Mem. S.A.It. Suppl. Vol. 19, 393


**Memorie** della
**Supplementi**

# VST: the telescope progress toward stars

P. Schipani[1], M. Capaccioli[2], S. D'Orsi[2], C. Marcozzi[2], L. Marty[2], G. De Paris[3], D. Fierro[3], C. Arcidiacono[4], J. Farinato[4], D. Magrin[4], R. Ragazzoni[4], G. Umbriaco[5], M. Brescia[1], C. Molfese[1], F. Perrotta[1] and L. Ferragina[2]

[1] Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, I-80131 Napoli, Italy
[2] Istituto Nazionale di Astrofisica – VSTCeN, Salita Moiariello 16, I-80131 Napoli, Italy
[3] Istituto Nazionale di Astrofisica – Sede Centrale, Viale del Parco Mellini 84, I-00136, Roma, Italy
[4] Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, I-35122, Padova, Italy
[5] Universitá degli Studi di Padova, Vicolo dell'Osservatorio 3, I-35122 Padova, Italy

**Abstract.** The VST telescope is in an advanced stage of integration in Chile, after a period of work spent mainly on the active optics system, started in mid-2007. We present the results of the recent work on the primary and secondary mirror support systems and on the mirror cell auxiliary units.

**Key words.** Telescopes – Active Optics

## 1. Introduction

The VST is a remarkable challenge for the Italian astronomical community: indeed it is the largest instrumental project realized by Italian-only research institutes for the European Southern Observatory (ESO), a very demanding customer being the organization which builds and operates the best ground-based telescopes worldwide; also, it is the first active optics medium-large telescope designed from scratch in Italy, not based on partial replicas of other existing telescopes. In 2007 the telescope mount, as well as the tracking system Schipani et al. (2008a), were considered by ESO at a sufficient readiness level to be shipped to Chile, where later they were reintegrated and tested. Despite this positive achievement, in the same year the Critical Design Review (CDR) of the primary and secondary mirror systems with ESO was largely unsuccessful, with the exception of some parts, triggering major changes in the project. The key problem identified by the reviewers was a considerable lack of system engineering in the project, which made unfruitful the efforts on the single subsystems, despite the investments and the previous industrial involvement. Therefore, starting from mid-2007 the primary and secondary mirror support systems were reviewed at a system engineering level by INAF very deeply, with a renewed organization. This revision had to be done pragmatically, within time and budget constraints that demanded to recycle as much as possible the existing parts.

*Send offprint requests to*: P. Schipani

This produced an unusual situation, where the non trivial redesign of the active optics system was further complicated by the boundary conditions set by the comprehensible push to save as much as possible the investements already done, and by the schedule. This new phase of work, although faced by an engineering team much smaller than ideally needed for such a large and complex endeavour, was successful: all the parts of the telescope still in Italy received the green light to be shipped to Chile. It took a bit less than two years, including manufacturing and tests.

## 2. Active optics: primary mirror support and safety system

The telescope error budget was revisited Schipani & Perrotta (2008a) and the concept of the primary mirror support and safety system (Fig. 1) was redesigned Schipani et al. (2010a), considering both performance and maintenance operations. The support system design, the control software Schipani et al. (2010d) and electronics Molfese et al. (2008a,b) were updated by INAF while the new mechanical parts were designed by Tomelleri srl under INAF requirements and supervision. The earthquake safety system has been designed in a common effort coordinated by INAF, that performed the analysis jointly with BCV srl and with the support from ESO Perrotta & Schipani (2010), while the mechanical design was committed to Tomelleri srl. In early 2009 the system was considered ready to be shipped jointly by INAF and ESO, but unfortunately a serious damage during the transportation caused a supplementary year of work in Italy, which has positively terminated with successful system tests on April, 2010 Schipani et al. (2010c). The damage shifted the schedule of the overall project exactly by one year, causing a new manufacturing and qualification test of the whole system and also of extremely critical (for their function and poor accessibility) components of the telescope, i.e. the custom made primary mirror supports. This came to be not just a mere repetition of the work previously done: the replacement of some obsolescent commercial components with nominally identical parts, caused unexpected problems that were solved with changes in the control system.

**Fig. 1.** The primary mirror system and two of the authors just before the shipment of the cell to Chile, at the end of a test session at Tomelleri srl premises (April, 2010).

## 3. Active optics: secondary mirror support system

The concept of the secondary mirror support system was also significantly updated and simplified by INAF Schipani et al. (2008b): reliability and performance were much improved. The mechanics was refurbished by ADS International srl, while the control part was shared between the legs electronics (ADS) and the Local Control Unit (INAF); the hardware was basically replaced in order to adhere as much as possible to the ESO standards. INAF wrote a new control software replacing the old one, suddenly obsolete because of the new hardware Schipani et al. (2010b). At the end of 2008 the secondary mirror support system (Fig. 2) was successfully tested at system

