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Re-invigorating the NTT as a New Technology Telescope

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1. Introduction

The justification for building the 3.5-m New Technology Telescope (NTT) went well beyond a mere quantitative increase of the research opportunities for the community after Italy and Switzerland had joined ESO (Woltjer 1980): with the NTT ESO wished to demonstrate the feasibility of the technological and conceptual breakthrough which is required for the transition from conventional telescopes to the Very Large Telescope (VLT).

Already at first light, the viability of the active optics principle and the benefits of a very compact enclosure were impressively confirmed (Wilson 1989) with an effective image quality of 0.33 arcsec. Comparison with the measurements obtained with the differential seeing monitor (DIMM2) on Vizcachas and La Silla shows that the probability of encountering such a good seeing even in the excellent period of 1988–1990 hardly ever exceeded 1–2 % for one-hour averages (Sarazin 1990). The fact that the exposure times at first light were as short as 10 seconds (the instrument rotator was not yet installed) may, therefore, have helped (see also Sarazin 1989). The legend insists in any case that the coincidence of first light and the birthday of the father of the active optics concept, Ray Wilson, were instrumental for this early success.

It has often been remarked that after the commissioning period the NTT apparently never fully repeated this early performance. However, it deserves to be noted that since the end of 1990 the average seeing recorded with DIMM2 kept deteriorating until the middle of 1993 when a dramatic improvement started which still has not levelled off. The most recent data are fully comparable to the 1988–1990 La Silla data and the Paranal measurements (Sarazin 1994). A more detailed report by Marc Sarazin will appear in one of the next issues of *The Messenger.* Moreover, preliminary analysis of 6 nights worth of SUSI observations in January 1994, during which DIMM2 measured an external seeing (averaged over the actual duration of the individual SUSI exposures) of 0.65 $\pm$ 0.15 arcsec, indicates that, if anything, the NTT delivered slightly better images than predicted by DIMM2.

In any event, sufficiently many excellent observations have been obtained to raise the expectations of the observers community substantially above the traditional level. However, these hopes have often been disappointed. The specific technical reasons are diverse but often relate to a lack of reliability. With the benefit of hindsight it is obvious today that the commissioning period of the NTT was too short and the complexity of the NTT and its subsystem requires more attention than corresponds merely to the increase in the number of telescopes on La Silla from eleven to a dozen.

The potential of the NTT in preparing for the VLT was re-emphasized by J. Schwarz acting as an external adviser to the Director General. Starting in August

1993, ESO has therefore performed a detailed analysis of the present status of the NTT and various strategies for improvements. With the support and encouragement of the ESO committees concerned and the Working Group Scientific Priorities for La Silla, a concerted effort is now being undertaken to more fully exploit the potential of the NTT, in the interest of its own users as well as of the VLT.

2. Objectives of an NTT Upgrade

From the above it is clear that the most immediate objective must be to stabilize the performance of the NTT. Once this has been achieved, better use should be made of the NTT in preparation for the operation of the VLT. This leads to objectives Nos. 2 and 3, namely to test the VLT control system and to verify the VLT operations concept with the NTT.

To achieve the latter goals will not be inexpensive. However, any major teething problems of the VLT will be incomparably more costly. The NTT is the only ESO telescope which provides a suitable platform for these efforts because in many ways it anticipates VLT concepts. Although implemention of the VLT control system and operations plan are not required from a pure NTT point of view, it is also clear that the *technical realization* of the present NTT control system does not offer much of an option for gradual but significant upgrades. For instance, only complete replacement of the computer hardware will give the NTT a new long-term perspective.

These three objectives will be pursued in three consecutive phases, I, II, and III.

