ESO and AMOS Signed Contract for the VLTI Auxiliary Telescopes

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The company AMOS (Liège, Belgium) has been awarded, last June, an ESO contract for the delivery of the Auxiliary Telescopes (ATs) of the Very Large Telescope Interferometer (VLTI). Each of these telescopes has a main mirror of 1.8-metre diameter. They move on rail tracks on the top of the Paranal mountain. Together with the main 8.2-m VLT Unit Telescopes (UTs), they will ensure that the VLTI will have unequalled sensitivity and image sharpness that will allow front-line astronomical observations.

This contract was signed for the design, manufacturing and testing in Europe of two ATs and of the full set of on-site equipment for the 30 AT observing stations. An option for a third Auxiliary Telescope is also part of the contract. The delivery in Europe of the first AT is planned for June 2001 and the first observations with the first two ATs at Paranal are planned for early 2002.

More details can be found at: http://www.eso.org/outreach/press-rel/pr-1998/phot-25-98.html

The photo of a 1/20 scale model built by AMOS in response to the call for tender illustrates the main conceptual features of the VLTI Auxiliary Telescopes. The 1.8-m telescope (with an Alt-Az mount, i.e. exactly like the Unit Telescopes) is shown here in observing conditions. It is rigidly anchored to the ground by means of a special interface. The light is directed via a series of mirrors to the bottom of the telescope from where it is sent on to the underground delay line tunnel. The AT Enclosure consists of segments and is here fully open. During observation, it protects the lower part of the telescope structure from strong winds. The Enclosure is supported by the transporter (the blue square structure) that also houses electronic cabinets and service modules (the grey boxes) for liquid cooling, air conditioning (the red pipes), auxiliary power, compressed air, etc., making the telescope fully autonomous. When the telescope needs to be relocated on another observing station, the transporter performs all the necessary actions such as lifting the telescope, closing the station lid (the white octagon), translating the telescope along the rails, etc. The complete relocation process will take less than 3 hours and shall not require re-alignment other than those performed remotely from the control room at the beginning of the next observation.

UT1 Passes “With Honour” the First Severe Stability Tests for VLTI

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1. Introduction

Over the past years, a significant effort has been put in verifying and improving the capability of the VLT Unit Telescope (UT) to reach the very demanding Optical Path Length (OPL) stability at the nanometer level, as required by the VLT Interferometer (VLTI). Up to now, this has been done primarily by analysis using detailed Finite Element Models with inputs from dedicated measurement campaigns such as the characterisation of micro-seismic activity at Paranal [1], [2], vibration tests on IR instruments closed-cycle coolers and pumps [3], as well as tests at subsystem level on the M2 unit, on the enclosure, on the telescope structure equipped with dummy mirrors, etc. [4].

With the commissioning of the first VLT telescope at Paranal, time has come to directly measure the dynamic stability of the 8-m telescopes in real operational conditions.

A dedicated commissioning task was undertaken on July 23–30 to monitor the mirror vibrations with highly sensitive accelerometers. A brief summary of the results is presented here.

2. Measurement Set-up

The measurement equipment consisted of eight high-sensitivity accelerometers (Wilcoxon 731A) connected to two digital acquisition units (DSPT SigLab 20-42) controlled from a PC running Matlab.

The accelerometers were placed as follows:

4 accelerometers attached at the outer edge of the primary mirror M1 sensing motion along the optical axis. The signals are averaged to obtain an estimate of the M1 axial displacement (piston).

1 accelerometer inside the M2 unit monitoring the motion of the mirror along the optical axis.

1 accelerometer on the M4 arm of the Nasmyth Adapter–Rotator sensing the motion along the normal of the future M4 mirror.

1 accelerometer on the M5 unit attachment flange sensing the motion along the normal of the future M5 mirror.

1 accelerometer on the M6 unit attachment flange sensing the motion along the normal of the future M6 mirror.

Post-processing was done using dedicated routines written in Matlab.

3. Main Results

Figure 1 shows the fringe visibility loss resulting from the mirror vibrations in various operational conditions and for three different observing wavelengths: visible (0.6 μm), near infrared (2.2 μm) and thermal infrared (10 μm). The VLTI error budgets call for a 1% visibility loss due to vibrations inside the telescope for any of these observing wavelengths. This corresponds respectively to an OPL variation of 14, 50 and 215 nanometers r.m.s.

