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Introduction

The very complete "History of the European Southern Observatory (ESO)" prepared by Prof. Blauuw furnishes a perfect background for my presentation on the present status and foreseeable future trend of ESO. I will therefore not repeat many of the basics regarding the creation, membership charter and early development of ESO except to summarize the most significant starting points for current and future activities. From its beginning in 1962 and through a number of successive developments outlined in Prof. Blauuw's report, ESO's observational facilities in La Silla grew in number throughout the first 30 years so that in 1993 they comprised 15 telescopes of all sizes and descriptions ranging from the 3.6 meter to 50 cm telescopes and including ESO's and national facilities. This is the basis of the statement that ESO runs one of the world's largest astronomical observatories.

As far as the quality of the observational capabilities is concerned, the most significant event was the study, development and construction of the 3.5 meter New Technology Telescope (NTT) which was initiated in 1980 and inaugurated in 1990. In the realization of this project ESO for the first time introduced technology which was ahead of the state of the art in the world. This development provided the technological foundation for the much more ambitious Very Large Telescope (VLT for short) project which was approved by the ESO Council in 1987.

With the approval of the VLT project the European Astronomical Community and ESO have decided to construct optical ground base facilities comparable, or superior, to any existing in the world. When the VLT array is completed in the first few years of the next century, it will furnish the largest integrated collecting area of any array in the world (200 square meters) as well as the most powerful interferometric capabilities and will come into operation in one of the most favourable astronomical sites in the world (Cerro Paranal).

The realization of this project has required profound changes in the organization while the project itself is being conducted. It has also strained the financial resources of ESO, and has forced a careful reassessment of priorities in order to establish a strategy for ground based optical and IR astronomy. In particular, the role of the La Silla Observatory during and after the development of VLT on Paranal has required a great deal of attention.

A further and important consideration needs to be introduced. The construction of large telescopes is a condition necessary but not sufficient to ensure the competitivity of European astronomy in the world. Just a trivial example: the notorious lag in development of optical CCD detectors in Europe has meant a loss of efficiency in the observations of about 50 %. It is evidently useless to build large telescopes, if we do not use them effectively. This implies the construction of forefront instrumentation and its proper use.

By proper use I mean the study and implementation of an end-to-end system for science operations. This includes: strategies for telescope utilization, ranging from traditional modes to service and remote observing; scheduling of observation (both long and short term) to best utilize the seeing qualities of the site; systems for data acquisition, calibration, reduction, distribution and archiving. By implementing this overall vision of how to carry out modern astronomical research, ESO indeed holds the promise of becoming the leading optical

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observatory world-wide. In what follows I will describe the progress we have made in some of the areas mentioned above and the prospects for the future.

Construction of the VLT and the Paranal Observatory

The construction of VLT has been a new and unique challenge for ESO. When completed in 1987, the cost of the NTT telescope corresponded to less than the budget of ESO for one year. The VLT total cost corresponds to 8 times ESO's yearly budget. The cost to completion, including internal and external costs, will amount to more than 1 billion DM. The execution of this undertaking has required a complete revamping of the administrative, accounting and managerial structure of ESO with the introduction of modern management tools appropriate for a project of this size. During early 1993-1994 Work Breakdown Structure accounting was introduced first for VLT and then for ESO as a whole. In this approach each major task is assigned manpower and financial resources and a responsible person is placed in charge of its completion within a fixed schedule. Progress is reported on VLT in biweekly programme meetings and formally in two programme reports to Council per year. Once a year ESO wide reviews are conducted in which goals and objectives for each division are discussed. The adoption of these techniques was recommended and /or endorsed by an outside consulting committee chaired by Prof. Lund and supported by an industrial firm (Lurgi) in early 1994.

In the last few years the VLT project has substantially maintained schedule notwithstanding the adverse impact of the issues which have arisen with the Chilean Government. The first completed mirror will be delivered in Paris (by the Reosc firm) on November 21. The steel structure for the first telescope is being assembled and tested at the Ansaldo firm in Milan for delivery to Paranal in June 1996. The rest of the hardware and software is on schedule for a first light at the end of 1997 and commissioning by June 1998. The other three telescopes are on schedule for completion of the array by 2001. The interferometric use of the 4 telescopes of 8 meters and the auxiliary three telescopes of the 1-2 meter class had to be delayed due to financial constraints. However, the full infrastructure required for the implementation of VLTI is being prepared on Paranal. The civil engineering portion of the construction is almost completed and the erection of the telescope domes is well under way. An essential difference between the construction of NTT on La Silla and VLT on Paranal is that the realization of the VLT project has required the simultaneous creation of a new observatory in the Atacama Desert with all the appropriate logistic support.

