11. Enclosure and infrastructures

This chapter deals with the telescope enclosure and the main infrastructures installations serving the observatory.

To a large extent infrastructures like power production plant. access roads. water supply. etc. are dependent on the site and sometime on the country where the observatory will be erected.

For the purpose of this document it has been decided to use the experience gained in constructing the Paranal Observatory in an undeveloped area close to reasonable industrial infrastructures (harbours. access roads in the vicinity). Extrapolation to more remote sites conditions have been done based on the study for the site characterization of Gamsberg in Namibia developed on 1993.

The enclosure is on the other hand defined largely by functional considerations which are less dependent on the site which will be chosen. The environmental and geotechnical characteristics of the site influence the actual structural design. and for this reason two typical astronomical sites with very different conditions have been compared to assess the impact on the feasibility and on the costs of the enclosure.

The assumptions taken in assessing requirements which are strongly site dependent. like water supply. power production. actual soil geomechanics. are simple and conservative and the final design/choice shall be made after detailed study when the site has been chosen.

11.1 Telescope enclosure

The aim is to design and build an enclosure for OWL. which can be built at reasonable cost and still provide the needed functions required to the sheltering structure of a telescope.

The cost impact on the project of such structure shall be limited to the minimum. not only as capital investment but also for maintenance and operations. For this reason it should be as small and as simple as possible. with the functions implemented as close as feasible to the ground level. and therefore easily reachable for maintenance. with the least number of mechanisms. It shall perform the functions of protecting the telescope from the sun exposure during the day. shelter the telescope from excessive wind load and from rain or snow. The need of protecting the telescope from wind load during operation will be assessed in the design phase. Only limited volumes enclosing those parts of the telescope with long thermal time constant are conditioned. The heat introduced by the solar radiation is removed passively using air volume exchange or natural convection close to the outside wall. Based on the above considerations the enclosure for OWL has been envisaged as a huge but simple hangar which. sliding on rails is moved away to allow observations. This type of sheltering structure is not new in astronomical application; see for example the first concept for the ESO VLT.

In designing the baseline concept the following requirements have been taken into consideration:

- Smallest possible enclosed volume and developed surface for economic reasons (the cost of such buildings can be considered proportional to the developed surface). yet allowing the telescope free rotation in all its allowable range.
- Protect the telescope from solar exposure during the day. from extreme environmental conditions like survival wind load. rain or snow / ice.
- Keep the inner air volume temperature at a convenient value. so that the telescope structure and optics are as close as economically attainable to thermal equilibrium with the external environment at the start of the observation. In this way the time that the telescope will need to go to thermal equilibrium with the outer air volume will be minimized and therefore the induced degradation of the seeing is minimized.
- Try to minimize the so-called "dome seeing". This function is obtained. in the modern enclosures. by letting the air flow inside the enclosed volume. so that the structural parts and the floor surrounding the telescope are brought in short time. and kept. at the thermal equilibrium with the external environment. In the case of OWL the enclosure is simply completely removed so that the “hot air” inside the telescope volume is swept away by the wind and the telescope platform is cooled by radiation and convection.

	Site 1	**Site 2**
Temperature		
Temperature Operational	0 to +15 ºC	-2 to +19 ºC
Temperature Survival:	-10 to +30 ºC	-10 to +35 ºC
Typical temperature gradient at night time	0.7 ºC/h	1.8 ºC/h
Average air temperature difference between day and night	4 ºC	10 ºC
Snow load		
Operational Max. snow height	65mm	200mm
Survival Max. snow height	65mm	2250mm
Ice load		
Operational Max. ice height	50mm	50mm
Survival Max. ice height	50mm	230mm
Wind speed		
Max. wind speed operational including gusts	27 m/s	27 m/s
Max. wind speed survival including gusts	51 m/s	67 m/s
Ground Peak acceleration (OBE)	0.24g	0.04g
Ground Peak acceleration (MLE)	0.34g	0.04g
Geotechnical characteristics		
Classification of soil according to EUROCODE 8	A	A
Density [t/m3]	2.7	2.6
Unconfined compressive strength [MPa]	98	20
Point load strength index (Is) [MPa]	9.8	2
Young modulus static [MPa]	10000	1100
Shear modulus static [Mpa]	3800	430
Young modulus dynamic [MPa]	45000	5400
Shear modulus dynamic [MPa]	17500	2100
Poisson ratio	0.27	0.29

Table 11-1. Main sites characteristics.

The protection of the telescope from wind action is left to yet to be abalyzed other means (e.g. wind screen). The reasons for this decision at this time are based on economical and structural reasons. Results of wind tunnel tests carried on within the VLT program in 1992 and 1994 where also used to assess the choice. In addition. CFD results suggested that a traditional enclosure would increase high frequency pressure turbulence.

In those tests (8.6.AR1 and 8.6.AR2) were measured the characteristics of the wind flow in the area of the primary mirror. The results have shown that to provide a good protection from turbulent wind in the whole frequency domain. and not only in low frequency. it is necessary to reduce the outside mean wind speed by a factor at least 70%. This means that in case of low open air wind speed it is necessary to vary the porosity of the wind screen to allow for mirror surface flushing.

In order to gain some feeling on the effect of environmental and geomechanical characteristics on the design. industrial studies have been carried out considering two typical observing sites with very different characteristics (RD38). The main ones are here summarized in Table 11-1 to facilitate the understanding of the following chapters.

11.1.1 Baseline design description

The concept for the OWL enclosure has been developed as a hanger which can be opened and moved away to allow the observation. This solution leaves the telescope in free air flow which will minimize the thermal effect which degrade the local seeing.

This design largely relies on already available technologies and is based on the design of the already existing Cargo-lifter building in Brandenburg (Figure 11-1).

This concept puts somehow unprecedented requirements on the site.

Figure 11-1: Cargolifter building

The site should provide

- A large flat summit or a summit with a shape that will not require large amount of blasting (in the order of 300x700 square meters for the operation of the enclosure plus the space needed for construction. and access for maintenance).

- It should exhibit a reasonable homogenous geomechanic situation. such that the operations of ground consolidation or over dimensioned foundations are not needed.

Compared to other preliminarily studied concepts. like the radome type. it will make use of less structural steel. and therefore will be less expensive. The costs due to the preparation of the site will be traded off at a later stage.

The design is based on already available technology and the mechanisms have been already widely proved in operation at the Cargolifter building.

Based on the experience gained by operating that building some simplifications have been implemented like the elimination of the large segmented door. The segmented door has proved to pose problems of design and construction because the precision needed in the structures is at the limit for these dimensions. For this reason. it has been decided to propose a symmetrical construction based on 4 arches hinged at the top. This brings better stability. less demanding requirements on the precision of the construction of the guides. and secures the hinge at a more stable point. which is safer from the earthquake pointy of view.

The enclosure is made of one fixed arch and three mobile arches which rotate about the central hinge held on the fixed arch. Boogies are mounted at the bottom of the three rotating arches to allow the opening of the doors. Each boogie has four motorised wheels with a diameter of 1 m. Boogies are also mounted at the bottom of the non-rotating central arch. When the three arches are opened and hosted by the central arch the enclosure is moved using a cable system. This allows to concentrate the drives power system in four points easily accessible for maintenance and servicing. is less expensive then a boogies system like the one used in the telescope drives. It allows to provide a cinematic cycle to meet the goal of sliding the enclosure between the two parking position in about 10 minutes. The three arches open in about 10 minutes. the telescope have full free view after a total of about 15 minutes. In case of closing the complete operation from start from night parking position to telescope completely protected would be about 29 minutes.

Cladding is made by insulated sandwich material. A Faraday cage is realised by the secondary structure on which the cladding panels are fixed. Inflatable seals are provided among the arches and at the bottom of structure to provide a water tight system.

The enclosure is designed to let the service platform with the primary mirror covers move close the telescope at the beginning of the night and at the end of the observing run to protect the mirror.

Figure 11-2 shows the enclosure at its day and night park position.

The central structural arch is the heavier and weighs about 15000 tons and is mounted on wheels. It will support the other three arches when they are opened.

The primary mirror is protected by 6 covers placed on a movable platform. The platform has to be moved close to the mirror to remove the segments at night start. In this concept the aperture through which the platform with the six covers for M1 will be brought in the position is provided by opening the middle arch segment of the enclosure.

The use of the four arches concept allows minimizing the wind cross-section while moving the opened enclosure.

A top view of the enclosure and foundations is shown in Figure 11-3.

In day parking position the foundations allow the transfer of the load under all possible survival conditions while in night parking position the foundations dimensioning take into consideration only the MLE conditions. The railing foundations take into account the possibility to have an MLE during the opening/closing operation. The foundations are presently calculated assuming a homogenous soil condition. that is no significant faults or difference in the geomechanics of the soil are present on the site. This has the consequence that the bearing capability of the soils is principally equal all over the site. and it allows to have almost independent foundations with no connections among them. This condition is expected to be found in many typical astronomical sites. especially on the Andes. in other areas a geomechanical study will be carried out to verify this assumption. In the case that strong differences in bearing capability of the soil will be detected measures need to be taken which will impact more or less severely the costs.

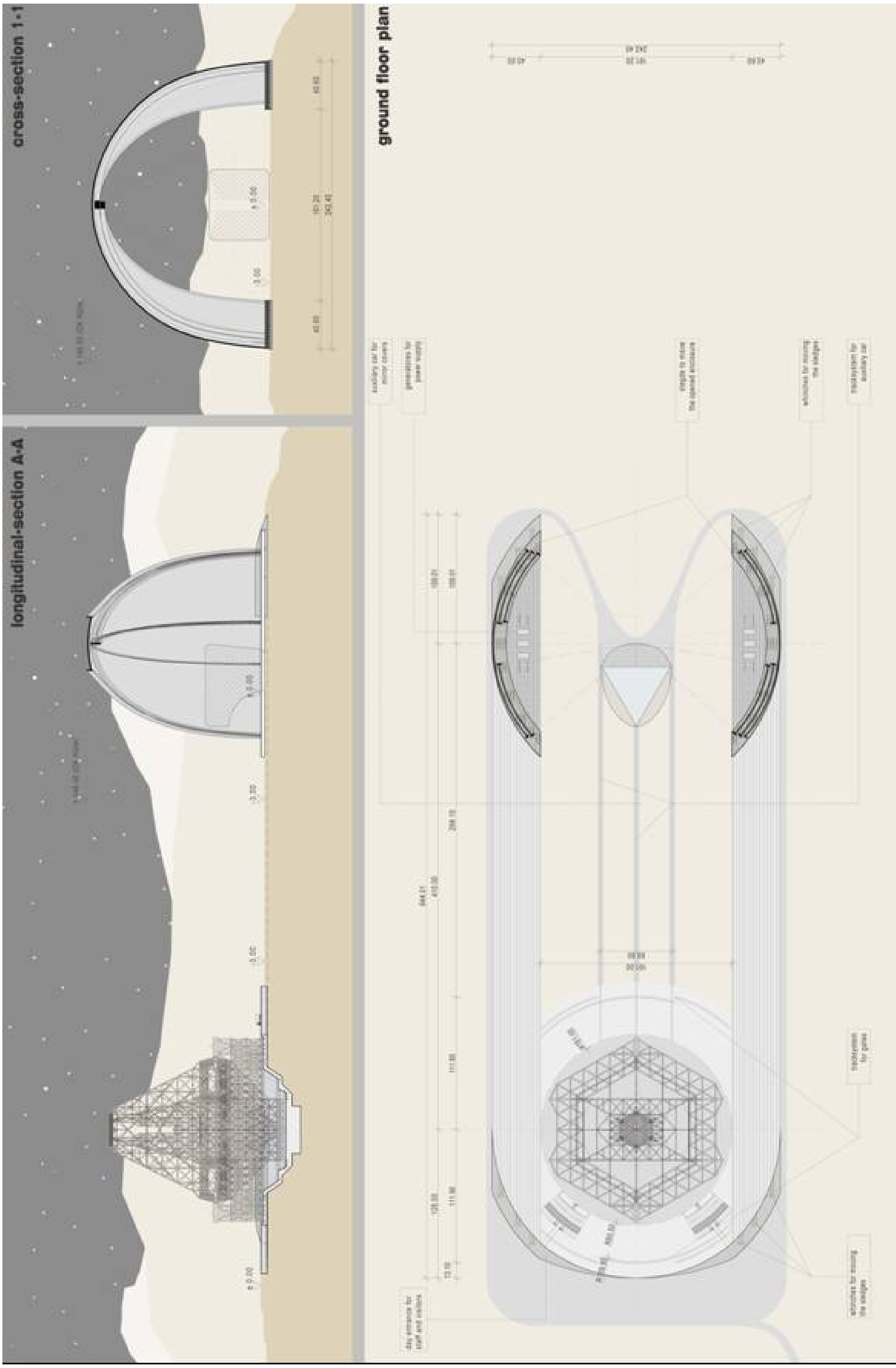


Figure 11-2: Baseline lay-out (courtesy CI-Map)

