaña
Managing Director

19 December 1998

[NB: The Grand Total includes the microwave link option for communications between the site and OSF, which we have removed in our total.

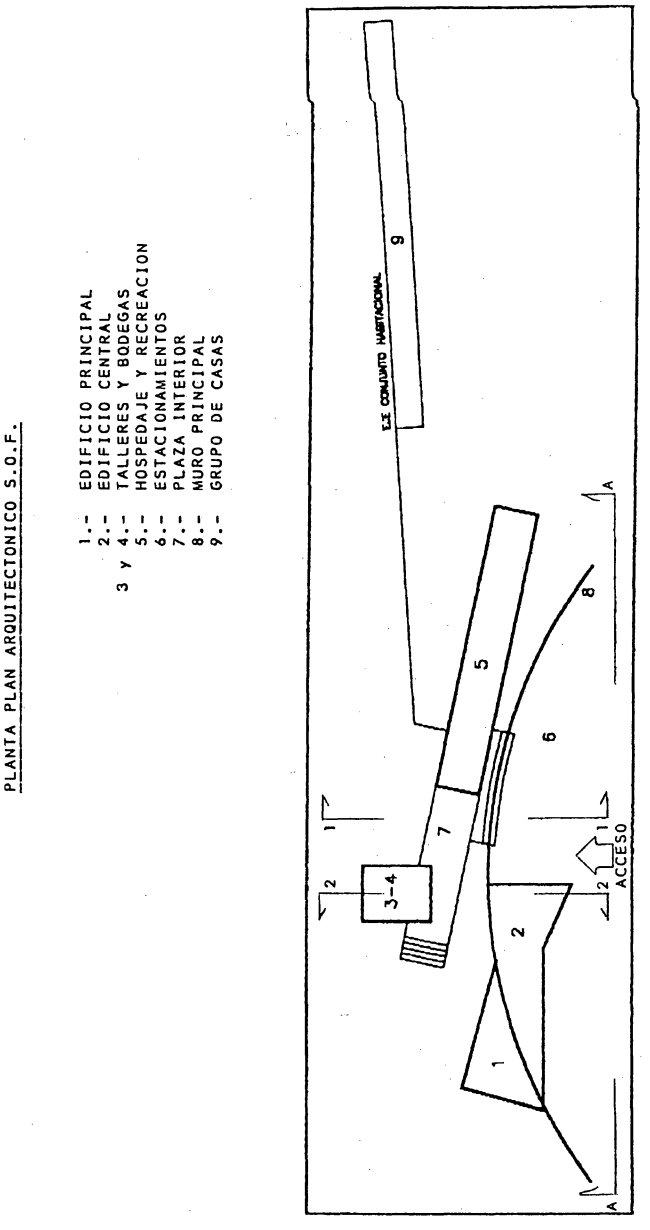

Figure 2 Architectural layout of the Operations Support facility

1. Main building
2. Central building
3. and 4. Workshops and warehouses
5. Dormitory and recreation
6. Parking lot
7. Interior patio/plaza
8. Main wall facing the highway
9. Group of family houses

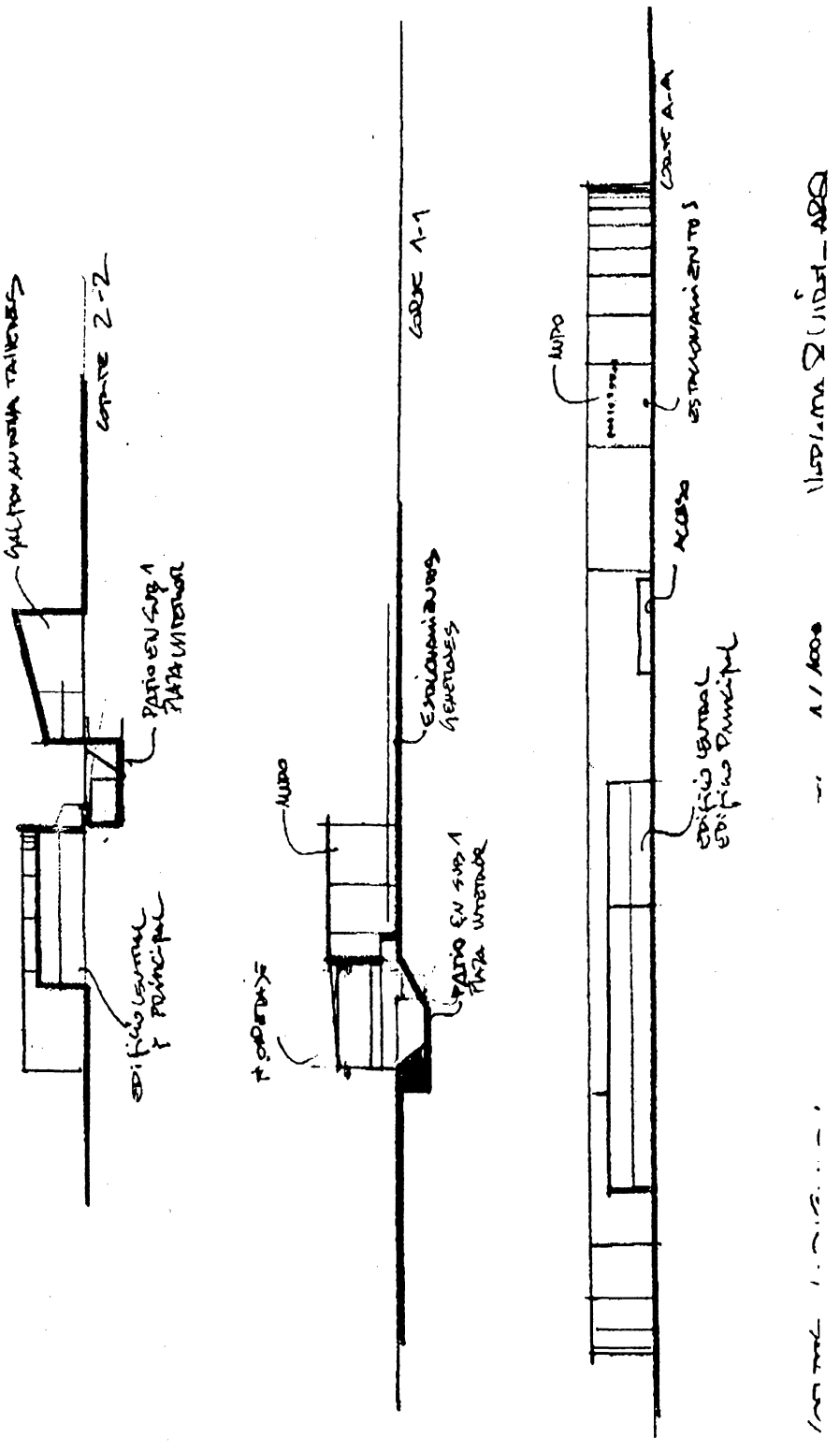

Figure 3 Various cross-sections though the OSF referred to numbers in the previous figure.

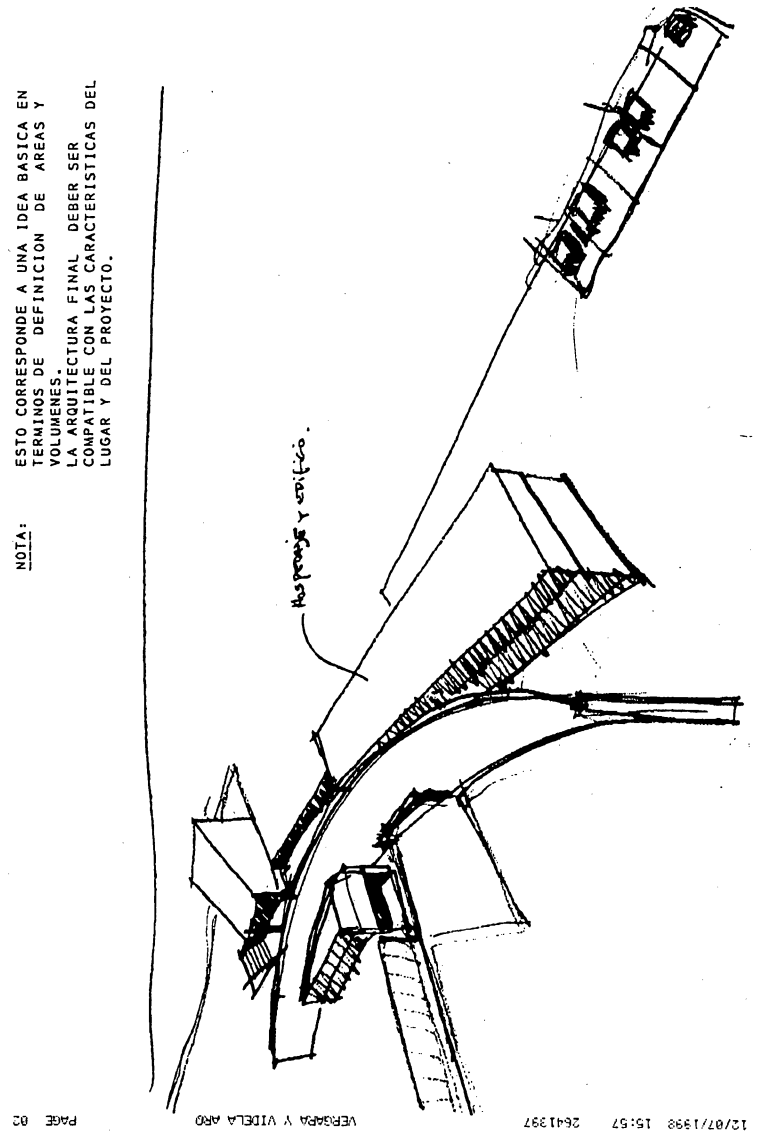

Figure 4 View from Southeast toward the Northwest

Section: 2-2 East through main building, patio and interior plaza, workshops and warehouses
Section: 1-1 West through patio, auditorium, and parking area
Section: A-A North though main building, central building, entrance driveway, auditorium, and parking area

This view gives a conceptual idea as to the use of area and volume. Hostel indicated. Family homes at right. The final architecture ought to be compatible with the characteristics of the location and of the project.

[Fax from Indura S. A., Industria y Comercio
Fax (56-2) 557 3471 - Fono (56-2) 530 3270

Translation by M. A. Gordon]

FAX: 055-331414
To: OCEGTEL S.A.
Attention: Sr. Víctor Realini

From: Gabriel Rodríguez
Date: 3 December 1998

Dear sirs:

Responding to your request, we have the pleasure to present an estimate of the costs to implement an Oxygenation System for the Radio-astronomical Observatory, to be constructed in Region II, at approximately 5,000 m above sea level.

INSTALLATION COST OF AN OXYGENATION SYSTEM

The indicated values envision the installation with the following principal parts:

- Installation of the liquid oxygen tank. (The same tank remains the property of Indura and the client pays rent for it.)
- Installation of a pipe network that will bring oxygen to the antenna and control buildings.
- Installation of the control panel for oxygen injection: one for the antenna building, the other for the control room, and another for the area of offices, dormitories, and library
- Valves and pressure regulators for each area.

We have not considered other civil works such as the foundation for the oxygen tank and excavations or trenches for the pipes; those will be minor expenses if done by the project's general contractor.

Moreover, the general contractor ought to supply accommodation facilities, living rooms, and bathrooms to Indura personnel to install the Oxygenation System.

TOTAL COST OF INSTALLATION approximately US$65,000 plus IVA tax

OPERATIONS COSTS

These costs will be dominated by the cost of the oxygen. Here the value indicated is based on the following assumptions:

- The observatory will be located about 5,000m above sea level.
- The oxygen concentration in the interior of the compound will be 26%, which is similar to an attitude of approximately 3,500m.
- Good hermetic sealing [air-tightness] within the building.
- Exchange rate of fresh air no more than 50% of the volume of each area per hour.
- Hours of use each day:

Antenna building:		10 hours
Control room:	2	4 hours
Offices and dormitory:		10 hours

OXYGEN COST PER MONTH approximately $US80,000 plus IVA tax

GENERAL CONSIDERATIONS

Because the information supplied by you is very general, the costs that we are supply should be considered to be an estimate of costs and therefore should not be interpreted as firm costs.

In case this project becomes concrete, we propose to execute a letter of commitment or contract that would specify all of the conditions necessary for the final study and installation of the oxygenation system. In this study we would consider the fundamental conditions that would allow more accurate calculations about the real consumption of oxygen.

Without other particulars, we remain at your disposal to supply additional information as convenient.

Sincerely yours,

[signature]

Gabriel Rodríguez Matta
Product manager for Special Gases

B. Estimación de costos para las Obras Civiles del telescope MMA

CALAMA, 19 de Diciembre de 1998.-
OCEG. 167/98/

Señores
National Radio Astronomy Observatory
949 North Cherry Avenue
Campus Building 65
Tucson, Arizona.

Atención : Sr. Mark A. Gordon

Referencia: Estimación de costos de obras civiles para radio telescopio MMA.-

Estimados señores:

Estamos adjuntando a ustedes el resultado del estudio solicitado a nuestra Empresa sobre los costos estimados por la construcción de las obras civiles, de arquitectura y facilidades para la operación, necesarias para el proyecto de construcción del radio telescopio MMA en el sitio de Chajnantor y de las instalaciones de soporte operacional en la localidad de San Pedro de Atacama, Segunda Región, Chile.

Hemos tratado de reflejar en nuestra evaluación, en la forma más realista, basado en nuestra experiencia como empresa de obras civiles y de montajes industriales, los costos que significarían construir en las condiciones de ubicación respecto de centros poblados y autosuficientes y en las condiciones de altura respecto al nivel medio del mar y climáticas del lugar.

Considerando los datos preliminares entregados por ustedes sobre la magnitud del proyecto hemos estimado que las obras aquí evaluadas serían posible de realizar en un plazo de 24 meses, por lo tanto, todos los valores que les estamos adjuntando están concebidos bajo esa perspectiva. Creemos que todo lo consultado por ustedes está respondido en el informe adjunto, sin embargo, les manifestamos que estamos a vuestra disposición para responder y aclarar cualquier duda que pueda surgir o para evaluar algún otro aspecto que sea necesario.

Esperando que este estudio satisfaga plenamente vuestros requerimientos, les saludamos atentamente.

[signature]
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Estimación de costos para la Obras Civiles del Telescopio MMA

1.- Obras en el Sitio MMA en Llano de Chajnantor..-

1.1.- Mejoramiento de la ruta de acceso.-
Hemos considerado una franja de circulación de 7 m de ancho que en una primera etapa se haría la apertura de esta franja, corrigiendo pendientes y curvas y, posteriormente, la confección de una sub-base de suelo seleccionado de 20 cm de espesor de acuerdo a las Norma Chilena de Carreteras. Se incluye en este precio barreras de protección , señalizaciones camineras necesarias y su diseño.-.

1.2.- Caseta de proyecto.-
Esta se trata de instalaciones temporales que se usarán durante el período de construcción del observatorio, por lo tanto, se ha considerado la utilización de un edificio tipo contenedor o algún tipo de construcción del tipo modular que cumpla con condiciones para soportar el clima del lugar, incluyendo sistemas de climatización y de enriquecimiento de oxígeno. Se incluye el alhaja miento de la oficina.-

Se recomienda la compra de estas instalaciones pues un sistema de arriendo por un plazo muy extenso resulta más caro y considerando que tendrían un valor residual importante.-

1.3.- Generador eléctrico.-
Se ha considerado la compra de un grupo generador de 10 KVA que sería utilizado durante el período de construcción, por las mismas razones anteriores. Este grupo estaría cubierto por una pequeña caseta para protegerlo de las condiciones climáticas.-
Se ha incluido el consumo de combustible por 24 meses.-

1.4.- Dormitorio de emergencia:-
Se ha considerado una construcción del tipo modular con equipamiento de baño y sistema de climatización y enriquecimiento de oxígeno. Este dormitorio formaría un conjunto con la caseta del proyecto y alimentado por el grupo generador.-
Se incluye el alhaja miento del dormitorio.-
Para el uso de baño se ha considerado la instalación de una fosa séptica portátil que se eliminaría una vez terminado su uso. También, se considera un estanque de agua de 500 lt para alimentar el baño y que se llenaría diariamente.-

1.5.- Caminos en el sitio.-
Se ha considerado la construcción de 20 Km de caminos que uniría las 145 bases para antenas de un ancho de 7 m. Teniendo en cuenta que por este camino circularían cargas pesadas se ha considerado la apertura de una franja de 7 m siguiendo la forma

natural del suelo del sitio, rectificando las pendientes y curvas que dificulten el desplazamiento de estas cargas pesadas. Sobre esta franja se colocaría una capa de suelo seleccionado de 20cm compactado según las exigencias de la Norma Chilena para Carreteras y sobre ella se colocaría un doble tratamiento asfáltico.-

Este sistema descrito se ha elegido considerando que en el sitio se producen precipitaciones nieve que podrían ablandar la zona de circulación y por ella circularían cargas pesadas.-

1.6.- Fundaciones de antenas.-

Se ha considerado la construcción de las 145 bases para antenas en una misma etapa, cada una de aproximadamente 45 m3 de hormigón.-

Para la construcción de estas antenas se ha considerado previamente el estudio de mecánica de suelo para cada fundación y el diseño de estas de acuerdo a las características soportantes del suelo.-

El hormigón a utilizar sería de alta resistencia H30 y con incorporador de aire para resistir el ciclo hielo-deshielo. En el estudio se ha considerado la preparación del hormigón en el sitio a partir de una mezcla seca llevada hasta el lugar en grandes bolsas (big bag) y en el sitio se instalaría solamente la planta mezcladora. El hormigón sería transportado hasta el lugar de vaciado en camiones mezcladores. Se ha elegido este procedimiento por recomendación hecha por la empresa Ready Mix especialista en este rubro después de evaluar la dificultad de producir hormigón en el sitio y por la escases de áridos en el lugar y en San Pedro de Atacama que cumplan con las exigencias de la Norma Chilena para Hormigones.-

El acero considerado para la armadura de refuerzo del hormigón cumple con la Norma Chilena de Acero para hormigones armados.-

El moldaje a usar sería del tipo prefabricado que cumpla con las condiciones de resistencia y estanqueidad necesarias para este tipo de estructuras.-

En la evaluación se ha incluido, además, el costo del estudio geotécnico, ensayos de materiales y muestreos exigidos por normas.-

1.7.- Red de energía.-

Esta red considera la transmisión de energía eléctrica desde la sala de generación hacia los distintos puntos de consumo: bases de antenas, edificio de control, galpón para antenas y bodega.-

Se han considerado las exigencias de la Norma Chilena de transmisión en 50 Hz en tensiones de 13,2 KV, 380 V y 220 V.

