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VLT instrumentation control: the collaboration of OATs with ESO

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Abstract. The collaboration of the Astrophysics Technology Group (ATG) of the Astronomical Observatory of Trieste with ESO will be presented. It may be considered as an example of a good practice in the collaboration of a peripheral Institute with ESO. Started in 1985, it spans almost all the time since Italy joined ESO in 1982. The Trieste Astrophysics Technology Group (ATG) participated in many technological enterprise of ESO, from Remote Observing to VLT instrumentation and to ALMA ACS, and is now looking for the challenging E-ELT.

Key words. Instrumentation: Control

1. Introduction

The collaboration of the Astrophysics Technology Group of the INAF - Astronomical Observatory of Trieste spans 27 years, almost the entire period of thirty years of participation of Italy to ESO, that will be celebrated during this Workshop. I believe that this may be considered as an example of a good practice in the collaboration of a relatively small group of a peripheral Institute with the Technical Divisions of ESO, in the field of state-of-the-art technology applied to Astrophysics.

Let's start with some dates : Italy joins ESO in 1982, and the Astrophysics Technology Group was formed in Trieste in 1975. We immediately recognized the need of strict contacts with the Technology Divisions of ESO, to stay connected with the state-of-the-art technology in Astrophysics, and we started a preliminary collaboration (still continuing today). The technological driver of this long-lasting and fruitful collaboration throughout the whole period has ever been the participation to the projects involving the periodic ESO innovations in the fields of Instrumentation Control Software, Instrumentation Control Electronics and Data Processing Software, giving always attention to the cross-section with the scientific interests present at OATs.

The different projects in which ATG has been involved in this 27 years will be presented, in chronological order, with an introduction also to a couple of collaborations before the VLT era.

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2. Pre-VLT era - Image Display (1985 - 1988)

In the first years of the eighties ESO started to develop MIDAS (Munich Image Display and Analysis System) as a tool to handle the astronomical data produced by the instrumentation at La Silla. The image display was implemented via a Ramtek image display system, very powerful for those times but also very complex, heavy, cumbersome to handle and, last but not least, very expensive. Those were times when theb European astronomical institutes could not allow for local Data Processing Centers and ESO provided a central facility in Garching HQ for the analysis of the astronomical data. At the same time new graphic and image display were arriving on the market, lighter and cheaper. An international working group was set up among ESO, STScI, Starlink and Astronet for the definition of the IDI, Image Display Interfaces, a set of standard software interfaces to match the existing image display software systems to the new class of devices on the market. ATG was representing Astronet. In 1987 the IDI were finalized and published (Terret et al. 1988) and ATG started a collaboration with the ESO MIDAS group for the implementation of the IDI for MIDAS. The portable MIDAS system was born (pMIDAS), with image display capabilities available for a large number of devices, and it was possible from that time for ESO to distribute it to the peripheral astronomical institutes that could create local DPCs.

