



Closing the observing loop across continents: data transfer between Chile and Europe

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The different tasks supporting the operations of ESO telescopes in Chile are carried out at widely separated locations, with some taking place at the observatory site and others in Europe at ESO's headquarters. A fundamental requirement to make such operations scheme viable is the need for a stable way of transferring the large amounts of data generated by the telescopes to Europe on the shortest possible timescale. We review technical progress that has allowed ESO in the last years to move from the transfer of data on physical media, with delays of up to two weeks, to the current transfer of most of the data stream through the internet within hours. We also describe the possibilities that will be open in the near future with EVALSO, an European Union co-funded project to provide full-fiber connectivity from the ESO observatory site on Paranal, and the nearby Cerro Armazones hosting the telescopes of the University of Bochum, all the way to Europe. Given the recent choice of Cerro Armazones as the future location of the European Extremely Large Telescope, upgrades in the communications infrastructure of Paranal and Cerro Armazones are very relevant to the ability to operate the current and future facilities there.

Why a fast data transfer?

Data availability in the ESO archive in Garching within a short time from acquisition positively impacts both the user experience and the observatory operations:

- *Principal Investigators* of programs executed in Service Mode can access their proprietary data in almost real time to speed up their scientific exploitation. More than 100 dataset downloads a month are made on the average
- *Data handling operations* are simplified on both sides of the Atlantic.
- *Science Operations on Paranal* has reduced its workload as the dedicated Data Processing and Quality Control group in Garching can perform in-depth quality control in near-real time. Instrument health status is typically certified within one hour from when the suitable frames are acquired.

An operational scheme where mission-critical tasks, needed to assess the instrument performance, are not carried out at the observatory is enabled in this way, in application of the principle 'bring data to people, not people to data'. Only the results are then fed back to the observatory itself, enabling the decision-making required for operations.

Data volumes, capabilities, and evolution:

- Current data rate from VLT + VLTI: 25 GB/night (now)
- Expected data rate from VISTA + VST: 110 GB/night (2011)
- Expected data rate from VLT with 2nd generation instrumentation: 95 GB/night (2012)
- Expected data rate from VLTI with 2nd generation instrumentation: 20 GB/night (2014)

Total from Paranal, full steam, 2014: 225 GB/night

Current capability: 95 GB/night

- E-ELT (estimate): ~1 TB/night (ca. 2020)

Current data transfer path will need replacement soon to cope with data volumes in the near future

Future demands: EVALSO

The daily transfer of the Paranal and Armazones data production over the internet will require a bandwidth increase of roughly one order of magnitude with respect to the capabilities of the current setup over the next decade.

This may be feasible given the ever increasing availability of bandwidth with time, but only addresses the baseline requirement of being able to transfer the complete data stream over a period of 24 hours.

Some of the advantages of the data transfer over the internet materialize only if the transfer time becomes much shorter and closer to real time:

- Closure of the quality control loop within less than one hour for all the future facilities on Paranal and Armazones
- Implementation of new observing capabilities requiring real-time remote access

The EVALSO project (for 'Enabling Virtual Acces to Latin South American Observatories), funded by the European Union under its Framework Program 7 and currently under construction, is expected to provide such capabilities for Paranal and Armazones already in the very near future.

EVALSO will create the missing parts of the physical infrastructure to connect the Paranal and Cerro Armazones observatories to Europe with a high capacity link, in particular an optical fiber link connecting Paranal and Armazones with the Chilean backbone. A consortium was formed in 2007 by seven European institutions (the GARR consortium, the University of Trieste, and the Astronomical Observatory of Trieste in Italy, Queen Mary University of London, NOVA in the Netherlands, the Astronomical Observatory of the Ruhr University of Bochum, and ESO) directly interested in the exploitation of possibilities offered by the availability of a high capacity link, plus the REUNA and RedCLARA networks in Chile. The project plans to use the ALICE/ALICE2 research network infrastructure created with EU support for high-capacity interconnectivity within South America and transatlantic connection to European National Research Networks (NREN). The physical infrastructure has been recently completed and preliminary have offered very promising results, allowing end-to-end data transfer rates in excess of 100 Mbsp. Tests in the operational environment will take place in the next months.