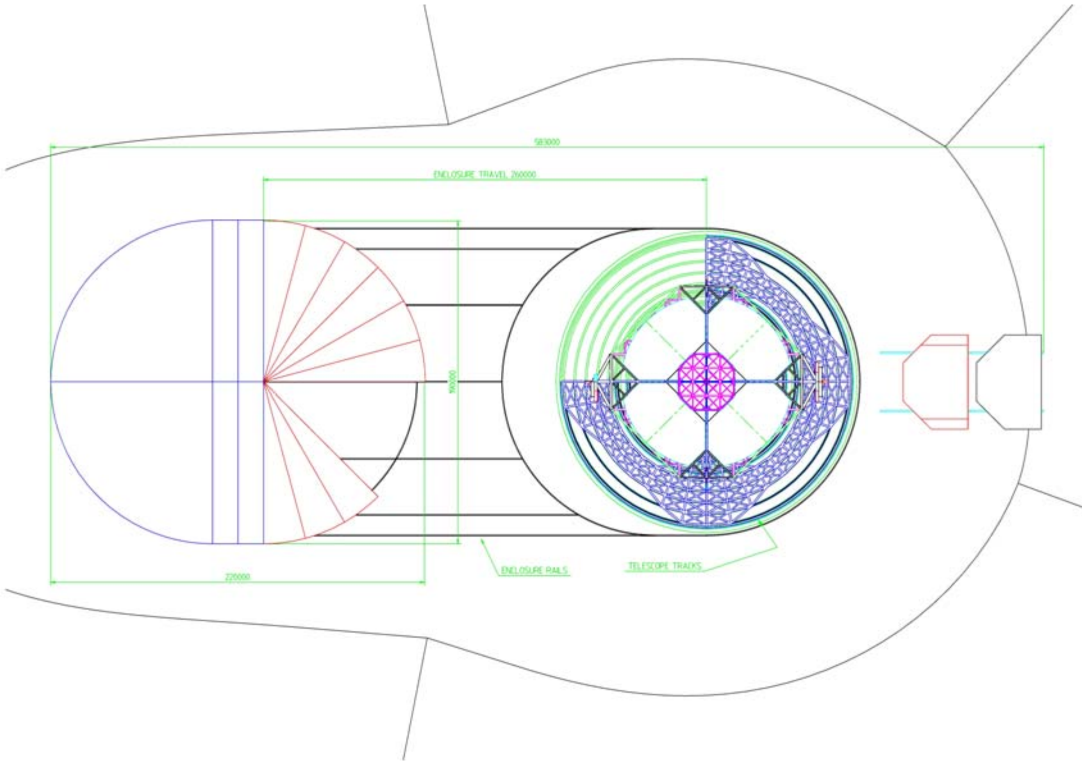


Figure 11-3. Top view of the enclosure and telescope foundations.

One of the requisite of classical enclosures is also to maintain during the day the same temperature inside which was measured the previous observing night. such that at the opening the telescope and its optics are already close to thermal equilibrium with the environment. avoiding local seeing degradation. This is normally obtained conditioning the overall enclosure volume. In the case of OWL the volume to condition would be in the order of 45000000 cubic meters (for comparison the complete conditioned volume at the VLT. four enclosures. is about 100000 cubic meters). This volume is unusual to be conditioned also in civil engineering because of its large demand of energy. Being an observatory erected in remote areas where energy must be normally locally produced. a more economic way to prepare the telescope for starting the observation must be found.

One of the typical characteristic of astronomical sites in desert areas at relatively high altitude (order of 2500 m) is that the temperature of the air during the day is not too far from the temperature of the air during night (typically the difference in average lies between 4 to 10 °C). Moreover the external surface of the building will be treated in such a way to reflect up to 90% the incoming solar radiation. The peak solar heat flow is estimated in 110 MW. therefore only about 10 MW will contribute to heat up the inner volume of the enclosure.

The baseline concept is to open windows placed at the top of the roof to allow the inner volume of air to be exchanged using natural convection. The natural convection is triggered by the difference of air density and the difference of height from the bottom and the top of the enclosure where appropriate openings have been built (see Figure 11-4 for a principle scheme).

The heat removing capability of such a stream can be estimated considering that the drag force or pressure difference (T) acting on a fluid volume with different density with respect to the outside and a difference in the geodetic terms is

$$T = \Delta P_{\text{bottom-top}} = g^{*}\Delta\rho_{\text{bottom-top}}{}^{*}\Delta z_{\text{bottom-top}} \text{ in N/m}^2$$

Where g is the gravity acceleration. ρ is the fluid density and z is height.

In our case Δρ bottom-top is in the order of .05 kg/m3 . assuming a difference in temperature of 10 ºC between inner and outer air. and Δz bottom-top is of the order of 200m. therefore the dragging pressure is in the order of T=98 N/m2 or 98 Pa.

Under these conditions and assuming that the losses in the generated flow are negligible (to be verified according to the type of filtering applied at the entering openings). and that the outgoing aperture is ~5 times smaller than the incoming section at the bottom. the outgoing flow speed is 5 times higher than the incoming flow speed. one can estimate the heat removing capacity of this induced flow.

The order of magnitude is:

$$V = (T*2/\rho_{fluid})^{1/2} = 12.9 \text{ m/s}$$

Where V= is the flow induced speed. ρ_{fluid} is the density of the internal fluid. equal to 1.17 kg/m3 (density of air at 25 ºC).

Assuming 80 m^2 as outgoing section. the flow is 1032 m^3/s. This flow has a heat removal capacity (H) of (assuming heat capacity equal to 1005 Ws/kg ºK)

$$H=1005[Ws/kg\ ºK]*1.17[kg/m^3]*1032[m/s]*10[ºK]=12.1\ MW$$

This is more than is expected to be introduced into the enclosure by solar radiation. More detailed estimation of the openings area shows that considering the actual pressure losses in the flow the openings' area will be about 600 m^2.

In such a case at the night opening the telescope would be warmer than the outside ambient air by 4 ºC or 10 ºC. depending on the site.

More specific though simple calculations. using the model shown in Figure 11-5. have shown that the inner air volume at opening will have in the average 6 to 12 °C (depending to the site). temperature difference with respect to the ambient air. The typical temperature evolution is shown in Figure 11-6.

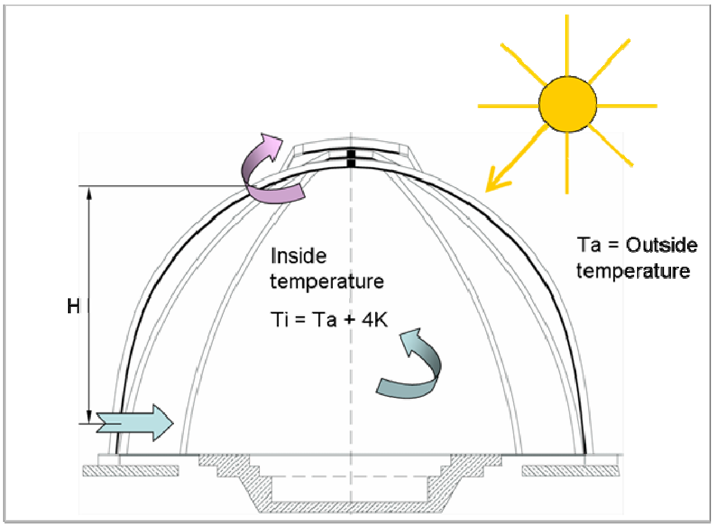


Figure 11-4: Principle scheme of natural cooling of the enclosure volume

Preliminary tests on a steel pipe (representative of an OWL sturtural beam) on Paranal have shown that the thermal equilibrium of the structural parts of the telescope should be reached shortly after opening the enclosure.

The operational cycle of the enclosure in a typical observation night will then be the following:

- 1 hour before the sunset the enclosure. open the central mobile arch to allow the platform holding the M1 covers to move close to M1 mirror to start the operation of uncovering the mirror (three minutes after the start of opening). and remove the mirror sectors 6 covers.
- 0.5 hour before sunset the enclosure opens the three arches and starts to move from day parking position (conditions must be operational; wind speed. ice and snow are operational; no OBE or MLE seismic event is taking place).

- The enclosure accelerates at a rate of 0.004 m/s^2 and after 125 m has reached the speed of 0.8 m/s. It will keep this speed for about 110 m and then will start to decelerate at a rate of -0.004 m/s^2 until the night parking position is reached. The complete operation will last 15 minutes.
- When the night parking position is reached the three segments will close. The operation will take 10 minutes.

The complete cycle of opening will last about 30 minute. In Figure 11-7 the opening cycle is shown in sequence.

As any other telescope shelter the enclosure needs to work reliably to avoid to leave the telescope exposed to precipitation or high wind speeds.

In the conceptual design it is envisaged to maximise the reliability providing redundancy in the drives sytem and it could be even envisaged to provide electrical traction on the enclosure itself as complete back up to power loss on the observatory (diesel generators on board of the enclosure structure. the economical impact is in the range of 10 M€).

In case of an emergency shut down. the time needed to protect completely the telescope. that is to bring the enclosure in day parking position and close the three arches. will take again 30 minutes.

This means that a meteorological forecast station needs to be put in place to monitor wind and precipitation conditions. The design of the enclosure allows to move it with up to 27 m/s wind speed and therefore it is needed to assure that the wind does not exceed this value within less than 30 minutes. from the start of the shut down cycle of the enclosure. In the conceptual design it has been assumed shut down operation will start when the wind speed reaches 16 m/s.