**Fig. 2.** The hexapod under test on a tilting device at ADS International srl premises (November, 2008).

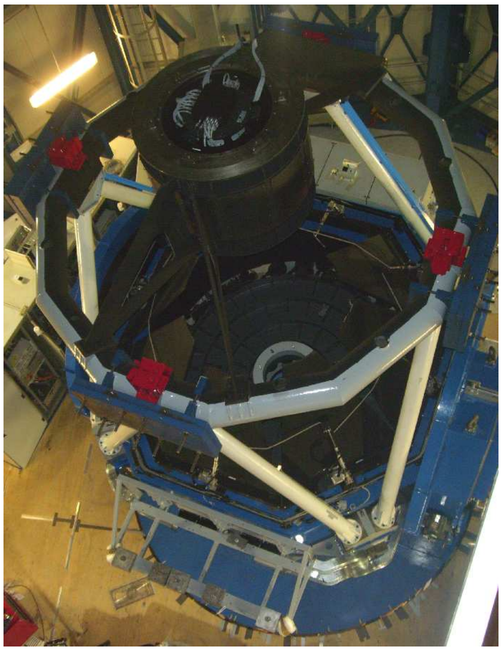

**Fig. 3.** The telescope during the integration in Chile (September, 2010). The hexapod is installed on the top ring; the primary mirror dummy is visible within the cell.

level by INAF and ADS in Italy Schipani et al. (2010e), and then shipped to Chile, where in early 2009 has been installed at the telescope and tested on site: a residual sporadic problem was carefully pointed out and removed by a firmware update.

## 4. Auxiliary units

With a few months of hard work in early 2009, the auxiliary units (adapter/rotator, probe with wavefront sensor, Atmospheric Dispersion Corrector) were also refurbished in the electromechanical parts, and completed in the optics and wavefront sensor, by an INAF team, with the industrial support of Tomelleri srl Farinato et al. (2010); Schipani et al. (2010f). The significant improvements led to the shipment to Chile in mid-2009. Afterward the units have been assembled on site, where the optical alignments have been checked and tuned, the detectors system has been made operational, and the electro-mechanical parts have been tested, driven by the control system. Several unexpected problems, due to the interfaces between hardware parts never jointly available before, have been solved on site, working sometimes harder than expected.

## 5. And more!

Meanwhile, many other activities were carried out. The telescope control software was improved and tested in real mode for all the modules not requiring sky images, and in simulation mode for the remaining parts, taking benefit also from the VLT control model facility at ESO headquarters. A cabling plan was carefully studied and then executed during the integration. Some parts of the cooling system were necessarily revisited because the old design did not fulfil all the real needs. The active optics operating model was studied in details, the wavefront sensing was simulated, optomechanical integrated analysis were performed Schipani & Perrotta (2008b); Perrotta & Schipani (2008), etc. Also, there has been

**Fig. 4.** The primary mirror cell integrated in the telescope (September, 2010). In the bottom part the guide probe is visible, as well as the technical CCDs controllers and the co-rotator control cabinet.

an increasing interaction with the OmegaCAM team, facing several interface problems and establishing a fruitful collaboration.

Last but not least, being an active optics telescope both a scientific instrument and a very complex plant, an infinite number of much less noble activities were performed, too modest to be mentioned but however time consuming! All the steps described here were periodically agreed and monitored by ESO, that has always been available to support the recovery efforts. The remaining part of integration of the whole telescope, and its commissioning, will still need a hard work, but the path toward stars has been recovered and we are going to see the (first) light.

## 6. Status

While this paper is being written (September, 2010) the integration of the telescope at Cerro Paranal has arrived at an advanced stage (Fig. 3, Fig. 4). The cooling system, one of the last parts, is going to be delivered. The mirrors are aluminized and are going to be integrated and aligned in the telescope in the next few months. After the end of the integration phase, the commissioning of the telescope and of the camera will finally start.

*Acknowledgements.* The first author wishes to thank the team members, whose working load has increased continuously in the last years (because many former team members do not work anymore to the project, including several authors of this paper). Special thanks go to the non permanent staff people who are fully committed to the project, despite this does not give them clear perspectives.

## References

Farinato, J., et al. 2010, Proc. SPIE, 7733, 773359
Molfese, C., et al. 2008a, Proc. SPIE, 7019, 701927
Molfese, C., et al. 2008b, Proc. SPIE, 7019, 701926
Perrotta, F., & Schipani, P. 2008, Proc. SPIE, 7017, 70171R
Perrotta, F., & Schipani, P. 2010, Proc. SPIE, 7738, 773820
Schipani, P., et al. 2008a, Proc. SPIE, 7018, 701844
Schipani, P., et al. 2008b, Proc. SPIE, 7018, 701845
Schipani, P., et al. 2010a, Appl. Opt., 49, 1234
Schipani, P., et al. 2010b, Appl. Opt., 49, 3199
Schipani, P., et al. 2010c, Proc. SPIE, 7739, 773931
Schipani, P., et al. 2010d, Proc. SPIE, 7740, 774037
Schipani, P., et al. 2010e, Proc. SPIE, 7739, 773932
Schipani, P., et al. 2010f, Proc. SPIE, 7739, 773948
Schipani, P., & Perrotta, F. 2008a, Proc. SPIE, 7017, 70171H
Schipani, P., & Perrotta, F. 2008b, Proc. SPIE, 7017, 70171K