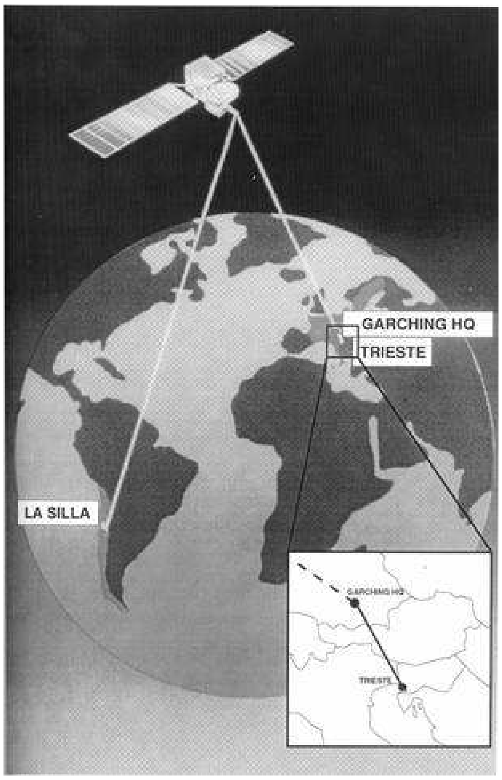


Fig. 1. Layout of the Second-level Remote Observing system from La Silla

3. Pre-VLT era - Remote Observing (1989 - 1992)

At that time the Remote Observing mode was already active at La Silla Observatory, operating with the CAT. ESO decided to go for a refurbishment and an upgrade of the system to be installed on the NTT. In the framework of a direct collaboration ATG is in charge of the implementation of the Client side (Garching client), and it is agreed that a feasibility study should also be started to verify the possibility to extend the Remote Observing capabilities to a different astronomical institute in Europe. In a three years effort the Garching Client has been completely rewritten. Moreover the Second Level Remote Observing system was implemented, providing observing capabi lities to any European astronomical institute. A second level client has been implemented, to be installed in the remote institute, together with a remote observing manager, running at ESO HQ in Garching, whith the full control of the operations (Balestra et al. 1992). See Fig. 1 for the geographical deployment.

Those were not times of Internet, wide band, fast communications and a complex hardware system has been designed and set up, providing a communication over three channels for data, video and voice, with a dedicated link of 64KB between Garching and Trieste(see Fig. 2).

At the end, after three years of implementation and tests, three nights have been allocated with NTT and 10 Italian astronomers from different Observatories observed with NTT and SUSI for a total of more than 30 hours of observing time (Balestra et al. 1992).

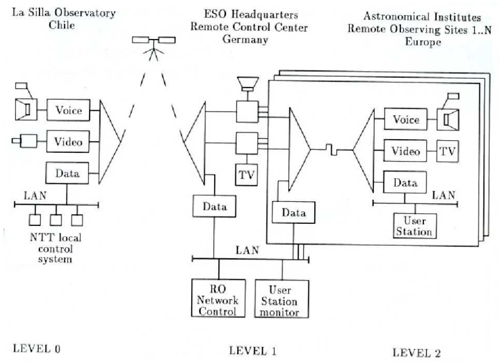


Fig. 2. Harware architecure of the Second-level Remote Observing system from La Silla

NOTE

In 2011, 19 years later, in the framework of the EVALSO EU FP7 project (partners were ESO, GARR, UniTS, CLARA, REUNA, QMUL, AIRUB, INAF OATs) the scheme was replicated on the VLT (4). In 2011 the Remote Control was implemented via a pre-loaded OB with P2PP from a remote institute, where the raw data were collected and a it was possible to modify and re-start the OB. The goals of the 1992 implementation were more ambitious, providing the full control of the telescope/instrumentation to the remote user (replicating the observatory user interface) and the availability of the raw data.

4. VLT - UVES Control Software (1992 - 1999)

With the advent of the VLT, Very Large Telescope, UVES (UltraViolet-Visual-Echelle-Spectrograph) was one of the first two instruments build under complete responsibility (and funding) by ESO, together with ISAAC. There was therefore no European Consortium in charge of its realization, and ATG was called by ESO Software Department for a direct collaboration. The activity was really challenging, for it was a first step in the VLT project and the VLTSW (the Software framework for the control of the VLT and of the instrumentation) was still in a development phase and we had in this way the possibility to participate to its com-

Fig. 3. UVES during the integration in Garching

pletion and tests. Moreover it was the moment of the transition of the VLTSW from the C programming language to the Object Oriented software technology and this fact was really stimulating.

In the preliminary agreement a feasibility study was included for the Data Reduction, which was closed after two years.

In the framework of the UVES project ATG delivered more than 10 man-years over a 7 years project. Figure 3 shows the instrument during its preparation in Garching, Figure 4 the ESO-ATG UVES team at Paranal and Figure 5 a snapshot of the celebration for the first light (September 27, 1999).

5. A strategic agreement

During the UVES realization a discussion started between ESO and ATG for the preparation of a formal agreement for future collaborations. At the end a document was prepared which stated (among other)

The Software Department in the Technical Division (TSW) at ESO and the Astrophysical Technologies Group (ATG) of the Astronomical Observatory of Trieste (OATs) acknowledge the long-standing and successful collaboration

Fig. 4. The UVES team in Paranal

Fig. 5. The UVES first light - September 27,1999

between the two groups in the field of astronomical instrumentation control. The purpose of this collaboration lies in the fact that on one side ESO can benefit of a qualified and professional team, with in depth knowledge and experience of the VLT Instrumentation and its control system, while ATG, on the other hand, will take advantage keeping in contact with the ESO technology, collecting experience to be used in the national and international ground based and space borne telescopes and instrumentation programs in which the OATs is involved, involving at the same time young staff in state-of-the-art projects. Both groups consider strategic for the future this collaboration.