The construction of the VLT and of the new observatory on Paranal has required an increase in the staff and in the budget. We have analyzed the efficiency with which the ESO staff operates the La Silla facilities and compared our findings to the reputedly best run observatories in the world. We find that ESO runs its facilities with efficiency comparable to the best.

Even with this level of efficiency, however, the operation of VLT would be too expensive given the magnitude and complexity of the task. We have therefore "reengineered" our operation plans at the outset and we plan to operate Paranal (4 x 8 m telescopes + 3 x 2 m telescopes) with a smaller yearly budget than La Silla. We do not yet know at what level the community will wish to maintain La Silla facilities during the VLT era (see discussion in the next section). In this section we have assumed no change to the La Silla effort before or after first light on UT-1. This will certainly not be the case and ESO will reduce La Silla facilities to those essential to complement the VLT following the recommendations of the "La Silla 2000" study.

The budget is projected to remain at a level of 141.5 MDM (in 1995 values) until the payments to outside contractors for VLT are completed in 2003. The staff complement projections under the same assumptions are for 253 international and 236 local members.

Role of La Silla during and after VLT construction

The problem of developing a strategy for the use of La Silla facilities while constructing the Paranal Observatory is one which has received a great deal of attention by ESO. It is clear that the financial constraints on the ESO budget which is capped (except for inflation) for the foreseeable future, prevent us from maintaining all existing 15 telescopes, big and small, open to the community. ESO has therefore concentrated on the mainten-

Recording the ceremony for the completion of the first VLT 8.2 m mirror. The figure shows a photograph of the team of REOSC experts who carried out the delicate task of polishing the mirror. Also in the photograph are the directors and managers of REOSC and ESO.

ance, improvement and operation of the major telescopes while placing the smaller facilities in the hands of the national project teams. This has meant a restructuring of the La Silla Observatory in 4 dedicated telescope teams, each having responsibility for one or a few telescopes (The telescope teams are the SEST, the 3.6 m and CAT, the NTT and the 2.2 and 1-5 meter telescopes). Supporting teams for optics, detectors and engineering provide observatory wide support. The remaining 8 telescopes are being operated by national teams on a permanent or project basis.

The focusing of efforts on the major facilities on La Silla has permitted us to improve their scientific performance and to use them as testing grounds for the VLT software, hardware and operating philosophy. In particular, we have undertaken a commissioning and upgrade effort on NTT, which is now in its second year. The purpose of this effort has been to

a) bring NTT to full operational status
b) to test VLT detectors and software
c) to test new modes of science operations.

The goals of a) and b) have largely been achieved. Technical downtime has been reduced on NTT to 2 %, an almost ideal performance in a technically advanced instrument. The third phase, designed to test the end-to-end science operation model for VLT, will occur next year.

As to the future utilization of these facilities, a Working Group known as "La Silla 2000" has been created under the aegis of the ESO Science and Technology Committee which has made its recommendation for the future. The main finding of this group has been that there will be a role for smaller telescopes (2-4 meters) in the VLT era for specialized tasks that the VLT will be ill suited to carry out efficiently. This will require, however, modernization of the instrumentation and operating philosophy of these facilities.

Scientific Methodology

The purpose of ESO is to provide the astronomical community of member states with up-to-date competitive facilities in order to excell in astronomical research. While there must be, of course, always room for the unique individual contributions of particularly gifted astronomers, much of the progress in modern astronomy depends on the collection of large quantities of data and their elaboration and analysis to solve specific astrophysical problems. Modern detectors produce data at a very high rate. In the case of the Hubble Space Telescope, rates of the order of a few gigabytes per day had to be handled and stored. From VLT we can expect between 10 and 100 times more data due to the increased size of the optical detector arrays, the development of large IR arrays and the speed of readout required in active and adaptive optics applications. In order to process and store such vast volume of data, standard procedures for calibration, reduction, processing, archiving and distribution have to be developed, if the data are to be effectively used by the observer and also (later) by the community.