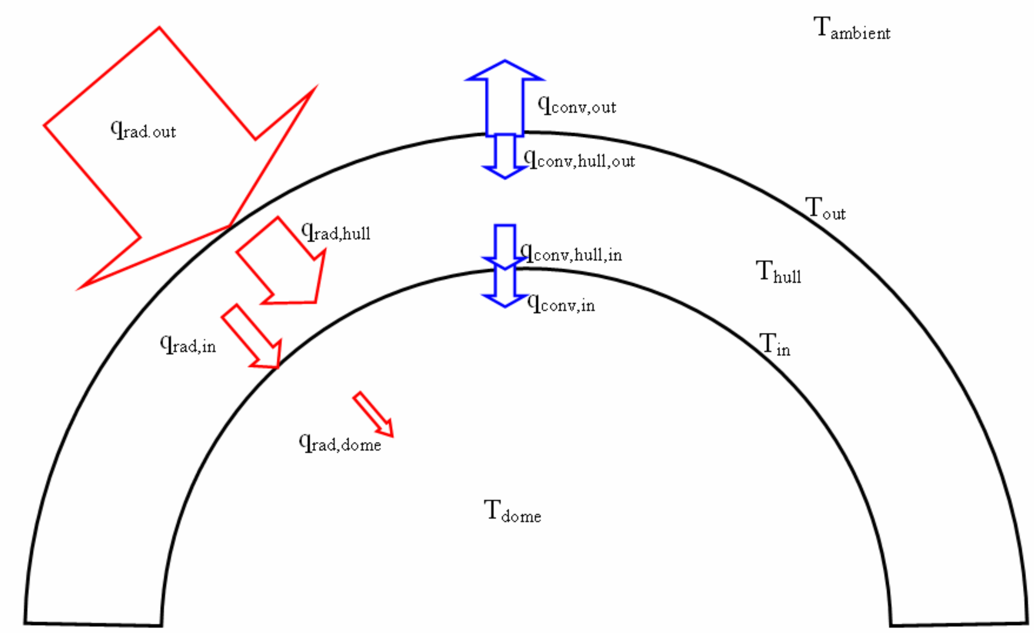


Figure 11-5 Simple thermal model of the enclosure

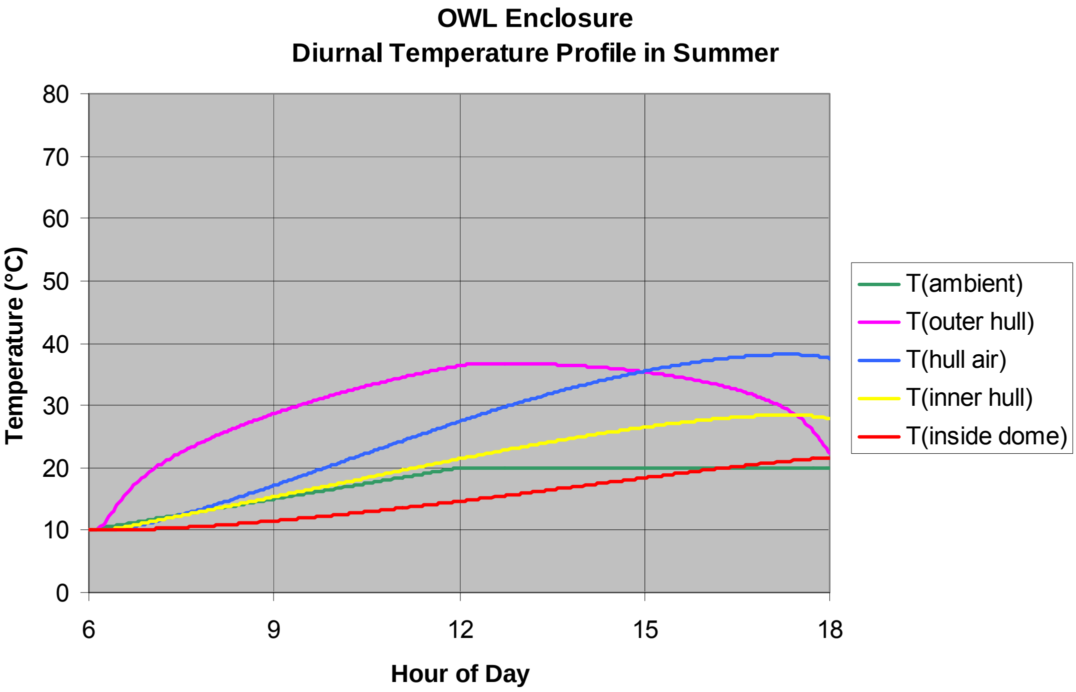


Figure 11-6 Typical temperature evolution of the enclosure assuming site 5 m/s wind speed

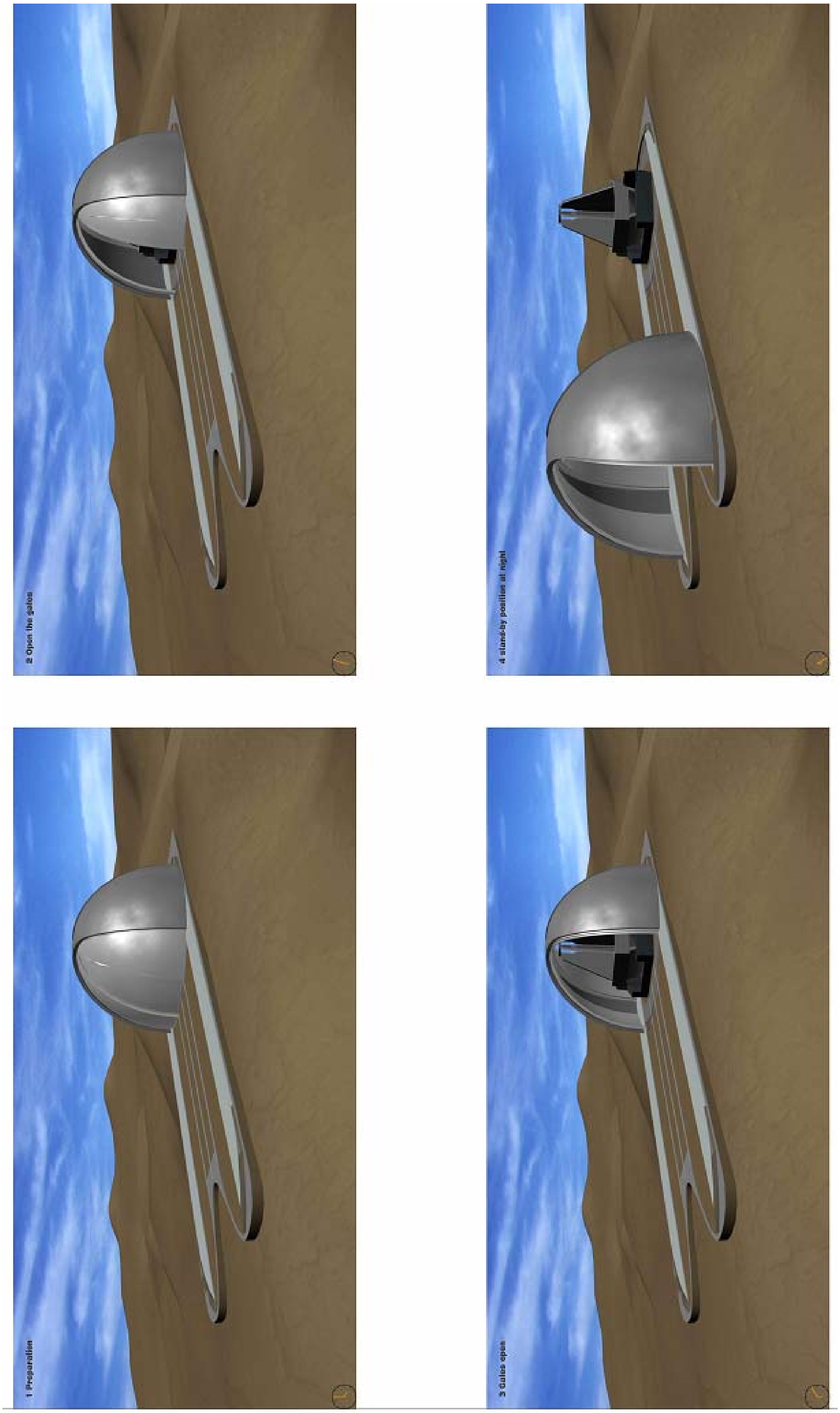


Figure 11-7 Enclosure opening cycle (courtesy CI-Map).

11.1.2 Concrete works

Under concrete works here are also included the auxiliary constructions like servicing roads and temporary construction/areas built during the construction phase.

The detailed conceptual design of the foundations is described in RD39.

The view of the foundations work is shown in Figure 11-8.

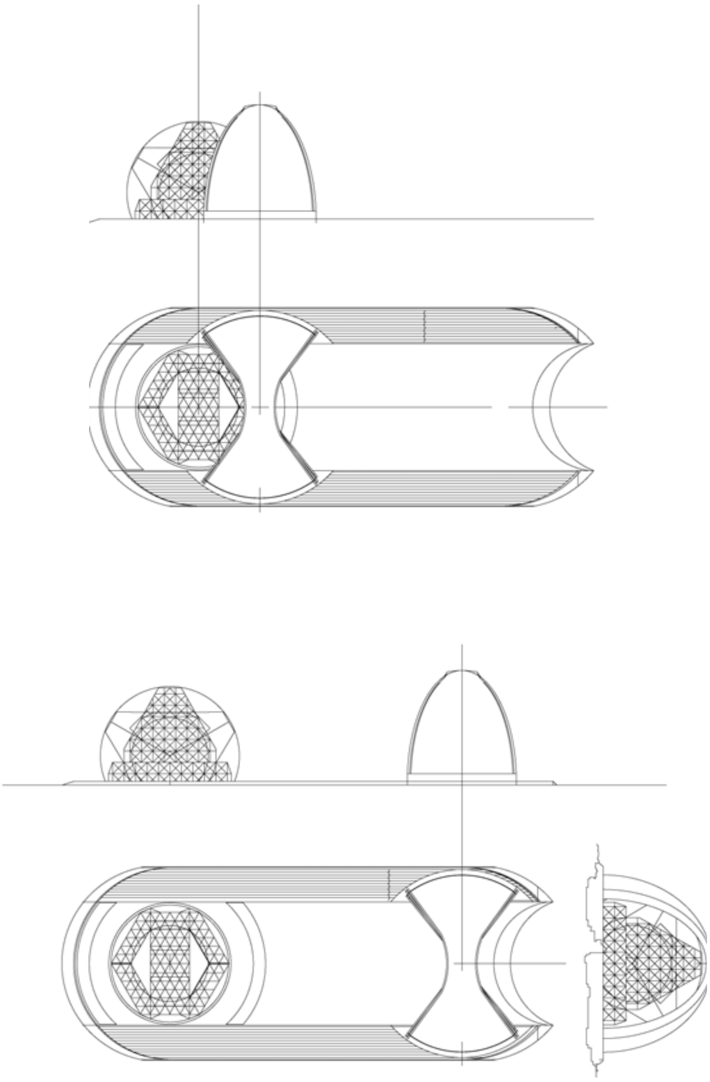


Figure 11-8: Enclosure foundations overview day park position (above). Night park position (bottom)

The main systems are:

- Day park position foundations
- The foundations of the guides on which the enclosure is sled
- Night park position foundations.

The loads which are to be considered while occupying the different positions are different. Namely. besides gravity:

- In day park position: survival wind. snow. ice loads and MLE earthquake loads are to be taken altogether.
- The foundation of the guides: operational wind. snow and ice loads plus MLE earthquake loads. and the loads deriving from the motion of the enclosure.

- Night park position: operational wind. snow and ice loads plus MLE earthquake loads.

The fact that the enclosure will be erected in night park position to allow parallel installation of the telescope requires that also the foundations at night park position are designed with the same load combinations than day parking position.

The foundations are built separately from the telescope foundations. such that in no case transfer of vibration will take place. In the foundations a number of auxiliary rooms are built to host utility rooms to store spare parts. working tools and equipment used for maintenance both for the enclosure and for the telescope.

Due to the large dimensions of the foundations and therefore the large quantities of concrete to be poured. special attention has to be given to removing the heat generated by the chemical reactions in the concrete curing process. Moreover an accurate management of the humidity content will be put in place in desert sites. to reduce cracking of the concrete.

The inert materials used to produce the concrete will be taken directly on site from the earth and rocks produced by the earth works to prepare the site.

The quantities of concrete and steel in the three main parts are summarised in Table 11-2.

	Concrete [m3]	**Steel [t]**
Day park position foundations	6500	506
Guides foundations	96000	7500
Night park position foundations	6500	506

Table 11-2: Concrete and steel quantities

Given the level of stresses calculated no special problems is present in the design of the foundations.

In Figure 11-9 the cross section of the doors guides and the typical reinforcement are shown.

During the erection of the enclosure and for operation and maintenance extra space and roads have been planned.