Se ha considerado instalar un switchgear de cinco circuitos y tablero general de fuerza con cinco circuitos en 13,2 Kv: un circuito para alimentar a la Sala de Control, un circuito para alimentar al Taller de antenas y bodega, un circuito para el arreglo menor de antenas y dos circuitos para el arreglo mayor de antenas.-

a) Circuito Sala Generación -Sala de Control:

circuito tendido en forma subterránea a través de conduit de PVC de alto impacto de 4" para fuerza y un conduit de 2" para control cubierto con una capa de hormigón H5 , según exige la Norma Chilena y con cámara de inspección a las distancias exigidas por la Norma. En la llegada a la Sala de Control se instalaría la subestación transformadora de 13.2 KV a 380/220 V y un tablero de Fuerza y Alumbrado de tres circuitos: un para sala de control, uno para la oficinas y uno para alumbrado.

b) Circuito Sala de Generación - Taller antenas y Bodega:
circuito tendido en forma subterránea a través de conduit de 4" para fuerza y un conduit de 2" para control cubierto con una capa de hormigón H5, según exige la Norma Chilena y con cámaras de inspección a las distancias exigidas por la Norma Chilena. En la llegada al Taller de Antenas de instalaría la subestación transformadora de 13,2 KV a 380/220V y un tablero de dos circuitos: uno para el taller de Antenas y un circuito para el edificio de Bodega.-

c) Circuito Sala de Generación- Arreglo menor:
Del mismo modo anterior se llevará el circuito de fuerza a través de conduit de PVC de 4" y uno de control en conduit de 2" protegido con una capa de hormigón H5 y cámaras de inspección a la distancia establecida en la norma. Se ha considerado que frente a cada base se haría una derivación hasta la subestación transformadora de 13,2 KV a 380/220 V.-

d) Circuitos Sala de Generación - Arreglo Mayor:
En este caso se ha considerado el tendido cumpliendo las mismas condiciones que para el circuito del arreglo menor pero dividido en dos circuitos con el propósito que cada uno alimente la mitad de las bases de antenas del arreglo mayor.-

1.8.- Subestaciones transformadoras.-
En este ítem sólo se consideran las subestaciones que irán instaladas en cada base de antena. Estas consistirán en transformadores de 20KW instalados en una estructura sobre terreno anclada a la base de hormigón de cada antena y un tablero con enchufes para conexión en 380 V y 220 V.-

1.9.- Generador uso continuo:-
Considerando la información entregada sobre el suministro de dos turbinas que vendrían en contenedores, se ha considerado el montaje de estos contenedores sobre una losa de hormigón y en ambos extremos se construiría una sala de estructura metálica con revestimiento de plancha de acero y aislación térmica de poliuretano de 40 kg/m3. En un extremo estarían ubicadas las válvulas de corte de la cañería de gas que alimentarían las turbinas y en otro extremo estarían los tableros de distribución de energía eléctrica. También, se cubrirían los

contenedores con una cubierta de techo con pendiente para evitar el acumulamiento de nieve sobre estos.-

1.10.- Red intra- fundación.-
Esta es una red de fibra óptica que va desde la sala de control a cada una de las bases de antena. La red considera cable de fibra óptica (Andrew 6 core, blindado en acero, modelo 242981-6) y cable heliax de 23 mm (Andrew FSJ4 -50B). Los cables serán instalados en dos canalizaciones de PVC de diám. 6", en una zanja y llevaría una capa de hormigón de

protección previo al relleno como lo estipula la norma. Se ha considerado cámaras de inspección a intervalos de 100 m., que se confeccionarán hormigón.- de 1m x 1m x 1m.

El alcance de la partida considera el suministro y montaje de la red con todas sus actividades incluida la puesta en servicio y mediciones de parámetros propios, para el caso de la fibra óptica se ha considerado también el equipo terminal de fibra completo, (caja y jumpers).

1.11.- Galpón de antenas.-
Este sería un galpón de unos 15m de ancho por unos 30 m de largo para cubrir aproximadamente 560 m2 y una altura de 20 m.-Este sería de estructura metálica cubierto con planchas metálicas con aislación térmica de poliuretano de 40 kg/m3 , tanto en sus muros como en la techumbre, sellado de tal forma que el sistema de climatización y enriquecimiento de oxígeno sean eficientes. Este galpón estaría dotado de un puente de grúa de 50 ton de capacidad.-

Se ha considerado un pavimento de losa de hormigón armado de 20cm de espesor para cubrir los 560 m2 interiores y una losa armada de acceso de 15m por 15m para facilitar el acceso al galpón.-

En cuanto a la instalación eléctrica del galpón esta contaría con circuitos de iluminación y circuitos de enchufes en tensiones de 380 V y 220 V.-

El precio incluye diseño, cálculo estructural, suministro y montaje de estructuras, materiales y elementos que conforman este edificio.-

1.12.- Bodega.-
Este sería un edificio de estructura metálica recubierto con planchas metálicas con aislación térmica de poliuretano de 40 kg/m3, adosado al edificio del galpón de antenas de 5m de ancho por 15m de largo y 3m de altura y techumbre con pendiente para evitar la acumulación de nieve. Este edificio no llevaría sistema enriquecedor de oxígeno y climatización.-

El pavimento seria una losa armada de 12cm de espesor.-

Se ha incluido la provisión de estantería metálica y un pequeño taller.-

1.13.- Edificio de control.-

Este sería un edificio de 1.400 m2 de los cuales 700 m2 serán destinados a la sala de control y la superficie restante sería destinada para oficinas, una biblioteca, comedor, cocina, baños para damas y varones, dormitorios de emergencia y un hall de acceso al edificio. Considera además el sistema de calefacción, aire acondicionado y enriquecimiento de oxígeno.

El cálculo para el sistema de calefacción y enfriamiento para la sala de control se ha tenido presente que se debe remover 150 kw de calor producido por el correlacionador digital. No se ha considerado en el costo la provisión de un instrumento de control exacto de humedad relativa para la sala del correlacionador digital, luego, si esto fuese necesario se debería agregar el costo equivalente a unos US$ 60.000.-

También, se ha previsto en la evaluación el costo del blindaje para radio frecuencia en todas las superficies de la sala de control, esta aislación se haría con láminas de Cu de espesor 0.3 mm.

La construcción de este edificio considera fundaciones y pavimentos de hormigón armado. Los muros consultan paneles autosoportantes, éstos son fabricados por láminas de acero zincalum prepintado al horno de espesor 0.6 mm, con núcleo de poliuretano inyectado en densidad de 40 kg/m3, (sin freón 11) de espesor 110 mm. y placa de terminación de acuerdo al uso de cada una de las dependencias. Los paneles permiten ser afianzados fuertemente por el sistema de ensamble macho hembra además de los conectores mecánicos accionados por excéntricas que traen incorporados en sus cantos.

Se ha considerado pavimentos antiestáticos para la zona de la Sala de Control, cerámico para el hall de acceso, baños, cocina y comedor y alfombra para la biblioteca y dormitorios.-

1.14.- Enlaces telefónicos.-

Se considera enlace telefónico desde la sala de control ubicada en el sitio MMA hasta el centro de soporte de operaciones en San Pedro de Atacama. Este enlace contempla dos opciones, cuyos valores se incluyen como partida en el presupuesto para que sea seleccionada por NRAO:

a) Enlace microondas: Este sistema se compone de 2 enlaces E1 que se unen back-back con capacidad de 2 mega bites/seg con 30 canales de telefonía cada uno, torre repetidora de 30 mts de alto, contenedor para repetidores y banco de baterías; equipo de poder y panel solar, solución sugerida por Entel Chile empresa de comunicaciones especialista en este tema.-.

b) Enlace Fibra Óptica: Este sistema se compone por tendido de cable Andrew 6 FO soterrado modelo 242981-6, cámaras de inspección y equipo terminales de fibra óptica.

Se recomienda este enlace aprovechando el enlace de fibra óptica que consulta el proyecto para la transmisión de datos. (Pto 1.16). Este sistema también fue evaluado y sugerido por Entel Chile.-

1.15.- Sistema de teléfonos.-

Se ha considerado una planta telefónica ubicada en el Edificio de Control con 176 estaciones de las cuales 145 corresponden a las bases de cada antena y el resto para oficinas y demás dependencias. De estas estaciones 32 corresponden a teléfonos multi lineas y 22 convencionales. Se ha tomado en cuenta la exigencia de transmitir datos , es decir, no son digitalmente multiplexadas. El tendido de las lineas multipares se hará en forma subterránea a través de conduit de PVC de alto impacto y cámaras de inspección de acuerdo a las normas.-

El sistema telefónico no considera la compra de las lineas telefónicas a la Compañía de Teléfonos de Chile, (C TC).

1.16.- Enlace de fibra óptica.-

Este enlace consiste en unir el sitio MMA en Chajnantor y el sitio OSF en San Pedro de Atacama a través de un cable de fibra óptica Andrews 6FO enterrado, modelo 242981-6. Este cable ira a través de una canalización subterránea de PVC de alto impacto y con cámaras de inspección a distancias establecidas en las normas.-

El valor incluye el suministro y montaje del cable, canalizaciones, terminales, cajas y cámaras, así como la excavación de la zanja, relleno posterior y capa de hormigón H5 de protección para el conduit.-

1.17.- Estación para aguas servidas.-

Considerando que las personas que trabajarían en el sitio no es muy numerosa hemos estimado que es suficiente para procesar las aguas servidas la construcción de una unidad sanitaria consistente en una fosa séptica y un pozo absorbente donde llegarían las cañerías de alcantarillado de las instalaciones sanitarias existentes en el edificio de control y del Taller de antenas.-

En el análisis del costo de este sistema se han considerado las líneas de alcantarillado.-

1.18.- Sistema de agua potable.-

De acuerdo a la consideración anterior estimamos que no se justifica la instalación de una planta de tratamiento de agua potable, por lo tanto, hemos considerado la instalación de un estanque metálico de almacenamiento de agua potable con aislación térmica. A la salida del estanque se instalaría un sistema levantador de presión para dar presión a las líneas de agua que alimentarían a las instalaciones sanitarias en la Sala de Control y en el Taller de Antenas. Luego, hay que considerar que este estanque debe ser abastecido permanentemente desde San Pedro de Atacama.-

En este sistema se han considerado las líneas de alimentación de agua potable.-

1.19.- Llave de gas reductora de presión.-

Entendemos que Gas Atacama hará la derivación en cañería de 6" de diámetro e instalará una válvula de corte en dicho lugar. A partir de esto, independiente del lugar

donde se instale, hemos considerado la provisión e instalación de una válvula reductora de presión en la línea de gas que alimentaría las turbinas generadoras.

1.20.- Línea de gas.-
Se ha considerado la instalación subterránea de una cañería de gas de 6" de diámetro de 1000 m de longitud, incluyendo su protección anticorrosiva . No se ha incluido protección catódica por sugerencia hecha por la empresa Bonatti experta en montaje de gasoductos.-
En la solicitud de evaluación se nos indicó que esta línea estaría a no más de 100m de distancia de la sala de generación, distancia que creemos es muy poco posible que ocurra.-

1.21.- Edificio del generador.-
En el punto 1.9.- se describió esta este edificio que consistiría, fundamentalmente, en aprovechar la estructura de los contenedores de las turbinas y construir adosado a ellas dos salas : una para el cuadro de válvulas de llegada del gas y otra para los equipos de distribución de energía eléctrica.-

1.22.- Terminación camino de acceso.-
Consistiría en recuperar la sub-base del camino descrito en el punto 1.1.- y posteriormente colocar una capa de asfalto en caliente de 5 cm de espesor.-

2.- Obras en el sitio OSF en San Pedro de Atacama.-

2.1.- Muro de seguridad.-
Hemos considerado que se contará con un sitio de 200 por 200 m junto al camino internacional entre Chile y Argentina. Como lo sugerido es el diseño de un acceso visualmente atractivo, los arquitectos de V&V Arquitectos nos han entregado un plan de distribución de espacios que considera un gran muro parabólico en el acceso construido bloques de hormigón revocado y pilares y vigas de hormigón. Los costados del sitio y el fondo estarían cerrados con muros semitransparente de tramos de adobes y malla metálica con pilares metálicos.-

2.2.- Edificio principal.-
De acuerdo al plan desarrollado por los arquitectos este es el edificio principal dentro este y esta íntimamente ligado al muro parabólico del acceso. Este sería un edificio de 1441m2 cuya proposición se divide en:

- hall y recepción	36 m2
- 50 oficinas de 8 m2 c/u	400 m2
- laboratorio	400 m2
- biblioteca	60 m2

- auditorio 100 personas	120 m2
- sala de reuniones	25 m2
- comedor 50 personas	90 m2
- cocina 30 %	30 m2
- servicios	40 m2
- estructuras y circulación	240 m2

Se ha considerado un edificio de excelentes terminaciones y del tipo prefabricado, con una arquitectura de acuerdo al lugar, con un buen sistema de climatización y con excelentes cualidades térmicas y acústicas.-

Los pavimentos interiores serían: alfombras en biblioteca, oficinas y salas de reuniones y cerámicos en hal de acceso, pasillos, comedores, cocina y servicios.-

En los costos estimados se ha incluido lo que corresponde a costo de arquitectura, ingeniería en todas sus especialidades.-

2.3.- Estación transformadora.-

Considerando la información entregada sobre el suministro de dos turbinas que vendrían en contenedores, se ha considerado el montaje de estos contenedores sobre una losa de hormigón y ambos extremos se construiría una sala de estructura metálica con revestimiento de plancha de acero. En un extremo estarían ubicadas las válvulas de corte de la cañería de gas que alimentarían las turbinas y en otro extremo estarían los tableros de distribución de energía eléctrica.-

Esta sala de generación quedaría ubicada en el extremo norponiente del sitio de tal forma que quede alejado de las instalaciones de dormitorios, oficina y casas habitación. Por tal motivo, las salas irán con recubrimiento interior de aislante acústico.-

2.4.- Red de poder.-

Considerando que la sala de generación está en el sector norponiente del sitio desde ese punto las lineas de alimentación hacia los diferentes edificios, de la forma que a continuación se describe:

- en la sala de distribución estarían los equipos eléctricos y el transformador de 13,2 KV a 380/220 V
- canalización subterránea desde sala de generación a Planta de tratamiento de agua potable, en conduit de PVC de alto impacto y cámaras de inspección según Norma Chilena.
- canalización subterránea desde sala de generación a Planta de tratamiento de aguas servidas, en conduit de PVC de alto impacto y cámaras de inspección según Norma Chilena.
- canalización subterránea desde sala de generación a Edificio Principal donde se instalaría el tablero general de fuerza desde donde se distribuiría en forma subterránea hacia los siguientes edificios: Dormitorios, recreación, talleres, bodegas, sala de control, iluminación de espacios exteriores e instalaciones deportivas.-

- tendido aéreo desde Sala de Generación a Pozo de agua, tendido que se haría en postes de hormigón de 8;5 m de altura y cable de cobre desnudo, considerando que este pozo estaría ubicado a unos 6 km de la sala de generación.-
- tendido aéreo desde Sala de Generación a Galpón de antenas tendido que se haría en postes de hormigón de 8;5 m de altura y cable de cobre desnudo, considerando que este edificio estaría a 1000 m del sitio OSF y que se trataría de una construcción temporal.-

2.5.- Gasoducto.-
Se ha considerado la instalación subterránea de una cañería de gas de 6" de diámetro de 5000 m de longitud, incluyendo su protección anticorrosiva . Se ha incluido protección catódica considerando dos estaciones y un transformador.

2.6.- Termogenerador.-
De acuerdo a lo descrito en el punto 2.3.- los termogeneradores se montarían sobre una losa de hormigón y las conexiones a la línea de gas y a la distribución de energía se alojarían en salas de estructura metálica ubicadas en los extremos.-

2.7.- Sistema telefónico
Se ha considerado una planta telefónica ubicada en el Edificio de Principal con 120 extensiones las que serán distribuidas a través del edificio. Se ha previsto permitir la transmisión de datos desde cualquier teléfono, asimismo las extensiones en el sitio MMA son alcanzables a través de este sistema. Se considera una central telefónica digital, 8 teléfonos son multilíneas y 112 son convencionales, la planta considera un máximo de 136 estaciones con E1. El tendido de las lineas multipares se hará en forma subterránea a través de conduit de PVC de alto impacto y cámaras de inspección de acuerdo a las normas.
El sistema telefónico no considera la compra de las lineas telefónicas a la Compañía de Teléfonos de Chile, (C TC).

2.8.- Pozo de agua.-
Se ha considerado la perforación de un pozo de 180 m de profundidad, entubado y con el suministro y montaje de la bomba para explotación del pozo.-

Todas las consideraciones se han hecho pensando que el lugar a perforar se encontraría a una distancia de 6 Km a la redonda del punto del sitio OSF.-

2.9.- Planta de tratamiento de aguas servidas.-
En el extremo nororiente de la zona cercada se ubicaría la planta de tratamiento de aguas servidas marca AGUASIN modelo LA-80, del tipo lodos activados, modalidad aireación extendida, esta planta fue recomendada por la empresa Aguas Industriales Ltda. para atender las aguas servidas generadas por un total de 100 personas considerando un aporte de aguas servidas de 160 lt/hab/día, el caudal medio diario que debe tratar es de

16000lt/día. La especificación de la planta considera elevación menor de 3000 m.s.n.m., caudal máximo medio diario 16100 lt/día, caudal máximo horario 4000 l/h, DBO5 2,9 a 4,0 kg/día y temperatura de diseño agua servida 15°C. El agua de salida tendrá las siguientes características: DBO5 menor de 30 g/m3, SST 105°C menor de 30 g/m3, coliformes fecales menor de 1000 NMP/100ml y volumen de lodo generado 700 l/30 a 40 días. Esta planta estaría conformada por un grupo motobomba de aire incluyendo todos sus elementos, mecanismos y accesorios tales como estanque de proceso de 35 m3, bombas dosificadoras de hipoclorito de sodio, bombas centrífuga sumergible, tableros eléctricos de fuerza y control analizadores de cloro, manifold, cables eléctricos y conduits.