The development of these techniques requires the ESO staff to take responsibility for the quality of the data obtained and therefore to acquire expertise and competence in the use of at least the most commonly used instruments configurations. Calibration of instruments require in turn physical modelling of their performance, development of a calibration programme, acquisition of the data, analysis and use of the updated parameters in the calibration algorithms. These capabilities will have to be developed whether or not we use them 100 % of the time. It is currently our intention to offer the community both traditional and service observing. The tools that are being developed will be useful for both.

The role of ESO scientists

Given the above, the old debate on whether ESO should itself be a research institution or only provide service to outside observers becomes mute. The complexity of the instrumentation and operations requires the involvement of qualified scientists. These scientists can be recruited and retained by ESO only if they are given the opportunity to carry out their own research. It is the current ESO philosophy to hire scientists only if needed to carry out ESO service functions. However, they are expected to continue to remain active in research with an ideal time split of 50 / 50 between research and functional work.

From the point of view of their research endeavours they form a kind of faculty or community of astronomers within ESO. They are instrumental in maintaining and strengthening the ties to the community we serve and ensuring that our facilities are designed, maintained and operated with the objective to achieve excellence in astronomy within the available resources. To ensure that these objectives are achieved we have created a Visiting Committee of distinguished Senior Astronomers under the chairmanship of Prof. George Miley and with membership from ESO member states and other nations. This committee reviews ESO activities every two years and reports on its effectiveness to the ESO Executive and to the Council.

Relations with Chile and states not members of ESO

Of great concern in the past few years have been our relations with the Chilean Government, Chilean astronomers and Chilean staff. The main issues at hand were guaranteed access to ESO facilities by Chilean astronomers, regulations affecting the local staff and the issue of ownership of the land surrounding the Paranal peak (some 72.000 square kilometers) which had been donated to ESO by the Chilean Government in 1988.

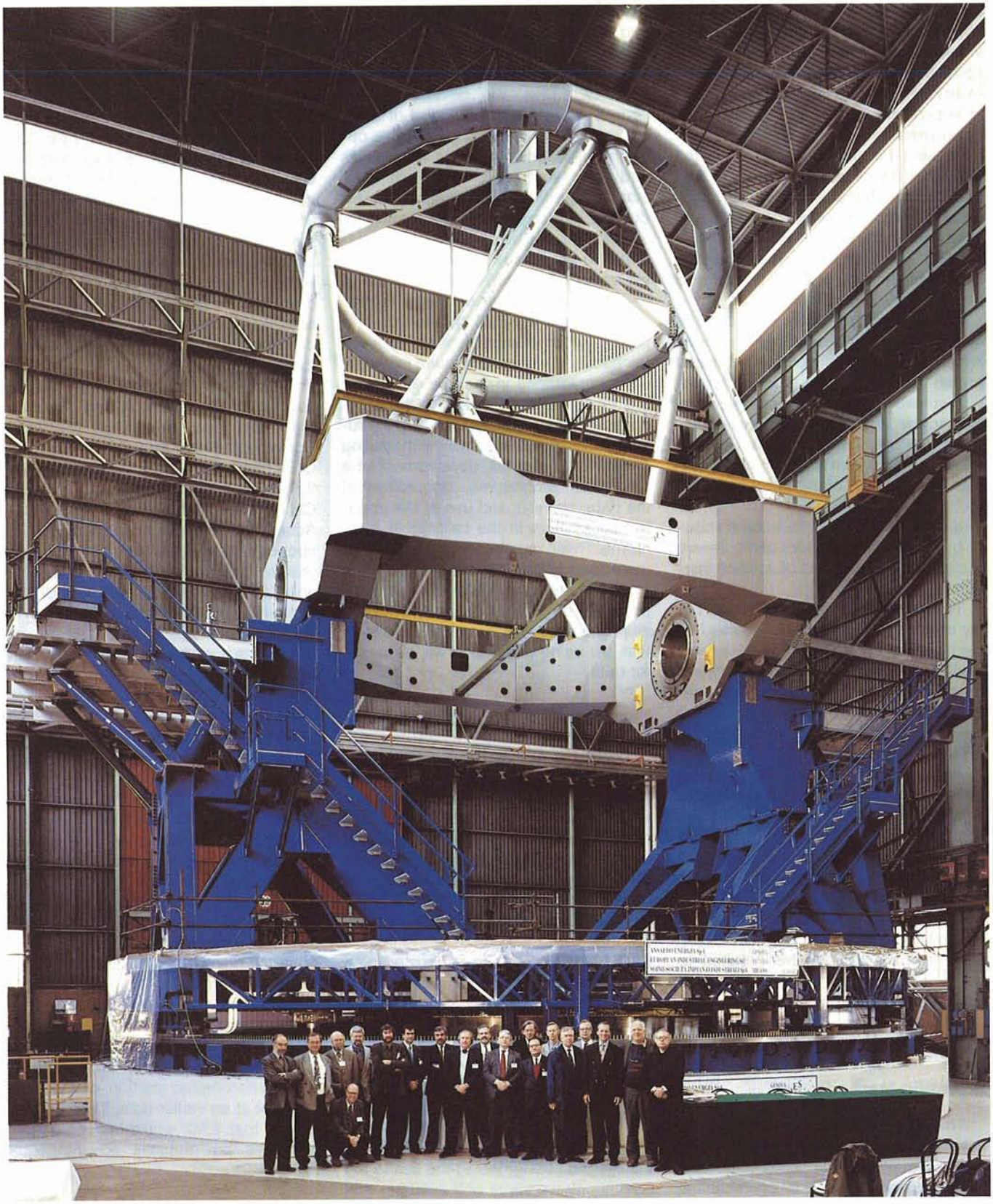
All of these issues are on the way to successful resolution. A new Acuerdo modifying and extending the 1963 Convention with the Government of Chile has been signed in April 1995 by the Director General of ESO and the Chilean Minister for Foreign Affairs. This Acuerdo foresees a greater degree of cooperation with Chilean astronomers, grants 10 % guaranteed time to meritorious Chilean projects and introduces elements of Chilean labour legislation in the local staff rules of ESO. The Acuerdo awaits ratification by the Chilean Parliament and the ESO Council which are expected in the near future. The issue of the ownership of the land has been resolved by the Chilean Government which has agreed to indemnify the claimants.

