EUROPEAN ORGANISATION FOR ASTRONOMICAL RESEARCH IN THE SOUTHERN HEMISPHERE

For Information

Council

135th Meeting
Lisbon, 10 and 11 June 2015

Paranal Instrumentation Programme 6 Monthly Progress Report

March 2015

This document is for ESO INTERNAL USE

Council is requested to note this report
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Executive Summary

KMOS has been in operation since October 2013. The two last remaining problems were the vacuum tightness and the arm reliability. Both issues were solved during the last six months and PAC was granted at the beginning of 2015.

After successful commissioning and science verification, MUSE was offered to the community for observation in Period 94, starting in October 2014. A few items (variable RON in some of the 24 detectors, long-term stability) required some short and long term interventions and monitoring, which brought excellent results. The open items towards PAE are being actively followed up.

Similarly, SPHERE is installed at Nasmyth A of UT3 and has successfully completed four commissioning runs and science verification, demonstrating excellent performance. SPHERE has been offered to the community for observation in Period 95, starting in April 2015. One mode of operation (DMI) is not offered, but will be commissioned soon.

The Adaptive Optics Facility (AOF) has completed the two phases of system tests for the GRAAL module: natural guide star adaptive optics mode and ground layer adaptive optics mode. The GRAAL PAE is scheduled in April 2015. GALACSI is being installed on ASSIST and this module system test will last until end of 2015. The first Laser Guide Star Unit of the 4LGSF was shipped to Paranal and is being re-integrated on site before installation on the telescope. Later this year the LGSU#1 and GRAAL will be interfaced and used together for preliminary laser guide star acquisition tests on-sky. The UT4 upgrade has been completed and the final acceptance report has been produced. By April 2015, the AOF project will have concluded five reviews within five months, a very intense pace that maintained the project aligned with its schedule.

ESPERRESSO passed the Δ-FDR; the first components have been assembled in Paranal and in Europe. The echelle grating received is on the low side of the specifications and possibilities to replace it are explored.

A new consortium to build ERIS is being formed. It is led by MPE and includes ETH, INAF-Arcetri, ESO and negotiations for an additional partner are ongoing. A new simplified technical concept is being developed in order to ensure the arrival of ERIS at the telescope on a fast schedule.

After signing the agreement with ESO, the MOONS kick-off meeting took place in October 2014 and the project is now in its preliminary design phase. This includes prototyping of the new fibre positioner.

4MOST is on its way to reach agreement signature. After closing of Phase A, a common understanding of the operational concept between ESO and the Consortium has been reached. This includes the consolidation of project organisation and funding and the clarification of the interfaces with the VISTA Telescope.
In order to improve the coherence of the upcoming interventions in Paranal and to implement important lessons learned from PRIMA, the various VLTI infrastructure projects have been reorganised under the VLTI Facility project. The transformation of VLTI in preparation of the arrival of the second-generation instruments GRAVITY and MATISSE has just started: while VLTI is shutdown during Period 95 (April – September 2015), the AT array and the VLTI laboratory are being upgraded. This work will be completed in time for a reopening in Period 96 (starting in October 2015), and the beginning of the GRAVITY commissioning with the ATs. Similar work on the UTs will be completed in time for Period 97 (starting in April 2016) and the GRAVITY commissioning on the UTs. NAOMI, the adaptive optics for the ATs, is ready for its May 2015 PDR, while negotiating a partnership with the Institut de Planétologie et d’Astrophysique (IPAG) in Grenoble. The Second Generation Fringe Tracker project, impacted by resource restrictions, is considering the use of the GRAVITY fringe tracker in support of MATISSE as a short-term solution.

The GRAVITY Beam Combiner Instrument (BCI) is currently undergoing the PAE process and will be integrated in the VLTI laboratory in the third quarter of 2015. A three-way metrology was successfully implemented to solve issues resulting from a high background that was induced by backscattering of the laser in the guide optics. Integration work on the IR AO systems is continuing at MPIA in Heidelberg.

MATISSE, the other second-generation VLTI instrument, is under manufacture and integration. The tests of the LM band cryostat are progressing, the warm optics are being integrated and interfaces with the VLTI infrastructure are finalized.

A turn-key Laser Frequency Comb (LFC) system has been procured from Menlo Systems GmbH, to feed the HARPS instrument. The LFC will be interfaced with the HARPS calibration unit and will improve the performance of HARPS, making the contribution of the wavelength calibration to the radial velocity error budget negligible. This will be the first Laser Frequency Comb facility installed at a high precision spectrograph dedicated mainly to the detection of extra-solar planets. The HARPS LFC was shipped to La Silla and will be commissioned in April.
1. Financial Status

The VLT March 2015 Financial Status is given in Table 1. Its breakdown follows the main elements of the VLTI Facility Project as listed in the LTP and the upgrade of UT4 to an Adaptive Telescope (AOF). Financial contributions from individual Member States and institutions, amounting to 11 470 kEUR (see ESO/Cou-935 rev. Add., dated 21.05.2004), are included implicitly in the Cost to Completion amount. The related GTO is 379 VISA nights. Additional contributions of 950 kEUR by MPE (ESO/Cou-994, dated 24.11.2004) and of 945 kEUR by the University of Cologne (ESO/Cou-1099, dated 24.05.2006) will be compensated by GTO of 38 UT nights.