2.10.- Sistema de distribución de agua.-

El sistema de abastecimiento de agua considera desde la matriz que sale del pozo a 6 KM hasta la planta de tratamiento y las cañerías que llevan el agua hasta los diferentes edificios, casas y otras dependencias dentro del recinto, incluyendo un estanque de almacenamiento de agua tratada a la salida de la planta de tratamiento.-

2.11.- Planta de tratamiento de agua potable.-

En el extremo norponiente de la zona cercada se ubicaría una planta de tratamiento de agua potable del tipo osmosis inversa capaz de tratar aguas de salobridad 200 ppm , a una temperatura de operación de 10° C, caudal de alimentación de 1532 lt/hr y un porcentaje de recobro del 50 %. Esta planta estaría conformada por un filtro de arena, dos bombas dosificadoras y un equipo de osmosis inversa, todo esto recomendado por la empresa Aguas Industriales Ltda. Especialista en este rubro.-

No se ha considerado galpón para alojar estas instalaciones.-

2.12.- Estacionamiento.-

Según el concepto de los arquitectos existiría una corta calle de acceso que se extendería en un área de estacionamiento junto al muro parabólico antes definido. Esta sistema de calle y estacionamiento comprende unos 1000 m2 de una superficie asfáltica de 5 cm de espesor confinada por soleras y solerillas de hormigón.-

2.13.- Estación de combustible.-

Se ha considerado la instalación de dos estanques de 20 m3: uno para gasolina y otra para petróleo, que irían enterrados y formando parte de una isla donde se instalarían los surtidores para entrega de combustible, según lo sugerido por Copec empresa especializada en el rubro.-

En el precio se ha considerado el diseño de esta estación y las inspecciones y certificados de los servicios autorizados como es el caso del SEC que es un oficina que debe autorizar dichas instalaciones.-

2.14.- Dormitorios.-

Este sería un edificio que contaría con un hall de acceso y recepción de 40 m2 y 40 habitaciones divididas en: 20 habitaciones con dos camas y baño en 480 m2; 5 habitaciones con una cama matrimonial y baño en 100 m2 y 15 habitaciones con una cama normal y baño en 180 m2.-

Formando parte de este conjunto de hospedaje estaría el área de servicios y equipamiento conformado por una cocina de 122 m2, comedor para el 50 % de los alojados en 40 m2, lavandería en 10 m2 y sala de estar de 90 m2.-

Este conjunto sería construido en albañilería por condición del pedido, con paredes estucadas por el exterior e interior y pisos cubiertos de alfombras en el caso de los dormitorios y sala de estar, cerámicos para la cocina, comedor y lavandería.-

En el precio se ha considerado las instalaciones eléctricas de alumbrado y enchufes y la instalación de sistema de climatización.-

Este edificio de hospedaje formaría un conjunto con el edificio recreacional definido por los arquitectos teniendo en cuenta el silencio que se debe conseguir en el area de dormitorios.-

No se ha considerado el alhaja miento de las dependencias.-

2.15.- Galpón de antenas.-

Este sería un galpón de unos 15m de ancho por unos 15 m de largo para cubrir aproximadamente 225 m2 y una altura de 20 m.-Este sería de estructura metálica cubierto con planchas metálicas , tanto en sus muros como en la techumbre. Este galpón estaría dotado de un puente de grúa de 50 ton de capacidad.-

Se ha considerado un pavimento de losa de hormigón armado de 20cm de espesor para cubrir los 225 m2 interiores y una losa armada de acceso de 15m por 15m para facilitar el acceso al galpón.-

En cuanto a la instalación eléctrica del galpón esta contaría con circuitos de iluminación y circuitos de enchufes en tensiones de 380 V y 220 V.-

Este galpón, por condiciones del plano regulador de San Pedro de Atacama no puede construirse en el sitio del OSF, por lo tanto, se ha considerado su construcción a unos 1000 m al oriente del sitio OSF a orillas del camino internacional entre Chile y Argentina.-

Se incluye en el análisis el costo de ingeniería de diseño de las estructuras y obras civiles.-

2.16.- Talleres.-

Se ha considerado una estructura metálica forrada en plancha de acero prepintada de 250 m2 de superficie de una altura de 3 m al hombro del marco. El interior será una losa de hormigón armado de 0,12 m de espesor.-

2.17.- Grupo de casas.-

La solicitud de NRAO fue que estas casas estuvieran ubicadas dentro del pueblo de San Pedro de Atacama pero ha resultado difícil conseguir un sitio que permita construir 5 casas dentro de una superficie agradable. Una alternativa de sitio tiene complicaciones

pues se encontraron restos de antiguos asentamientos indígenas, por lo tanto, no es recomendable insistir en dicho lugar.-
Por lo tanto, los arquitectos en su plan de ocupación de la cuatro hectáreas disponibles definieron un área para la construcción de estas casas de tal manera que mantengan su independencia respecto de las áreas de trabajo y hospedaje pero, a la vez, les permitiría tener acceso a las áreas de esparcimiento al aire libre.-
Se ha evaluado esta alternativa considerando casas del tipo prefabricada de muy buenas condiciones acústicas y térmicas y con un excelente nivel de terminaciones, incluyendo en estas el equipamiento de cocina (muebles, cocina, horno eléctrico) y lavandería (lavatorio enlozado y lavadora automática). También, se consideran algunos metros cuadrados de pavimentos exteriores en torno a la casa y un pequeño prado y árboles de la zona.-

2.18.- Bodega.-
Se ha considerado una estructura metálica forrada en acero prepintada de 375m2 de superficie de una altura al hombro de 3 m del marco. El interior será una losa de hormigón armado de 0,12 m de espesor.-
Este edificio es parte del conjunto de edificios que se construirían en el sitio OSF y ubicado en el sector definido por los arquitectos como de trabajo, junto al taller.-

2.19.- Piscina.-
Siguiendo con la propuesta global hecha por los arquitectos, existiría un area de recreación al aire libre donde iría ubicada una piscina construida de hormigón y revestida con cerámicos de 25 m de largo por 12 m de ancho y un metro de profundidad en la parte más baja y tres metros de profundidad en la parte más honda. También, se ha considerado pavimentos de hormigón por el contorno de la piscina , una pérgola y una barbacoa.-

2.20.- Edificio control.-
Este es un edificio similar al que se construiría en el sitio MMA, es decir, habrían 750 m2 de superficie para la instalación de equipos y todas sus paredes protegidas por una lámina de cobre de 0.3 mm de espesor y dotado de un equipo acondicionador de aire que mantenga la temperatura entre 20 y 25 grados Celsius.-
Edificio del tipo prefabricado y montado sobre una losa de hormigón armado de 12 cm de espesor.-

2.21.- Edificio recreacional.-
Consiste en un edificio compuesto por una sala de ejercicio o gimnasio, salas de estar, salas de televisión , sala de lectura, casino y cocina y planta libre para uso múltiple, como por ejemplo: mesas de pool, todo esto en una superficie de 750m2
El edificio sería del tipo prefabricado con materiales que garanticen condiciones térmicas y acústicas y una durabilidad de a lo menos 30 años. Montado sobre una losa armada de hormigón de 12cm de espesor y en un sólo nivel.-

2.22.- Cancha de tenis.-
Se ha considerado una cancha de tenis con una carpeta del tipo asfáltica y protegida con un cerco de pilares metálicos y malla metálica para evitar que se escapen las pelotas y para proteger del viento.-

2.23.- Cancha de fútbol.-
Creemos que lo más recomendable es construir una cancha de uso múltiple, es decir, donde se pueda practicar basquetbol, voleybol y baby futbol, y no una cancha de futbol que tiene grandes dimensiones y que cubrirla de pasto sería muy costoso y si fuera de tierra sería muy poco atractiva por su contaminación.-
Por lo tanto, hemos considerado una multicancha de hormigón de 12 cm de espesor y con los implementos para la practica de basquetbol, volleybol y baby futbol y protegida con un cerco de pilares metálicos y malla metálica.-

2.24.- Obras exteriores.-
El plan desarrollado por los arquitectos incluye áreas de circulación constituidas por veredas, escaleras, plazoleta, las que se han considerado construidas en hormigón y piedras de la zona. Se incluye en esto el sistema de iluminación de los espacios.-

3.- Observaciones generales:-

3.1.- Ingeniería y control de calidad: el estudio incluye los costos de ingeniería de detalle de todo lo que aquí se ha evaluado y los ensayos de mecánica de suelo para el diseño de las bases para antenas, fundaciones de edificios y construcción de caminos. También, se incluye los costos de ensayos de materiales y certificaciones exigidos por las normas.-

3.2.- Arquitectura: en los costos de los edificios se incluyó el costo de los proyectos de arquitectura y los costos de permisos de edificación que exigen las Municipalidades.-

3.3.- Pozo de agua: en este caso se ha evaluado sólo la construcción del pozo quedando pendiente los costos que puedan implicar el pago de derechos, servidumbres , compra de terreno en donde se descubra el agua y costos de exploración de este.-

3.4.- Enriquecimiento de oxígeno: creemos importante entregar en detalle lo que significa el sistema de enriquecimiento de oxígeno dado que su costo mensual de operación nos parece significativo, por lo cual, hemos agregado el Ítem 01.23.- y 01.24.- en forma especial.-

Luego, le adjuntamos el estudio hecho por la empresa Indura S.A. que es la empresa que ha instalado este sistema en plantas mineras en chile y que operan sobre 4000 m sobre el nivel del mar. Quizás, para el consumo mensual y el costo indicado se justifique instalar una pequeña planta productora de oxígeno que posiblemente exista en U.S.A. y cuya inversión se justifique en la vida útil del proyecto.-
Por otra parte,

3.5.- Enlaces telefónicos entre sitio MMA y OSF: Se incluye en el listado de partidas evaluadas dos alternativas de enlace, una a través de microondas y otro a través de fibra óptica.-
El enlace por fibra óptica aquí evaluado no tiene relación con el enlace en fibra óptica del ítem 1.16.- que sólo se considera para transmisión de datos. La utilización de esta vía para comunicaciones depende de NRAO.-

3.6.- Campamento en la etapa de construcción: Considerando que esta es una evaluación de lo que significaría construir el observatorio con toda su infraestructura de apoyo, estimamos conveniente tener presente que quien construya deberá tener o habilitar un campamento para su personal, por lo tanto, hemos incluido en el listado de partidas del presupuesto un ítem referido a este campamento.-
Para evaluar este costo hemos considerado la experiencia que se tiene de los grandes proyectos mineros que se han desarrollado en la región y hemos consultado a una empresa dedicada tanto a la construcción como al arrendamiento de este tipo de instalaciones.-

Hemos considerado la opción de arrendamiento de un campamento compuesto de lo siguiente: Movilización y desmovilización de los módulos y materiales al sitio y su habilitación en terreno y compuesto por cocina y casino para 300 personas, dormitorios para 50 personas de nivel superior y 250 dormitorios para obreros, edificio para recreación y entretenimiento y 50 oficinas para diferentes usos.-
El cálculo del costo de este campamento lo hemos hecho sobre la base que este sería un proyecto que se ejecutaría en un plazo de 24 meses.-

3.7.- Alimentación y estadía: del mismo modo, hemos considerado la experiencia respecto de las formas en que se han administrado la alimentación y estadía del personal en estos grandes proyectos. Lo habitual es que se contrate con empresas especializadas en alimentación y mantención de campamentos que se preocupan de la preparación y abastecimiento de alimentos y del aseo y recambio de ropa de cama de las habitaciones. Por este servicio estas empresas cobran del orden de US$ 15 por persona por día, este valor hemos considerado y multiplicado por las 300 personas de hemos supuesto como promedio en esta etapa de construcción estimada en 24 meses.-

3.8 .- Costos indirectos y gastos generales: para la ejecución de este proyecto se requiere de personal de dirección, administración y apoyo, por lo tanto, se incluye como parte de cada uno de los precios una organización capaz de administrar y conducir estas obras, los equipos indirectos necesarios para poder operar y los costos en implementación, comunicaciones y papelería necesaria. No hemos incluido costos de financieros para toda la inversión necesaria para la construcción y administración de estas obras, ni tampoco seguros que podrían ser exigencias del mandante.-
Cuando nos referimos a la estructura organizacional y su equipamiento no se incluye la organización ni la infraestructura que requeriría el mandante, en este caso NRAO.-

3.9.- Utilidades: en los precios se ha incluido un factor de utilidad que cargará quien construya el proyecto de un 12 % sobre la suma del costo directo e indirectos, margen habitual en este tipo de contratos.-

3.10.- Valor dólar de referencia: hemos considerado en nuestro estudio el valor de ch$ 475 por dólar norteamericano.

3.11.- Presupuesto: el total neto indicado en el presupuesto significa que se debe agregar a este valor el 18% de impuesto IVA (impuesto al valor agregado) que se debe pagar por los servicios que uno contrata.
El valor indicado corresponde a dólares norteamericanos.-

p. OCEGTEL S.A.

PREFACTIBILIDAD OBSERVATORIO MMA CHAJNANTOR
SAN PEDRO DE ATACAMA

Item	Partida	Unidad	Cantidad	Precio Unitario	Total Parcial
01.-	SITIO MMA CERRO CHAJNANTOR				
01.01.-	Mejoramiento ruta de acceso (12km de camíno asfaltado)	gl	1,00	440.932	440.932
01.02.-	Caseta para el proyecto	gl	1,00	31.347	31.347
01.03.-	Generador eléctrico	gl	1,00	83.255	83.255
01.04.-	Dormitorio de emergencia	gl	1,00	27.910	27.910
01.05.-	Caminos en el sitio	km	20,00	87.645	1.752.900
01.06.-	Fundaciones para antenas	c/u	145,00	49.042	7.111.090
01.07.-	Red de energía	gl	1,00	3.774.988	3.774.988
01.08.-	Subestaciones transformadoras	c/u	145,00	17.407	2.524.015
01.09.-	Grupo generador	gl	1,00	10.505	10.505
01.10.-	Fibra óptica entre fundaciones	gl	1,00	2.659.595	2.659.595
01.11.-	Galpón de antenas	gl	1,00	2.797.745	2.797.745
01.12.-	Bodega	gl	1,00	132.439	132.439
01.13.-	Edificio control	gl	1,00	1.713.253	1.713.253
01.14.-	Enlaces telefónicos opción fibra óptica (comunicación MMA - OSF)	gl	1,00	714.277	714.277
01.14.1.-	Enlaces telefónicos opción Microonda	gl	1,00	122.795	122.795
01.15.-	Sistemas de teléfonos sitio MMA	gl	1,00	1.432.758	1.432.758
01.16.-	Enlace de fibra óptica (transmisión de datos)	gl	1,00	3.637.544	3.637.544
01.17.-	Planta de tratamiento de aguas servidas y linea de alcantarillado	gl	1,00	35.502	35.502
01.18.-	Sistems de abastecimiento de agua potable	gl	1,00	17.523	17.523
01.19.-	Llave de gas reductora de presión	gl	1,00	44.879	44.879
01.20.-	Linea de gas	gl	1,00	321.882	321.882
01.21.-	Edificio del generador	gl	1,00	207.998	207.998
01.22.-	Terminación camino de acceso	gl	1,00	1.023.513	1.023.513
01.23.-	Sistema aire enriquecido (taller antennas, sala de control, oficinas, dormitorios, otros)	gl	1,00	99.466	99.466
01.24.-	Operación sistems aire enriquecido (consumo de oxigeno)	mes	1,00	122.420	122.420
02.-	EDIFICIO DE SOPORTE DE OPERACIONES OSF				
02.01.-	Cierre perimetral	ml	800,00	274	219.200
02.02.-	Edificio principal	gl	1,00	1.570.244	1.570.244
02.03.-	Estación transformadora	gl	1,00	184.276	184.276
02.04.-	Red de distribución eléctrica	gl	1,00	660.580	660.580
02.05.-	Gasoducto	gl	1,00	1.612.019	1.612.019
02.06.-	Termogenerador a gas	gl	1,00	1.292	1.292
02.07.-	Sistema telefónico sitio OSF	gl	1,00	174.144	174.144
02.08.-	Pozo de agua	g.	1,00	141.109	141.109
02.09.-	Planta de tratamiento de agua potable	gl	1,00	52.838	52.838
02.10.-	Sistem de distribución de agua	gl	1,00	358.641	358.641
02.11-	Planta de tratamiento de aguas servidas	gl	1,00	111.398	111.398
02.12.-	Estacionamientos	gl	1,00	34.678	34.678
02.13.-	Estación de combustibles	gl	1,00	53.176	53.176
02.14.-	Dormitorios	gl	1,00	1.318.487	1.318.487

SUBTOTAL ACUMULADO	37.332.613

PREFACTIBILIDAD OBSERVATORIO MMA CHAJNANTOR
SAN PEDRO DE ATACAMA

Item	Partida	Unidad	Cantidad	Precio Unitario	Total Parcial
02.15.-	Galpón de antenas	gl	1,00	966.182	966.182
02.16.-	Talleres	gl	1,00	189.748	189.748
02.18.-	Casas 186 m2	gl	5,00	192.219	961.095
02.19.-	Bodega	gl	1,00	247.050	247.050
02.20.-	Piscina	gl	1,00	188.146	188.146
02.21.-	Edificio control	gl	1,00	949.056	949.056
02.22.-	Edificio recreacional	gl	1,00	865.089	865.089
02.23.-	Cancha de tenis	gl	1,00	26.736	26.736
02.24.-	Multicancha	gl	1,00	41.278	41.278
02.25.-	Plaza dura y circulaciones	gl	1,00	98.770	98.770
02.26.-	Sistema aire acondicionado y calefacción OSF	gl	1,00	642.676	642.676
03.00.-	CAMPAMENTO Y HOSPEDAJE				
03.01.-	Campamento de construcción	gl	1,00	1.060.000	1.060.000
03.02.-	Alimentación y estadía	c/u	300,00	10.800	3.240.000
			TOTAL FINAL (Neto)		46.808.439

p. OCEGTEL S. A.
Víctor Realini Saldaña
Gerente General

19 DE DICIEMBRE DE 1998

Fig. 1

PLANTA PLAN ARQUITECTONICO S.O.F.