3. Phases of Implementation

For technical reasons, we start with the constraints which define the beginning of Phase II: Much of the justification for upgrading the NTT control system derives from the expected feedback into the version to be installed at the VLT. Accordingly, the NTT schedule is determined by the timetable for the VLT. Since the very first tests of the Telescope Control Software (TCS) should not be performed with a working telescope, the original plan foresaw that the NTT would only see build 2 of the TCS after build 1 had been thoroughly checked during the European assembly of the mechanical structure of unit telescope No. 1 in Milan. With the current schedule of the Milan tests extending into the first weeks of 1996 but no delay of first light, a more closely interleaved test pattern will have to be developed. The other constraint is that in order to have a profound effect on the actual VLT control system, full installation at the NTT should commence as early as possible. This will be in late 1995.

This Phase II will last for about one year. During the first 4–6 months, the installation will not permit any scientific observations to be carried out. Thereafter the plan foresees observations only in service mode. The reason is that only in this way the two most important and apparently conflicting requirements can be fulfilled, namely to let the telescope produce scientific data at the earliest possible moment and to give the technical staff enough time to fully re-commission the telescope. Service observers can more easily cope with temporary, varying, and not properly documented operating conditions. Flexible scheduling can ensure that always the technically most suitable and scientifically most important programmes are carried out.

Phase I covers the period between now and the beginning of Phase II. Its primary aim is to stabilize the performance of the NTT. This will mainly be done by introducing a more rigorous operations model of which more continuous monitoring of the performance will be an essential component. Substantial technical improvements are not foreseen. The emphasis will rather be on robustness, transparency, and quantitative accountability. If major repairs should turn out to be necessary, it will in each case be considered whether a lower loss of scientific opportunities would be incurred if they were postponed until Phase II. Clearly, the preparation of Phase II will continue throughout Phase I.

Finally, during Phase III also the model for operation of the VLT, which is due for the Council meeting in December 1994, should be tested and implemented step by step. In this way, the NTT would logically become the first (fifth) unit telescope of the VLT and serve as a training camp for future VLT operations staff.

Phases I and II have been approved, their implementation is proceeding. The discussion of Phase III will continue during the preparation of the VLT Operations Plan.

4. Operational Framework

The main organizational measure taken has been to form a dedicated team which as of April 1, 1994 will be put in full charge of the NTT. On La Silla, this NTT Team currently comprises 2 software (PG and RR), 1 electronics (DG), and 1 opto-mechanics (PhG) engineer as well as two astronomers (GM [also in charge of the local coordination on La Silla] and JS). In Garching, we so far have one software engineer (AW – software group leader and responsible for re-building the control system) and one astronomer (DB – project scientist). Vacancy notices for one astronomer each at both sites have been published recently. This edition of the *Messenger* contains the advertisement of a post-doctoral fellowship position which is to be re-filled at the end of 1994. Furthermore, two more software engineers will be recruited soon. They will start their work in Garching but for Phase II be transferred to La Silla together with one current member of the VLT software group (Eric Allaert) in Garching. Finally, the NTT Team is happy that Edmond Giraud was given the opportunity to take leave of absence from the Observatoire de Marseille in order to return to La Silla for one year and to work with the NTT Team until its scientific staff complement is complete.

In the domains of electronics, opto-mechanics, and all stand-by services, the above staffing level is far from being sufficient to fully cover all needs of the NTT. Areas such as detectors, maintenance and construction, wiring, mechanics, computer networking, etc., are not all represented on the NTT Team. This is intended because full self-sufficiency would not be a realistic goal if the costs are to be affordable. Therefore, the daily operation of the NTT will continue to rely strongly on the support by numerous technical services on La Silla, especially the Operations Group. On a rotating schedule, a fixed number of night assistants will maintain close familiarity with the NTT. In fact, the most fundamental role of the NTT Team will be to integrate a broad spectrum of expertise into one joint concept. Especially a stronger unification of ESO-Chile and ESO-Garching will have pilot character also for the operation of the VLT. The adequacy of the present staffing level will be carefully monitored and, if necessary, further adjusted.