Table 1: Financial Summary – VLT Infrastructure.

<table>
<thead>
<tr>
<th>VLT Infrastructure</th>
<th>Cost to Completion (k€)</th>
<th>Commitments (k€)</th>
<th>Invoiced (k€)</th>
<th>ESO FTEs (Planned)</th>
<th>Cost of ESO FTEs (Planned) (k€)</th>
<th>ESO FTEs (Actual)</th>
<th>Cost of ESO FTEs (Actual) (k€)</th>
<th>Guaranteed Time Observing (Nights) VISA / UT</th>
<th>Consortium Furnished Equipment (k€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLTI Facility Project</td>
<td>74 652</td>
<td>73 950</td>
<td>72 806</td>
<td>331.23</td>
<td>32 355</td>
<td>352.51</td>
<td>34 402</td>
<td>208 / 180</td>
<td>4 420</td>
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<tr>
<td>AOF *</td>
<td>21 293</td>
<td>20 336</td>
<td>19 060</td>
<td>116.60</td>
<td>12 253</td>
<td>148.79</td>
<td>17 089</td>
<td>0 / 30</td>
<td>597</td>
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<td>TOTAL</td>
<td>95 945</td>
<td>94 286</td>
<td>91 866</td>
<td>447.83</td>
<td>44 608</td>
<td>501.30</td>
<td>51 491</td>
<td>208 / 210</td>
<td>5 017</td>
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</table>

(*) AOF is funded by the EC in the amount of 680 k€ (Ref.: OPTICON Contract No. RI13-CT-2004-001566 dated 26 April 2004)

Remark to Guaranteed Time Observing: VISA nights are any number of ATs. UT nights are individual UTs, i.e., 60 UT nights convert into 30 nights on 2 UTs or 20 nights on 3 UTs. Following approval of Council at its 134th meeting in Leiden (ESO/Cou-1591 and ESO/Cou-1592 public), the 217 VISA nights originally awarded for PRIMA were converted to 120 UT nights. The grand total of VISA nights is now 587. The grand total of UT nights is 248 and comprises 38 UT nights for financial contributions and 90 UT nights for consortium furnished equipment and FTEs plus 120 nights for PRIMA compensation.
Detailed information for the major instruments with an approved ESO Cost to Completion exceeding the amount of 1 MEUR is given in Table 2.

Table 2: Financial Summary - 2nd Generation and New VLT Instruments.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cost to Completion (k€)</th>
<th>Commitments (k€)</th>
<th>Invoiced (k€)</th>
<th>ESO FTEs (Planned)</th>
<th>Cost of ESO FTEs (Planned) (k€)</th>
<th>ESO FTEs (Actual)</th>
<th>Cost of ESO FTEs (Actual) (k€)</th>
<th>Guaranteed Time Observing (Observing Nights) UT / (VISA)</th>
<th>Consortium Furnished Equipment (k€)</th>
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<tr>
<td>KMOS</td>
<td>5 350</td>
<td>5 519</td>
<td>5 384</td>
<td>13.40</td>
<td>1 316</td>
<td>15.39</td>
<td>1 639</td>
<td>250</td>
<td>2 276</td>
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<tr>
<td>MUSE</td>
<td>6 900</td>
<td>7 022</td>
<td>6 902</td>
<td>26.35</td>
<td>2 685</td>
<td>36.14</td>
<td>3 846</td>
<td>225</td>
<td>1 750</td>
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<tr>
<td>SPHERE *</td>
<td>6 550</td>
<td>5 045</td>
<td>4 899</td>
<td>12.25</td>
<td>1 267</td>
<td>20.37</td>
<td>2 438</td>
<td>260</td>
<td>2 750</td>
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<tr>
<td>ESPRESSO</td>
<td>4 095</td>
<td>3 248</td>
<td>1 765</td>
<td>21.15</td>
<td>2 689</td>
<td>20.08</td>
<td>2 468</td>
<td>273</td>
<td>4 776</td>
</tr>
<tr>
<td>MATISSE</td>
<td>1 300</td>
<td>1 358</td>
<td>1 322</td>
<td>20.77</td>
<td>2 344</td>
<td>17.17</td>
<td>2063</td>
<td>150 / (173)</td>
<td>3 125</td>
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<tr>
<td>GRAVITY</td>
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<td>1 094</td>
<td>1 073</td>
<td>15.67</td>
<td>1 962</td>
<td>18.32</td>
<td>2 278</td>
<td>273 / (157)</td>
<td>6 963</td>
</tr>
<tr>
<td>ERIS</td>
<td>2 615</td>
<td>736</td>
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<td>49.80</td>
<td>6 602</td>
<td>11.84</td>
<td>1 528</td>
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<td>MOONS</td>
<td>6 200</td>
<td>567</td>
<td>86</td>
<td>9.30</td>
<td>1 236</td>
<td>1.51</td>
<td>193</td>
<td>298</td>
<td>3 700</td>
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<td>4MOST</td>
<td>5 200</td>
<td>6</td>
<td>5</td>
<td>23.45</td>
<td>3 117</td>
<td>2.75</td>
<td>363</td>
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<td>GRAND TOTAL</td>
<td><strong>39 233</strong></td>
<td><strong>24 595</strong></td>
<td><strong>21 715</strong></td>
<td><strong>192.14</strong></td>
<td><strong>23 218</strong></td>
<td><strong>143.57</strong></td>
<td><strong>16 815</strong></td>
<td><strong>1 729/(330)</strong></td>
<td><strong>25 340</strong></td>
</tr>
</tbody>
</table>