6. VLT - BOSS: the standard OS (1999 - .....)

Starting from the experience of the first instruments, ESO decided to standardize as much as possible the Instrumentation Software, to make easier on one side the implementation of the software by the different Consortia and on the other the maintenance at Paranal Observatory of the running instruments. The scope was the implementation of a basic OS (the Observation Software control process), standard for all instruments, to customize according to the instrument architecture. BOSS was implemented, the Base Observation Software Stub, a standard Observation Software framework (Pozna et al. 2008). It is still a running project, and support all the instrumentation software. With the implementation of this software framework the standard common software is gaining in complexity (see Fig. 6), providing on the other hand a decrease in the complexity of the Instrumentation Software implemented by the instrument teams (see Fig. 7). Our team, through the implementation of the INS Software for many instruments collaborated (and is still collaborating) with the ESO responsible of BOSS for the improvement of the architecture and of the performance of the software package and for the complex tests on-the-field (Pozna et al. 2010).

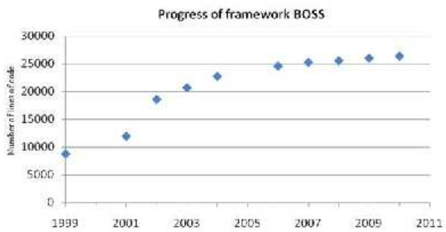


Fig. 6. Complexity of the BOSS package during its development

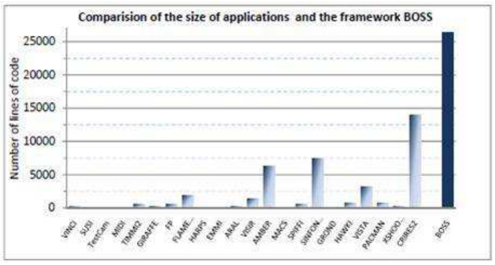


Fig. 7. Relative complexity of BOSS and of the INS software

7. VLT - FLAMES/GIRAFFE Control Software (1999 - 2002)

In 1999 ESO asked our team to participate in the realization of FLAMES/GIRAFFE. This instrument, a fiber-fed multi-object medium resolution spectrograph, was built by an European consortium plus Australian partners. ATG was not part of the consortium but it came out that it was a complex instrument to be controlled and it represented an optimum test-bed for the exploitation of the Unified OS (BOSS) and of the SuperOS concept. From the control point of view it was composed by three instruments:

- OzPoz - a fibre positioning robot with a double plate for parallel configuration and observation (Fig. 8)
- GIRAFFE - a fiber-fed medium resolution multi-object spectrograph (Fig. 9)
- UVES - a high resolution spectrograph, already operative on the opposite Nasmyth platform, fed with 8 dedicated fibers

The layout of the instruments on UT2 is shown in Fig. 10.

The parallelism was the key issue of the instrument operations. GIRAFFE and UVES can observe independently while the alternate plate of the Fibre Positioner is being configured for for the next observation.

The full parallelism was achieved with an architecture implementing

- three fully independent instruments, with a dedicated Observing software (BOSS) supervisor (BOSS-SuperOS) coordinating the operations

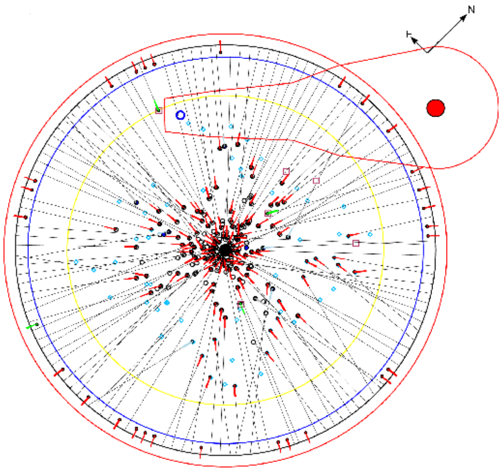


Fig. 8. The scheme of the fibre positioner of FLAMES

Fig. 9. OzPoz, the fibre positioner, and GIRAFFE (open)