The area strictly needed for the enclosure is about 170000 m2. To preassemble the structural parts before erecting them an extra area of about 60000 m2 has to be flattened. This area is used to accommodate a road to access with heavy trucks all the points along the guides and the two parking position. The space in between the two parking position is used to preassembly the structural parts of the enclosure before erecting them. Four large cranes. which can lift higher than 300 m. will be used to erect the enclosure. They will be placed around the night park position.

In case of rain or melting snow. large quantity of water has to be evacuated. Therefore a special net of channels with flow breaking materials or gravel at the bottom to break the energy of the water is built in day park position.

The area around the day park position is paved only where traffic is planned for erection and maintenance. In these areas paving for heavy loads has been foreseen. Everywhere light colour paving is planned to reject 80% of the solar radiation as a minimum. Gravel will be used for levelling the site where possible. Infrared camera measurements made at Paranal have shown that gravel covered areas reach thermal equilibrium with ambient in a shorter time.

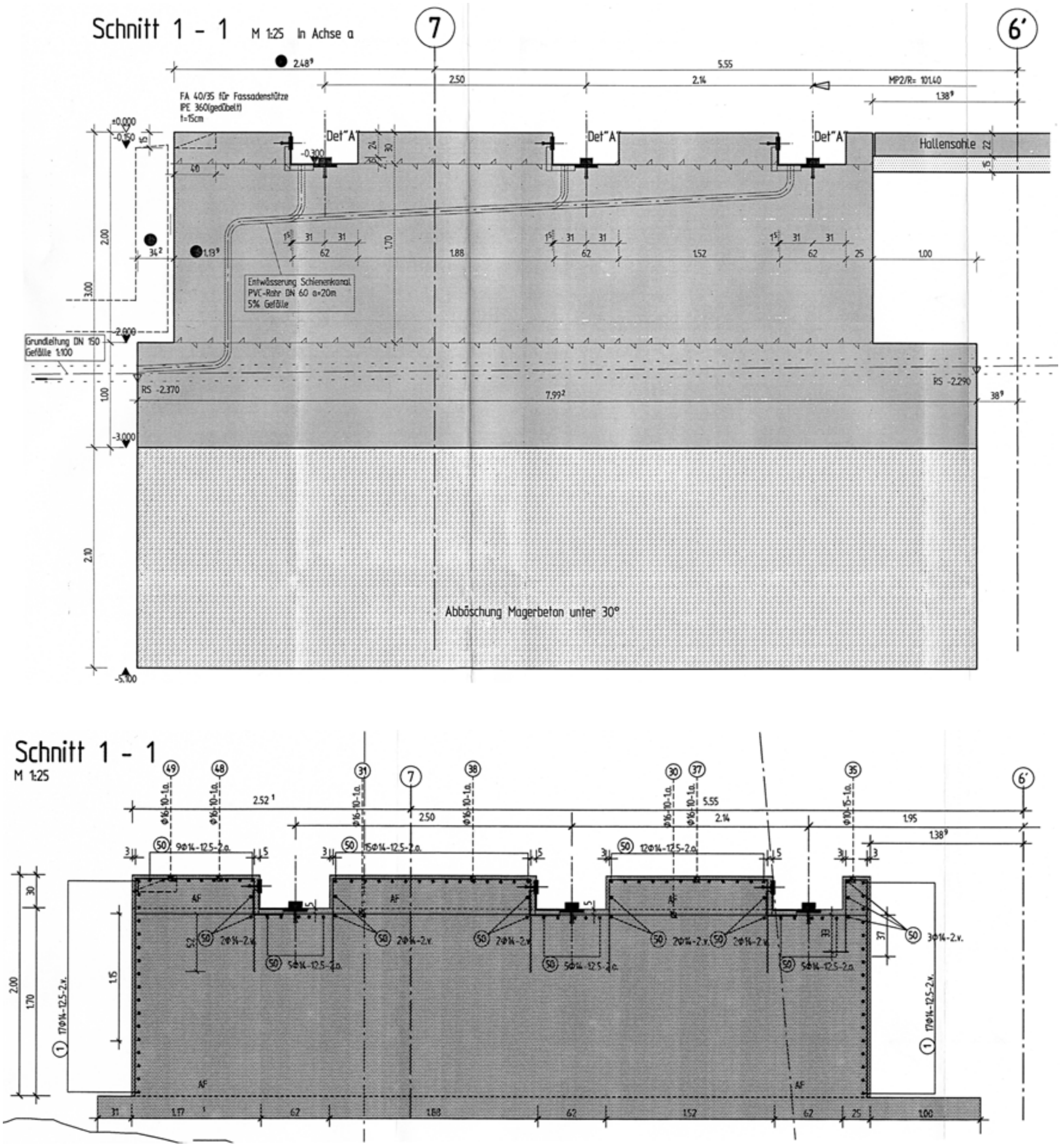


Figure 11-9: Typical reinforcement

11.1.3 Structure and mechanisms

The enclosure structure is made of one main arch and three rotating arches which rotate around a central hinge hold by the main arch.

Bogies are mounted at the bottom of the three rotating arches to allow the opening of the doors. Each bogie has four motorised wheels with diameter of 1m. Bogies are also mounted at the bottom of the non-rotating mainl arch. When the three arches are opened and supported by the main arch the enclosure is moved using a cable system. Cladding is made by insulating sandwich material Figure 11-10.

A Faraday cage is realised by the secondary structure on which the cladding panels are fixed.

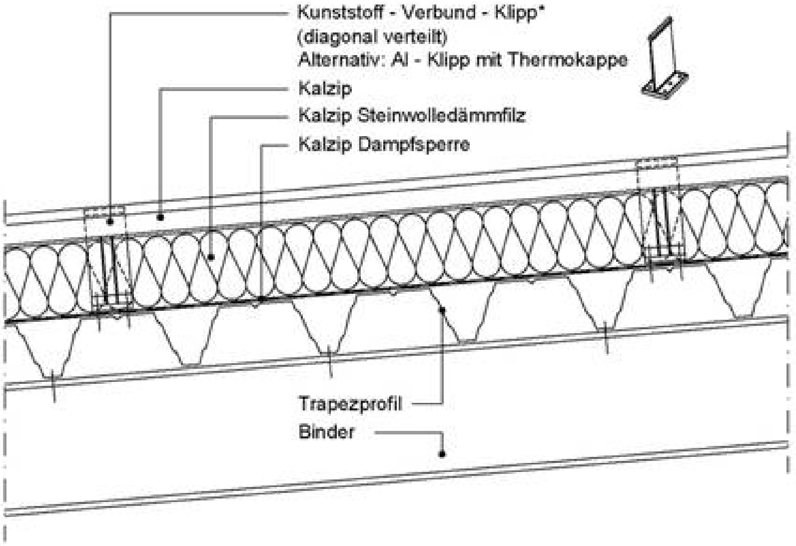
The architecture of the central arch is shown in Figure 11-11. The hinge is designed based on the successful concept used for the Cargolifter. It is shown in Figure 11-12.

The masses are summarised here below:

Main arch	15000 t

Movable arch	4500 (*3)t
Motorised boogie	2 t
Passive boogie	5 t
Cladding	5000 t

The bearings are subjected to loads which are in the order of 10MN while the doors are opening/closing with 27m/s wind speed.



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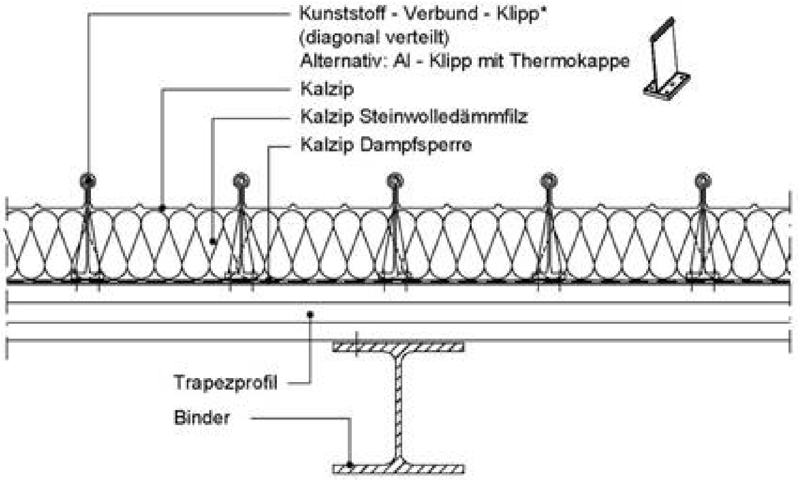