(*) SPHERE is funded by the EC in the amount of 900 k€ (Ref.: OPTICON Contract No. RII3-CT-2004-001566 dated 26 April 2004)
2. **Schedule**

The key project milestones for the VLT infrastructure and the major instruments are given in Tables 3 and 4.

Table 3: Schedule Overview - VLT Infrastructure

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<td>▼ PAC STS (UT) #1-4</td>
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<td>PAC STS (AT)#1&amp;2</td>
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<td>PAC DDLs #5&amp;6</td>
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<td>▼ PAC DDLs #1-6</td>
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<td>▼ Start NAOMI</td>
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<td>AT Maintenance Station Start</td>
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<td>AT Maintenance Station complete</td>
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Table 4: Schedule Overview – 2nd Generation and New VLT Instruments

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Note: PAC (MUSE only) ▼ PAC (with AOF)

Schedule Overview:
- 1Q14 ==> 1Q15
- 2Q15 ==> 3Q15
- 4Q14 ==> 1Q15
- 1Q16 ==> 2Q16
- PAC (MUSE only)
- PAC (with AOF)
- PAC (tbd)
3. VLT Infrastructure

3.1 VLTI Facility Project

All the projects related to the VLTI infrastructure are under the umbrella of the VLTI Facility Project which now covers the following sub-projects/activities:

- The construction of a new AT maintenance station.
- The upgrade of the VLTI Laboratory and Control Software to prepare the interface with the GRAVITY and MATISSE instruments.
- The installation of a dual field infrastructure including star separators at the Coudé of the ATs and the UTs, as well as differential delay lines.
- The modifications of the UT Coudé rooms and MACAO (Visible AO) to prepare the arrival of CIAO (Infraed AO), as part of the GRAVITY project.
- The development of NAOMI, a visible AO system for the ATs, designed to improve the overall performance of VLTI in median and poor seeing conditions, and enable robust fringe tracking with the ATs.
- The development of a Second Generation Fringe Tracker to support all VLTI instruments, both on-axis and off-axis.
- The improvement of the VLTI infrastructure performance, by means of an investigation programme, with the objective of supporting the performance requirements of the second generation instruments MATISSE and GRAVITY.

Even though the GRAVITY and MATISSE instruments are independent projects, the VLTI Facility Project addresses scheduling and system issues related to the integration of these two instruments into the VLTI infrastructure.

3.1.1 VLTI Overview, Management and System Engineering

A Statement of Work and a management plan have been produced for the VLTI Facility Project and are under review by the Paranal Instrumentation Programme. The schedule, with a specific emphasis on the Paranal interventions, has been defined and implemented in Open Plan. The requested manpower has been consolidated. Advising the VLTI Facility Project, a VLTI Office has been created, including key members involved in Garching with the VLTI Infrastructure, GRAVITY and MATISSE projects, and in Paranal with operations, and system engineering. A Change Control Board, with an oversight on the changes requested on Paranal by not only the infrastructure upgrade but also the GRAVITY and MATISSE project, has been implemented and started meeting once per month. The majority of the change requests related to GRAVITY have been approved, in support of its on-going PAE process. A VLTI-wide risk register has been implemented and will be integrated into the project reporting process. Finally, all communication tools (PDM Document Server, JIRA issue tracker, mailing lists, newsletter) are in place, in order to efficiently transform VLTI over the next two to three years.

Starting in March 2015, the VLTI has been shut down for seven months, in order to prepare for the arrival of GRAVITY and MATISSE. The two main objectives of the VLTI Facility project
are to deliver the four ATs upgraded with star-separators in time for the return in operation and the commissioning of GRAVITY in Period 96 (October 2015 – March 2016), and to deliver the UTs upgraded with star-separators for the GRAVITY commissioning on the UTs in Period 97 (April 2016 – September 2016).

3.1.2 AT Maintenance Station

The construction of the AT service station is well under way. Despite some delays, it has reached a state where it can be used for the upcoming AT upgrades. A number of installations and repairs need to be completed before the final acceptance of the station.

3.1.3 VLTI Laboratory, Combined Coudé and Control Software Upgrade

With the VLTI shut down at the beginning of March, the laboratory and combined Coudé overhauls are under way, ahead of the arrival of GRAVITY and MATISSE. New electrical and network distribution systems are being implemented. Hardware for cooling, cryogenics, vacuum, and false floor are being procured. Only the feeding opto-mechanics are still in a design phase. An upgrade is under way to align the control software of all VLTI subs-systems to VLTSW2014 release, except AMBER. It takes into account the removal of MIDI and the move of PIONIER to a new location in the interferometric laboratory. In addition, the modernization of the reflective memory network (RMN), the real-time backbone of VLTI, is being completed, ahead of its extension when GRAVITY arrives at Paranal.