Astronomers from other European nations have expressed an interest in having their nations join ESO. Portugal has expressed a desire to join ESO in the year 2000. Currently Portuguese representatives participate as observers on all ESO committees. Discussions have taken place with astronomers from Austria, Spain and in the last year with a non-European nation, namely Australia. New members would expand the range of interests and skills brought to bear on ESO's initiatives, and their contribution would improve the opportunity to realize the interferometric portion of the programme at an earlier date. Thus it is fair to say that ESO would welcome new members on mutually advantageous terms.

ESO in the context of European Astronomy

Finally, let us consider the role ESO is carrying out at present and extrapolate to the future.

Without question the most important task facing ESO in the near future is the proper utilization of the VLT and VLTI. This implies, in my opinion, several things:



Photograph taken on 28 November 1995 showing the ESO Council members in front of the mechanical structure of one of the VLT 8.2-metre unit telescopes, now being assembled at the Ansaldo factory in Milan (Italy). The structure stands about 24 metres tall and protrudes another 5 metres below the floor. The telescope mounting consists of a blue platform which rotates on circular tracks, and a silver open structure (the „telescope tube"). When the photo was taken, the cell that supports the main telescope mirror of 8.2 metres in diameter had not yet been installed at the bottom end of that structure. The total weight of the moving parts is about 430 tonnes.

The ESO Council delegates (from left to right) are: Philippe Brossier (France), Bernard Fort (France), Bengt Gustafsson (Sweden), Johannes Andersen (kneeling, Chairman STC, Denmark), Joachim Krautter (Chairman OPC, Germany), Edwin L. van Dessel (Belgium), Stephane Berthet (Switzerland), Jean-Pierre Swings (Vice-President, Belgium), Peter Creola (President, Switzerland), Emil A.A.M. Broesterhuizen (The Netherlands), Riccardo Giacconi (ESO Director General), Dietmar Reimers (Germany), Guglielmo Castro (Italy), Poul E. Nissen (Denmark), Gerhard Bachmann (ESO Head of Administration), Gustav Tammann (Switzerland), Arno Freytag (Germany), Franco Pacini (Italy) and Francesco Bello (Observer, Portugal).

a) First a strong community of users. While the education and training of a new generation of astronomers is mainly the task of the member states, it is clear that ESO can help by furnishing opportunity for training and research to students and young postdoctoral fellows.