Figure 11-10 Typical cladding panel

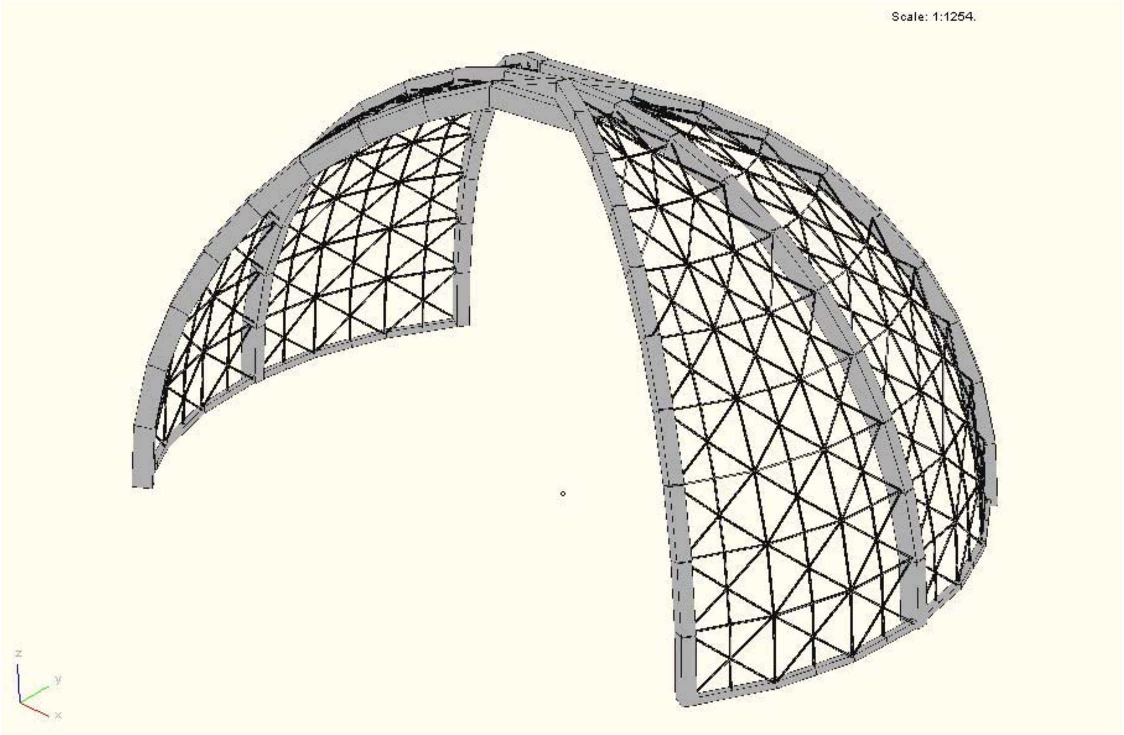

Figure 11-11: Main arch

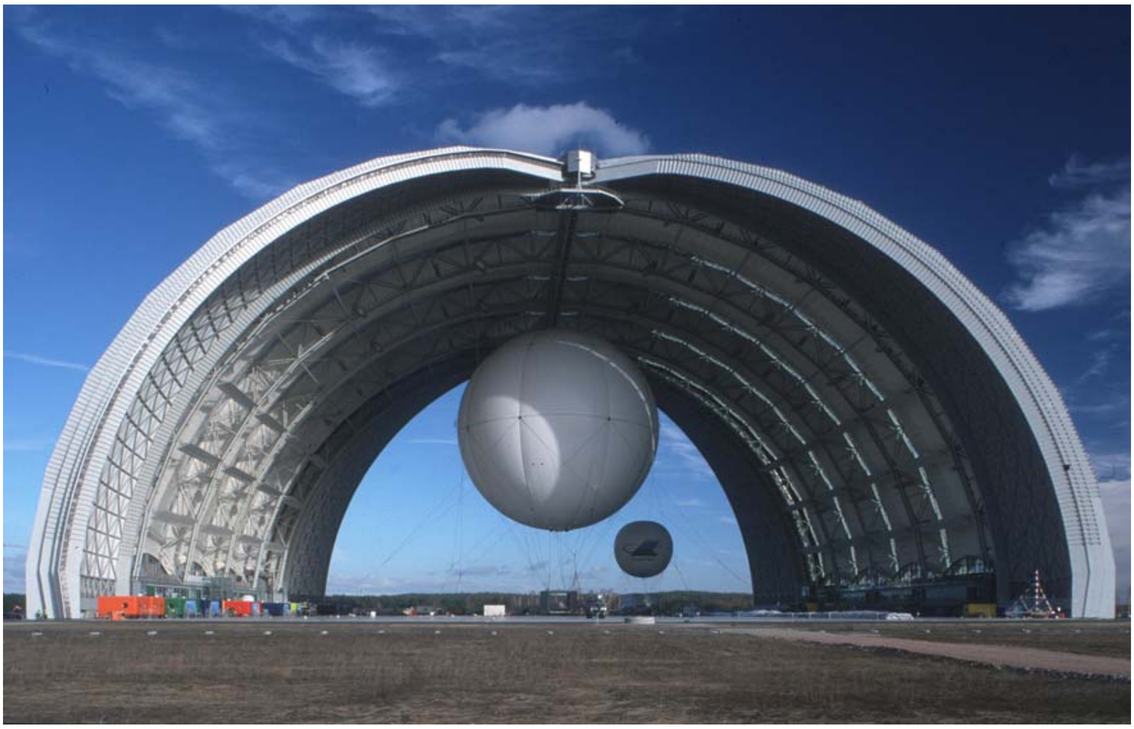

Figure 11-12: Hinge (courtesy cl-MAP)

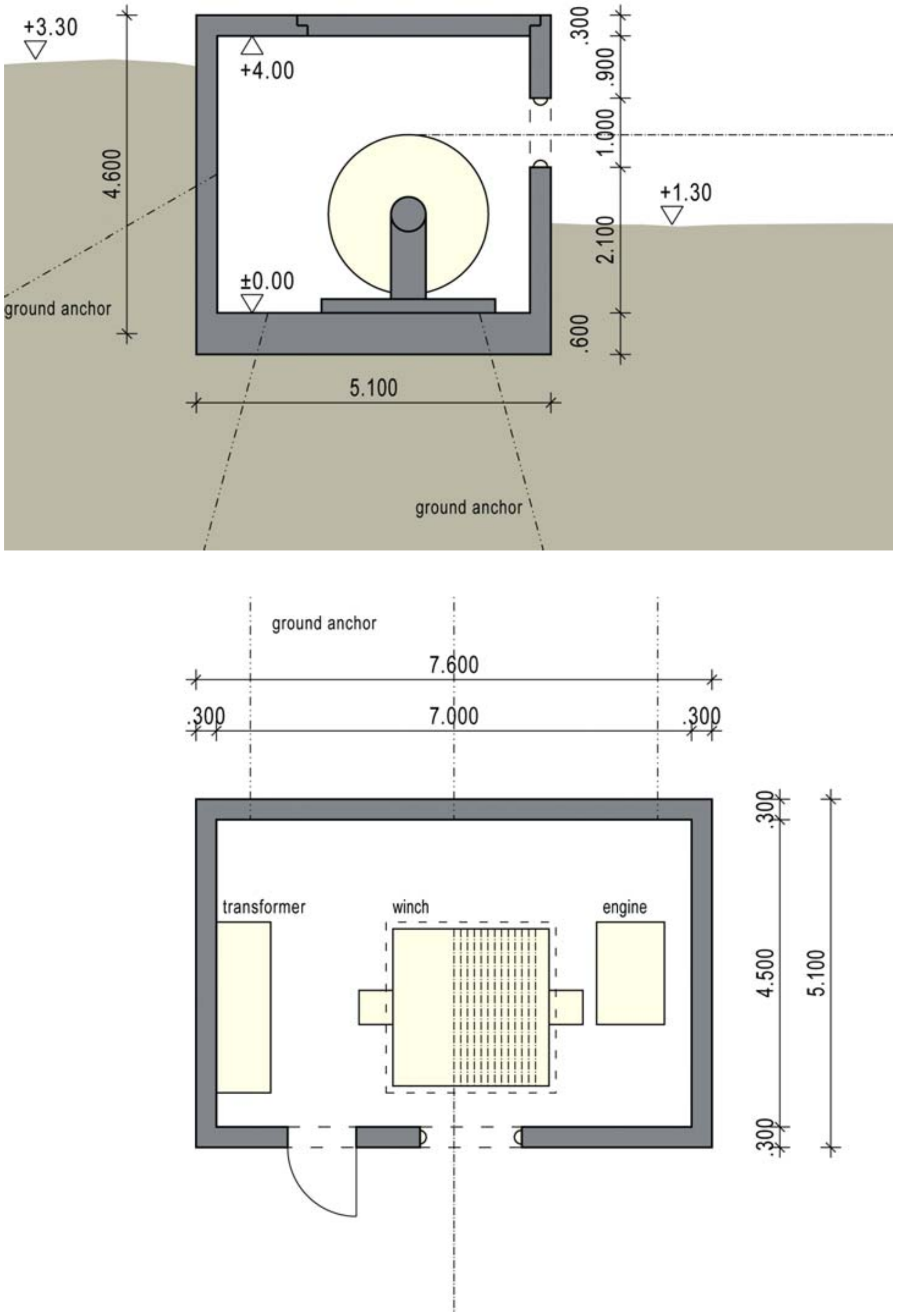

Figure 11-13: Conceptual design of the drive system

The dimensioning load cases have been the survival wind load .

Each segment has inflatable seals along the arch and at the base to realise water tight condition. In case during operation some water leak should happen. it will be easy to build a gutter system to collect it in a controlled way.

Smoke evacuation openings are built in at the top of the enclosure and are controlled and motorised. They are used also to perform the conditioning of the inner volume of air. The openings will be operated according to te wind blowing direction to assure their efficacity.

The drive system is realized with cables and winches.

The power needed to drive the enclosure in 10 minutes from day to night park position is composed of the power to drive the enclosure. the power needed to accelerate the enclosure and the power needed to win the wind resistance force in operational conditions.

Considering that the mass of the complete enclosure is about 34000 t. and assuming that the friction coefficient resisting to the motion if 0.005 the power required to drive the enclosure at a speed of 1 m/s against the 27 m/s wind opened as shown in Figure 11-8 is about 5.3 MW.

A schematic of the conceptual of the drive system is shown in Figure 11-13.

Ways to implement a purely mechanical safety closure system in case of catastrophic power loss when in emergency remains to be assessed in the design phase.

11.1.4 Alternatives

Alternative designed are still under consideration.

One alternative to the baseline is the same concept developed using an innovative approach to structural design. This design is described in RD40. The concept is still the sliding hangar. but the structure is supported by reinforced low pressure air cushions. This system allows to relieve the problem of buckling in the compressed trusses; therefore the quantity of steel used is much lower than in the classical structural design. Of course the design takes into account structural reserve to resist partially to compression so that in case of accidental loss of pressure in the auxiliary pneumatic structure the construction has reserve to take loads until repair.

The saving in material mass is considerable and brings to large cost savings. In Figure 11-14 the principle of this technology is illustrated in the typical case of building bridges. In Figure 11-15 the alternative developed design of the sliding hangar is shown.

The choice to build the main door in one segment is made possible by using this peculiar technology. The structure is very light. the structural steel. at this stage with no provision to resist to survival load in case of loss of pressure in the cushions. is as light as 5000 t. Taking into account the safety reserve to survive MLE event also in case of total loss of pressure. brings the total structural steel weight to about 10000 t.

The Membrane which covers the enclosure is plastic material cladded with sylicons.

Figure 11-14: Principle of the air supporting structure (courtesy Airlight)

Another concept investigated is the one referred to in SPIE paper year 2000.

The principle is shown in Figure 11-16

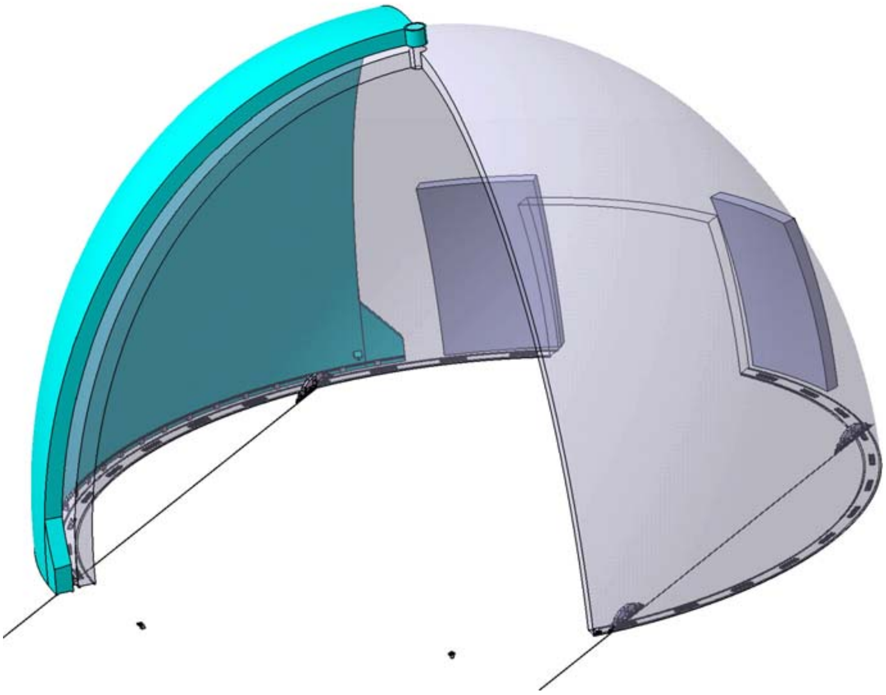

Figure 11-15: Lay out of the alternative design of the OWL enclosure

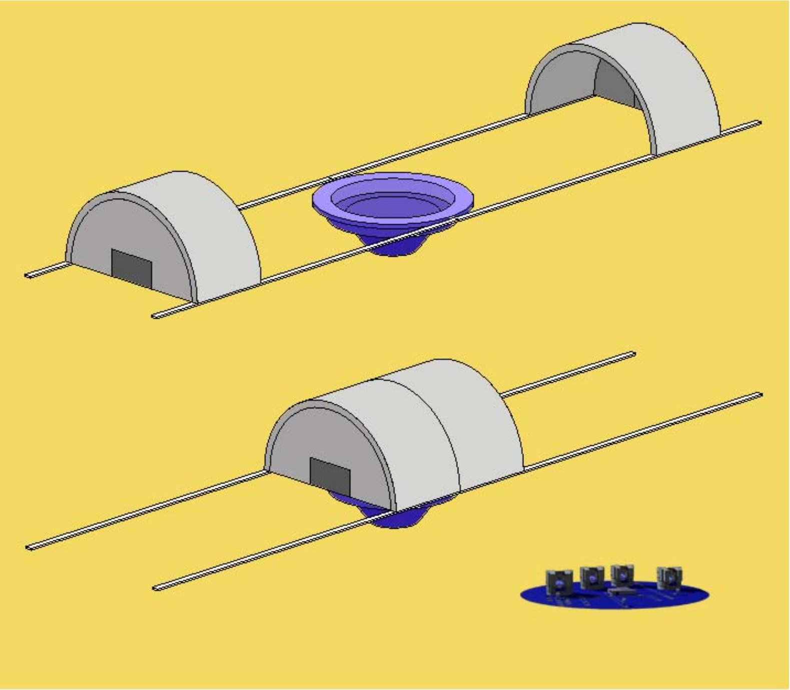

Figure 11-16. Two halves concept (right below teh VLT telescopes platform)

The main advantages of this concept are that no large arches are to be rotated. and this will facilitate the operation and the functionality of the enclosure. Moreover seals are needed only at the junction arch. which makes easier the water tightness management (in case of unforeseen leakage it is even easier to implement a conveyor system). The disadvantages are in the large space required to accommodate the concept.