3.1.4 Auxiliary Telescopes and Star Separators

The project is ready to install STSs on AT1 and AT2 (they were already installed by PRIMA on AT3 and AT4). On all four ATs, new Technical CCDs (acquisition cameras), STRAPs (visible tip/tilt sensors), and Variable Curvature Mirrors (VCMs) with over-pressure chambers, have been procured/manufactured and are ready to be installed. These operations will be completed before the integration of the GRAVITY Beam Combiner in the VLTI laboratory in September 2015. Their first use by GRAVITY is expected in October 2015.

In addition, due to a much-degraded transmission of the AT Coudé train, a Call for Tender is being prepared for the replacement of its optics, an operation which is envisioned in 2017.

3.1.5 Unit Telescopes, Coudé Rooms, MACAOs and Star Separators

The design for the UT outer Coudé rooms upgrade is now complete and only the design of the Coudé rooms themselves is still ongoing. A contract for the implementation of the cooling in the outer ring of the UTs 1 to 3 has been signed (note: UT4 has already been implemented as part of the AOF upgrade). The procurement for the cryogenic lines and pumps is under way. The production of the new service contact point (SCP) towers has started. New cabinets expected to host the MACAO and Star Separators electronics have been manufactured and are being shipped to Paranal. Already performed on UT3&4, the upgrades of the MACAO RTCs will be extended to UT1&2 in the coming months, along with the upgrade of the deformable mirrors drive electronics and APD counter boards on UTs 1 to 4. These MACAO activities, addressing obsolescence issues and supporting the arrival of CIAO, should be
completed by the time the VLTI reopens. With a current focus on the Star Separators of the ATs, no significant progress is reported for those on the UTs, since the successful interferometric verification of the partly installed star separators on UT1 and UT3 in July 2014.

### 3.1.6 NAOMI

Due to limited resources at ESO, the project looked for community partners. After a Call for tender to institutes, contacts with the Institut de Planétologie et d’Astrophysique de Grenoble (IPAG) have been established. IPAG is interested in joining the project as a partner or consortium member. The project will be developed and led by ESO in collaboration with the possible partner IPAG for the corrective optics development and integration of three AO systems after the commissioning of a first system in Paranal. This system will be initially built and optimized by ESO. In March, a proposal was received from IPAG and is under review. If the proposal is accepted, ESO will take over the hardware cost and expenditures of the IPAG contributions and IPAG will provide manpower compensated by GTO time on the ATs.

In order to be able to chop with the NAOMI Corrective Optics, the chopping stroke requirement has been reduced, to a level that still meets the MATISSE requirements. Top-level requirements have been updated accordingly. The Corrective Optics concept, a critical item for the project, consists now of a commercially available ALPAO deformable mirror mounted on a 5 degrees of freedom quasi-static mount, paired with a standard ALPAO DM controller.

All interface electronic boards between the ALPAO controller and the real time computer have been prototyped at ESO. The operation and calibration strategy is being updated according to the design changes including the operation of the Corrective Optics.

While the design of the NAOMI test bench is advancing, lab space in the new technical building is being prepared to receive it. Prototyping the NAOMI wavefront sensor, streams of real-time pixel data from the Andor camera, via a modified AONGC CCD controller, have been streamed to the SPARTA Light Real Time Control platform. The setup has been installed in the NAOMI lab.

All design work of the Preliminary Design phase of NAOMI has been completed and the review itself is scheduled in May. The current timeline foresees FDR in the fourth quarter 2015 and shipment of the first system to Paranal in the third quarter 2017.

### 3.1.7 Second Generation Fringe Tracker

In collaboration with the MATISSE consortium, a feasibility study was authorised in 2014 investigating the possibility of using GRAVITY’s internal fringe tracker for MATISSE.

The MATISSE consortium, on a shorter time-scale, studied which key science objectives of MATISSE can be achieved at which performance levels of a fringe tracker: the fringe tracker of GRAVITY could significantly increase the target space observable with MATISSE, but may not enable all the original science cases of MATISSE, mainly due to limited sensitivity.
An ESO report has been produced and complements the aforementioned findings of the MATISSE consortium by a detailed discussion about technical and managerial aspects. Using GRAVITY as a fringe tracking facility for MATISSE is feasible. In addition to fringe tracking, MATISSE could also benefit from GRAVITY’s pupil and image guiding system. The effort for the realization of GRAVITY for MATISSE is estimated to be moderate and the involved risks for all stakeholders manageable. The Phase A review will be held soon.

3.1.8 Infrastructure Performance Investigations

The instantaneous Strehl improvements of using the UTs without powering on the secondary mirrors have been validated on sky. This mode of operation is now a standard for the VLTI-UT runs. The MACAO real-time controllers upgrades on UT4 and UT3 respectively in October and December 2014 have been validated on sky. They show a significant performance improvement for bright objects due to an increase in control bandwidth (loop rate from 420 Hz to 1050 Hz) and the implementation of vibration rejection algorithms.