1.- EDIFICIO PRINCIPAL
2.- EDIFICIO CENTRAL
3 y 4.- TALLERES Y BODEGAS
5.- HOSPEDAJE Y RECREACION
6.- ESTACIONAMIENTOS
7.- PLAZA INTERIOR
8.- MURO PRINCIPAL
9.- GRUPO DE CASAS

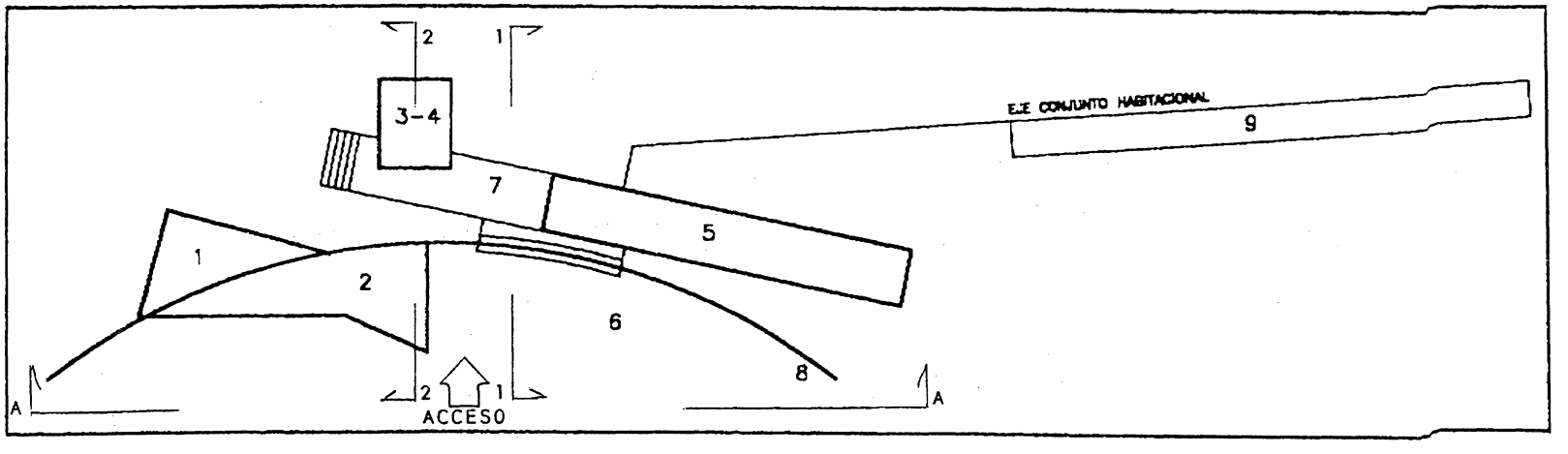
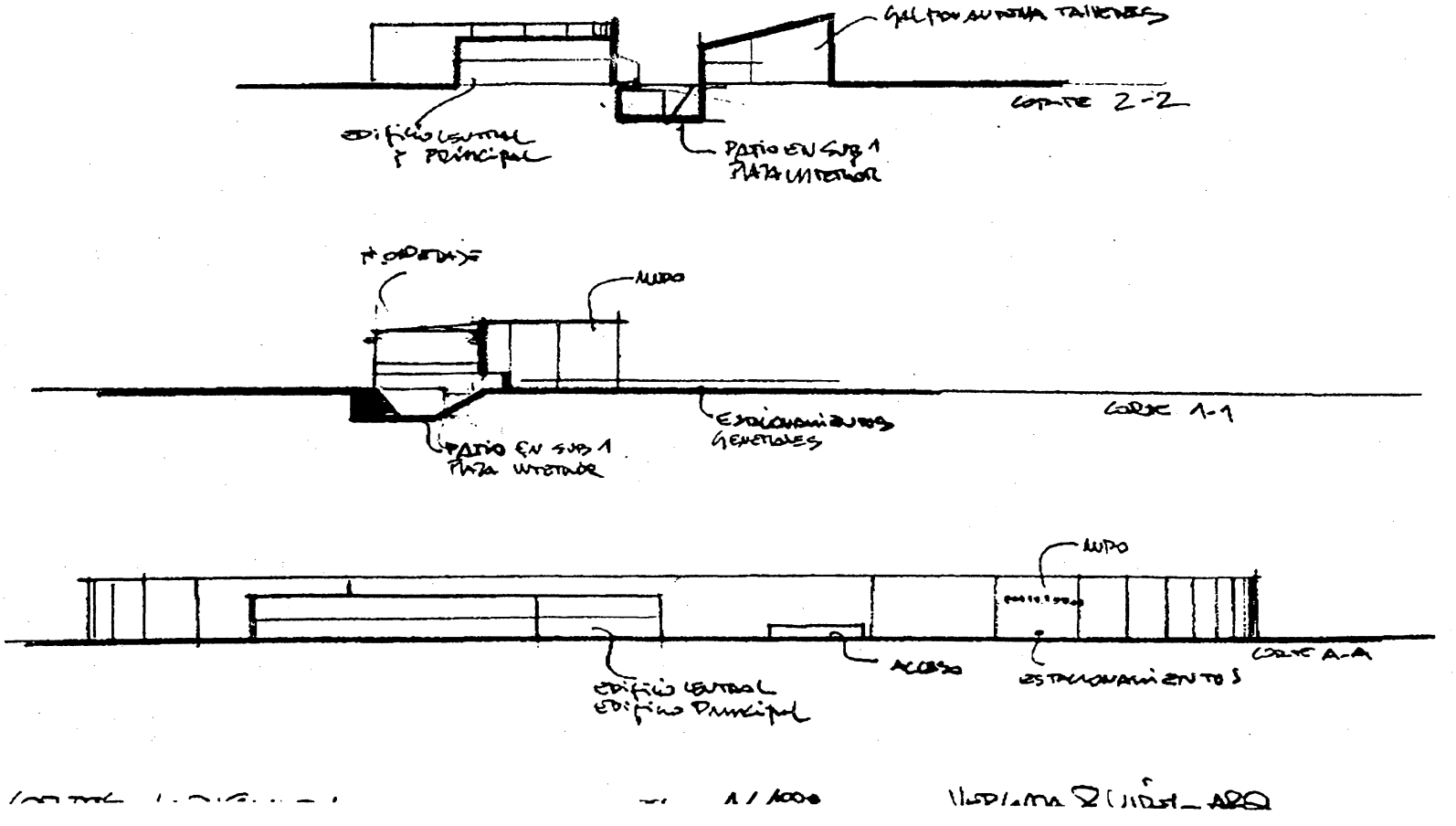


Fig. 2


GALERIA AUTOMATA TALLERES
CORTE 2-2
EDIFICIO CENTRAL
Y PRINCIPAL
PATIO EN SUB 1
PLAZA INTERIOR
MURO
CORTE 1-1
ESTACIONAMIENTOS
GENERALES
PATIO EN SUB 1
PLAZA INTERIOR
MURO
ACCESO
CORTE A-A
EDIFICIO CENTRAL
EDIFICIO PRINCIPAL

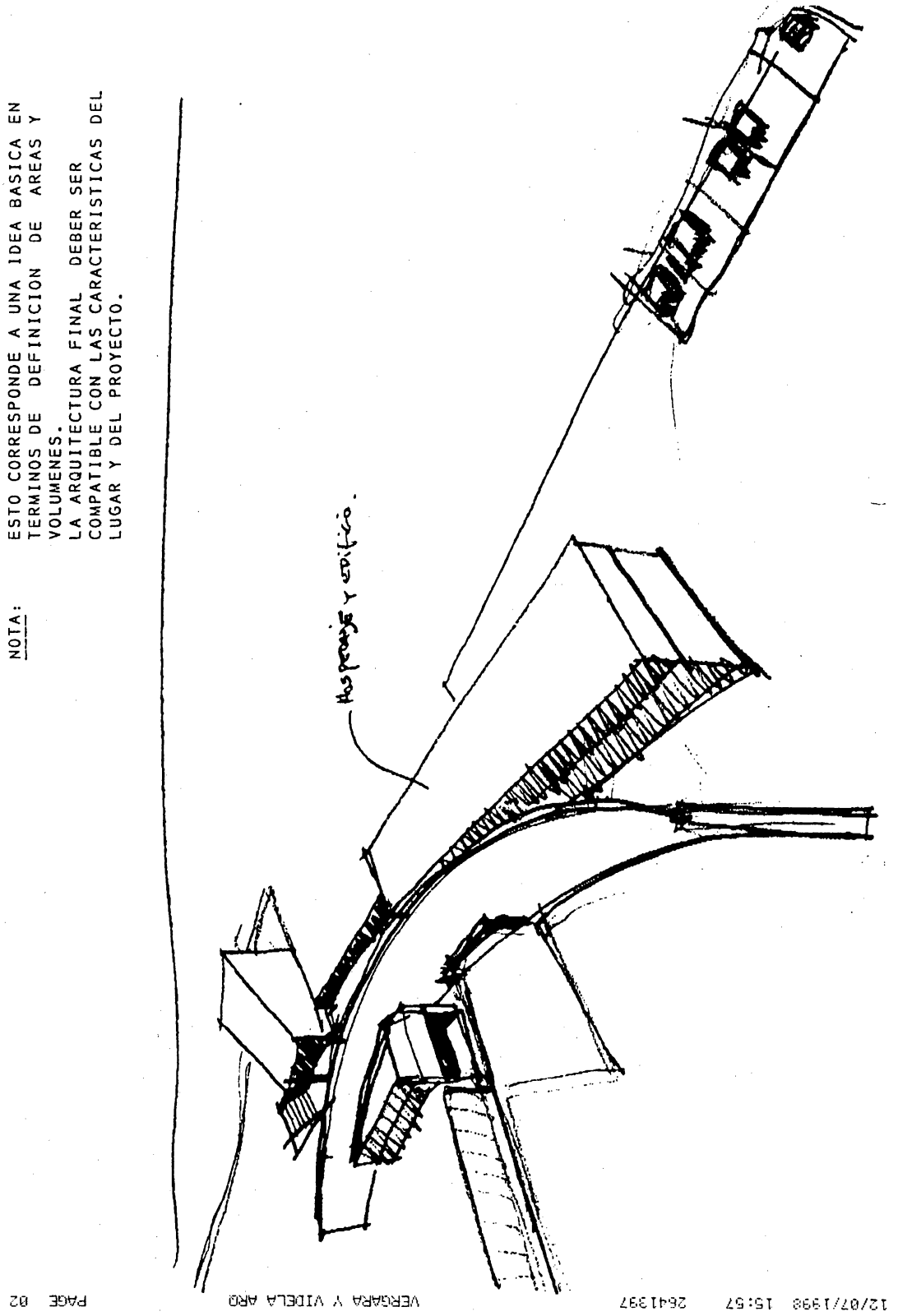

NOTA:
ESTO CORRESPONDE A UNA IDEA BASICA EN TERMINOS DE DEFINICION DE AREAS Y VOLUMENES.
LA ARQUITECTURA FINAL DEBER SER COMPATIBLE CON LAS CARACTERISTICAS DEL LUGAR Y DEL PROYECTO.
Hospedaje y edificio.
12/07/1998 15:57 2641397 VERGARA Y VIDELA ARQ PAGE 02

Fig. 3

ESTUDIO HECHO POR INDURA S.A.

Esto corresponde al punto 3.4 del texto **"Estimación de costos para las Obras Civiles del Telescopio MMA",** en que nosotros les decimos que les adjuntamos el estudio hecho por la empresa Indura S.A. para mandar por E-MAIL transcribimos el texto y corresponde literalmente a lo siguiente:

" COSTOS INSTALACION SISTEMA OXIGENACION

Los valores indicados contemplan la instalación de las siguientes partes principales:

- Montaje de estanque de Oxígeno Líquido (el estanque mismo permanece de propiedad de Indura y el cliente paga un arriendo por él).
- Instalación de red de cañerías que conducen el oxígeno hasta el taller de antenas y el edificio de control.
- Instalación de tres tableros de control de inyección de oxígeno: uno para taller de antenas, otro para sala de control y otro para sector oficinas - dormitorios - biblioteca.
- Válvulas y reguladores de presión para cada sector.

No se han considerado algunas obras civiles tales como fundación estanque de oxígeno y excavaciones o zanjas para el paso de cañerías, las que tendrían costos menores si son ejecutadas por el Contrastista General de la Obra.

Además, el contratista General deberá otorgar facilidades de alojamiento, casinos, baños para el personal de Indura que instale todo el Sistema de Oxigenación.

COSTO TOTAL INSTALACION Aprox. US $ 65.000 + IVA

COSTOS OPERACION

Estos están datos fundamentalmente por el costo del oxígeno. En todo caso, el valor indicado está basado en los siguientes supuestos:

- Observatorio estará ubicado a aprox. 5.000 m.s.n.m.
- Concentración de oxígeno en el interior de los recintos será de 26 % lo cual simula una altura de aprox. 3.500 m.s.n.m.
- Buena hermeticidad de los edificios.
- Tasa de renovación de aire fresco no mayor al 50 % del volumen de cada recinto por hora.

- Horas diarias de funcionamiento :- taller antenas: 10 hrs.
  - Sala control : 24 hrs.
  - Oficinas y dormitorios: 10 hrs.

COSTO MENSUAL OXIGENO Aprox. US $ 80.000 + IVA

CONSIDERACIONES GENERALES

Teniendo presente en cuanto a que la información entregada por ustedes es muy general, los valores que informamos solo pueden ser considerados como una estimación de costos y por lo tanto, no puede ser interpretados como una cotización a firme.

En caso de concretarse este proyecto, les proponemos firmar una Carta Compromiso o Contrato, en la cual se especifiquen todas las condiciones para la realización del estudio final e implementación del sistema de oxigenación. Por medio de este estudio se realizarán pruebas en terreno, que permitan calcular con más exactitud los consumos reales de oxígeno. También incluira los costos exactos de todo el sistema.

Sin otro particular, quedamos a su disposición para en tregarles cualquier información complementaria que estimen conveniente.

Les saluda muy atentamente,

Gabriel Rodríguez Matta
Product Manager Gases Especiales

NATIONAL RADIO ASTRONOMY OBSERVATORY
949 NORTH CHERRY AVENUE CAMPUS BUILDING 65 TUCSON, ARIZONA 85721-0655 USA
TELEPHONE (520) 882-8250, x112 FAX (520) 882-7955 EMAIL mgordon@nrao.edu

October 20, 1998

To: Víctor Realini S.
Gerente, Operaciones
OCEGTEL CIA, LTDA

From: Mark A. Gordon
Head, Site Development, Chile

Subject: Estimates for Civil Construction for the MMA telescope

Background
The National Radio Astronomy Observatory (NRAO) is planning to build a radio telescope (MMA) on a 5,000m site east of San Pedro de Atacama. The instrument will be operated from an Operations Support Facility (OSF) to be built at a lower altitude, near the airport of SpdA. The web site *http://www.mma.nrao.edu* describes the project.

The US National Science Foundation will fund the telescope. They have asked us to give them an estimate of the cost of the project, that is, within ±15%, by the end of 1998. We expect to begin construction in January 2001.

We plan to build two facilities in Region II to support this telescope: One is the site itself, a Science Preserve of Chile managed by CONICYT and known to us as Llano de Chajnantor; the other, the OSF to be located on Terra Fiscal near the airport of SpdA.

Attached materials
Attached to this letter are three documents describing the *civil construction* proposed for Llano de Chajnantor and for the OSF.

1 Page B of a spreadsheet listing construction for the OSF near SpdA in the order we need them

2 Page A of the spreadsheet listing construction for the MMA listed in the order we need them

3 Page C of the spreadsheet lists older costs, some of which you or Amanda Muñoz provided a few years ago.

4 A description of each item on pages A and B of the spreadsheet

Requirements

Please review my lists and estimate the cost of each item. Units of UF would be excellent but 1998 Chilean pesos would also be acceptable. I already have accurate costs for the electrical generators themselves. Also, GasAtacama will provide the gas taps at no charge to us.

Please make suggestions where you think my ideas are unsound. I value your judgement.

Eduardo Hardy can answer most questions that you may have.

Description of Spreadsheet Items

October 16, 1998
Revised, October 21, 1998

The spreadsheet has three pages, A, B, and C. Two pages list construction items for the MMA site at Llano de Chajnantor and one, for the Operations Support Facility near San Pedro de Atacama. The third page, C, lists costs for different aspects of construction estimated by various sources. I describe items contained in pages A and B below.

"Extra" means extra-structure, that is, exterior to the site itself
"Infra" means infra-structure, that is, part of the site itself.

Page A – MMA Site near Cerro Chajnantor (Llano de Chajnantor)
Construction items for this site should enable the MMA to operate as trouble-free as possible over at least a 30-year lifetime. Architectural decisions should focus more on the durability and functionality of the buildings rather than on artistic style. Nevertheless, we would welcome new construction techniques such as prefabricated buildings that provides the same utilitarian value and durability at a lower cost.

A complication comes from the 5,000m altitude. We plan to increase the partial pressure of oxygen from 21% (normal for 5,000m) to 26% (normal for 3,500m) in most site buildings where people will work. The total atmospheric pressure will not increase. No special construction will be required other than good sealing of joints, windows, and doors. No air locks will be necessary but the buildings must be well made.

The O_2 enrichment devices are known as "molecular-sieve oxygen generators". We call them concentrators. Reportedly, El Tambo mine near La Serena is now using these concentrators. We have heard that the new mine at Colluasi (4,600m) will also be using O_2 concentrators in their dormitories, office buildings, and trucks. The estimates below need not include the costs of purchasing or installing these devices.

This list is ordered by time of delivery.

1. Access road upgrade	The work involves improvements to the (approximately 12 km) mining road between the Paso de Jama highway and the MMA site. The width should be at least 7m to allow transport of antennas from SpdA. The minimum radius of curvature should be 13m.The work involves improving the surface, installing guard rails in appropriate places, and installing traffic warning signs where required. Trucks carrying up to 60 tonnes will be using this road to transport material to the MMA site beginning in January 2001. We plan to delay the final double asphalt surface until construction is completed near the year 2006.
2. Project Shack	This temporary building will serve as a construction office for up to 4 NRAO employees needing to work at the site. It should contain desk space, telephone equipment, a lunch area, and an emergency area in which to sleep. A used building would be acceptable. Heating. Oxygen enrichment
3. Generator, light duty	This device will provide electricity for the Project Shack. The fuel could be gasoline or diesel. You choose the fuel. This unit could be leased until permanent electricity is available.

4. Dormitory, emergency

This is a small permanent building to be used as an emergency dormitory. It need not be fancy, but it should be comfortable and easy to clean and maintain. Heating . Oxygen enrichment

5. On-site roads

These roads will connect the 145 concrete pads supporting the antennas. The will allow "transporters" to move antennas from one pad to another and allow maintenance personnel to reach each pad. The widths will be 7m. We estimate about 20 km of these roads, but will not know the exact length until the configuration is complete. These roads should support 60 tonnes of weight of the transporter and the antenna, distributed over an adequate number of axles, and at a speed of about 5 km/h. They may not require hard surfaces. The route of the roads must be selected to avoid steep grades.

6. Antenna pads

These reinforced concrete pads will support the antennas and provide connections to electrical power and signal cables. I estimate each pad will require about 45 m^3 of reinforced concrete at an approximate cost of US\$450 m^{-3} . Does this price seem reasonable?

7. Power network

This network will distribute electric power from the generators to all buildings and to the antenna pads. The gas turbine generators will include a switchgear interface -- included in their purchase price -- between the turbines and the intra-site power distribution system. I estimate that the MMA will require approximately 1.2MW. We will adopt the Chilean standard of 50Hz and 220VAC for normal use, and will use buried cables to transmit 13.2kV to each antenna pad. [Chilean decree #327 stipulates these to be "standard" voltages.]

8. Transformer stations

These 20kW transformers will be located at each antenna pad. They will convert the generated power to the three-phase 380 VAC needed to run the antenna motors. A 220VAC tap will also be needed to power the lights and electronics devices.

9. Generator, continuous duty

We have a price for this item. We will choose two Solar Turbines' Mercury 50, natural gas powered turbine generators. Each has a sea level output of about 6MW but only 2MW at 5,000m. (Amortizing the capital costs over 10 years gives a production cost of US\$0.05/kWh for electricity.)

10. Intra-pad network

This network consists of fiber optic cable (Andrews 6 core, steel armored, model 242981-6) and direct burial, 0.5 in (23mm) heliax cable (Andrews FSJ4-50B) to carry signals from the control building to each antenna pad. (Page C lists their costs.) I estimate about 40 km of cables. These should be installed in two 6-inch (~15cm) PVC pipes in a trench, with "pull-boxes "at 100m intervals. Messenger lines (pulling cords) should also be installed in each pipe.

The pull boxes will consist of 1m x 1m x 1m, prefabricated, simple, concrete boxes connecting the PVC pipe. They should have a metal access lid. The boxes should be placed on gravel to allow water to drain. We will need about 400 of these. Approximate cost?

11. Antenna barn

This building, 560 m^2 and 20m high, will allow repair of antennas at the site. One side should open to allow an antenna to be brought inside. The doors should then shut tightly to preserve an oxygen-enriched atmosphere. There should be three bays. The roof should support a traveling crane capable of lifting 20 tonnes.

12. Warehouse — This building will store supplies needed for repairs to the antennas and electronics. It could be pre-fabricated. An area should be set up for a small machine shop, to be equipped with lathes, mills, band saws, shears, bending brakes, drill presses, work benches and welding equipment. Oxygen enrichment is needed only for the shop area.

13. Control building — This building will house all of the electronics needed to control the antennas and process the signals coming from them. It should be a good quality building with oxygen enrichment. A large room for the electronics needs RF shielding, i.e., the walls, doors, and floors must be covered with a copper screen; the doors will require "finger-stock" shielding. [We can price this as an "add-on".] The Heating and Cooling System must be sized to remove 150 kW of heat produced by the digital correlator.

14. Telephone links — We plan to install 2 E1 microwave links from the control building to the Operations Support Center at San Pedro de Atacama. A tower relay may be required at the edge of the geologic bench. This may be eventually replaced with a fiber optics cable (see below.)

