

# **EVALSO: a high-bandwidth communication infrastructure to efficiently connect the ESO Paranal and the Cerro Armazones Observatories to Europe**

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## **ABSTRACT**

This paper describes the technical choices and the solutions adopted to create high bandwidth (>1Gbps) communication links to both the ESO Paranal and the Cerro Armazones Observatories located in the Atacama Desert, in the Northern region of Chile. The complete system is planned to be in place by mid-2010. This infrastructure is part of the EVALSO (Enabling Virtual Access to Latin-America Southern Observatories) project that is done by a consortium of 9 members and co-founded by the EC (European Commission) within the frame of the FP7-INFRASTRUCTURES-2007-1.2-02. More on the project is available at [www.evalso.eu](http://www.evalso.eu)

**Keywords:** high bandwidth communication, WAN, Wide Area Network, Academic Network, Research Network

## **1. INTRODUCTION**

For very obvious reasons, Observatories tend to be built in remote areas where high capacity communication infrastructures are not normally available or easily accessible. This is the case for the ESO Paranal and the Cerro Armazones Observatories, located in the Atacama Desert, in the Northern region of Chile. Although computing and networking infrastructures are available and continuously evolving at the sites, the possibility to fully exploit in real time such facilities is limited by the available bandwidth to connect them to the rest of the research and academic world. To fully exploit such remote sites (from fast data transfer to rapid response mode, from remote monitoring and engineering to virtual presence) high capacity links, i.e., bandwidth >Gigabit-per-second (Gbps), are necessary.

Driven by this idea, a consortium of 9 members<sup>[2][3][4][5][6][7][8][9][10]</sup>, has been created in 2007 aiming to create a physical infrastructure (and the tools to exploit it) to efficiently connect the two Observatories to the Latin American network and from there to Europe. This proposal was presented at the European Commission Frame Program 7<sup>[11]</sup> (EC-FP7) and in late 2007 was granted co-funding. The EVALSO (Enabling Virtual Access to Latin-American Southern Observatories) project was born!

The project (see fig.1) sets focus on two aspects:

- The creation of the communication infrastructure needed to efficiently connect the selected sites to the European Astronomical Community by procuring all missing paths and by linking to the international infrastructures created in the last years with the EC support (ALICE<sup>[9]</sup>, trans-atlantics link, GEANT<sup>[12]</sup>)
- A set of research activities with the objective to make possible and validate new ways to interact with remote facilities by exploiting the new capabilities made available by high-bandwidth communications<sup>[14][15][16][17]</sup>.

This paper describes the process, technical choices, and results of the delivery of the communication infrastructure.

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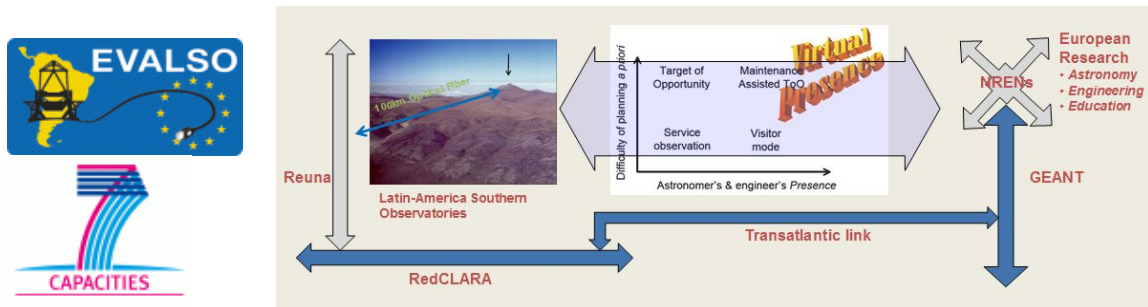


Figure 1. The EVALSO and EC 7<sup>th</sup> Frame Program logos and the project concept.