Another concept only shortly investigated is the “radome” (cupola) concept shown in Figure 11-17

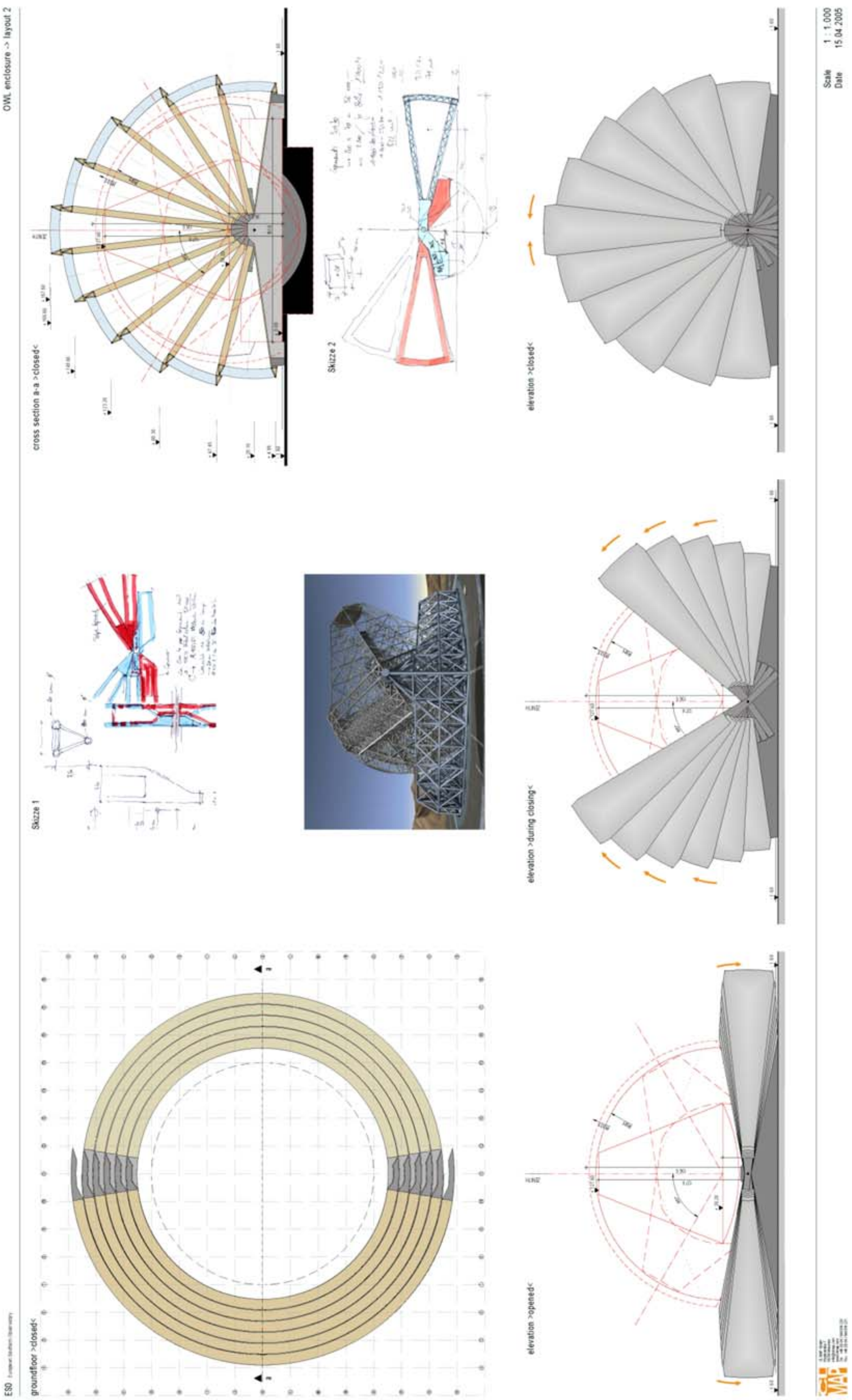

Figure 11-17: Radome concept (cupola) for OWL (courtesy cl-MAP)

This concept has significant advantages from the site dimension requirements point of view. On the other hand preliminary structural calculations have shown that a larger steel quantity is required to meet the technical specifications set for OWL enclosure than for the sliding hangar concept. and therefore the costs would have been much higher in this case. The biggest unknown in this concept is the two large hinges to which all arches are connected. So far no such a component with so high load bearing capability has ever been built.

Using the air cushion technology the same “radom” concept looks more viable. although prototyping will be needed to qualify it for the purpose. How this concept may look like is shown in Figure 11-18 The main feature which makes this technology interesting is the capability to close the dome using the same air pressure which stabilises the structural construction. The arches are hinged singularly on an arch-like structure and this way remove the problem of the previous design. see Figure 11-19.

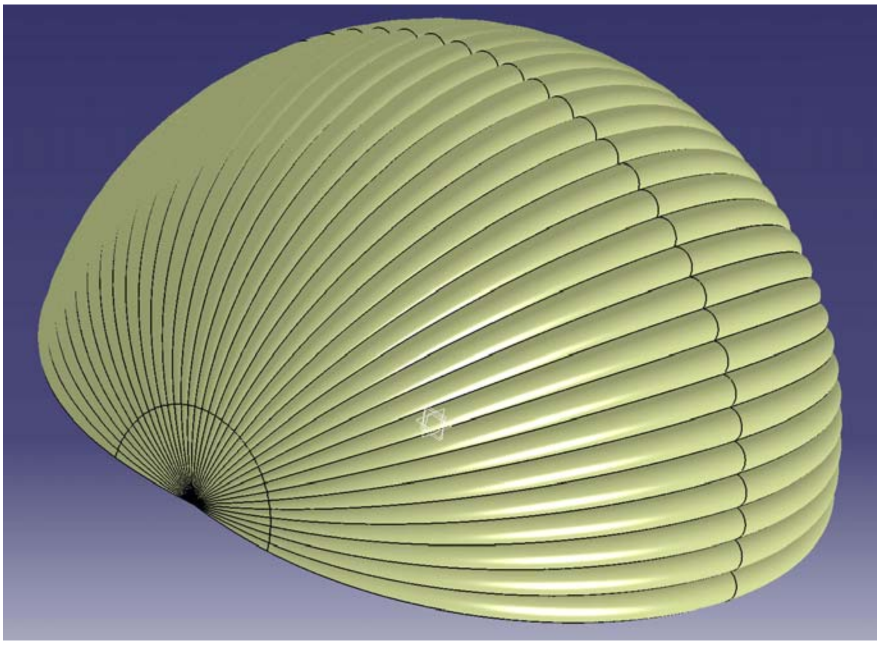

Figure 11-18: Radome concept using air cushion technology (courtesy AirLight)

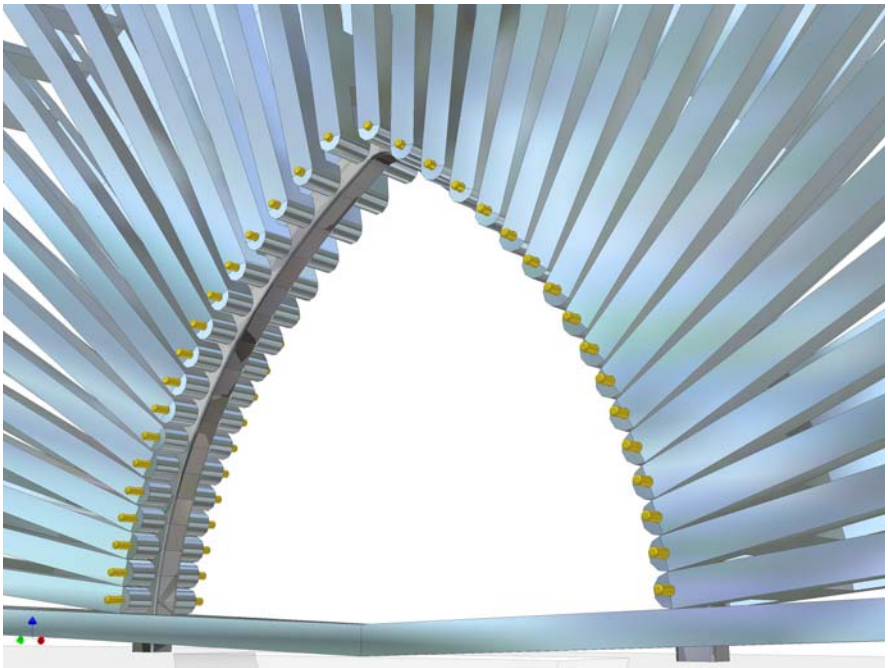

Figure 11-19 Arch-like structure fixing the arches holding the membranes

The airtensity technology allows to have arches with minimal structural cross section and therefore the cross section of the enclosure when open is reduced to minimum. about 9 m height.

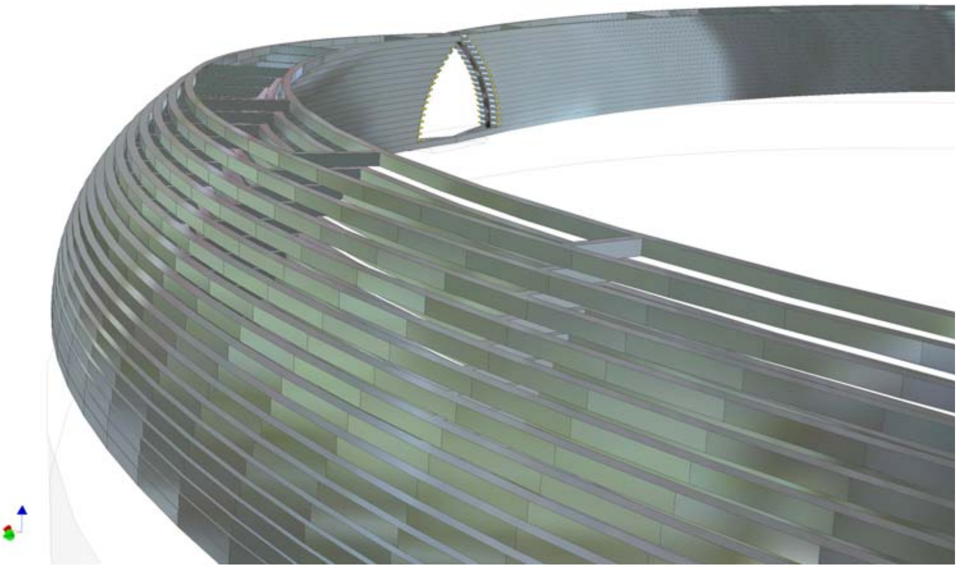

Figure 11-20 Airtensity concept radome enclosure open

In the future activities it is planned to look further in detail into the different alternatives to trade off the costs in all their aspects and therefore to identify the best solution. This may include building prototypes to validate promising construction technologies.

11.2 Infrastructures

As a starting assumption (and without prejudice to the global search for an OWL site) for the design the OWL infrastructure two typical observing sites have been considered. One is a new completely undeveloped site in northern Chile close to Paranal. at 2800 m altitude (Ventarrones). The required development of this site is very similar to the development carried out for Paranal. and allows a fairly accurate assessment of the costs involved.

The second site is Roque de los Muchachos at La Palma in The Canaris Islands. This site is developed. access roads are present. and power is delivered by the national net.