15. Telephone system — This is the internal telephone system for the MMA site. It should include handsets at each of the 37 antennas, ten handsets in the control building, 3 handsets in the warehouse, two handsets in the dormitory, 3 handsets in the antenna barn, 1 handset in the generator building for a total of 54 separate extensions. Additionally, telephone connections should exists at each of the 145 antenna pads so that the antenna telephones can be connected. These lines should be able to transmit data, i.e., not be digitally multiplexed. Each extension should be reachable directly, no operator should be needed.

16. Fiber-optic link — The MMA site should connect, eventually, with the Operations Support Facility in San Pedro de Atacama via fiber optic-cable. The Andrews fiber-optic cable specified above (Item 10) would be used. This cable would be buried in a trench connecting the MMA site with the OSF. No conduit would be necessary; this is a "direct-burial" cable.

17. Waste-water station — This system would collect, process, and dispose of waste water from toilets and sinks in the buildings in accordance with Chilean regulations. Or, perhaps each building should have its own waster disposal system.

18. Water system — Two options are possible:

Option 1: Bring potable water by tank truck from San Pedro de Atacama, or

Option 2: Drill a well on the MMA site and process water for drinking at the MMA site. Geological reports suggest that water could be found beneath the surface but this is uncertain. Furthermore, we don't know how deep. Additionally, this system would deliver water to the buildings on the site equipped with toilets and washing facilities.

19. Gas tap/pressure reducer — GasAtacama will install the gas tap at no charge. The MMA will pay for a device to reduce the gas pressure to about 20 atmospheres. I don't know whether this device is installed at the gas tap or at the turbine generators.

20. Gas line	Approximately 100m of 6-inch gas pipe will connect the turbine generators to the gas tap on the GasAtacama . This pipe will be lie in a trench about 1 m below the surface of the ground. Installation will require cathodic protection.
21. Generator building	The gas turbines come in weatherproof enclosures. However, given the winds and altitude, we believe it would be better to place them in a generator building to facilitate service and repairs.
22. Access road, finish	After most of the construction is complete, it will be time to complete the access road between the Paso de Jama highway and the site by installing a double asphalt surface.

Page B. Operations Support Facility near San Pedro de Atacama

This facility will be the center of operations for the millimeter array. Most personnel will work here. It will contain facilities to support astronomers, business, administrative, engineering, programming, and maintenance personnel. We should expect up to 100 people for normal operation.

I am concerned that the architecture blend well with the traditions of the village wherever possible.

I've ordered the list in priority of when we need them.

1. Security wall	This wall will protect the Operations Support Facility. It will surround the entire OSF recinto. It should be equipped with a large gate sufficient to allow large vehicles to enter and depart. It should be visually attractive, possibly constructed of adobe. I estimate the area of the OSF to be about 4 hectares.
2. Building, principal	This building will house offices, electronics laboratories, library, auditorium, and dining facilities for the MMA staff. It might consist of more than one building, depending upon the suggestions of the architect. I think that, at least, part of it should be built first to provide (1) an identity for the project and (2) a place to meet with contractors.
3. Transformer station	This facility will provide electricity for the OSF separate from the electrical system of the village. It should produce 50Hz 220VAC for general use and three-phase 380 VAC for antenna motors and heavy equipment. We plan to assemble the MMA antennas here, equip them with the electronics packages, test them, and then transport them to the MMA site. Maximum power will be 400kW.
4. Power network	This network will distribute electrical power throughout the OSF.
5. Gas pipeline, 5 km	This may be a optional item. We estimate that the GasAtacama gas tap will lie approximately 5 km from the OSF. We can either Option 1: locate our generators near the gas tap and bring electricity to the OSF via a buried, 13.2kV cable, or Option 2: install a 6 inch gas line from the gas tap to the OSF and generate electricity within or near the OSF.

6. Generator, gas-fired	We have already acquired two 500 kW, reciprocating, natural gas-fired continuous duty generators. These will require installation in Chile within a weather-proof housing and connection to the gas line. Our plan is to alternate between these two units. The enclosure should be acoustic if the generators are located near the OSF [see item 5, above] to minimize "noise pollution" from the reciprocating engines.
7. Telephone system	This is the internal telephone system for the OSF. I would guess about 120 handsets (extensions) scattered through the buildings. We probably will have a receptionist/operator for these facilities. This system should allow data transmission from any telephone. The MMA site extensions should also be reachable through this system, perhaps through a tie line reached by, say, dialing 6 before the MMA extension.
8. Well, water	This well will supply water to the OSF. Officials at the Explora Hotel told me that they needed to drill to 180m to reach adequate supply of water. This item would include drilling, casement, pump, and pressure storage.
9. Water treatment facility	This facility would (1) purify water from the well and (2) process waste water from showers, sinks, and toilets, reclaiming whatever portion is cost-effective. Aquasin (02-238-1199) in Santiago is a contact for these products.
10. Water distribution system	This system would distribute potable water to all buildings within the recinto. It would also collect waste water for reclamation.
11. Sewage Treatment plant	See item 9 above. This system would dispose of all unreclaimed water.
12. Parking lot	This would provide parking spaces for all vehicles used in the operation of the OSF. I estimate 40 vehicles.
13. Fueling station	Equipped with appropriate, environmentally sound storage tanks, the facility would supply gasoline and diesel fuel to all vehicles.
14. Dormitory	This is a building where temporary visitors and Sistema de Turno employees will sleep. It needs to be masonry. It should have beds for 60 persons, including some camas matrimonias for married couples.
15. Antenna barn	Similar building to antenna barm for site. 186 m^2 floor, 20m high. Traveling roof crane must lift 20 tonnes. Used for assembling antennas.
16. Building, shops	Houses mechanical shops: machine, carpentry, welding, and automotive.
17. House lots	Locations in or around San Pedro de Atacama. Used for 5 family houses. I would prefer these lots to be separated, to integrate their occupants into the SPdA community if possible and to allow their occupants some relief from working together all day..
18. Houses, ~186m^2	Five houses for families. Should blend with local architecture. Good quality. Could be prefabricated. Security protection as required.
19. Warehouse	Storage facility for supplies for MMA. Could be prefabricated.

20. Swimming pool	Recreational facility for employees (and families) working at the OSF.
21. Building, control	Building for controlling the MMA. It could be separate from the "principal" building described above (item 2). Needs to be good to excellent quality. Prefabrication is acceptable if the architecture would blend with the village. (And, not with the Hotel Explora!)
22. Building, recreational	Here my concept is vague. The primary purpose of this building is to serve the Turno employees. It could include a TV room, pool tables, an exercise gym, and perhaps a small basketball court – whatever is usual for Chilean employees.
23. Tennis courts	Two good quality tennis courts, with adequate fences to contain wild balls.
24. Football field	For soccer.

Page B of LAYOUT.WB2

OSF

Location	Item	Group	Purpose	Lifetime	Level of Architecture	Availability Priority	Delivery Time (months)	Cost (US$k)
San Pedro	Wall, security	Infra	Protect MMA material	permanent	high	1		
San Pedro	Building, main, 1120 m2	Infra	Office, labs, auditorium, library, dining	permanent	high	2		746
San Pedro	Transformer station	Extra	Manage voltage levels	permanent		3		
San Pedro	Power network	Infra	Distribute power to buildings, pad	permanent		4		
San Pedro	Gas line, 5km	Extra	Connect OSF to gas line	permanent		5		200
San Pedro	Generator, gas-fired	Extra	Provide electricity to OSF	permanent		6	2	20
San Pedro	Telephone system, internal	Infra	Communications system	permanent		7		?
San Pedro	Well, water	Extra	Provide water for OSF	permanent		8	2	55
San Pedro	Water treatment station	Extra	Process water for drinking	permanent		9		100
San Pedro	Water distribution system		Convey water from treatment sta. to buildings			10		
San Pedro	Sewage treatment plant	Extra	Dispose of waste water	permanent		11		?
San Pedro	Parking lot, 40 vehicles	Infra	Parking	permanent		12		
San Pedro	Fueling station, tanks	Infra	Dispense diesel & gasoline	permanent		13		?
San Pedro	Dormitory, masonry,750 m2	Infra	Housing for transients	permanent	high	14	6	752
San Pedro	Antenna barn, 186 m2	Infra	Antenna assembly	temporary	functional	15		119
San Pedro	Building, shops, 280 m2	Infra	House welding, carpentry, mechanical	permanent	functional	16		196
San Pedro	House lots, 5	Extra	Location or residences	permanent		17		
San Pedro	Houses, 5, each 186 m2	Extra	House resident families, phased	permanent	high	18		930
San Pedro	Warehouse, 375 m2	Infra	Parts storage	permanent	functional	19		240
San Pedro	Swimming pool	Infra	Recreation	permanent		20		?
San Pedro	Building, control, 740m2	Infra	Array control center	permanent	high	21		493
San Pedro	Building, recreational 750 m2	Infra	Facilitate leisure activities	permanent	good	22		684
San Pedro	Tennis courts, 2	Infra	Facilitate tennis	permanent		23		
San Pedro	Field, football	Infra	Facilitate soccer	permanent		24		

File LAYOUT.WB2
Sequences improvements for Chilean sites

M. A. Gordon 13-Aug-98

Revised 20-Aug-98

Page A of LAYOUT.WB2
MMA at Chajnantor

Location	Item	Group	Purpose	Lifetime	Level of Architecture	Oxygen Generation ?	Availability Priority	Delivery Time (months)	Cost (US$k)
Chajnantor	Access road, Upgrade , 12km	Extra	Connect Paso de Jama highway to site	temporary			1	3	
Chajnantor	Project shack	Infra	Office & shelter for NRAO personnel	temporary	functional	y	2	1	30
Chajnantor	Generator, light duty	Infra	Support Project Shack	temporary			3	1	
Chajnantor	Dormitory, emergency, 100 m2	Infra	Shelter for emergencies, prefab	permanent	good	y	4	3	67
Chajnantor	On-site roads,20km	Infra	Connect antenna pads	permanent			5		
Chajnantor	Antenna pads, 145	Infra	Support antennas, with elec connections	permanent			6		65
Chajnantor	Power network	Infra	Distribute electric power thru site	permanent			7		
Chajnantor	Transformer stations	Infra	Convert 12.5kV to 408V at each pad	permanent			8		290
Chajnantor	Generator, continuous duty	Infra	Support construction & testing	temporary			9		2,910
Chajnantor	Intra-pad network	Infra	Distribute IF, LO, telephone to pads	permanent			10		240
Chajnantor	Antenna barn,560 m2	Infra	Building for repairing antennas	permanent	functional	y	11		358
Chajnantor	Warehouse,100m2	Infra	Storage, prefab	permanent	functional	n	12		64
Chajnantor	Control building, 1400 m2	Infra	Main building at site, prefab	permanent	good	y	13		932
Chajnantor	2E1 links to SPdA, E1 to Calama	Extra	Wideband telephone communications	permanent			14		30
Chajnantor	Telephone system	Infra	Enable voice communications	permanent			15		
Chajnantor	Fiber-optic link	Extra	Connect Chajantor with SPdA	permanent			16		
Chajnantor	Waste-water station	Infra	Process waste water	permanent			17		
Chajnantor	Water system	Infra	Store & supply water to site buildings	permanent			18		
Chajnantor	Gas tap/ pressure reducer	Extra	Supply gas to permanent generator	permanent			19	1	0
Chajnantor	Gas line, 100m of 6-inch pipe	Extra	Connect gas to permanent generators	permanent			20		15
Chajnantor	Generator building, 190 m2	Infra	House generators, prefab ?	permanent	functional	n	21		
Chajnantor	Gas turbine generators, 2	Infra	Supply electric power	permanent			22	12	5,820
Chajnantor	Backup generator(s)	Infra	Produce standby electric power	permanent			23		
Chajnantor	Access road, Finish	Extra	Connect Paso de Jama highway to site	permanent			24		

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Cost Data

Item	Characteristic	Cost	Units	Notes	Source
dormitory	masonry	1,002	US$/m2	Figure from OCEGTEL, May 1995	Amanda Muñoz
office building	prefab	666	US$/m2	Figure from OCEGTEL, May 1995	Amanda Muñoz
shop	prefab	700	US$/m2	guess	Mark Gordon
recreation building	prefab	924	US$/m2	Figure from OCEGTEL, May 1995	Amanda Muñoz
warehouse	prefab	640	US$/m2	Figure from OCEGTEL, May 1995	Amanda Muñoz
access road	double-asphalt	75,000	US$/km	OCEGTEL, April 1995	Víctor Realini
electric generators	gas turbine, 2MW at site	2,910,000	US$/unit	Solar Turbines, October 1998	Ed C. Monroe
transformers	13.2kV to 380V	2,000	US$/unit	Guess, based upon experience at KPNO	
house, residential	prefab	1,000	US$/m2	Guess	Mark Gordon
house lot, SPdA		?			
pipe, natural gas,site	6-in gas pipe	150	US$/m	GasAtacama	Skip Macinnes
pipe, natural gas, SPdA	6-in gas pipe	50	US$/m	GasAtacama	Skip Macinnes
parking lot		?			
fuel station		?			
fiber-optic cable	Andrews 6-48,#242981-1-6, installed	6	US$/m	Ron Beresford, 12 Nov 97	
Heliax RF cable	1/2 inch, installed	9	US$/m	Andrew FSJ4-50B, supply catalog	Dewey Ross, Oct 98
electric power cable	13.2kV, direct burial, installed	?	US$/m		
on-site roads	stabilized but unpaved	?			
wall, security	masonry with gates	?			
water treatment plant	purification & storage	100,000	US$	From Aguasin, LTD	aquasin.wp6
water well	180m deep	824	US$/m	Cost of well for Explora Hotel	Manager, Explora Hotel
telephone link	E1 to Calama, 2 E1 to site	30,000	US$	Quote from ENTEL, 2 Aug 1995	letter to MAG
reinforced concrete	adequate strength for pads	450	US/m3	Estimate from Peter Dejonge	Interview, "dejonge.mem", 15 Nov 94
pull-boxes	1m x 1m x 1m, prefab concrete	100	US$/box	A wild, irresponsible guess	Mark Gordon

NATIONAL RADIO ASTRONOMY OBSERVATORY
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October 28, 1998

A: Víctor Realini S.
Gerente, Operaciones
OCEGTEL CIA, LTDA

De: Mark A. Gordon
Gerente, Desarrollo de Sitios de MMA, Chile

Ref: Estimaciones Para la Obra Civil del Telescopio MMA

Generalidades

El National Radio Astronomy Observatory (NRAO) está planeando construir un radio-telescopio (MMA) en un sitio a 5,000 m de altura cerca de San Pedro de Atacama. El instrumento será operado desde un Centro de Soporte de Operaciones (Operations Support Facility, OSF), a ser construido a una altitud menor cerca del aeropuerto de San Pedro de Atacama. El sitio web *http://www.mma.nrao.edu* describe el proyecto.

La National Science Fundación de Estados Unidos de Norteamérica financiará el telescopio. Ellos nos han requerido les entreguemos una estimación de los costos del proyecto, esto es, con un error del 15%, a finales de 1998. Nosotros esperamos iniciar la construcción en Enero del 2001.

Nosotros planeamos construir dos facilidades en la Segunda Región para soportar este telescopio: Una es el sitio en si mismo, una Reserva Científica de Chile manejada por CONICYT y conocida como Llano de Chajnantor; la otra, el OSF a ser ubicado en Terreno Fiscal cerca del aeropuerto de San Pedro de Atacama.

Material adjunto

Adjunto a esta carta van tres documentos describiendo la construcción civil (obra civil) propuesta para el Llano de Chajnantor y para el OSF.

1 Página B de una hoja de cálculo listando las construcciones para el OSF, cerca de San Pedro, ordenadas de acuerdo a cuando nosotros necesitamos de ellas.

2 Página A de la hoja de cálculo listando las construcciones para el MMA, ordenadas de acuerdo a cuando nosotros necesitamos de ellas.

3 Página C de la hoja de cálculo listando costos anteriores, algunos de los cuales usted o Amanda Muñoz entregaron hace unos pocos años atrás.

4 Una descripción de cada ítem en las páginas A y B de la hoja de cálculo.

Requerimientos

Por favor revise mi lista y estime el costo de cada ítem. Unidades de UF sería excelente, pero pesos chilenos de 1998 podrían ser también aceptables. Yo ya tengo costos exactos para los generadores eléctricos. Además, GasAtacama proporcionará las llaves de Gas sin cargo.

Por favor haga las debidas sugerencias cuando usted estime que mis ideas son poco razonables. Yo valoraré sus juicios.

Eduardo Hardy puede responder muchas preguntas que usted pudiera tener.

Descripción de Itemes

Octubre 16, 1998
Reviste, Octubre 21, 1998

[Traducción de Pablo Altamirano]

El documento ("spreadsheet" en ingles) tiene tres páginas, A,B y C. Dos páginas contienen la lista de los itemes para el sitio del MMA, ubicado en el Llano de Chajnantor, y otra para el Edificio de Soporte de Operaciones cercano a San Pedro de Atacama. La tercera página, C, enlista los costos para los diferentes aspectos de la construcción, estimada por varias fuentes. A continuación describo los itemes contenidos en las páginas A y B.

"Extra" : significa extra-estructura, esto es, exterior al sitio mismo.
"Infra" : significa infra-estructura, esto es, parte del sitio.

Página A B Sitio MMA cercano al Cerro Chajnantor (Llano de Chajnantor)
Los elementos de construcción de este sitio deberían habilitar al MMA para operar libre de fallas, tanto como sea posible, considerando al menos unos 30 años de vida útil.

Las decisiones arquitectónicas deberían enfocarse más en la durabilidad y funcionalidad de las construcciones más que en el estilo artístico. Sin embargo, serían bienvenidas nuevas técnicas de construcción tales como construcciones prefabricadas, a condición de que signifiquen la misma durabilidad y valor utilitario a un menor costo.

Una complicación sobreviene de los 5,000 m de altitud del sitio. Nosotros planeamos aumentar la proporción de oxígeno desde 21% (normal para 5,000m) a 26% (normal para 3,500m) en muchos de los edificios donde la gente trabajará. La presión atmosférica total no aumentará. No se requerirá de construcciones especiales, salvo un buen sellado de uniones, ventanas y puertas. No será necesario un sellado para aire, pero las construcciones deberán ser hechas correctamente.

Los equipos enriquecedores de O_2 son conocidos como "Amolecular-sieve oxygen generators". Nosotros les llamamos "concentradores". Actualmente la mina El Tambo, cerca de La Serena, está usando estos concentradores. Hemos sabido, además, que la nueva mina en Collauasi (4,600m) usará también concentradores de O_2 en sus dormitorios, edificios de oficinas, y camiones. Las estimaciones abajo indicadas no incluyen necesariamente los costos de compra o instalación de estos equipos.

Esta lista está ordenada por prioridad temporal.