b) Second a commitment to support efficient operations. We have seen with NTT how important it is to properly commission and maintain sophisticated telescopes and instruments in order to obtain high scientific efficiency. We are working now to ensure that we will have a complete science verification, commissioning and maintenance programme prior to the VLT entering into operations.

c) The construction of new instruments. There are 16 possible focal plane instrument stations at the four 8 m telescopes. At the beginning 4 instruments will be completed and commissioned and 2 more will be in an advanced state of completion. If we were to provide 2 new instruments per year, the oldest instrument would be 15 years old at the building of the 16th instrument. Since ESO itself could certainly not provide more than a small fraction of this work, it is clear that much will have to be done by astronomical institutions in the member states to ensure that VLT will use front-line instruments.

d) The reduction and analysis of the data by the original observer must be made as effective as possible. ESO will support default options for calibration and reduction of the data which will guarantee a minimum set precision. ESO will also take responsibility for the archiving and distribution of the data to the community for additional research.

While the above activities will require a very considerable effort, it is also clear that attention needs be given to other sources of data on astronomical objects in a wide range of wavelengths. For this purpose we carry out a number of cooperative programmes with the European Space Agency (ESA) and the Space Telescope Science Institute (STScI).

The European Coordinating Facilities (ECF) is a joint ESA-ESO institution operated by ESO to manage the European participation in the use of the Hubble Space Telescope (HST). It has carried out its tasks with a high level of expertise which has resulted for instance in a joint successful development with STScI of the HST archival system. This expertise has been placed at the disposal of ESA to support other ESA missions such as ISO and will be fully utilized on VLT. ECF scientists have taken the lead in the scientific proposals for future ESA instruments for HST. It is possible that more extended ESA-ESO cooperative programmes could be undertaken in the future.

In a general way the collaboration between ground based and space observatories should be seen in the light of a modern view of astrophysical research in which the boundaries between specific wavelength domains or techniques are becoming irrelevant to the pursuit of astrophysical knowledge. For instance, there is a great deal of interest in the astrophysical community for the study of the large number of objects which have been or will be discovered from space missions, such as Rosat, ISO, XMM, etc.

In these collaborations ESO's strength resides in its ability to interpret and represent the scientific requirements of the community and to ensure the maximum scientific utilization of the data.

Upon successful completion of the VLT and VLTI, ESO will have developed the managerial, engineering and contractual capability needed to carry out large astronomical programmes in remote locations. Such capability will be unique in Europe. While the main task for the future will be the proper exploitation of VLT and VLTI, we expect that resources will also become available to undertake new major projects that may be advocated by the astronomical community. ESO will strive to continue to provide service to the community with excellence in astronomy as its goal.

The VLT Sequencer[1]

E. ALLAERT, ESO

Introduction

Software designed to control extremely complex equipment like the VLT is unavoidably itself also pretty complex. It contains impressive quantities of procedures, programs, libraries and other sorts of files. And even if from the very beginning a lot of attention is paid to the requirements of flexibility – with all these different instruments – it is difficult to foresee and manage all the possible combinations within monolithic executable programs. And if you want to add a feature to a program or change its behaviour, you have to edit its source code, compile it, link it with the necessary libraries and launch it again (many times just to see that the wrong line of code was modified). This is obviously a time-consuming exercise. Moreover, on top of a solid programming experience, also a profound knowledge of the VLT software structure is required to do that.

Specific user interfaces, which guide the users through the preparation and execution of their observations, already ease the pain offering some flexibility, as they allow the users to choose between various alternatives or to fill out specific values in forms. Still, this approach has its limitations, as changing such a graphical user interface (*GUI*) itself to e.g. add another parameter is again not trivial.

That means there is a real need for more and better tools to glue the basic commands and applications together, offering an easy means to control the VLT and its instruments at a higher level.

The Sequencer

Looking at how any telescope and instrument are operated, it is obvious that many commands are repeated in a certain sequence, sometimes with only slightly different values for the arguments. From an operational point of view, users differ one from the other as each of them repeats his own set of sequential commands. From this fact, the concept of Sequences was defined for the VLT control software; they are any

[1]This is part of a series of regular reports on VLT Control Software, started with issue number 81 of the Messenger (Raffi 1995)