Technical time had been requested in February 2015 to obtain a new VLTI performance baseline following these changes but was mostly lost due to high wind and poor seeing conditions. Both UT and MACAO improvements have been advertised in the P96 Call for Proposal, but without specific limiting magnitude numbers. MACAO investigations have progressed and seem to indicate that a characterization of the deformable mirrors influence functions needs to be performed, something also needed for the integration of CIAO.

Fringe tracking datasets collected in Paranal, with some of the performance improvements mentioned above in place, are being used to qualify the GRAVITY fringe tracker before its Preliminary Acceptance Europe. This should help decide on the usefulness of a still undecided vibration metrology.

3.2 AOF (Adaptive Optics Facility)

The Adaptive Optics Facility (AOF) is an ESO development to upgrade UT4 to an Adaptive Telescope. A ‘telescope simulator’ called ASSIST for the end to end testing in Europe has been contracted to the University of Leiden and funded by NOVA. The AOF comprises a new M2-Unit hosting a Deformable Secondary Mirror (DSM) with 1170 actuators, four Laser Guide Stars (4 x 20 W Sodium beacons) launched from the telescope centrepiece and two wavefront sensor systems (GALACSI and GRAAL) to provide users with optimised adaptive modes with the HAWK-I and MUSE instruments. This effort is also a pathfinder towards the E-ELT design.

The AOF project set ambitious goals last year in order to bring systems to Paranal and keep them on schedule. Five project reviews have been held or are in preparation since November:

1. The Operation Review was held in Vitacura in November. The review presented an operation concept for the AOF, the usual instrument related documents, (GRAAL/HAWK-I: observation preparation, ETC, templates definition etc.) and the status of the Laser Traffic Control Software and Astronomical Site Monitoring Upgrade. The reception was positive, valuable inputs were recorded by the design team and the review was granted.
2. The 4LGSF team worked intensively before year-end to complete the tests of the first Laser Guide Star Unit and prepare the relevant documentation. In February, a review was held to reassure that the unit is ready for shipment to Paranal and installation on UT4. The review was granted and the board appreciated the thorough tests and characterization of the system fully documented with the package delivered for the review. At present, a subset of the 4LGSF team is integrating LGSU#1 in Paranal. Tests continue on LGSU#2 in Garching and LGSU#3 is in final stages of integration/alignment.

3. The Full Assembly Test review of the GALACSI adaptive optics module was held in February. Mostly test reports were provided plus an extensive CIDL providing an accurate snapshot of the documentation status of the project. The test reports show a sound system with reproducible behaviour, fulfilling specifications. Actions were recorded and a summary of the board findings has been prepared. The GALACSI system can proceed with the system test phase until end of 2015.

4. The Astronomical Site Monitoring Upgrade has completed its design phase. This integrates the new installed tower with MASS and DIMM, the recently paranalised SLODAR, a new database, server and new displays to visualize the data. A review will be held in April to coordinate with Paranal staff and review the last implementation plans before to proceed. The documentation package has been uploaded already on the PDM system. After the April implementation in Paranal the old and new ASM infrastructure will run in parallel for a given period to allow comparison of the data and ensure a smooth switch over to the new system.

5. The GRAAL PAE has been launched in early 2015 for a review meeting scheduled in April. The system has completed the system tests with all specifications fulfilled and performance matching expectations. The test reports were provided and a complete as-built design package has been uploaded on the ESO PDM system. The AOF project is confident that GRAAL AO module is ready for shipment to the observatory, a topic that will be the subject to the PAE review. A review plan has been defined for the AOF PAE of which the present review represents the first instalment of a series of three. The scope has been agreed to encompass the whole AOF system aspects in the individual reviews (GRAAL-GALACSI and 4LGSF).

The UT4 infrastructure upgrade has been completed and the final acceptance report has been released.

The commissioning activities have been triggered by the reviews quoted previously and the shipment of systems to Paranal that followed them. The Laser Guide Star unit is being integrated and installed on UT4 for sky tests in May 2015. In July 2015, the GRAAL module will be re-integrated and later installed on UT4 for combined tests with LGSU#1 in August 2015. The operations are being coordinated by the Paranal AOF system responsible and two staff members from Garching who have now taken up duty in Chile to accompany the shift of activities to Chile. This should ensure a smooth transition to the commissioning phase of the AOF systems.
The supplier (SAFRAN-REOSC) has successfully repaired the spare thin shell and Microgate/ADS (DSM supplier) is now integrating the shell with coatings and magnets. It is also envisioned to launch a maintenance contract with Microgate for the DSM. This would support the remaining system tests in Garching and later the operation in Paranal.

The Laser Pointing Camera developed by the Observatory of Rome has been delivered and is being tested in Garching. In May it will be delivered to Paranal for installation on UT4.

All four units of the Lasers for the 4LGSF have been delivered and accepted. The spare unit will undergo acceptance testing soon and a maintenance contract has been negotiated with TOPTICA in order to support the remaining tests in Europe and the installed system in Paranal.