1. Mejoramiento de la ruta de acceso	El trabajo incluye mejoras a la ruta minera (aprox. 12 Km) entre la carretera El Paso de Jama, y el sitio MMA. El ancho debe ser de al menos 7m para permitir el transporte de las antenas desde SpdA. El mínimo radio de curvatura debe ser de 10m. El trabajo incluye mejoramiento de la superficie, instalación de guardarrieles en los lugares apropiados, y la instalación de señales camineras donde sea requerido. Camiones con carga de hasta 60 toneladas usarán este camino para transportar material hacia el MMA, comenzando en Enero del año 2001. Nosotros planeamos retardar la superficie final de asfalto doble hasta que la construcción esté terminada, cerca del año 2006.

2. Caseta de Proyecto

Esta construcción temporal servirá como una oficina de construcción para hasta 4 empleados del NRAO, cuyo trabajo sea necesario en el sitio. Esta debería contener espacio para escritorio, equipamiento telefónico, un área para colación, y un área de emergencia en la cual se pueda dormir. Una costrucción usada podría ser aceptable. Calefacción. Enriquecimiento de oxígeno.

3. Generador eléctrico

Este equipo debe entregar la electricidad para la Caseta de Proyecto. El combustible puede ser gasolina o petróleo diesel. Usted puede escoger el combustible. Esta unidad puede ser arrendada hasta que el suministro eléctrico permanente esté disponible.

4. Dormitorio, emergencia

Esta es una pequeña construcción permanente que será usada como un dormitorio de emergencia. No es necesario que sea elegante, pero debe ser cómodo y fácil de limpiar y mantener. Calefacción. Enriquecimiento de oxígeno.

5. Caminos en el sitio

Estos caminos conectarán las 145 fundaciones de concreto que soportan las antenas. Ellos permitirán a los Atranporters mover las antenas desde un fundación a otra, y permitirán al personal de mantenimiento alcanzar cada un de las fundaciones. El ancho será de 7m. Estimamos unos 20 Km de estos caminos, pero no sabremos el total exacto hasta que la configuración esté completa. Estos caminos deben soportar las 60 toneladas de un transportador y una antena, distribuidos sobre un adecuado número de ejes, y a una velocidad aproximada de 5 km/h. Estos podrían no requerir de superficies duras. Las rutas deben ser seleccionadas para evitar pendientes empinadas.

6. Fundaciones para Antenas

Estas almohadones de concreto reforzado soportarán las antenas y entregarán las conexiones a las fuentes de energía eléctrica y a los cables de señales. Estimo que cada almohadón requerirá de unos 45 m^3 de concreto reforzado, a un costo aproximado de US$ 450. ¿Es este valor razonable?

7. Red de energía

Esta red distribuirá la energía eléctrica desde los generadores a todos los edificios y a las fundaciones de las antenas. Las turbinas de gas generadoras incluirán una interfaz de interruptores –incluida en su precio de compra—entre las turbinas y el sistema de distribución de energía intra-site. Estimo que el MMA requerirá de aproximadamente 1.2 MW. Nosotros adoptaremos la norma chilena de 50 Hz y 220 VAC para uso normal, y usaremos cables subterráneos para transmitir 13.2 kV a cada almohadón de antena. [El decreto chileno N 327 estipula estos voltajes estantandar]

8. Subestaciones transformadoras

Estos transformadoras de 20 kW estarán ubicados en cada fundación de antenas. Ellos convertirán la potencia generada a voltaje trifásico de 380 VAC necesario para accionar los

motores de la antena. Un tap para 220 VAC será también necesario para energizar las luminarias y los dispositivos electrónicos.

9. Generador, uso continuado

Nosotros tenemos un precio para este ítem. Escogeremos dos Solar Turbines Mercury 50, turbinas generadoras a gas natural. Cada una tiene una salida, a nivel del mar, de unos 6MW, pero solo 2MW a 5,000m (Amortizando los costos de capital sobre 10 años resulta en un costo de producción de US$0.05/KWh)

10. Red intra-fundación

Esta red consiste de cable de fibra óptica (Andrews 6 core, blindada en acero, modelo 242981-6) y cable heliax de 23mm (Andrews FSJ4-50B) de entierro directo, para portar las señales desde los edificios de control a cada fundación de antenas (Los costos se enlistan en la página C). Estimo unos 40 Km de cables. Estos deben ser instalados en dos canalizaciones de PVC de 6 pulgadas (15 cm) sobre una zanja subterránea, con cajas de acceso a intervalos de 100 m. Lineas mensajeras (lauchas) deben también ser instaladas en cada canalización. Las cajas de acceso consistirán de cajas simples de concreto prefabricado de 1m x 1m x 1m, conectando las canalizaciones de PVC. Estas deben tener una tapa metálica. Las cajas deben ser ubicadas en gravilla para permitir el drenaje de agua. Nosotros necesitamos unas 400 de estas cajas. ¿Cuanto es el costo aproximado?

11. Galpón de Antenas

Esta construcción, 560 m^2 y 20m de altura, permitirá la reparación de las antenas en el sitio. Uno de los lados debe abrirse para permitir que una antena sea transportada al interior. Las puertas deben entonces cerrar ajustadamente para preservar una atmósfera oxígeno-enriquecida. Deben existir 3 aperturas. El techo debe soportar una grúa móvil capaz de levantar 20 toneladas.

12. Bodega

Esta construcción deberá almacenar los suministros necesarios para las reparaciones a las antenas y los equipos electrónicos. Puede ser prefabricado. Un área debe ser preparada para un pequeño taller, a ser equipado con tornos, molinos, sierras de banda, cizallas, caballetes de flexión, fresas de presión, escaños de trabajo y equipos de soldadura. Enriquecimiento de oxígeno es solo requerido para el área del taller.

13. Edificio de control

Esta construcción alojará toda la electrónica necesaria para controlar las antenas y procesar las señales provenientes de ellas. Debe ser una construcción de buena calidad, con enriquecimiento de oxígeno. Una gran sala para la electrónica necesita blindaje de radiofrecuencia, es decir: las paredes, puertas y pisos deben ser cubiertos con una pantalla de cobre; las puertas requerirán blindaje en las manijas. (podemos incluir el precio como un "Add-on"). El sistema de calefacción y enfriamiento debe ser dimensionado para remover 150kW de calor producido por el correlacionador digital.

14. Enlaces telefónicos	Planeamos instalar 2 enlaces de microondas E1,desde el edificio de control hasta el Centro de Soporte de Operaciones en San Pedro de Atacama. Una torre de enlace puede ser requerida en el borde del asentamiento geológico. Este puede ser eventualmente reemplazado con un cable de fibra óptica (ver abajo).
15. Sistema de teléfonos	Este es el sistema telefónico interno para el sitio MMA. Debe incluir equipos en cada una de las 37 antenas, 10 equipos en el edificio de control, 3 en la bodega, 2 en los dormitorios, 3 en el galpón de antenas y 1 equipo en el edificio de generación, para dar un total de 54 extensiones separadas. Adicionalmente deben existir conecciones telefónicas en cada una de las 145 fundaciones para antenas, para que el teléfono en cada antena pueda ser conectado. Estas líneas deben ser capaces de transmitir datos, es decir: no ser digitalmente multiplexadas. Cada extensión debe ser alcanzable directamente, sin la intervención de un operador.
16. Enlace de fibra óptica	El sitio MMA debería conectarse, eventualmente, con el Edificio de Soporte de Operaciones en San Pedro de Atacama, por medio de un cable de fibra óptica. El cable de fibra óptica Andrews, especificado arriba (ítem 10) podría ser usado. Este cable podría ser enterrado en una zanja conectando el sitio MMA con el OSF. Podría no ser necesario un conduit puesto que este cable es de tipo "entierro directo".
17. Estación para aguas sucias	Este sistema podría colectar, procesar y disponer las aguas sucias provenientes de baños y sumideros en los edificios, de acuerdo a las regulaciones chilenas. O bien, quizá cada edificio debería tener su propio sistema de desagüe.
18. Sistema de agua	Dos opciones son posibles: Opción 1: Suministrar agua potable mediante camiones cisterna desde San Pedro de Atacama, o Opción 2: Perforar un pozo en el sitio MMA y procesar el agua para beber en el lugar. Reportes geológicos sugieren que puede encontrarse agua bajo la superficie pero esto es incierto. Más aún, no sabemos que tan profundo. Adicionalmente, este sistema podría proporcionar agua a los edificios del sitio equipados con baños y lavaderos.
19. Llave de Gas/reductor de presión	GasAtacama instalará la llave para gas sin cargo. El MMA pagará por un dispositivo para reducir la presión de gas a unas 20 atmósferas. Yo no se si este dispositivo es instalado en la llave de gas o en las turbinas generadoras.
20. Línea de gas	Aproximadamente 100m de tubería de gas de 6 pulgadas conectará las turbinas generadoras a la llave de gas de GasAtacama. Esta tubería estará oculta en una zanja a 1m bajo

	la superficie del suelo. La instalación requerirá protección catódica.
21. Edificio del generador	Las turbinas de gas van en contenedores impermeables. Sin embargo, dados los vientos y la altitud, nosotros creemos que sería mejor ubicarlas en un edificio para facilitar el servicio y las reparaciones.
22. Camino de acceso, terminación	Finalizada la mayor parte de la construcción, será el tiempo de completar el camino de acceso entre la carretera del Paso de Jama y el sitio, instalando una superficie de asfalto doble.

Página B. Edificio de Soporte de Operaciones (OSF) cercano a San Pedro de Atacama.

Este edificio será el centro de operaciones para el MMA. La mayor parte del personal trabajará aquí. Este contará con facilidades de soporte para personal administrativo, de negocios, astronomos, ingenieros, programadores y personal de mantenimiento. Nosotros deberiamos esperar hasta un total de 100 personas para operación normal.

Yo estoy preocupado de que la arquitectura combine bien con las tradiciones de la villa, tanto como sea posible. He ordenado la lista en prioridad de acuerdo a cuando nosotros necesitemos de ellos.

1. Muro de seguridad	Este muro protegerá el OSF. Rodeará el recinto completo. Debe ser equipado con una gran puerta, lo suficiente para permitir el paso de grandes vehículos. Debe ser visualmente atractivo, posiblemente construido en adobe. Estimo que el área del OSF es de 4 hectáreas.
2. Edificio, principal	Este edificio albergará oficinas, laboratorios electrónicos, biblioteca, auditorio y facilidades para la colación del personal. Este podría consistir de más de un edificio, dependiendo de las sugerencias del arquitecto. Creo que, al menos, parte de este debería ser construido primero para dar (1) una identidad al proyecto y (2) un lugar de reunión con los contratistas.
3. Estación transformadora	Esta facilidad proveerá electricidad para el OSF, separadamente del sistema eléctrico de la villa. Debería producir energía en 220VAC 50Hz para uso general, y 380VAC trifásico para los motores de las antenas y el equipo pesado. Nosotros planeamos ensamblar las antenas del MMA allí, equiparlas con los bloques electrónicos, probarlas, y luego transportarlas al sitio del MMA.
4. Red de poder	Esta red distribuirá energía eléctrica al OSF.
5. Gaseoducto, 5 km	Este puede ser un ítem opcional. Estimamos que la llave de gas de GasAtacama estará aproximadamente a 5km del OSF. Tenemos dos opciones:

Opción 1: ubicar nuestros generadores cerca de la llave de gas, y transmitir la energía hacia el OSF via cable subterráneo de 13.2kV

Opción 2: instalar una linea de gas de 6 pulgadas, desde la llave de gas hasta el OSF , y generar la electricidad dentro o cerca del OSF.

6. Termo generador, gas

Nosotros ya adquirimos dos termo generadores de 500kW, de uso continuado, recíprocos, a gas natural. Estos requerirán instalación en Chile dentro de una construcción resistente a las inclemencias del tiempo, y la conexión al gaseoducto. Nuestros planes son alternar el uso entre las dos unidades. El encierro debería ser acústico (aislante) si los generadores están ubicados cerca del OSF [ver ítem 5, arriba] para minimizar la contaminación acústica desde las máquinas en movimiento.

7. Sistema telefónico

Este es el sistema telefónico interno para el OSF. Yo creo que cerca de 120 extensiones estarán distribuidas a través del edificio. Nosotros probablemente tendremos un recepcionista/operador. Este sistema debe permitir la transmisión de datos desde cualquier teléfono. Las extensiones en el sitio MMA deberían también ser alcanzables a través de este sistema, quizá a través de una línea alcanzable, digamos, discando el 6 antes de la extensión en el sistema MMA.

8. Pozo, agua

Este pozo entregará el agua al OSF. Oficiales en el Hotel Explora me dijeron que ellos necesitaron perforar 180m para alcanzar un adecuado suministro de agua. Este ítem incluiría perforación, encajonamiento, bomba y almacenamiento presurizado.

9. Planta de tratamiento de agua

Esta debería (1) purificar el agua del pozo y (2) procesar las aguas sucias provenientes de las duchas, sumideros y baños, el tratamiento de cualquier porcentaje es costo-efectivo. Aquasin (02-238-1199) en Santiago está en contacto para estos productos.

10. Sistema de distribución de agua

Este sistema podría distribuir agua potable a todos los edificios dentro del recinto. Podría además recoger las aguas sucias para tratamiento.

11. Planta de tratamiento de alcantarillado

Ver ítem 9 arriba. Este sistema dispondría de todas las aguas no tratadas.

12. Estacionamiento

Este daría espacio para todos los vehículos usados en la operación del OSF. Estimo 40 vehículos.

13. Estación de combustible	Equipada con tanques de almacenamiento ambientalmente adecuados, este recurso suministrará la gasolina y el combustible diesel a todos los vehículos.
14. Dormitorio	Este es un edificio donde los visitantes temporales y los trabajadores del Sistema de Turnos dormirán. Necesita ser de albañilería. Debe tener camas para 60 personas, incluyendo algunas camas matrimoniales para parejas casadas.
15. Galpón de Antenas	Construcción similar al galpón de antenas para el sitio MMA. 186 m^2 de superficie, 20 m de altura. La grúa aérea móvil debe levantar 20 tonalidades. Usado para ensamblar las antenas.
16. Talleres	Barracas talleres mecánicos: máquinas, carpintería, soldadura y mecánica automotriz.
17. Grupos de casas	Ubicaciones en, o en torno a San Pedro de Atacama. Ocupados por 5 casas familiares. Yo prefiero que estos lotes estén separados, para integrar a sus ocupantes a la comunidad de SPdA, si es posible, y permitir a sus ocupantes algún descanso de trabajar juntos todo el día.
18. Casas, ~186 m^2	Cinco casas para familias. Deberían armonizar con la arquitectura local. Buena calidad. Podrían ser prefabricadas. Protecciones de seguridad son requeridos
19. Bodega	Local de almacenamiento para insumos del MMA. Podría se prefabricado.
20. Piscina	Infraestructura recreacional para empleados (y familias) trabajando en el OSF.
21. Edificio, control	Edificio para controlar el MMA. Podría estar separado del edificio "principal" descrito arriba (ítem 2). Necesita ser de calidad buena a excelente. Prefabricación es aceptable si la arquitectura armoniza con la villa (¡y no con el hotel Explora!).
22. Edificio, recreacional	Aquí mi concepto es vago. La primera propuesta para este edificio es servir a los empleados en Turno. Podría incluir una sala de televisión, mesas de pool, un gimnasio de ejercicios y quizá una pequeña cancha de basquetbol o cualquiera que sea usual para empleados chilenos.
23. Cancha de tenis	Dos canchas de tenis de buena calidad, con defensas adecuadas para contener pelotazos violentos.

24. Cancha de fútbol	Para fútbol soccer.

E. Estimate for Gas-powered Turbine Generators at Chajnantor

The advent of a new, high-pressure gas line on the periphery of the MMA site makes natural gas available for powering the MMA. The owners of the gas line, GasAtacama, have agreed to provide a tap at the MMA site.

Perhaps the most important characteristic of the MMA's generating plant is reliability. For this reason, we recommend using gas-powered turbines rather than reciprocating engines as electric generators. Turbines require extremely low maintenance. Solar Turbines, Inc., is a division of Caterpillar. It supplies approximately 75% of the turbine generators used throughout the world. Several sources told us that it is not unusual for a Solar Turbine generator to perform continuously for more than a year without a shutdown.

The table below lists the non-recurring and operating costs of two Solar Turbines, each of which can produce 2MW of power at 5,000m. One will serve as backup. The diesel engine generator set starts the turbine.

Cost of Electric Power at the Llano de Chajnantor Site

Item	*Number*	*Price (US$)*
Mercury 50 package with cogeneration and enclosure	2	4,000,000
Power distribution equipment (switchgear)	1	120,000
150-200kW diesel generator	1	70,000
Transportation to site	2	500,000
Installation and commissioning		140,000
Local contractor		600,000
Subtotal		$5,430,000
6% Contingency		325,800
Total Non-recurring Expense		$5,755,800
Monthly maintenance and fuel costs		63,455
Ten years of operating expenses (120 times the above)		7,614,600
Ten-year cost of turbines and operating costs		$13,370,400
Total electricity generated over ten years (kW-hr)		175,320,000
Average electricity costs ($/kW-hr)		$0.043
Average electricity cost with amortization ($/kW-hr)		$0.076

The 6% contingency on the total non-recurring expense reflects the greater uncertainty in the installation costs than in the price of the turbines.