## 2. LOCATIONS

The project aims to create new physical connectivity at the following locations (see fig.2):

- The ESO Paranal (PAO) and Cerro Armazones Observatories (OCA), located in the Atacama Desert in the North of Chile.
- The REUNA offices in Antofagasta (approximately 120 km from the Observatory)
- The ESO and REUNA Offices in Santiago de Chile (about 1200 km south of Antofagasta)

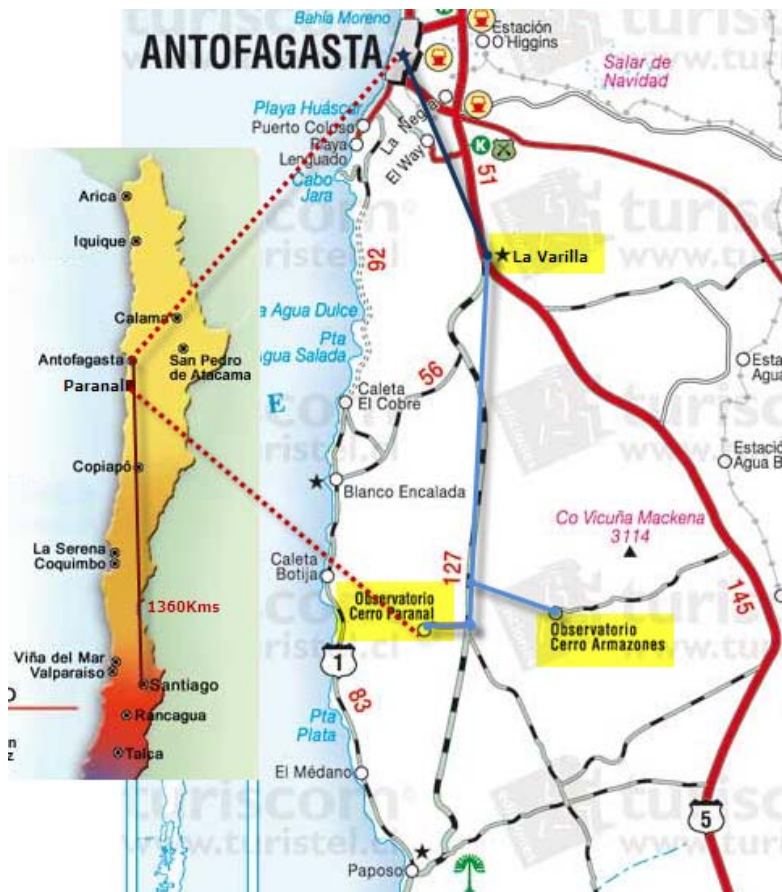


Figure 2. The Northern Region of Chile and the detail of the area where new fibers will be constructed.

### 3. MARKET SURVEY

The first task was to identify the technical and commercial options available. For that a market survey including both field survey and contacts with providers was done in 2008. We also had a close look to a similar experience, the AUGIERACCESS<sup>[13]</sup> project, taking place in Argentina.

Considering that the closest communication infrastructure to the Observatories is found along the main road backbone (Ruta 5 or Panamericana in fig.2) it was clear that new infrastructures had to be built from the Observatories to at least this axis. For that both aerial lines and underground solutions were investigated. For the long haul transport Antofagasta-Santiago, the two providers with infrastructure in the area gave their availability for a fixed wavelength solution (OTU1 or OTU2, i.e. 2.5 Gbps or 10Gbps). It is important to notice that in Chile access to a wavelength is not part of the normal service portfolio of the Telecommunications companies, therefore it was crucial to invest time exploring the available solutions and convincing them to open new options by explaining the relevance of this infrastructure for the scientific activity and for the Chilean community. For that the presence in the EVALSO Consortium of REUNA, the Chilean National Research Network (NREN), was important as this guarantees the non commercial exploitation of the infrastructure and also establishes synergy with the Chilean scientific community

Concerning equipment, it was clear that a Dense Wavelength Division Multiplexing (DWDM) based choice would have offered the best platform in terms of flexibility in use and operation of the optical infrastructure.

Having achieved the technical feasibility and with promising first budgetary estimations, the project moved into the procurement phase.

### 4. PROCUREMENT PHASE

To better suit the different procurement processes and know-how of the project members, the overall system was divided in two parts:

- The optical infrastructure serving OCA, ESO-PARANAL, REUNA-ANTOFAGASTA, ESO-VITACURA, REUNA-SANTIAGO to be procured by ESO on behalf of the project.
- The DWDM communication equipment for all sites to be procured by REUNA on behalf of the project.