- a double-BOB user interface for the Observation and Fibre Setup

The ATG team played a double role within this project

- a direct collaboration with ESO, under a specific agreement for the implementation of the overall Control Software of FLAMES/GIRAFFE
- member of the ITAL consortium (Bologna, Cagliari, Palermo and Trieste Observatories) in the framework of the FLAMES international consortium (Australis, Paris-Meudon, Geneve and

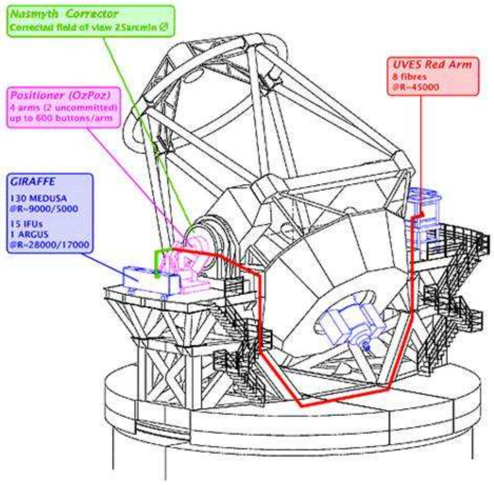


Fig. 10. FLAMES and UVES on UT2

Lausanne Obs., ITAL) for the upgrade of the UVES control software.

The internal software of the robot of the fibre positioner OzPoz was implemented by the Australian partners. The man-power delivered for the whole project by the ATG team has been of 5 man-years.

8. VLTSW - Linux (2002 - 2003)

Linux was knocking at the door. The VLTSW was tied to a hardware architecture created around Unix HP workstations and VME electronics. The Linux revolution was bringing a free, open-source software running on a wider choice of hardware, cheaper and with higher performances. ESO made available to ATG a preliminary beta version of the VLTSW running under Linux for the first tests. During the last phases of the commissioning of FLAMES the sw has been unofficially installed on an Armada laptop under Linux and run in parallel with the official control workstation. The result has been an improvement of a factor of three in compilation performances and of a factor up to 10 in panel handling performances. ESO and ATG started a project to verify the feasibility of a mixed environment with an Instrument Workstation running Linux. The Test Camera on the VLT was selected as a testbed and its control software was rewritten in Trieste and ported under Linux. Three nights have been allocated for a commissioning run in January 2003 demonstrating that the new Op Sys was compatible with the VLT installation. As a result Linux WS have been selected as Instrument Workstations (e.g. X-shooter).

9. ACS - ALMA Common Software (2003 - 2010)

After 15 years of VLT Software ESO, for the new great enterprise is moving towards a new software infrastructure, ACS ALMA Control Software. ACS provides a common software infrastructure to all the ALMA developers and creates a distributed environment for its software tools and services. ACS is based on the most advanced software technologies (e.g. OO, C++, CORBA) for the management of its distributed objects. Thanks to a specific agreement with ESO and to the involvement of ATG in the development of ACS, the Trieste Observatory becomes an ALMA partner (see Fig. 11).

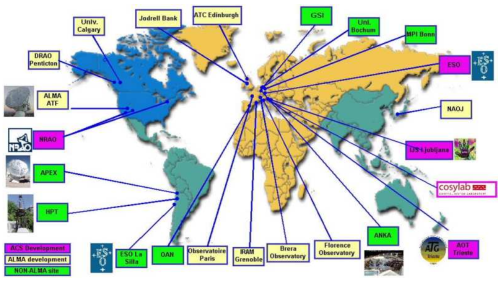


Fig. 11. The ALMA partners around the world

The collaboration covers several aspects of ACS. In particular at OATs two main software packages have been implemented and tested : the Sampling System, to provide sampling of the properties of the system for the instrument telemetry, and the Bulk Data System, the core of the data transfer from the antennas, providing a transfer rate of up to 800 Mbps.

10. VLT - X-shooter Control Software (2004 - 2009)

X-shooter, a medium resolution multi-wavelength spectrograph, is a second generation instrument fully Linux based. Three arms, optimized for the Blue, Visible and near IR bands, were to be controlled, synchronized (to obtain fully parallelism) and keep aligned. Most of the complexity of the software resides in the Observation Templates, where the full parallelism was implemented and where a complex real-time procedure was implemented to check and maintain the alignment of the three arms during the exposures. Before each scientific exposure two calibration exposure are taken, with different configuration of the instrument. The resulting images are then correlated to verify any displacement of the spectra. If the result of the correlation is good the observation template can then proceed.