Equipment for Antofagasta office

Item	Location	Group	Subgroup	Source	Units	Unit (US$)	Total (US$)	Basis	Notes
Binding machine, spiral	Antofagasta	Operations	Office		1	422	422		GBC desktop model
Blackboards	Antofagasta	Operations	Office		4	200	800		whiteboards, wall, 48" x 72"
Bookcases, office	Antofagasta	Operations	Office	Steelcase GSA	5	150	750		Steelcase, 730 series, 15" deep x 36" wide x 72" high
Cabinets, file	Antofagasta	Operations	Office	Steelcase GSA	5	190	950		Steelcase 1700s, steel, vertical, 4-drawer, locking
Cabinets, storage	Antofagasta	Operations	Office	Steelcase GSA	5	320	1,600		Steelcase 730 model, 36"x80"
Chairs, conference type	Antofagasta	Operations	Office	Steelcase GSA	10	150	1,500		Steelcase 475 Player chair, no arms
Chairs, desk	Antofagasta	Operations	Office	Steelcase GSA	4	350	1,400		Steelcase 453, Criterion line. Includes secretarial chairs
Chairs, side	Antofagasta	Operations	Office	Steelcase GSA	4	130	520		Steelcase 475 Player chair, arms
Coffee maker	Antofagasta	Operations	Office		1	100	100		unspecified household brand
Computers, desk	Antofagasta	Operations	Office	Gateway	4	2,500	10,000		Gateway or equivalent
Computers, laptop	Antofagasta	Operations	Office	Gateway	1	2,500	2,500		Gateway or equivalent
Cooktop, small, for miscellaneous snacks etc.	Antofagasta	Operations	Office		1	300	300		unspecified household model
Copier, xerox	Antofagasta	Operations	Office		1	0	0		Lease
Desks	Antofagasta	Operations	Office	Steelcase GSA	4	750	3,000		Steelcase 9000 series, 36" x72" (full size)
Desks, credenzas	Antofagasta	Operations	Office	Steelcase GSA	3	700	2,100		Steelcase 9000 series
Facsimile machine	Antofagasta	Operations	Office		1	2,200	2,200		Sharp FO-6550 or equivalent
Fork lift	Antofagasta	Operations	Office		1	15,000	15,000		Yale or similar brand
LAN/ network router	Antofagasta	Operations	Office		1	4,000	4,000		Cisco router + CSU/DSU box
Miscellany, forgotten	Antofagasta	Operations	Office		1	3,000	3,000		Things omitted from this list, like area rugs, lamps, pictures, etc.
Oven, microwave	Antofagasta	Operations	Office		1	100	100		unspecified household model
Package binder, metal straps	Antofagasta	Operations	Office		1		0		
Postage meter machine	Antofagasta	Operations	Office		1	300	300		Choice depends upon Chilean postal regulations
Printer, network	Antofagasta	Operations	Office		1	3,000	3,000		HP5 SI Mx or equivalent
Projector, slide	Antofagasta	Operations	Office		1	500	500		Commercial Kodak or Leitz model
Projector, transparency	Antofagasta	Operations	Office		1	500	500		unspecified commercial model
Refrigerator, snacks	Antofagasta	Operations	Office		1	350	350		unspecified household model
Scales, for mailing and shipping boxes	Antofagasta	Operations	Office		1	300	300		Packages only, postage meter weighs letters
Table, meeting type	Antofagasta	Operations	Office		1	800	800		Six person circular table for meetings--my estimate
Table, office	Antofagasta	Operations	Office	Steelcase GSA	30	250	7,500		Steelcase, unspecified model
Tables, office	Antofagasta	Operations	Office		4	300	1,200		Unspecifiec brand, my estimate
Teleconferencing equipment	Antofagasta	Operations	Office		1	15,000	15,000		Audio-visual
Telephones	Antofagasta	Operations	Office		6	0	0		Included in phone company installation costs
Television, conference room	Antofagasta	Operations	Office		1	300	300		Unspecified household brand
Unspecified office supplies	Antofagasta	Operations	Office		1	1,000	1,000		Staplers, tape dispensers, scissors, paper, etc.
VCR	Antofagasta	Operations	Office		1	300	300		Unspecified household brand
Car, sedan	Antofagasta	Operations	Vehicles		1	20,000	20,000		
Truck, 1 ton, stakebed	Antofagasta	Operations	Vehicles		1	30,000	30,000		
						Total:	131,292		
						Office:	81,292		
						Vehicles:	50,000		

Equipment for Llano de Chajnantor

Item	Location	Group	Subgroup	Source	Units	Unit (US$)	Total (US$)	Basis	Notes
Bedding	Llano de Chajnantor	Operations	Dormitory		8	200	1,600		Includes pillows, sheets, blankets, bedspread, towels
Bedroom equipment	Llano de Chajnantor	Operations	Dormitory		4	200	800		Includes mirror, lamps, wastebaskets
Beds with mattresses	Llano de Chajnantor	Operations	Dormitory		4	500	2,000		
Curtains	Llano de Chajnantor	Operations	Dormitory		4	500	2,000		Decorative curtains, emergency nature of site bedrooms makes blackout curtains unnecessary
1.5 GHz Oscilloscopes	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	2	29,995	59,990	Catalog	
100 MHz Oscilloscopes	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	4	2,550	10,200	Catalog	
26.5 - 325 GHz Harmonic Mixers	Llano de Chajnantor	Operations	Electronics	Several	2	32,000	64,000	Catalog	spectrum analyzer frequency range extension
Antenna Electronics Test & Measur. Transp. Vans	Llano de Chajnantor	Operations	Electronics	Dodge	2	40,000	80,000	Guess	Interior specifically built to accommodate antenna test equipment
Bench Top DMM	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	10	995	9,950	Catalog	
Bench Top Power Supplies	Llano de Chajnantor	Operations	Electronics	Several	1	25,000	25,000	Catalog	DC Supplies, 0 - 60V, up to 2000 W.
Bench Top Tool Boxes	Llano de Chajnantor	Operations	Electronics	Several	10	1,300	13,000	Catalog	tool box, tools assortment, soldering iron etc..
CW Counter & Power Meter - up to 46 GHz	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	15,500	15,500	Catalog	
Frequency Counter 110 GHz	Llano de Chajnantor	Operations	Electronics	EIP	3	20,000	60,000	Catalog	
Frequency Synthesizers - 20 GHz	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	2	38,460	76,920	Catalog	
Function Generators	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	2	8,069	16,138	Catalog	
Handheld DMM	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	10	299	2,990	Catalog	
Lightwave Multimeter and Sensor Modules	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	36,000	36,000	Catalog	
Lightwave Test Equipment and Miscell. Hardware	Llano de Chajnantor	Operations	Electronics	Several	1	100,000	100,000	Guess/Cat.	
Low Frequency Dynamic Signal Analyzer	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	3	20,245	60,735	Catalog	
Miscellaneous Stocked Components/Hardware	Llano de Chajnantor	Operations	Electronics	Several	1	25,000	25,000	Guess	discrete, passive and active digital/analog components
Miscellaneous Waveguide Equipment & Components	Llano de Chajnantor	Operations	Electronics	Several	1	100,000	100,000	Guess/Cat.	
Optical Attenuator	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	8,160	8,160	Catalog	
Optical Spectrum Analyzer	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	66,000	66,000	Catalog	
Oscilloscope Accessories	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	4,000	4,000	Catalog	
Power Meters	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	3	2,850	8,550	Catalog	
Power Sensors .01 - 110 GHz	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	3	14,515	43,545	Catalog	
RF & Microwave Test Accessories	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	1	40,000	40,000	Catalog	noise sources, detectors, switches, couplers, attenuators etc..
Spectrum Analyzers, 9 KHz to 26.5 GHz	Llano de Chajnantor	Operations	Electronics	Hewlett-Packard	3	40,720	122,160	Catalog	high performance, portable
Workbenches	Llano de Chajnantor	Operations	Electronics	Several	10	1,500	15,000	Catalog	with lights, anti-static equipment, drawers, etc..
Binding machine, spiral	Llano de Chajnantor	Operations	Office		1	422	422		GBC desktop model
Blackboards	Llano de Chajnantor	Operations	Office		4	200	800		whiteboards, wall, 48" x 72"
Bookcases, office	Llano de Chajnantor	Operations	Office	Steelcase GSA	10	150	1,500		Steelcase, 730 series, 15" deep x 36" wide x 72" high
Cabinets, file	Llano de Chajnantor	Operations	Office	Steelcase GSA	10	190	1,900		Steelcase 1700s, steel, vertical, 4-drawer, locking
Cabinets, storage	Llano de Chajnantor	Operations	Office	Steelcase GSA	10	320	3,200		Steelcase 730 model, 36"x80"
Chairs, conference type	Llano de Chajnantor	Operations	Office	Steelcase GSA	10	150	1,500		Steelcase 475 Player chair, no arms

Chairs, desk	Llano de Chajnantor	Operations	Office	Steelcase GSA	20	350	7,000	Steelcase 453, Criterion line. Includes secretarial chairs
Chairs, side	Llano de Chajnantor	Operations	Office	Steelcase GSA	20	400	8,000	Steelcase 475 Player chair, arms
Coffee maker	Llano de Chajnantor	Operations	Office		2	100	200	unspecified household brand
Computers, desk	Llano de Chajnantor	Operations	Office	Gateway	10	2,500	25,000	Gateway or equivalent
Computers, laptop	Llano de Chajnantor	Operations	Office	Gateway	4	2,500	10,000	Gateway or equivalent
Cooktop, small, for miscellaneous snacks etc.	Llano de Chajnantor	Operations	Office		1	300	300	unspecified household model
Copier, xerox	Llano de Chajnantor	Operations	Office		1	0	0	Lease
Desks	Llano de Chajnantor	Operations	Office	Steelcase GSA	20	750	15,000	Steelcase 9000 series, 36" x72" (full size)
Desks, credenzas	Llano de Chajnantor	Operations	Office	Steelcase GSA	2	700	1,400	Steelcase 9000 series
Facsimile machine	Llano de Chajnantor	Operations	Office		1	2,200	2,200	Sharp FO-6550 or equivalent
Fork lift	Llano de Chajnantor	Operations	Office		1	15,000	15,000	Yale or similar brand
LAN/ network router	Llano de Chajnantor	Operations	Office		2	4,000	8,000	Cisco router + CSU/DSU box
Miscellany, forgotten	Llano de Chajnantor	Operations	Office		1	5,000	5,000	Things omitted from this list, like area rugs, lamps, pictures, etc.
Oven, microwave	Llano de Chajnantor	Operations	Office		1	100	100	unspecified household model
Printer, network	Llano de Chajnantor	Operations	Office		1	3,000	3,000	HP5 SI Mx or equivalent
Refrigerator, snacks	Llano de Chajnantor	Operations	Office		1	350	350	unspecified household model
Table, meeting type	Llano de Chajnantor	Operations	Office		2	1,000	2,000	Six person circular table for meetings--my estimate
Table, office	Llano de Chajnantor	Operations	Office	Steelcase GSA	10	250	2,500	Steelcase, unspecified model
Tables, office	Llano de Chajnantor	Operations	Office		4	300	1,200	Unspecifiec brand, my estimate
Teleconferencing equipment	Llano de Chajnantor	Operations	Office		1	1,000	1,000	Polycom, audio only
Telephones	Llano de Chajnantor	Operations	Office		20	0	0	Included in phone company installation costs
Unspecified office supplies	Llano de Chajnantor	Operations	Office		1	2,000	2,000	Staplers, tape dispensers, scissors, paper, etc.
First aid supplies	Llano de Chajnantor	Operations	Safety		1	30,000	30,000	Oxgen, bandages, defibrilator, O2 monitor, etc
Vehicle, ambulance suitable	Llano de Chajnantor	Operations	Safety	surplus	1	30,000	30,000	For transport injured to helicopter pad
Vehicle, fire, small	Llano de Chajnantor	Operations	Safety	surplus	1	40,000	40,000	Like the one on Kitt Peak
Bandsaw, horizontal, 7-inch x 12-inch	Llano de Chajnantor	Operations	Shop	Wilton	1	3,000	3,000	
Bandsaw, vertical, 41-inch	Llano de Chajnantor	Operations	Shop	Drake	1	15,000	15,000	
Benches, work	Llano de Chajnantor	Operations	Shop		5	400	2,000	
Brake, bending, 52"	Llano de Chajnantor	Operations	Shop		1	8,000	8,000	
Cabinets, drawered, parts storage	Llano de Chajnantor	Operations	Shop	Steel Case	50	110	5,500	
Drill press, benchtop, 12"	Llano de Chajnantor	Operations	Shop		1	500	500	
Drill press, floor, 16"	Llano de Chajnantor	Operations	Shop		1	1,000	1,000	
Drill press, floor, 24"	Llano de Chajnantor	Operations	Shop		1	1,500	1,500	
Grinder, 12"	Llano de Chajnantor	Operations	Shop		1	300	300	
Lathe, 12" x 34"	Llano de Chajnantor	Operations	Shop		1	10,000	10,000	
Lathe, 30" x 60"	Llano de Chajnantor	Operations	Shop		1	60,000	60,000	
Milling machine, vertical, CNC, 10" x 54" bed	Llano de Chajnantor	Operations	Shop		1	20,000	20,000	
Notcher, corner	Llano de Chajnantor	Operations	Shop		1	100	100	
Press, arbor, 10 ton	Llano de Chajnantor	Operations	Shop		1	2,000	2,000	

Sander, belt, 1"	Llano de Chajnantor	Operations	Shop		1	200	200	
Sander, belt, 12"	Llano de Chajnantor	Operations	Shop		1	500	500	
Shear, shear, 52"	Llano de Chajnantor	Operations	Shop		1	6,000	6,000	
Stools, shop	Llano de Chajnantor	Operations	Shop		5	100	500	
Surface plate, 4' x 8'	Llano de Chajnantor	Operations	Shop		1	1,000	1,000	
Table, acorn, 5' x 5'	Llano de Chajnantor	Operations	Shop		1	7,000	7,000	
Toolboxes, with tools	Llano de Chajnantor	Operations	Shop		3	5,000	15,000	
Vises, 12"	Llano de Chajnantor	Operations	Shop		3	400	1,200	
Welder, acetylene-oxygen	Llano de Chajnantor	Operations	Shop		1	2,000	2,000	
Welder, electric, Metal Inert Gas (MIG)	Llano de Chajnantor	Operations	Shop		1	8,000	8,000	
Welder, electric, Tungsten Inert Gas (TIG)	Llano de Chajnantor	Operations	Shop		1	10,000	10,000	
Welding accessories	Llano de Chajnantor	Operations	Shop		1	10,000	10,000	
Antenna Maintenance Vehicle (AMV), diesel, "3/4-tonne"	Llano de Chajnantor	Operations	Vehicles	Dodge	3	30,000	90,000	Equipped with stairway to antenna Rx cabin, toolboxes
Backhoe	Llano de Chajnantor	Operations	Vehicles		1	50,000	50,000	Quote to Pat Lewis for new unit. $30k for good, used unit
Bulldozer, D-6 or equivalent	Llano de Chajnantor	Operations	Vehicles	Catapillar	1	175,000	175,000	Quote to Pat Lewis for new unit. Good used ones for about $100k
Bus, 40 seat, diesel	Llano de Chajnantor	Operations	Vehicles	surplus?	1	50,000	50,000	Tour support, etc – guess
Crane, portable, 50-tonne,20 m extension	Llano de Chajnantor	Operations	Vehicles	surplus	1	0	0	On hand, at 12m telescope
Fork lift	Llano de Chajnantor	Operations	Vehicles		1	15,000	15,000	warehouse
Front-end loader	Llano de Chajnantor	Operations	Vehicles	surplus?	1	120,000	120,000	Quote to Pat Lewis for new, articulated unit. Used ones available.
Manlift, 20-m boom, for antenna maintenance	Llano de Chajnantor	Operations	Vehicles	Simon	2	85,000	170,000	Self-propelled
Pickup truck, 3/4 tonne, welder equipped, diesel	Llano de Chajnantor	Operations	Vehicles	Dodge	1	37,000	37,000	$25k for truck; $12k for welder
Pickup trucks, light, fuel-injected or diesel	Llano de Chajnantor	Operations	Vehicles	Toyota	4	15,000	60,000	
Receiver Maintenance Vehicle (RMV), diesel, "1-tonne"	Llano de Chajnantor	Operations	Vehicles	Dodge	2	40,000	80,000	Equipped with scissor lift box, like airline food service vehicles, w electronic test lab (unpriced)
Road grader	Llano de Chajnantor	Operations	Vehicles		1	150,000	150,000	Quote to Pat Lewis for new unit. Good used ones for about $70k
Surface compactor	Llano de Chajnantor	Operations	Vehicles	surplus?	3	30,000	90,000	estimate
Truck, dump, 5 cubic meter	Llano de Chajnantor	Operations	Vehicles	surplus?	1	50,000	50,000	guess
Van, 15 seat, personnel	Llano de Chajnantor	Operations	Vehicles		2	30,000	60,000	
Van, box, diesel	Llano de Chajnantor	Operations	Vehicles		2	25000	50,000	Supply transport
Water truck	Llano de Chajnantor	Operations	Vehicles		1	70000	70,000	Transport potable water to MMA site

Total:	2,795,110
Dormitory:	6,400
Electronics:	1,062,838
Office:	118,572
Safety:	100,000
Shop:	190,300

Vehicles: 1,317,000

Summary of Non-recurring Costs for Chilean MMA Sites Revision 24 June 1999:MAG

Site	*Category*	*Amount (US$)*	*Site Total (US$)*	*Contingency (included)*
Antofagasta	Buildings (lease)	0		
	Office Equipment	81,292		$3,000
	Vehicles (new)	57,500		
		Subtotal	$138,792	
Llano de Chajnantor	Development	26,336,907		20%
	Turbine Generators	6,244,500		15%
	Fiber-Optic Link to OSF	4,662,665		20%
	Emergency Dorm Furniture	7,360		15%
	Electronics Test Equipment	1,222,264		15%
	Office Equipment	136,358		15%
	Safety Equipment	115,000		15%
	Shop Equipment	218,845		15%
	Vehicles (new & used)	1,514,550		15%
		Subtotal	$35,795,784	
San Pedro de Atacama	Development	17,218,817		20%
	Const. Camp & Support	4,607,143		15%
	Dormitory Furnishings	169,050		15%
	Electronics Test Equipment	3,757,932		15%
	Food Service Equipment	117,897		15%
	Office Equipment	738,696		15%
	Recreation Equipment	5,750		15%
	Shop Equipment	222,300		15%
	Supplies	57,500		15%
	Vehicles	11,500		15%
		Subtotal	$26,906,584	
Santiago	Building (lease)	0		
	Office Equipment	88,115		15%
	Vehicles (new)	$51,750		15%
		Subtotal	$139,865	
		Total	$54,850,518	

Equipment for OSF, San Pedro de Atacama

Item	*Location*	*Group*	*Subgroup*	*Source*	*Units*	*Unit* (US$)	*Total* (US$)	*Basis*	*Notes*
Bedding	San Pedro de Atacama	Operations	Dormitory		120	200	24,000		Includes pillows, sheets, blankets, bedspread, towels
Bedroom equipment	San Pedro de Atacama	Operations	Dormitory		60	200	12,000		Includes mirror, lamps, wastebaskets
Beds with mattresses	San Pedro de Atacama	Operations	Dormitory		60	500	30,000		Includes a mix of double and single
Chair, desk	San Pedro de Atacama	Operations	Dormitory		60	100	6,000		
Chair, easy, small	San Pedro de Atacama	Operations	Dormitory		60	300	18,000		
Curtains, blackout	San Pedro de Atacama	Operations	Dormitory		60	500	30,000		Seals light from windows & decorative curtains
Desk, student	San Pedro de Atacama	Operations	Dormitory		60	150	9,000		
Drawers, chest of	San Pedro de Atacama	Operations	Dormitory		60	300	18,000		
1.5 GHz Oscilloscope	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	3	29,995	89,985	Catalog	general purpose and troubleshooting
100 MHz Oscilloscope	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	6	2,550	15,300	Catalog	general purpose and troubleshooting
26.5 - 325 GHz Harmonic Mixers	San Pedro de Atacama	Operations	Electronics	Several	2	32,000	64,000	Catalog	spectrum analyzer frequency range extension
8 1/2 Digit Multimeter	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	8,907	8,907	Catalog	high precision standard
Bench Top DMM	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	12	995	11,940	Catalog	general purpose and troubleshooting
Bench Top Power Supplies and Voltage Standard	San Pedro de Atacama	Operations	Electronics	Several	1	35,000	35,000	Catalog	DC Supplies, 0 - 60V, up to 2000 W, Precision volt/amp source
Bench Top Tool Boxes	San Pedro de Atacama	Operations	Electronics	Several	30	1,300	39,000	Catalog	tool box, tools assortment, soldering iron etc..
CW Counter & Power Meter - up to 46 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	15,500	15,500	Catalog	
Digitizing Oscilloscope & Accessories - up to 50 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	50,000	50,000	Catalog	
Frequency Counter 110 GHz	San Pedro de Atacama	Operations	Electronics	EIP	4	20,000	80,000	Catalog	
Frequency Multipliers - up to 345 GHz	San Pedro de Atacama	Operations	Electronics	Several	1	100,000	100,000	Guess	
Frequency Synthesizers - 20 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	2	38,460	76,920	Catalog	
Function Generators	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	2	8,069	16,138	Catalog	general purpose and troubleshooting
Handheld DMM	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	30	299	8,970	Catalog	general purpose and troubleshooting
Lightwave Multimeter and Sensor Modules	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	36,000	36,000	Catalog	
Lightwave Test Equipment and Miscell. Hardware	San Pedro de Atacama	Operations	Electronics	Several	1	100,000	100,000	Guess/Cat.	
Low Frequency Dynamic Signal Analyzers	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	4	20,245	80,980	Catalog	
Miscellaneous Measurement Equipment	San Pedro de Atacama	Operations	Electronics	Several	1	30,000	30,000	Catalog	LCR, Temperature, Gauss meters, etc..
Miscellaneous Stocked Components/Hardware	San Pedro de Atacama	Operations	Electronics	Several	1	50,000	50,000	Guess	dIscrete, passive and active digital/analog components
Miscellaneous Waveguide Equipment & Components	San Pedro de Atacama	Operations	Electronics	Several	1	250,000	250,000	Guess/Cat.	
Mixed Signal Oscilloscope	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	6,032	6,032	Catalog	general purpose and troubleshooting
MM-Wave Receivers Automated Test System	San Pedro de Atacama	Operations	Electronics	Several	4	80,000	320,000	Guess	cryogenics support, control & monitor sys., data acquisition sys.
Optical Attenuator	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	8,160	8,160	Catalog	
Optical Spectrum Analyzer	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	66,000	66,000	Catalog	
Oscilloscope Accessories	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	6,000	6,000	Catalog	general purpose and troubleshooting
Phase Noise Measuring System	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	120,000	120,000	Catalog	
Power Meters	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	3	2,850	8,550	Catalog	
Power Sensors .01 - 110 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	3	14,515	43,545	Catalog	
Pulse Generators	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	2	52,000	104,000	Catalog	
RF & Microwave Test Accessories	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	60,000	60,000	Catalog	noise sources, detectors, switches, couplers, attenuators etc..
SMT Components Workstations	San Pedro de Atacama	Operations	Electronics	Several	2	3,000	6,000	Catalog	surface mount components workstation