4. **VLT Instrument Status**

4.1 **Instruments in Operation**

X-shooter, FORS, KMOS, UVES, FLAMES, VIMOS, SINFONI, MUSE NACO, SPHERE, VISIR and HAWK-I are in science operations on the VLT on Paranal. SPHERE has replaced ISAAC and NACO uses the focus of CRIRES, which was shipped to Garching to be upgraded. The VLTI is closed for preparing the infrastructure to host GRAVITY and MATISSE. AMBER will be re-installed and MIDI will be decommissioned.

On La Silla, SOFI and EFOSC2 are operated at the NTT, HARPS at the 3.6m. A Call for Proposal for a new NTT instrument has been issued. Five proposals for new instruments have been received and are in the process of being evaluated.

4.2 **Instrument Upgrades**

The shortcomings of the VISIR 1k x 1k Si:As Aquarius arrays (a new development at Raytheon funded by ESO) and its root cause, which was diagnosed by ESO experts using Garching laboratory facilities, have been described previously. Since the observed excess low frequency noise (ELFN) is inherent to the design of the device, which had been optimized for operations in a low background environment, it cannot be remedied without a new detector design. Faster chopping with the VLT’s secondary (M2) has been identified as the best available mitigation option. Following extensive analysis and testing, an improved M2 field stabilization control loop taking advantage of the frame transfer capability of the new technical CCD has been implemented and commissioned at UT3 (Cassegrain focus). It provides for chopping frequencies up to 5 Hz. A problem with the controller of the NTCCD was resolved by replacing the hardware.

The commissioning team has successfully conducted three commissioning runs so far. The basic templates for acquisition and observing with VISIR have been updated and are functional. The synchronisation algorithm between NGC and templates has been implemented and results in clean chop-nod images for all read-out modes. The behaviour of the sensitivity as a function of frequency and filter bandwidth is in line with expectations based on previous
laboratory and on-sky testing. Hence chopping works as mitigation measure for the major shortcoming (ELFN) of the detector. On-sky performance has been demonstrated showing equal or better sensitivity than the old VISIR; for spectroscopy at 10 μm a gain of a factor >6 is realised in observing efficiency. The new science modes (coronagraphy and sparse aperture mask) have been partially commissioned with good preliminary performance results. During a final commissioning run in early April, the remaining work on the observing templates will be done and VISIR is expected to be ready for science operations thereafter. Additional effort will be required to optimise the calibration of the UT, which shows some imperfect behaviour having a negative impact on VISIR image quality.

VISIR will resume science operations with imaging and low and high-resolution spectroscopy in Period 95 (starting in April 2015) and further modes will be released after commissioning.

The ESO contribution to CRIRES+ has resumed end of October 2014. The project team prepared the documentation for PDR, which is scheduled for end of April. The instrument team proposed a FDR on the optical design and optical components in parallel with PDR in order to save time on the procurement of long lead-time optical components. Accordingly, all documents have been prepared.

The CRIRES instrument is currently being reassembled in Garching in the new integration hall. It is foreseen to rebuild the instrument in its current status and to re-measure the throughput of the entire instrument before upgrading to CRIRES+.

A set of six RGL gratings was delivered in October. The collaboration with the PTB Berlin was continued and a setup was designed to measure the absolute efficiency of each grating at its respective operating wavelength. It is planned to have first results in time for the review meeting to complement the optical FDR report.

The warm part of CRIRES has been received in Garching and the damage is almost fully analysed. Once this investigation is complete, a recovery plan will be issued. The recovery of the warm part and the MACAO refurbishment form a new work package and the required resources have been requested. In addition, the CRIRES+ project includes also the refurbishment of the AO system overcoming its obsolescence (calibration slide, high voltage amplifier, counter board, Real Time Computer, recoating of the relay optics). As this is already planned for the MACAO VLTI systems, the CRIRES MACAO system will be refurbished in a similar manner.

In addition to the data set required for PDR and optical FDR, which define the baseline concept of CRIRES+ for the PDR review, the project has carried out several trade-off studies to help understanding and presenting further concepts for the instrument. These studies are not concepts for PDR but conclude how the project should evolve towards FDR. They include the use of etalons and linear polarimeters, fixed positions for the echelle grating as well as the cross dispersion elements.
4.3 Instruments in PAE or Commissioning

4.3.1 KMOS

KMOS is an infrared 0.9-2.5µm spectrograph providing a resolving power ~ 3500 and offering multi-object capability using ~ 24 deployable IFUs with pixels of 0.2" and FoV of ~ 2x2". The instrument was offered to the community starting in October 2013.

The instrument has been in operation since October 2013. The two last remaining problems were the vacuum tightness and the arm reliability. Both issues were solved during the last six months. The vacuum level has been nominal since the last fixing in September 2014. In February, the linear bearings of all arms were exchanged and a re-commissioning of the arms took place beginning of March.

During this re-commissioning, the calibration of the arm position on-sky was determined. The arm flexure and repeatability was measured to be comfortably within specifications at better than +/-1 pixel. Throughput of each channel after the optical realignment of the arms is as high as before. All science modes of the instrument were tested and KMOS is now back to operations.