The procurement processes run during 2009 and early 2010 and lead to quite interesting solutions that are currently in the implementation phase, planned to be completed within end of the third quarter of 2010. The coming sections are detailing the outcomes for the two areas defined above.

## 5. OPTICAL INFRASTRUCTURE

### 5.1 Overview

Both for technical and procurement reasons, the optical infrastructure is broken down into the following items (the reference numbers are with respect to fig.3):

- New fiber cables (1 and 4) to serve the ESO Paranal and the OCA Observatories up to Ruta 5 (La Varilla);
- A pair of fibers (par of 1) from the existing installation along Ruta5 from La Varilla to Antofagasta;
- Fixed Wavelengths (one Lambda) (2) between TELCO Point of Presence (PoP) in Antofagasta and Santiago area;
- Housing space for EVALSO equipment at the TELCO PoP in Antofagasta (6) and Santiago (3);
- Dark fibers (5) between TELCO PoP and the end points in Santiago, namely ESO/Vitacura and REUNA/Providencia.

The following sub-sections will detail the lay-out and technical characteristics of every part.

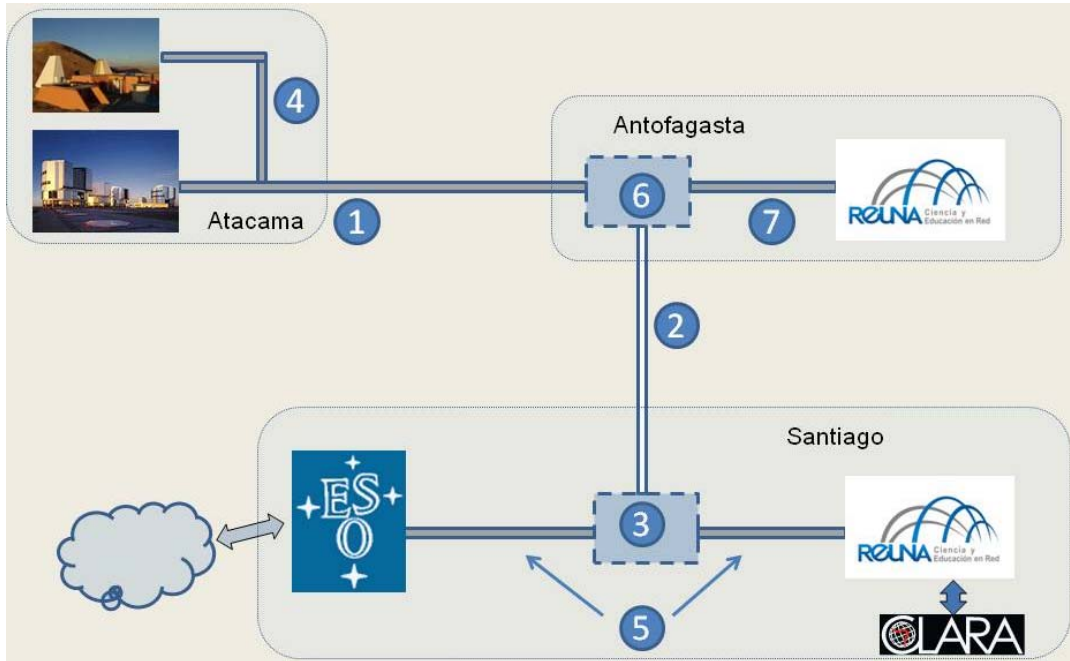


Figure 3. Overview of the EVALSO Optical Infrastructure

### 5.2 New fiber cables OCA/ESO Paranal/La Varilla (Ruta 5)

In order to connect the two Observatories to the infrastructure of the selected TELCO operator in LA Varilla, three new cables have to be built (fig. 4): a main cable along the Road B-710 and the two branches to OCA and PAO.