The two sites topography are shown in Figure 11-21 and Figure 11-22

Figure 11-21: Ventarrones (top right of the figure)

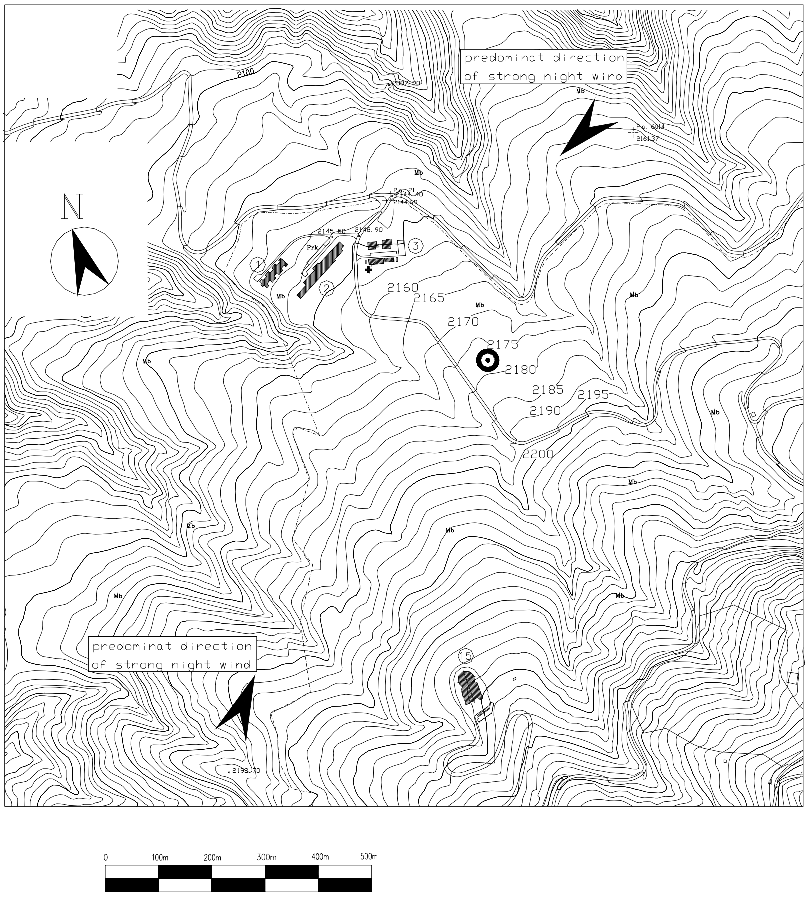

Figure 11-22: La Palma

The infrastructures here considered are the following:

- Mirrors maintenance building with mirror coating plant.
- Laboratories for mechanics. electronics. optics and instrumentation integration and testing.
- Offices and control room.
- Personnel accommodation building
- Power station
- Chilled water and conditioned air production plant
- Earth works and site preparation
- Access and services roads

The services will be supplied. as in the VLT. grouping them in Service Connection Points (SCP). Each SCP will be equipped with:

- Power supply: normal 230V and 400V. UPS 230V and 400V. current rated at 150 A. which allows to draw 104 kVA three-phase power and 34.5 kVA single-phase power.
- Cooling liquid inlet and outlet: flow at -8 ºC with respect to ambient temperature for economical reasons. The flow can remove 90 kW thermal power maximum (diameter of the pipe is 3”. cooling liquid speed is 1.3 m/s and the temperature difference between inlet and outlet is 4 ºC). In case the difference between inlet and outlet is allowed to be 6 ºC the 130 kW thermal power can be removed.
- Compressed air.
- Optical fibres unit.
- Liquid nitrogen distribution: flow equal to 600 l/hours.

The needs for drinkable or sanitary water. fuel and services supply is not discussed here.

Two main buildings are considered in the conceptual design:

- The **service building**. this includes offices. laboratories. instruments assembly/test hall. mirror maintenance hall. utilities (air conditioning and chilled liquid production plants). electrical power distribution and storage area.
- The **hotel** which offers accommodation facilities for the personnel.

Moreover there is an area on which the construction which houses the electrical power production plant is built (if needed).

11.2.1 Mirrors maintenance

Depending on the ventual coating technology. OWL will require recoating of up to 5 segments every day. and every 2 years to recoat 4 mirrors with diameters varying from 2.3 m to 8.2 m.

For this operation we plan to use the same type of coating plant used in Paranal for the large mirrors with yearly need of recoating. and an in-line coating plant completely automatic for the everyday recoating of the segments.

A possible line horizontal coating plant is shown in Figure 11-23. A vertical in-line coating plant would also be possible (e.g. by Laybold Optics).

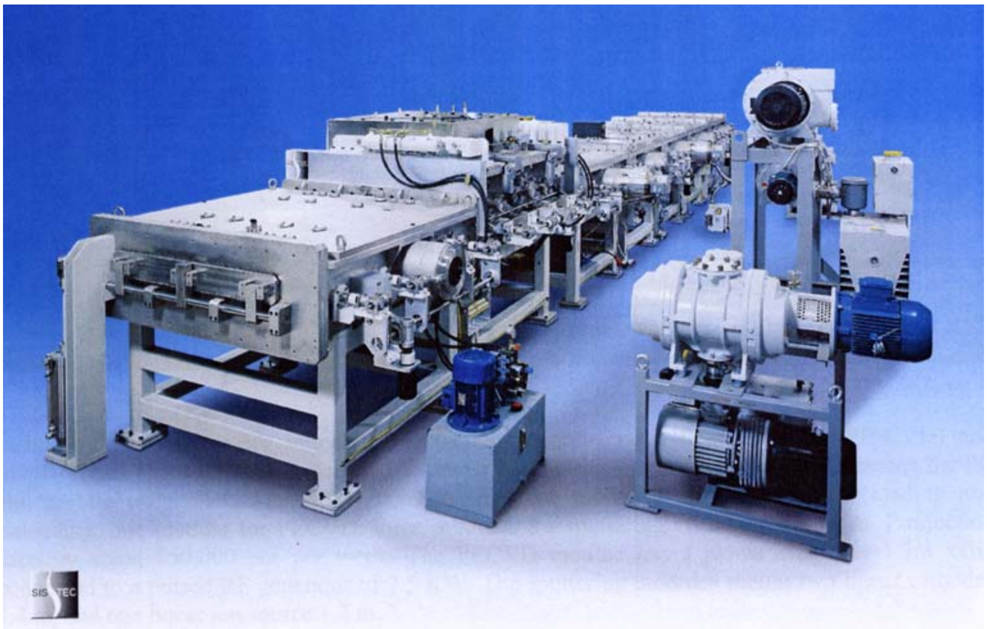

Figure 11-23: Horizontal in-line coating plant (courtesy SISTEC-It)

It might be possible to include in the in line plant a pre-cleaning treatment stage using linear ion source or plasma etching.

The plants are modular and can be designed to accept extensions or change in process like for example coating with Ag or Au.

The large number of spare segments allows to plan to build one in-line plant only. In case of failure during the repair period one can use the large coating plant to re-coat up to12 segments a day by changing the 8.2 m mirror support structure.

The use of one single coating vessel for the 4 large mirrors must be studied in detail. considering the different radii of curvature and inner holes diameters.

The mirrors maintenance building is located close to the storage building and to the laboratories.

The dimensions of the building are 50x30x10 m. In this space one finds:

- The handling area. in which the segments/mirrors are dismounted from the support.
- The Washing area. in which the surface is prepared for recoating housed in a clean room class 1000.
- The coating plant for large mirrors.
- The area in which the on line coating plant is installed.

A gantry crane with lift capacity of 30 t equips the building.

11.2.2 Laboratories

Under laboratories are included the areas where the mechanic. electronic and optics workshops will be housed and the instruments assembly and test hall will be provided.

The laboratory area in the building is subdivided as follows:

- Mechanical workshop 25m x 20m x 10m
- Electronic workshop 25m x 10m x 10m
- Optic workshop 25m x 10m x 10m

- Instruments assembly/test hall 25m x 20m x 7.5m. in this area a clean room class 10000 is located.

The height of the buildings is defined by the maximum height of the instruments. which is provisionally set at 5 m. and the space to operate the gantry crane.

The workshops are equipped as follows:

- Supplies are provided for water. cooling. compressed air. power. normal and UPS. 230V and 400V. signals.
- In the instrument assembly hall also a supply line for liquid nitrogen is provided.
- All the workshops are equipped with gantry cranes with following capacity:
    - Mechanical workshop: 20 t
    - Electronic workshop: 5 t
    - Optical workshop: 2 t
    - Instruments assembly hall: 20 t

The instrument assembly hall is dimensioned to allow the handling of a maximum of two instruments at a time.

An assembly hall where the correctore is separated into the different mirror units is provided before the mirror maintenance building. It has the dimensions of 40 m x40 m x15 m. It is equipped with agantry crane with the capacity of 50 t.

11.2.3 Control room and personnel offices

At the second floor of the service building an area of about 2100 m^2 3.5 m height is occupied by staff offices and by the telescope control room.

The control room is planned to occupy an area of about 200 m^2. The height of the room is 3.1 m and a false floor 40 cm deep is provided for cabling and services.

The offices space is planned to receive about 90 persons at up to 20 m^2 of space each.

11.2.4 Air conditioning and chilled water plants

For cost reason the design of OWL is such that only only limited volumes require air conditioning.

Those volumes are:

- M1 mirror: total volume enclosed 102845 m^3.
- M2 mirror: total volume enclosed 4115 m^3
- The corrector: total volume enclosed 4801 m^3
- The focal station: total volume enclosed 6172 m^3

The total volume to be conditioned is 117933 m^3. This volume is about the one conditioned in total in Paranal. The same installation type used in Paranal has been therefore foreseen. The total power needed is about 1 MW. The chilled liquid will be produced in the centralised plant placed in the utilities room. The global need is calculated as about 600000 l/h.

The cooling liquid will be delivered to the utilities by a pumping station installed in the utilities room.

11.2.5 Fluid distribution

Besides chilled water and compressed air. in the SCPs in the instrument room on the telescope and in the service building. it is planned to distribute liquid nitrogen and pure helium gas.

In the case of liquid nitrogen one has to provide a jacketed line under vacuum to have good thermal insulation. A total of about 500m line needs to be installed. Due to the length it is necessary to keep the vacuum using vacuum pumps about every 100 m.

In the utility room a tank will be installed to house the liquid nitrogen. No decision whether nitrogen should be delivered by a company or produced locally has been taken yet.

The nitrogen will be also made available in gaseous form for cleaning purposes. The supply and return line for clean helium gas Is under study. This will allow not mounting close cycle cooler on the telescope. avoiding source of vibration.

Dry and compressed air will be distributed at all Service and Connection Points (SCPs).

11.2.6 Power station

Unless electric power is derived from an interconnected system (*network*). a power station will have to be installed and operated. A medium-voltage power distribution system will be required to distribute the power to the main buildings and structures. each of which will be provided with its low-voltage (typically 400 V a.c.) power distribution system. The environmental impact of the choice shall be minimized.

The generators can be based on internal combustion engines (diesel engines. gas engines or gas turbines). according to the available fuels and their price. the use planned and while taking into account the maintenance services available in the country of the site.

By analogy with the solution adopted at the VLT Observatory at Cerro Paranal. four generating sets may be installed. To cover the maximum demand three gen sets will be required to operate in parallel while the fourth one in stand-by. The fourth gen set will be called upon duty when one of the others is out-of-order or in maintenance. A more reliable alternative would be a power station comprising five gen sets. three in operation to cover the maximum demand. one in hot stand-by and the fifth under preventive or corrective maintenance.