Parallel to this last activity, the PAC was granted by the Head of Paranal Instrumentation Programme in agreement with the Director of LPO. The opportunity was taken to congratulate the KMOS consortium for the quality of the work performed and the excellent cooperation that was established between the Consortium and ESO over the last ten years.

The guarantee period has now started and will end in January 2017.

4.3.2 MUSE

MUSE is a second-generation Integral Field facility for the VLT. With a FoV of 1x1 arcmin, fine sampling, intermediate spectral resolution (R=3000) and large spectral coverage in the visible, MUSE will also be used with Laser Tomographic Adaptive Optics correction in its narrow field mode.

The instrument started science operations in October 2014. Preliminary feedback from observatory and users is very positive and it is highly demanded by the community. The monitoring of the instrument, the analyses of the data obtained during the commissioning periods and the daily calibrations have given rise to some technical aspects that have required intervention and follow up to understand the instrument behaviour and to maintain its expected high performance. Punctual interventions on the instrument have been agreed and coordinated to avoid impact on the science operations activities:

- A slight evolution of the instrument alignment is present since its installation on the telescope in January 2013. The data analysis shows that, after removal, the thermal effects a global trend on all channels remains, showing a change in their alignment, all
in the same direction but with different amplitude. Four channels were realigned successfully in December 2014 and the instrument continues being monitored.

- For some of the channels, the detector performance showed variations that may impact the long-term quality of the data provided by MUSE. An action plan, coordinating the consortium, ESO Garching and Paranal, was discussed and consolidated. The origins of the issues were found and the corrective actions implemented: Read out Noise variability is being fixed by upgrading detectors preamplifiers to Type III, channel #01 detector has been exchanged to avoid the LED glow detected from time to time with the original detector in this channel and a new set of voltages and clocking patterns are being implemented to improve the subtraction of the bias structure detected in long exposures.

- The vignetting detected during PAE in NFM, and confirmed after reintegration at Paranal, has been analysed and an intervention was scheduled to carry out the realignment. As this alignment has an impact on the performance of the IRLOS (GALACSI InfraRed Low Order Sensor) port, a plan has been coordinated between the consortium and ESO. The intervention took place successfully in March 2015.

Considering to complete the technical activities, the closure of the remaining action items and the update of the documentation, PAC of MUSE (without AOF) is expected to be in the third quarter 2015. PAC of the MUSE Facility (i.e. MUSE plus AOF) is expected to be in the fourth quarter 2017.

### 4.3.3 SPHERE

The objective of SPHERE is to gain at least one order of magnitude with respect to NACO in the detection/physical analysis of faint objects very close to bright stars, ideally being able to directly detect giant planets. The instrument is designed to sharpen and suppress the light of the star and to study exoplanets via spectral and polarimetric analysis. SPHERE consists of an Extreme Adaptive Optics module (SAXO), a coronagraph, an Infrared Differential Imager and Spectrograph (IRDIS), an infrared Integral Field Spectrograph (IFS) and a differential imaging polarimeter (ZIMPOL).

SPHERE is installed at Nasmyth A of UT3 and is fully operational. The AO performance is excellent with H-band Strehl ratios of about 90% routinely achieved on-sky in good observing conditions. Contrast performance is exceeding expectations. Commissioning data confirms that contrast performances of better than $10^{-6}$ are reached in good conditions. This opens up a new window for the direct imaging of giant extrasolar planets exclusively accessible to SPHERE.

The instrument has completed commissioning and science verifications and started early GTO observations. It is offered for open time observations in Period 95 starting in April 2015. Considering the current list of actions, it is expected to grant PAC in the third quarter of 2015.
5. Second Generation VLT/I Instruments in Development

5.1 GRAVITY

GRAVITY is a second-generation VLTI instrument being developed by a consortium led by MPE (Garching), and including MPIA (Heidelberg), University of Cologne, LESIA (Paris), IPAG (Grenoble), and SIM (Portugal). GRAVITY is a four-way, K-band, beam combiner. GRAVITY will make use of all four 8m Unit Telescopes to measure astrometric separations of objects located within the 2” field-of-view of the VLTI. With the sensitivity of the UTs and 10µas astrometric precision, it will measure orbital motions near the Galactic Centre with an unprecedented precision, sufficient to test predictions of general relativity. Other modes of the instrument include imaging and the use of the 1.8m Auxiliary Telescopes.

The Beam Combiner Instrument (BCI) is currently undergoing the Preliminary Acceptance Europe (PAE) process. A three-beam metrology scheme was integrated into the instrument over the last months. This solved issues related to backscattering of laser light in the guided optical components. Shipping is expected to take place in June 2015, followed by integration in the Paranal integration hall in July/August, and in the VLTI laboratory in September. Gravity will afterwards start commissioning on the ATs. The Coude Infrared Adaptive Optics (CIAO) systems for the UTs are progressing, albeit slower than expected. ESO has recently studied in detail how the CIAOs can be integrated into the existing systems (UT Star Separator and MACAO), aligned, operated, and maintained. This has led to a number of modifications at system level, which are now being implemented. The goal remains to have the first CIAO system ready for integration in UT1 by the end of 2015.