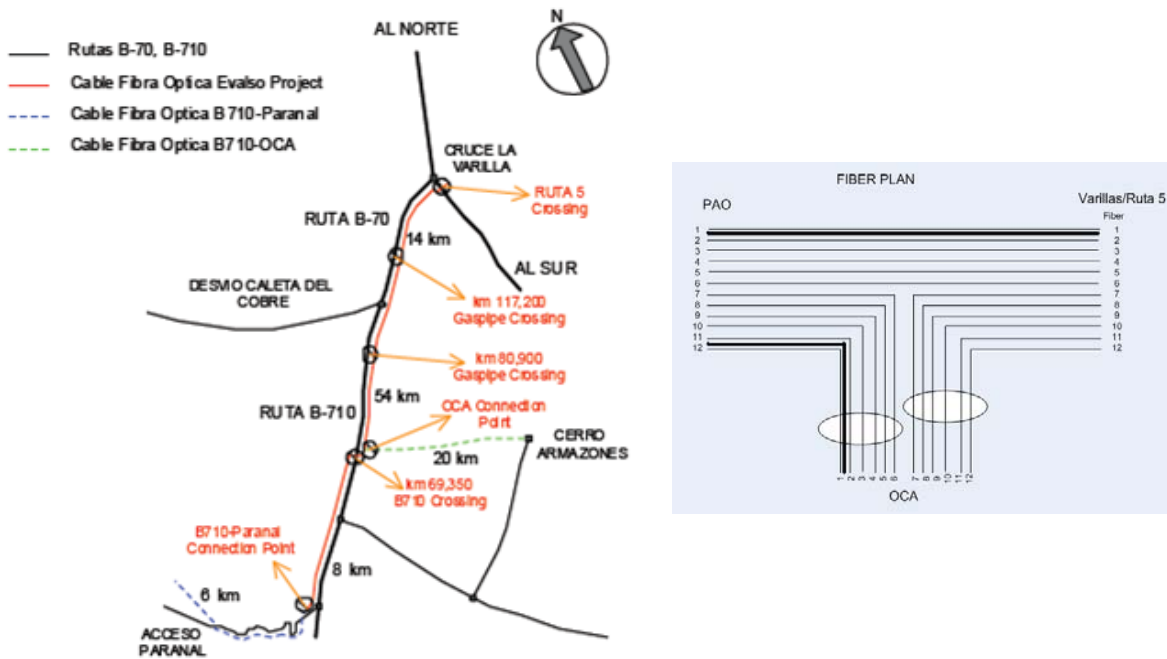


Figure 4. The lay-out of the new fiber cables and the way the cores are connected.

The selected solution is to use a 12-core ITU G652.D cable for direct underground installation. As shown in fig.3, the two cables get joined at an intermediate point along the road B-710. Out of all the available pairs, two optical paths are used by the project:

Paranal Observatory – La Varilla	OCA Observatory – Paranal Observatory
Length: 75 Kms	Length: 30 Kms
Attenuation: 18,5dB @ 1550nm	Attenuation: 9dB @ 1550nm

The rationale to have the OCA traffic routed to PAO and there merged on a single path to Antofagasta is to save costs (only one fiber pair needs to be procured between La Varilla and Antofagasta and, using the DWDM capability, dedicated channels can be created). The remaining fiber cores are available as spare and for future projects. One potential use is the planned ESO E-ELT that has chosen Cerro Armazones as site.

The selection of an underground construction, in addition to offer a safer construction, limits the visual impact on the pristine desert environment. The installation is done by means of special machines that cut a trench, about 20cm wide and 80 to 120 cm deep, depending on the soil nature. The cable is suitable for direct installation (no ducts). Reels of 4km length are used and splicing boxes are placed in chambers at the same distance. The project foresees several crossing of the existing roads and gas pipeline.

As the construction takes place along a public road, special permits had to be obtained in advance from the Chilean authorities (Ministerio de Obras Publicas, MOP). For that a complete and detailed design of the whole installation had to be prepared and delivered in order to receive the needed authorization (granted in January 2010).

Fig .5 to 8 provide some images of the ongoing installation. Completion is planned for the end of August 2010.



Figure 5. (Right) the cutting tool used to create the trench where the cable will be laid down and (left) the excavation.



Figure 6. (Right) the fiber cable is directly installed in the trench that is then (left) filled back with excavation material that is then compacted.



Figure 7. (Right) excavation for the installation of a concrete manhole (left) that will host the splicing box used to connect two consecutive sections of cable, about every 4km.