System/utility	**Active power P [MW]**	**Apparent power S [MVA]**	**Power factor P/S (based on Paranal data)**
Telescope	2	2.5	0.8
Enclosure	5.3	6.6	0.8
Chilling liquid plant	0.5	0.56	0.9
Air conditioning unit	1	1.25	0.8
Large mirrors coating plant	0.4	0.44	0.9
Line recoating plant	0.18	0.2	0.9
Small loads	0.1	0.13	0.8
Compressed air plant	0.2	0.22	0.9
SCPs instrumentation chamber	0.6	0.75	0.8
Total	10.28	12.65	0.81
Maximum demand during operation	8.58	10.58	0.81

Table 11-3: Power consumption estimation

If four gen sets are installed. each would be rated ~3.5 MW at 2800 m above sea level.

The maximum demand of the observatory is calculated based on the following assumptions about the time coincidence of the maximum demands of the individual structures and buildings.

- Enclosure is moved at maximum speed (1 m/s) and telescope is slewed at maximum speed with wind speed 16 m/s.
- The air conditioning of the telescope is off while telescope is moving.
- Chilled liquid production plant is on.
- Recoating process of the mirror segments is taking place.
- Recoating of the larger mirrors takes place when telescope and enclosure are in park position.
- The small power loads (lighting. socket-outlet circuits. etc.) are assumed to be like those in the VLT Observatory (the occupation of the site is similar).
- Only half of the Service Connection Points (SCP) are used at the maximum power.

The estimated power requirements are listed in Table 11-3.

Installing four generators rated 3.5 MW at 2800 m height. rated about 4.5 MW at 300 m height. and operating continuously one obtains a safety factor with respect to the maximum demand during operation of about 20%.

A choice of the power supply system shall be made only after a detailed specialized study. In this study the different possibilities shall be explored both technically and economically. An analysis of the power demand waveform shall also be performed to exclude the need to adopt flywheels to cope with fast switching mode. In this conceptual study this was excluded on the basis of ESO experience in operating the VLT.

11.2.7 Personnel accommodation building

The building to host the personnel and the visitors is located on the north side of Ventarrones to take advantage of the sun exposure during winter time.

In La Palma the hotel area is placed downhill of the telescope.

No concept desisgn has been developed. At this stage it is assumed that a solution similar to Paranal’s would be adequate.

11.2.8 Site preparation

Site preparation activities are:

- Construction of the access roads
- Mountain blasting and levelling
- Telescope platform blasting/excavating for telescope. enclosure foundations and utilities
- Site blasting/excavating to create area for service building and hotel building.
- Preparation of first infrastructure like construction camp. sewage. drinkable water supply.
- Concrete foundations for buildings enclosure and telescope.

All these activities are strongly dependent on the nature of the site.

In order to cover the largest possible situations. the exercise to design and to estimate the effort involved has been carried out for two typical sites:

- Ventarrones in Northern Chile

and

- Roque de los Muchachos in La Palma. Canaris Islands.

The work performed in 1993 for the Max Planck Institute for Astronomy of Heidelberg to study the feasibility of infrastructure construction in Gamsberg in Namibia has been source of inspiration.

11.2.8.1 Camp and first infrastructures

Before starting the erection of the OWL observatory a camp will be established on the site.

The camp is made of standard containers. After a first phase during which occupancy is estimated in about 50 persons. to prepare the access roads to the telescope site. the occupancy will grow with the arrival of the contractors to prepare the site (Blasting).

It is expected that the camp will then grow in the first year up to a maximum occupancy of about 300 people during the integration of enclosure and telescope.

An unpaved road from the closest existing one to the site will be built (Old Panamericana in the case of Ventarrones and the closest observatory road for La Palma).

In Ventarrones also a service unpaved road will be built to connect the telescope platform to the service area.

11.2.8.2 Earth works for telescope platform

Due to the large dimensions of the installation the earthworks to flatten the telescope area. to prepare the trenches for the foundations of the enclosure and of the telescope and to prepare the areas to build the auxiliary buildings will be a non negligible cost in the project.

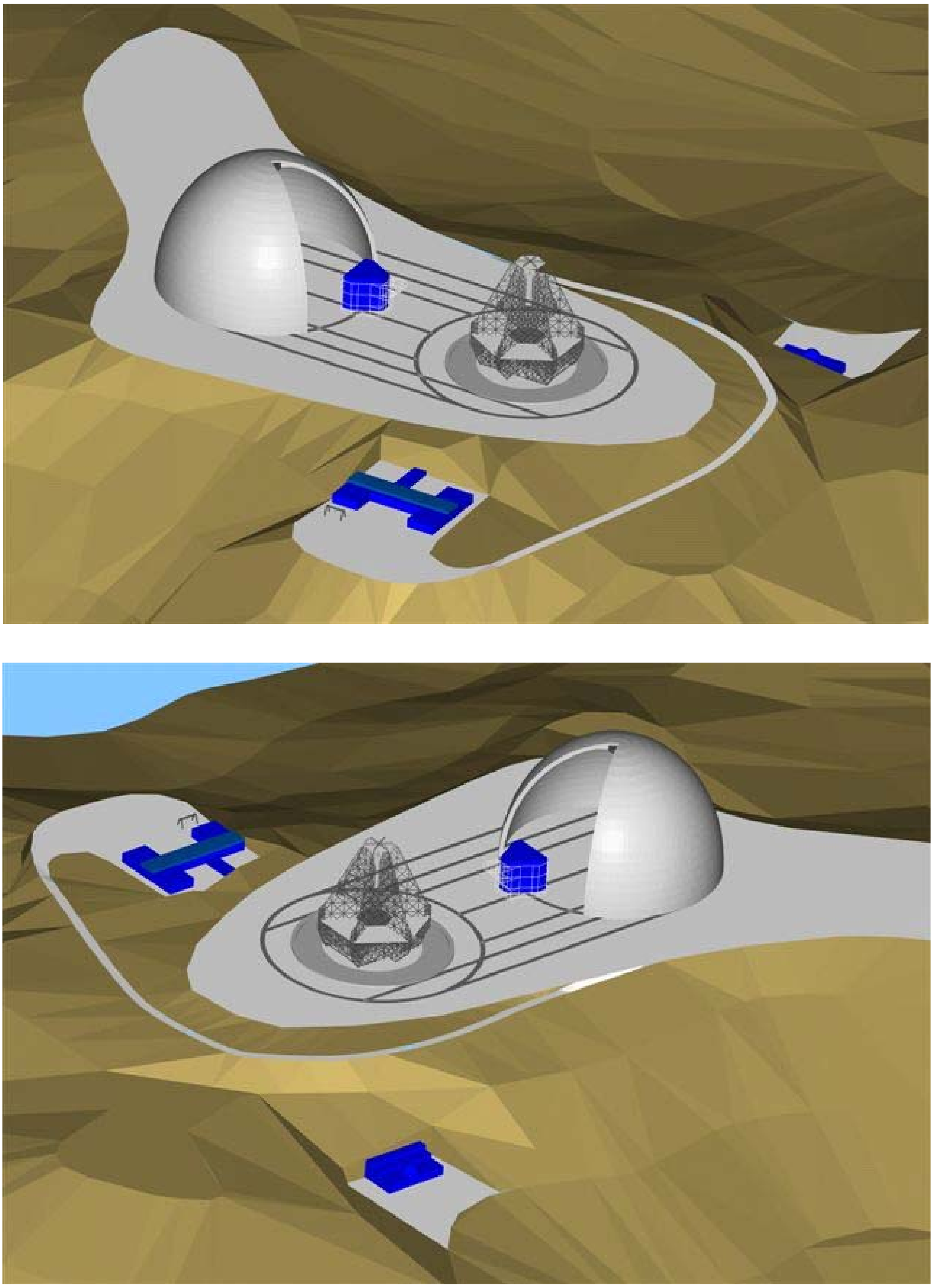

Figure 11-24: Ventarrones: Observatory lay out (auxiliary building side above; hotel side below)

Figure 11-24 and Figure 11-25 show a possible site excavation for the sites of Ventarrones and La Palma. respectively..

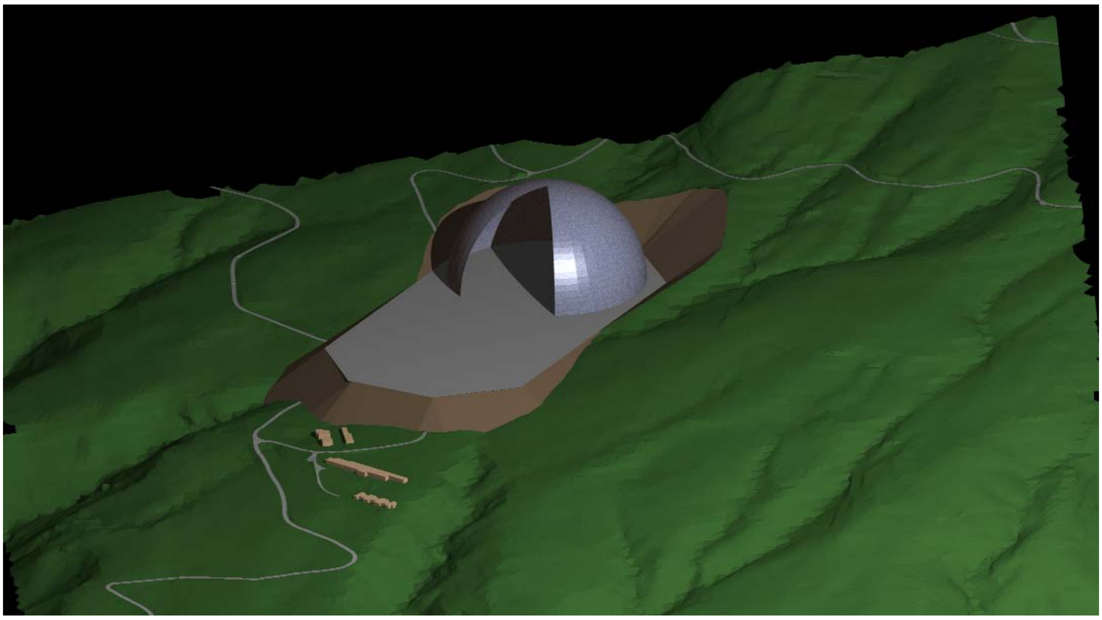

Figure 11-25 The enclosure installed in La Palma

The volume of rock to be blasted for the two sites is summarized in Table 11-4.

Due to the large quantity of material to be blasted and relocated in both sites. it will be most economic to bring up to the mountains the equipment which will be used also to crash the rocks in the right dimensions to prepare the aggregate for the concrete and for the compacted relocated material. In this case it is believed. and therefore assumed. that the cost to blast crash and relocate the material will be the same for the two sites.

item	**Ventarrones volumes [m^3]**	**La Palma volumes [m^3]**	**remarks**
Telescope platform	3000000	2375000	Here it is considered. conservatively that both enclosure’s and telescope’s foundations lies on solid rock and not on compacted soil. If one assumes that the enclosure’s foundations can be built on compacted soil then the volumes decrease to about 2000000 for both sites.
Enclosure foundations	65000	65000	
Telescope foundations	170000	170000	
Service building	30000	21500	Includes the tunnel to telescope.
Hotel	9000	5000	

Table 11-4: Volume of earth to be removed to prepare the site.

11.2.8.3 Access roads to the Observatory

In a second phase the roads prepared will be paved. In the case of an undeveloped remote site this will require to build locally the plant to produce the tar.

The length of roads required for the two sites are of course very different.

In the case of Ventarrones the site is located at about 10 km from the Old Panamericana. a situation very similar to Paranal.

In the case of La Palma only the service roads are to be built.

The estimated total lengths of roads for the two sites are

- Ventarrones: 15 km
- La Palma: 3 km.

The roads have a maximum slope of 7%. and in Ventarrones are 15m wide.

11.2.8.4 Miscellaneous

During the construction of the observatory services will be needed. These services must be purchased. The following must be procured: drinkable water supply. catering services. transport services. transportation means and salty water supply to compact the roads before they are paved.

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