The Trieste Observatory was part of the international X-shooter consortium (Denmark, Italy, Nederland, France, ESO) and for the Control Software of the instrument ATG delivered 7 man-years (out of a grand total of 70 man-years for the full instrument).

11. VLT - ESPRESSO (2009 - .....2015) : the present

ESPRESSO (Echelle SPectrograph for Rocky Exoplanets and Stable Spectroscopic Observations), the current instrument, is a second generation VLT instrument and marks two important steps for the developers:

- it is the first VLT instrument to use the Combined Incoherent Focus. This means that it is a Coude instrument, installed in the CCL (Combined Coude Laboratory) which can combine the beam of up to four VLT UTs . An important task will be therefore the upgrade of the VLT INS Common Software to use more than one telescope (that is the standard behavior for all the installed instruments up to now.
- ATG/OATs is responsible in the case of ESPRESSO of the Instrument Control Software and of the Instrument Control Electronics.A big revolution is ongoing at ESO in the field of Control Electronics, abandoning the old LCUs based on a VME/VxWorks architecture and adopting a new modern architecture based on distributed PLCs with the OPC-UA concept.

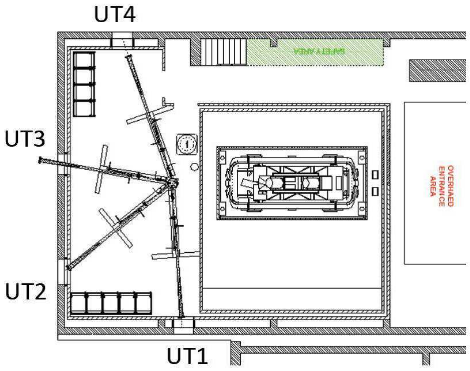


Fig. 12. The layout of the Coude Combined Laboratory with ESPRESSO

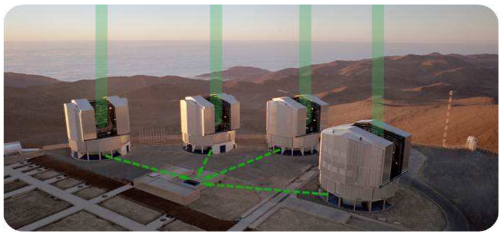


Fig. 13. The four VLT Unit Telescopes combining the beams

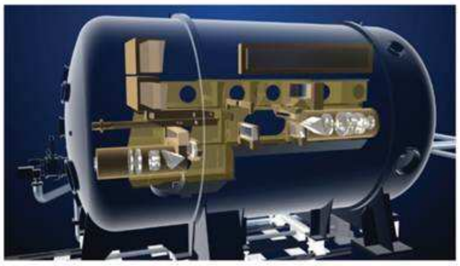


Fig. 14. ESPRESSO inside its container

12. E-ELT : the future

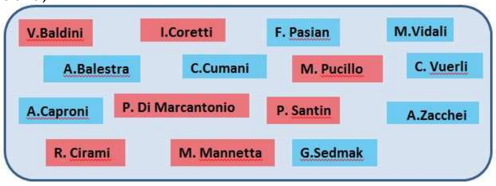
In the framework of the Concept Studies (Phase A) for the E-ELT Instrumentation an agreement has been settled between the ESO Technology and Software Development Division and the Instrumentation and Control Group at OATs to study the control software and electronics architecture of three (possible) first-light spectrographs for E-ELT

- CODEX
- OPTIMOS-EVE
- OPTIMOS-DIORAMAS.

Fig. 15. E-ELT - the European Extreme Large Telescope

A first result of this work, discussing advantages and/or disadvantages in terms of costs, complexity and ease of integration took into consideration the ALMA-ACS software framework. The conclusions were anyway not satisfactory, and a common decision has been taken to proceed to further evaluation (Di Marcantonio et al. 2009).

Acknowledgements. As a conclusion of this review of a collaboration lasting almost 30 years, and on behalf of all the people @OATs that were part pro-tempore of the Instrumentation and Control Group (the red boxes list the currently active team members)



I wish to thank all the ESO collegues in Garching and Paranal for their friendship and helpful collaboration.

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