Figure 8. (Right) road sign to comply with safety regulation during installation along the road and (left) the plastic ribbon installed about 30 cm above the cable to mark its presence.

### 5.3 The fiber La Varilla – Antofagasta (along Ruta5, i.e. Panamericana)

From the end of the new cable, La Varilla, to the nearest installation of the provider (Antofagasta) there are about 50km. This distance has been covered by procuring, in 10year Indefeasible Right of Usage (IRU) mode, a fiber pair from the existing facility. This is an aerial cable along the Ruta5, type of fiber ITU G652.D.

One fiber pair from the new cable and the one from the existing one are fused together to create a single continuous optical medium between Paranal Observatory and the TELCO PoP of approximately 125Kms, with an expected total Attenuation of 30dB @ 1550nm. This can be handled without the need of intermediate amplification, saving the need of active equipment along the installation.

### 5.4 The “LAMBDA” between Antofagasta and Santiago

For the transport between Antofagasta and Santiago, a fixed wavelengths (one Lambda) has been procured in 10year IRU mode. As this is part of the provider backbone, the solution include automatic backup of the line at optical level. The interface complies with the regulations for an OTU2 (10Gbps) bandwidth link. To be noted that there is no traffic management by the provider and all traffic management is done by the project equipment in the nodes.

### 5.5 The dark fibers in the Santiago metropolitan area

Last but not least, two more dark fibers in 10year IRU mode are procured in the Santiago Metropolitan area to connect the ESO Office, in Vitacura, and the REUNA Office, in Providencia, to the TELCO PoP.

## 5.6 Housing space at Antofagasta and Santiago TELCO PoP

To facilitate the interface of the EVALSO equipment with the Telco equipment regarding lambda interconnection it was preferred to ask for suitable housing in the Telco PoP in Antofagasta and Santiago. This includes access controlled and protected rack space with power and air conditioning. A dark fiber in the Antofagasta area connects the housing space to the REUNA Offices.

## 6. DWDM EQUIPMENT

To fully exploit the capability and flexibility of the optical infrastructure and to optimize current and future use of the infrastructure, the project decided to procure and operate the active equipment. Fig.9 provides an overview of the system.