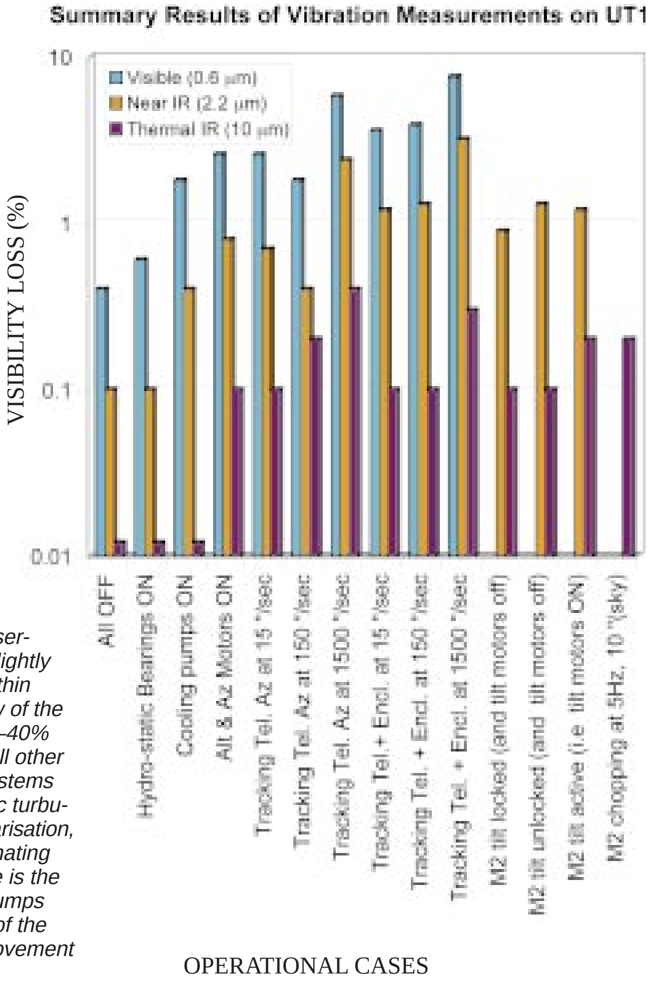

Figure 1: Summary of the results from vibration test on UT1 for VLTI application. The graph shows the total visibility loss due to mirror vibrations inside UT1 for three observing wavelengths (visible, near IR, thermal IR) and various operational conditions. The VLTI error budgets ask for a 1% visibility loss due to vibration inside the telescope. This corresponds to an OPL variation of 14, 50 and 215 nanometers r.m.s. for the three wavelengths respectively. This requirement is achieved in most cases for the IR ranges. For observation in the visible it is slightly exceeded but remains within acceptable margin in view of the global visibility loss of 30–40% which is aimed at when all other error sources and sub-systems are included (atmospheric turbulence, figuring errors, polarisation, delay lines, etc.). A dominating disturbance for the visible is the vibration of the cooling pumps located in the basement of the enclosure for which improvement can easily be achieved.

over 10, 48 and 290 msec for the three wavelength bands.

The left-most case marked *"All OFF"* on Figure 1 shows the results when basically all sub-systems of the telescope are switched off. It represents the contributions of the background environment noise. It is well below the 1% level for all wavelengths.

The second case shows the influence of the altitude and azimuth Hydro-Static Bearing System (HBS). The insignificant impact of the HBS is one of the most comforting results of these tests, since it was still largely unknown and potentially important, as indicated from results on other existing telescopes. The credit goes to the use of screw-type pumps, a good isolation of the pumps and careful overall design.

On the other hand, the third case shows a significant impact, for observation in the visible, of the liquid-cooling pumps located in the basement of the enclosure. It has been checked that these vibrations are mainly transmitted to the telescope through the ground and telescope pier and not through the distribution pipes fixed on the telescope structure. Here, easy improvement is possible by better isolation between the pumps and the ground and between the pipes and the telescope pier.

The next case shows a slight influence (especially at 10 µm, i.e. low-frequency disturbance) of the altitude and azimuth motors' noise. The exact origin of this low-frequency disturbance is still not fully understood but it will very likely improve when the bandwidth of the axis control will be increased to its nominal value.

From the tests performed during tracking of the telescope, we can conclude that the associated disturbance remains acceptable for IR wavelengths and remains dominated by the cooling pumps for the visible except for the highest speed of 1500″/sec which corresponds however to the quite exceptional case of observing at 0.5° from the zenith.

The next cases during which the enclosure was also tracking evidence a slight deterioration both for visible and near IR. Improvement in this area is possible by a better tuning of the enclosure rotation mechanism which, at the present stage, still produces audible noise.

The last cases shown concern the use of the M2 tip-tilt and chopping capabilities for interferometric observations in the Near IR (for atmospheric tip-tilt correction) and thermal IR (for background subtraction) respectively. It was originally planned to use smaller and lighter mirrors in the coudé train to perform these functions for VLTI because of the high OPL stability requirements. Tests on the M2 at Dornier in November 1997 [4] had shown, however, that the outstanding axial stability of the M2 during tilt and chopping should be good enough to use it for VLTI. The results presented here confirm this preliminary conclusion. Tip-tilt correction and chopping can be done with M2 for VLTI observation in the near IR and thermal IR, respectively.

Other sub-systems were also positively tested as to their impact on the OPL stability such as active optics during a typical correction, operation of louvers and windscreens, fans and transformers in electronic cabinets, etc. In this last category, it is worth mentioning the following anecdote. The first set of measurement was constantly showing a much-too-high visibility loss of typically 40% in the visible and 5% in the thermal IR. After extensive investigations, it was found to be caused by two cooling fans located in the electronic cabinets of the Test Camera attached at the Cassegrain focus. Contrary to most of the other cabinets, these are not vibration isolated due to the temporary nature of this first-light instrument. These small fans were able to excite the "pumping" mode of the 80-ton telescope tube at 40 Hz creating about 90 nm rms over 10 msec and 500 nm rms over 290 msec. This shows the importance of a careful design down to that level of detail.

Conclusion

Although these tests cannot be considered as the final ones since several mirrors were not yet installed (M3 and coudé train), they confirm the very strong potential of the VLT 8-m telescope to fulfil the very stringent stability requirement imposed by VLTI. Indeed, they show that the global vibration of the overall structure remains within an acceptable range. Any future problems which could appear should be of a local nature (e.g. resonance of a given coudé mirror cell) and therefore more easy to solve by appropriate local damping or stiffening. These tests also enabled us to identify, at an early stage, a number of possible improvements such as better isolation of the cooling pumps in the enclosure basement, stiffening of the M4 arm and improvement of the enclosure rotation smoothness.

References

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