At least during Phase I, the operation of IRSPEC will not be directly integrated into the responsibilities of the NTT Team. Since the Infrared Team is generally acknowledged to function well, the chances of immediate improvements are relatively minor whereas the price to be paid for a discontinuity could be non-negligible. This approach is, of course, made easier by the present lack of concrete plans for the upgrading (or even replacement) of IRSPEC.

5. Phase I

Because of their large number, we here only list the activities in extreme brevity:

- Perform complete inventory of problems and assets.
- Complete commissioning of NTT and accomplish transfer of know-how to NTT Team.
- Establish automatic operation of active optics system as default mode; use ~ 80 % of light from guide star for continuous image analysis and telescope autofocussing. Make results more transparent to users; perform automatic quality and plausibility checks.
- In addition to the La Silla site monitor, use second guide probe in Nasmyth station B (EMMI) for independent image quality monitoring and log NTT dome-internal meteorological conditions. The objective is to identify constellations which significantly compromise the effective NTT seeing. A prototype of the VLT enclosure management system will be developed for the NTT in order to actively minimize degradation.
- Introduce regular computer system management (back-ups, configuration control, load monitoring, etc.).
- Perhaps upgrade CPU of NTT computer; if unavoidable ditto for operating system. The present workload of the NTT computer runs at a level of 60 % of its capacity. This had for a while been seen as one possible reason for one or more of the real-time nodes (altitude axis, azimuth axis, and rotator) often losing synchronization with the NTT computer. However, since September 1993 this problem has essentially vanished after a bug in the recovery procedure had been discovered and corrected.
- Install computer-based problem tracking system for reporting by users, follow-up by maintenance staff, and as a source of recipes for future problems.
- Document limiting performance of telescope and instruments. Comparison of actual results against these reference data will enable early recognition of anomalies as well as false alarms.
- Regularly measure key characteristics of CCD detectors. Provide simplified procedures for checks also by Visiting Astronomers.
- Step by step identify areas in need of regular preventive maintenance.
- Introduce procedures towards putting soft- and hardware under strict configuration control.
- Continue remote observing from Garching at modest level. This observing mode had a rather successful start (Balestra et al. 1993, Baade et al. 1993) and helps to ensure that the La Silla and Garching view of the NTT do not differ too widely.
- Extend scope of MIDAS Data Organizer (Péron et al. 1994) to on-line applications in order to better support quality and health control of the data sets acquired.
- Enhance logging of normal telescope and instrument operations and unscheduled events. Use database to measure observing efficiency (later compare old and new control system), identify possible problems and design solutions (for instance, in this way it was possible to track down a problem in the CCD control software which caused the data to be irrecoverably lost in about 1 % of all cases).
- Perform several field tests of individual components of the new control system (cf. Section Phase II). Always return to the old system.

Most of these activities have started already. Obviously, they rely in many cases strongly on the active support and always on the advice by other groups and individuals at ESO.

To the above list have to be added the routine support of Visiting Astronomers and the rescue operations in case of acute failures. However, the ultimate purpose of many of the above measures is, of course, that the incidence and severity of open crises and latent problems will be significantly reduced.

6. Phase II

That the development of a new NTT control system according to VLT standards is at all affordable, is due to the modular, layered design of the VLT control software which foresees a large proportion of shared general-purpose utilities (Raffi 1992). The NTT effort, then, largely consists in implementing the NTT specific applications on top of this lower-level software. This work has been broken down into 19 work components. They closely follow the schedule according to which the VLT software is being written. At the same time, they provide an additional corset to that timetable and via the advanced field tests with the NTT some extra check points of the products.

The first two tests are scheduled for May 1994 and comprise the VLT Local Control Unit (LCU) common software in stand-alone mode and embedded in the VLT Central Control Software (CCS), respectively. The first application will be the control of the NTT building. In an analogous fashion, work component 3 concerns secondary and tertiary mirror of the NTT and will take place in September 1994.