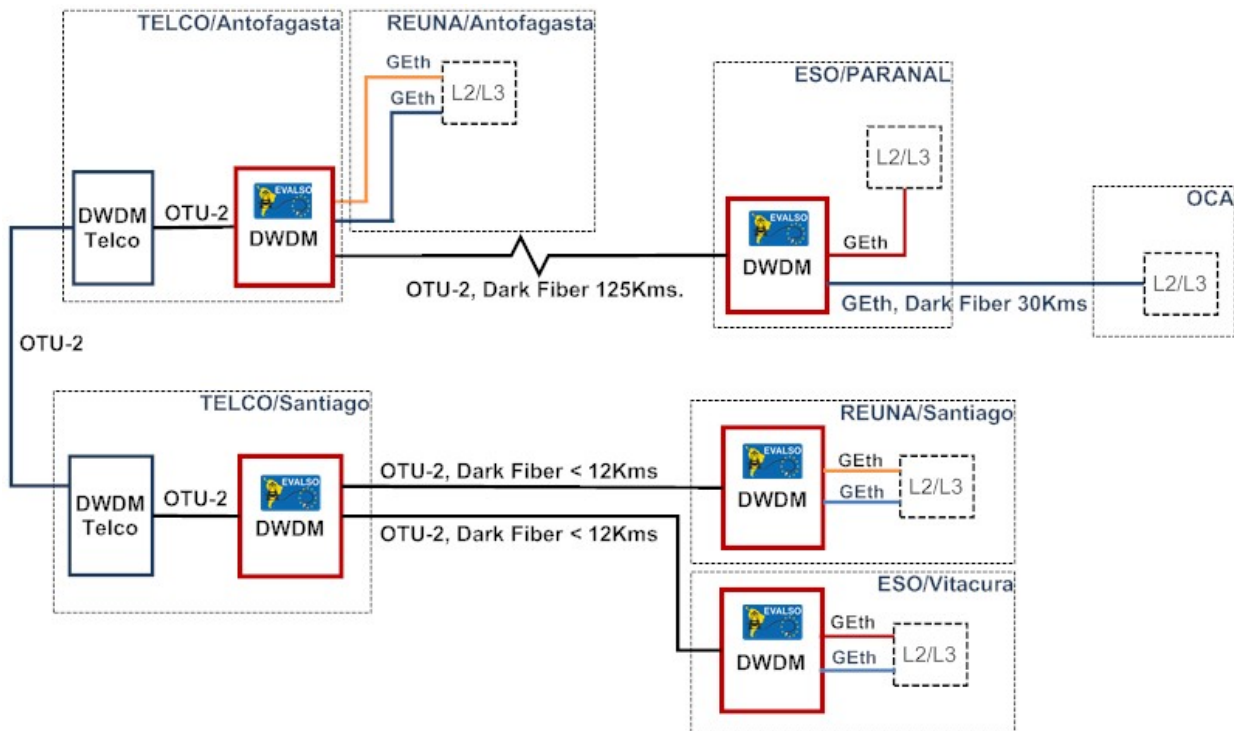


Figure 9. Overview diagram of the EVALSO active equipment.

There are five nodes where EVALSO equipment will be installed:

- At the ESO Paranal Observatory border. This unit will manage the traffic that ESO PAO and OCA will generate and send using an OTU2 channel to the Antofagasta node. This equipment is hosted in the ESO Paranal base camp.
- At the TELCO PoP in Antofagasta. This unit will receive the traffic from the Observatories and from REUNA offices in Antofagasta and feed the OTU2 to Santiago. The equipment is physically housed at the Antofagasta TELCO PoP.
- At the TELCO PoP in Santiago. This unit will receive the traffic from Antofagasta and distributed to the Santiago end points, ESO and REUNA.

- At the ESO Offices in Vitacura, Santiago. This unit will receive the traffic from the ESO Observatory and feed the traffic to Europe via REUNA and the academic and research networks.
- At the REUNA Offices in Providencia, Santiago. This unit will receive the traffic from REUNA Antofagasta and ESO Santiago.

In addition, at both ends of the dark fiber between ESO Paranal and Antofagasta, an optical amplifier plus modules for the Chromatic Dispersion Compensation are installed.

The selected equipment is CIENA CN 4200 family. Some characteristics of the equipment selected:

- Main cards to be used:
  - F10-A: 2x Client interfaces (10Mbps to 2,7Gbps) + 1xOTU-2 (10Gbps)
  - M3: 3x Client interfaces (10Mbps to 2,7Gbps)
  - G10: 10x Client interfaces (10x1Gbps or 9x1Gbps + 1xOTU-1 (2,7Gbps))
- Be able to transport one lambda in the first stage but have the potentiality to transport more than one if it is needed in the future.
- The client traffic is GigaEthernet and the network traffic is OTU-2 OTN G.709
- The client traffic is moved to the network interface through a non blocking backplane (3 channels of 4xODU1, i.e. 30Gbps cross-connections between the interfaces)
- Support and in of band management as well as an out of band management to be able to monitor the infrastructure in a 7x24 modality. CLI, html or java management interfaces not a proprietary application.
- Fan and power supply redundancy

## 7. CURRENT AND FUTURE USE

The overall system is planned to be fully tested and ready for use within end of August 2010. Till the end of the EVALSO project (mid2011), it will be available for the Research Activities of the EVALSO Consortium. After that time, the infrastructure will be used according to mutual agreements that are being discussed among ESO, OCA, and REUNA. Some key concepts:

- ESO will be responsible for the maintenance of the optical infrastructure;
- REUNA will be responsible for the maintenance of the DWDM equipment and for the network operation for all nodes;
- Dedicated channels will be established between: OCA and REUNA/Antofagasta, ESO/Paranal and ESO/Santiago, REUNA/Antofagasta and REUNA/Santiago, ESO/Santiago and REUNA/Santiago;
- More channels may become active as result of future projects and agreements.

## 8. CONCLUSIONS

High-bandwidth communication has become a key factor for scientific installations as Observatories. Where it is not available as commodity, dedicated effort are requested. The EVALSO project demonstrates that, by properly exploiting synergies and modern technologies, such high capacity channels can be created and it will deliver within 2010 Gbps-capable channels to the project beneficiaries.

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