Spectrum Analyzers, 9 KHz to 26.5 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	3	40,720	122,160	Catalog	high performance, portable
Synthesized Microwave Sweepers - up to 110 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	102,680	102,680	Catalog	
Temperature Chamber	San Pedro de Atacama	Operations	Electronics	TestEquity	1	18,000	18,000	Catalog	7Cu Ft inside
Time-Interval Counter	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	2	36,500	73,000	Catalog	
Unspecified Test & Measurement Equipment	San Pedro de Atacama	Operations	Electronics	Several	1	500,000	500,000	Guess	approx. 15% of equipment total specified above.
Vector Network Analyzers - up to 800 GHz	San Pedro de Atacama	Operations	Electronics	Hewlett-Packard	1	500,000	500,000	Guess	
Workbenches	San Pedro de Atacama	Operations	Electronics	Several	30	1,500	45,000	Catalog	with lights, anti-static equipment, drawers, etc..
Appliances, serving, miscellaneous	San Pedro de Atacama	Operations	Food service		1	2,000	2,000		tray racks, silverware racks, salt & peppers, napkin dispensers, etc.
Blender, commercial	San Pedro de Atacama	Operations	Food service		2	250	500		estimate
Chairs, dining	San Pedro de Atacama	Operations	Food service		100	60	6,000		estimate
Coffee maker, commercial	San Pedro de Atacama	Operations	Food service	Bunn	1	500	500		estimate
Crockery	San Pedro de Atacama	Operations	Food service		100	60	6,000		basic service
Decorations, dining room	San Pedro de Atacama	Operations	Food service		1	5,000	5,000		estimate of decorations, curtains, etc.
Dishwasher table, connects to washer	San Pedro de Atacama	Operations	Food service		1	900	900		Stainless steel, unspecified maker
Dishwasher, commercial	San Pedro de Atacama	Operations	Food service	Hobart	1	7,235	7,235		HOBAM14
Dispensor, soft drinks	San Pedro de Atacama	Operations	Food service		3	500	1,500		estimate
Flatware	San Pedro de Atacama	Operations	Food service		100	20	2,000		basic stainless steel
Freezer, commercial	San Pedro de Atacama	Operations	Food service	Hobart	1	5,652	5,652		HOBDAF2-1 (double door)
Fryer, gas	San Pedro de Atacama	Operations	Food service	Vulcan	1	2,280	2,280		GRS35
Glasses	San Pedro de Atacama	Operations	Food service		200	3	600		estimate
Grinder, food, commercial	San Pedro de Atacama	Operations	Food service	General	1	1,822	1,822		GENMC-112
Icemaker with storage cabinet	San Pedro de Atacama	Operations	Food service	Scotsman	1	4,825	4,825		SMNCME656AE-32 & SMNHTB555G
Mixer, food, commercial	San Pedro de Atacama	Operations	Food service	Hobart	1	8,262	8,262		HOBD340-5009a
Oven, warming	San Pedro de Atacama	Operations	Food service		2	2,000	4,000		estimate
Pots and pans	San Pedro de Atacama	Operations	Food service		1	2,000	2,000		miscellaneous pots and baking pans
Processor, food, commercial	San Pedro de Atacama	Operations	Food service	Hobart	1	5,425	5,425		HOBFP350-1B
Range, grill, and ovens, commercial	San Pedro de Atacama	Operations	Food service	American	1	4,650	4,650		ARCOAR2AG, contains 6 gas burners, 1 gas-fired grill, 2 ovens
Refrigerator, commercial	San Pedro de Atacama	Operations	Food service	Randall	2	5,010	10,020		RMI2020
Scales, food prep	San Pedro de Atacama	Operations	Food service		2	200	400		estimate
Slicer, food, commercial	San Pedro de Atacama	Operations	Food service	General	1	1,998	1,998		GENSM-12A
Tables, dining	San Pedro de Atacama	Operations	Food service		25	250	6,250		estimate
Tables, food preparation	San Pedro de Atacama	Operations	Food service		3	900	2,700		Stainless steel, unspecified maker
Tables, serving, refrigerated	San Pedro de Atacama	Operations	Food service		1	2,000	2,000		estimate
Tables, steam	San Pedro de Atacama	Operations	Food service		2	2,000	4,000		estimate
Utensils, cooking	San Pedro de Atacama	Operations	Food service		1	2,000	2,000		spoons, knives, colanders, etc.
Warmer-server, soup	San Pedro de Atacama	Operations	Food service		2	1,000	2,000		estimate
Binding machine, spiral	San Pedro de Atacama	Operations	Office		2	422	844		GBC desktop model
Blackboards	San Pedro de Atacama	Operations	Office		4	200	800		whiteboards, wall, 48" x 72"
Bookcases, library type	San Pedro de Atacama	Operations	Office	Acme	50	300	15,000		Acme, cantilever shelves, steel, adjustable
Bookcases, office	San Pedro de Atacama	Operations	Office	Steelcase GSA	50	150	7,500		Steelcase, 730 series, 15" deep x 36" wide x 72" high
Books & periodicals	San Pedro de Atacama	Operations	Office	gifts?	1	200,000	200,000		Initial setup of library

Cabinets, file	San Pedro de Atacama	Operations	Office	Steelcase GSA	50	190	9,500	Steelcase 1700s, steel, vertical, 4-drawer, locking
Cabinets, storage	San Pedro de Atacama	Operations	Office	Steelcase GSA	5	320	1,600	Steelcase 730 model, 36"x80"
Chairs, auditorium type, movable	San Pedro de Atacama	Operations	Office	Steelcase GSA	100	250	25,000	Steelcase 475 Player chair, with folding tablet and linking device
Chairs, desk	San Pedro de Atacama	Operations	Office	Steelcase GSA	60	350	21,000	Steelcase 453, Criterion line. Includes secretarial chairs
Chairs, side	San Pedro de Atacama	Operations	Office	Steelcase GSA	60	400	24,000	Steelcase 475 Player chair, arms
Coffee maker	San Pedro de Atacama	Operations	Office		4	100	400	unspecified household brand
Computers, desk	San Pedro de Atacama	Operations	Office	Gateway	60	2,500	150,000	Gateway or equivalent
Computers, laptop	San Pedro de Atacama	Operations	Office	Gateway	10	2,500	25,000	Gateway or equivalent
Cooktop, small, for miscellaneous snacks etc.	San Pedro de Atacama	Operations	Office		1	300	300	unspecified household model
Copier, xerox	San Pedro de Atacama	Operations	Office		1	0	0	Lease
Desks	San Pedro de Atacama	Operations	Office	Steelcase GSA	60	750	45,000	Steelcase 9000 series, 36" x72" (full size)
Desks, credenzas	San Pedro de Atacama	Operations	Office	Steelcase GSA	10	700	7,000	Steelcase 9000 series
Facsimile machine	San Pedro de Atacama	Operations	Office		2	2,200	4,400	Sharp FO-6550 or equivalent
Fork lift	San Pedro de Atacama	Operations	Office		1	15,000	15,000	Yale or similar brand
Furniture, library	San Pedro de Atacama	Operations	Office		1	10,000	10,000	Reading chairs, tables, lamps for library
LAN/ network router	San Pedro de Atacama	Operations	Office		1	4,000	4,000	Cisco router + CSU/DSU box
Miscellany, forgotten	San Pedro de Atacama	Operations	Office		1	15,000	15,000	Things omitted from this list, like area rugs, lamps, pictures, etc.
Oven, microwave	San Pedro de Atacama	Operations	Office		1	100	100	unspecified household model
Package binder, metal straps	San Pedro de Atacama	Operations	Office		1	1,000	1,000	estimate
Postage meter machine	San Pedro de Atacama	Operations	Office		1	300	300	Choice depends upon Chilean postal regulations
Printer, network	San Pedro de Atacama	Operations	Office		2	3,000	6,000	HP5 SI Mx or equivalent
Printer, network, color	San Pedro de Atacama	Operations	Office		1	8,000	8,000	Tectronics 560 Color Printer
Projector, slide	San Pedro de Atacama	Operations	Office		2	500	1,000	Commercial Kodak or Leitz model
Projector, transparency	San Pedro de Atacama	Operations	Office		3	500	1,500	unspecified commercial model
Readers, microfiche, etc.	San Pedro de Atacama	Operations	Office		3	1,000	3,000	Library
Refrigerator, snacks	San Pedro de Atacama	Operations	Office		1	350	350	unspecified household model
Scales, for mailing and shipping boxes	San Pedro de Atacama	Operations	Office		1	300	300	Packages only, postage meter weighs letters
Table, large meeting type	San Pedro de Atacama	Operations	Office		2	3,000	6,000	20 person long table for meetings --my estimate
Table, meeting type	San Pedro de Atacama	Operations	Office		4	800	3,200	Six person circular table for meetings--my estimate
Table, office	San Pedro de Atacama	Operations	Office	Steelcase GSA	3	250	750	Steelcase, unspecified model
Tables, office	San Pedro de Atacama	Operations	Office		4	300	1,200	Unspecifiec brand, my estimate
Teleconferencing equipment	San Pedro de Atacama	Operations	Office		1	15,000	15,000	Audio-visual
Telephones	San Pedro de Atacama	Operations	Office		60	0	0	Included in phone company installation costs
Television, large, conference room	San Pedro de Atacama	Operations	Office		2	1,500	3,000	Designed for ceiling mounting in conference room
Unspecified office supplies	San Pedro de Atacama	Operations	Office		1	10,000	10,000	Staplers, tape dispensers, scissors, paper, etc.
VCR	San Pedro de Atacama	Operations	Office		1	300	300	Unspecified household brand
Furniture, deck	San Pedro de Atacama	Operations	Recreation		1	5,000	5,000	Exterior funiture for pool and deck area
First aid supplies	San Pedro de Atacama	Operations	Safety		1	5,000	5,000	Augment local clinic

Bandsaw, horozontal, 16"	San Pedro de Atacama	Operations	Shop		1	4,000	4,000	
Bandsaw, vertical, 24"	San Pedro de Atacama	Operations	Shop		1	15,000	15,000	
Benches, work	San Pedro de Atacama	Operations	Shop		5	400	2,000	
Brake, bending, 52"	San Pedro de Atacama	Operations	Shop		1	8,000	8,000	
Cabinets, drawered, parts storage	San Pedro de Atacama	Operations	Shop	Steel Case	30	110	3,300	
Drill press, benchtop, 12-inch	San Pedro de Atacama	Operations	Shop	Wilton	1	500	500	
Drill press, floor, 20-inch	San Pedro de Atacama	Operations	Shop	Wilton	1	5,000	5,000	
Drill press, floor, 8-inch (micro)	San Pedro de Atacama	Operations	Shop	Servo	1	700	700	
Drill, radial, heavy duty, 40-inch	San Pedro de Atacama	Operations	Shop	Fosdick	1	30,000	30,000	
Grinder, 12"	San Pedro de Atacama	Operations	Shop		1	300	300	
Lathe, 12" x 34"	San Pedro de Atacama	Operations	Shop		1	10,000	10,000	
Lathe, 30" x 60"	San Pedro de Atacama	Operations	Shop		1	60,000	60,000	
Milling machine, vertical, CNC, 10" x 54" bed	San Pedro de Atacama	Operations	Shop		1	20,000	20,000	
Notcher, corner	San Pedro de Atacama	Operations	Shop		1	100	100	
Press, arbor, 10 ton	San Pedro de Atacama	Operations	Shop		1	2,000	2,000	
Sander, belt, 1"	San Pedro de Atacama	Operations	Shop		1	200	200	
Sander, belt, 12"	San Pedro de Atacama	Operations	Shop		1	500	500	
Shear, shear, 52"	San Pedro de Atacama	Operations	Shop		1	6,000	6,000	
Stools, shop	San Pedro de Atacama	Operations	Shop		5	100	500	
Surface plate, 4' x 8'	San Pedro de Atacama	Operations	Shop		1	1,000	1,000	
Table, acorn, 5' x 5'	San Pedro de Atacama	Operations	Shop		1	7,000	7,000	
Toolboxes, with tools	San Pedro de Atacama	Operations	Shop		3	5,000	15,000	
Vises, 12"	San Pedro de Atacama	Operations	Shop		3	400	1,200	
Welder, acetylene-oxygen	San Pedro de Atacama	Operations	Shop		1	2,000	2,000	
Welder, electric, Metal Inert Gas (MIG)	San Pedro de Atacama	Operations	Shop		1	8,000	8,000	
Welder, electric, Tungsten Inert Gas (TIG)	San Pedro de Atacama	Operations	Shop		1	10,000	10,000	
Welding accessories	San Pedro de Atacama	Operations	Shop		1	10,000	10,000	
Hardware, general	San Pedro de Atacama	Operations	Supplies		1	50,000	50,000	Fasteners, metal stock, welding rods, cutting oils, spray containers, etc.
Truck, lo-boy, 18-wheel	San Pedro de Atacama	Operations	Vehicles	surplus	1	10,000	10,000	Shipping only

Total:	4,451,930
Dormitory:	147,000
Electronics:	3,267,767
Food Service:	102,519
Office:	642,344
Recreation:	5,000
Shop:	222,300
Supplies:	50,000
Vehicles:	10,000

Equipment for Santiago office

Item	Location	Group	Subgroup	Source	Units	Unit (US$)	Total (US$)	Basis	Notes
Binding machine, spiral	Santiago	Operations	Office		1	422	422		GBC desktop model
Blackboards	Santiago	Operations	Office		4	200	800		whiteboards, wall, 48" x 72"
Bookcases, office	Santiago	Operations	Office	Steelcase GSA	5	150	750		Steelcase, 730 series, 15" deep x 36" wide x 72" high
Cabinets, file	Santiago	Operations	Office	Steelcase GSA	5	190	950		Steelcase 1700s, steel, vertical, 4-drawer, locking
Cabinets, storage	Santiago	Operations	Office	Steelcase GSA	5	320	1,600		Steelcase 730 model, 36"x80"
Chairs, conference type	Santiago	Operations	Office	Steelcase GSA	10	150	1,500		Steelcase 475 Player chair, no arms
Chairs, desk	Santiago	Operations	Office	Steelcase GSA	4	350	1,400		Steelcase 453, Criterion line. Includes secretarial chairs
Chairs, side	Santiago	Operations	Office	Steelcase GSA	4	400	1,600		Steelcase 475 Player chair, arms
Coffee maker	Santiago	Operations	Office	Gateway	1	100	100		unspecified household brand
Computers, desk	Santiago	Operations	Office	Gateway	4	2,500	10,000		Gateway or equivalent
Computers, laptop	Santiago	Operations	Office	Gateway	1	2,500	2,500		Gateway or equivalent
Cooktop, small, for miscellaneous snacks etc.	Santiago	Operations	Office		1	300	300		unspecified household model
Copier, xerox	Santiago	Operations	Office		1	0	0		Lease
Desks	Santiago	Operations	Office	Steelcase GSA	4	750	3,000		Steelcase 9000 series, 36" x72" (full size)
Desks, credenzas	Santiago	Operations	Office	Steelcase GSA	3	700	2,100		Steelcase 9000 series
Facsimile machine	Santiago	Operations	Office		1	2,200	2,200		Sharp FO-6550 or equivalent
Fork lift	Santiago	Operations	Office		1	15,000	15,000		Yale or similar brand
LAN/ network router	Santiago	Operations	Office		1	4,000	4,000		Cisco router + CSU/DSU box
Miscellany, forgotten	Santiago	Operations	Office		1	3,000	3,000		Things omitted from this list, like area rugs, lamps, pictures, etc.
Oven, microwave	Santiago	Operations	Office		1	100	100		unspecified household model
Package binder, metal straps	Santiago	Operations	Office		1	1,000	1,000		estimate
Postage meter machine	Santiago	Operations	Office		1	300	300		Choice depends upon Chilean postal regulations
Printer, network	Santiago	Operations	Office		1	3,000	3,000		HP5 SI Mx or equivalent
Projector, slide	Santiago	Operations	Office		1	500	500		Commercial Kodak or Leitz model
Projector, transparency	Santiago	Operations	Office		1	500	500		unspecified commercial model
Refrigerator, snacks	Santiago	Operations	Office		1	350	350		unspecified household model
Scales, for mailing and shipping boxes	Santiago	Operations	Office		1	300	300		Packages only, postage meter weighs letters
Table, meeting type	Santiago	Operations	Office		1	800	800		Six person circular table for meetings--my estimate
Table, office	Santiago	Operations	Office	Steelcase GSA	3	250	750		Steelcase, unspecified model
Tables, office	Santiago	Operations	Office		4	300	1,200		Unspecifiec brand, my estimate
Teleconferencing equipment	Santiago	Operations	Office		1	15,000	15,000		Audio-visual
Telephones	Santiago	Operations	Office		6	0	0		Included in phone company installation costs
Television, conference room	Santiago	Operations	Office		1	300	300		Unspecified household brand
Unspecified office supplies	Santiago	Operations	Office		1	1,000	1,000		Staplers, tape dispensers, scissors, paper, etc.
VCR	Santiago	Operations	Office		1	300	300		Unspecified household brand
Car, sedan	Santiago	Operations	Vehicles		1	20,000	20,000		
Truck, 3/4 ton	Santiago	Operations	Vehicles		1	25,000	25,000		

Total:	121,622
Office:	76,622
Vehicles:	45,000