One of the central work components is the control software for EMMI. It plays a special role also in so far as it has been taken on by the software group on La Silla (G. Andreoni and R. Schmutzer are the main responsibles). This is a major contribution of the La Silla observatory in the framework of the VLT development. Although the support of the latter cannot at this phase be a significant responsibility of La Silla, it is, on the other hand, important that all ESO sites share the same technical and methodological standards. The EMMI work component is one more step into this direction.

Important improvements are expected from the replacement of the present ISIT TV cameras with VLT technical CCD cameras. Higher effective sensitivity, lesser non-linearity, larger dynamical range come to everyone's mind as expected improvements. At least as important appears the resulting potential of direct digital signal processing which will, for instance by automatic detection and centring of sources, noticeably enhance the observing efficiency. – Also for the scientific CCDs the VLT CCD controller will be installed, thereby closing another feedback loop prior to the coming into operation of the VLT.

For selected observing modes, for instance imaging through frequently used standard filters and grism spectroscopy, an attempt will be made to maintain an on-line calibration database. When combined with automatic data reduction procedures, this will permit the observer a quantitative on-line quality control. Although publication quality may in many cases not be a realistic goal, quick and objective quality control is of course of central importance in the case of service observing.

A close companion of service observing will be flexible scheduling. Among the possible operations features which are presently being discussed for the VLT, this couple clearly marks the most drastic deviation from the standard model for ground-based observatories. Promising though the theoretical supporting arguments are, without prior practical tests and quantitative measurements the risk might be inacceptably high.

7. Phase III

The goal of this period will be to establish a VLT-like operations model. In order to obtain meaningful feedback about it, it is essential that the hardware be changed as little as possible. For a while this may also mean the exclusion of visitor instruments. Possible upgrades which might be considered include the replacement of IRSPEC (which was first installed at the 3.6-m telescope in 1985 and in Phase III will be rather old given the ever accelerating

evolution of IR technology) and rapid tip-tilt guiding with M3 (the solution adopted by the Italian *Galileo* project) or M2 (borrowing from the VLT concept). Because of its commonalities with the VLT, the NTT will provide optimal training opportunities for VLT operations staff both in Chile and Garching.

8. Further Sources of Information

The NTT Team will do its best to support prospective applicants for observing time as well as actual observers. An updated edition of the EMMI/SUSI users manual will soon become available. A completely revised version is expected to be ready for the September 30 deadline and will be accessible also via anonymous ftp and under Xmosaic.

News too recent for inclusion into manuals will be posted in the dedicated usenet newsgroup eso.visas.ntt. For the time being, this newsgroup will not be exported. Any messages posted can be read only after logging onto the captive account esobb on the ESO computers (Internet address: 134.171.8.4 or ftphost.hq.eso.org).

Any additional inquiries we request to be e-mailed to the dedicated NTT account (ntt@eso.org on Internet or ESO::NTT on SPAN). Because of the time difference between Europe and Chile, the weekly shift system on La Silla, and duty trips or vacations of NTT staff members, this is the only way to make sure that your message is processed within the shortest possible time.

9. User Feedback

No service can be expected to be better than the constructive criticism which it receives from its clients. The NTT is no exception. On the contrary, the numerous tasks and the very tight schedule will make insufficiencies unavoidable. Your echo will help us to find the right course more quickly. Every NTT Team member will be happy to accept and forward your suggestions. A particularly efficient communication channel may again be the NTT account mentioned before.

10. Acknowledgements

As explained above, the NTT Team has been conceived such as to always depend substantially on the support by numerous staff in virtually all departments at both La Silla and Garching. We have already seen many examples that this concept is a viable one and take this opportunity to cordially thank all colleagues concerned. Since all of them are already very busy with the VLT or the other La Silla telescopes, their help should not be taken for granted. The expectation is that eventually the experience with the NTT will pay some dividend also for them.

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