5.2 MATISSE

MATISSE (Multi-Aperture mid-Infrared SpectroScopic Experiment) is a mid-infrared spectro-interferometer, 4-way beam-combiner, designed to be sensitive from the L to the N band. MATISSE’s multi-way combination will provide a capability to create simple images at interferometric resolution of a wide range of targets. It is considered a successor to MIDI, enhancing it in terms of both the number of telescopes and in wavelength coverage. MATISSE is a second-generation VLTI instrument being developed by a consortium led by Observatoire de Cote d’Azur (OCA - Nice) and including MPIfR (Bonn), MPIA (Heidelberg), NOVA (Leiden), ITAP (Kiel) and Universität Wien (Vienna).

The complete MATISSE hardware system is now present at OCA following the arrival of the LM-band cryostat and the corresponding electronics cabinet and NGC system. The final electronics cabinet underwent EMC testing by ESO staff and was found to be fully compliant. Assembly integration and tests of the various subsystems has continued apace and mostly on schedule. The outstanding problem concerning the delivery of compliant cylindrical optics has been successfully resolved, removing one of the most likely causes of delay.

The behaviour of the periscopes has been characterised to allow software correction for tip/tilt drifts occurring during travel. Early tests indicate that the software correction is successful.
Tuning of the cryogenic motors revealed problems with frequent occurrence of following errors. After detailed investigations by ASTRON and ESO engineers, it was found that the errors could be avoided with some mechanical fine-tuning (bearings and spring constants). During the MAIT phase, the situation shall be monitored in case attrition causes the components to degrade and the problem to reoccur.

Many details of the VLTI infrastructure have begun to crystallise: electronics cabinet damping; cable ducts; feed-throughs; false floors; power connections; coolant supply. The MATISSE sections of the “Requirement for the upgrade of the VLTI-Complex infrastructure for 2nd generation instruments” have been updated with input from consortium and ESO engineers.

A draft plan describing a definitive test of the Becker’s pit cover stability and defining criteria that would trigger the implementation of an alternative support structure (that would isolate MATISSE from the cover) has been presented to the consortium and Paranal and is being iterated. A MATISSE pipeline end-to-end dry run was held at ESO with participation from the consortium developers. Several iterations of the pipeline were executed and difficulties and results were discussed.

5.3 High Resolution Ultra-stable Spectrograph (ESPRESSO)

The Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations (ESPRESSO) is a super-stable Optical High Resolution Spectrograph for the Combined Coudé focus of the VLT. It can be operated by either one of the UT or collecting the light from the four UTs simultaneously. ESPRESSO is being developed by a Consortium comprising the Observatoire de Genève, University of Bern, INAF-Trieste and Brera, Instituto de Astrofísica de Canarias, Universidade do Porto and Lisboa and INETI – Lisbon. ESO is a partner in the Consortium and responsible for several work packages (Detector and cryogenic systems, VLT interfaces, Echelle, Cameras and Laser Frequency Comb).

The combined coude laboratory is now ready to host ESPRESSO and the external and the intermediate thermal enclosures are already installed. Work is progressing along the light path to place the coude train interfaces. All optics, spectrograph and coude train, are in the manufacturing phase, and the first subsystems (vacuum vessel, calibration unit) have begun to arrive in the integration hall in Geneva, in preparation for the assembly phase prior to PAE. In February, a Delta-FDR was held, addressing some specific aspects as required by the FDR Board (RAMS, coude train optomechanics, etc.); the FDR milestone was granted pending some actions. The echelle gratings mosaic is assembled but efficiency is at the lower edge of the acceptable range, and corrective measures are being considered. The operation scheme of ESPRESSO is being developed in detail and reviewed internally. The integration readiness meeting will be held in Geneva next May. The schedule is confirmed, with PAE at the end of the first quarter of 2016 and PAC in early 2017.
5.4 Enhanced Resolution Imager and Spectrograph (ERIS)

ERIS is a new instrument for the Cassegrain focus of UT4, consisting of a new diffraction limited IR imager which will replace a set of the most important NACO capabilities, a new AO WFS module (visible NGS, LGS) which will use the AOF deformable secondary mirror and any one of the 4 AOF lasers (one at a time), a modified version of SPIFFI to adapt it to the new AO module.

Following the new strategy for the ERIS procurement reported last time, the ERIS consortium has now formed with MPE as PI institute, and Arcetri Astrophysical Observatory, and ETH Zürich as Co-I institutes. Arcetri will provide the AO WFS system, negotiations are ongoing to ensure an additional partner to lead the construction of the IR imaging camera NIX, and ETH will provide funds for the IR detector. ESO will do the tests of the IR detectors, provide the detector mounts and electronics, and deliver the AO WFS cameras, the RTC, and the handling tool.

SPIFFI will undergo a preliminary upgrade in 2015/16 and then be re-integrated in SINFONI to be available for GC observations in 2016-2019. After that period, SPIFFI will be modified for use in ERIS and integrated with the NIX camera into the ERIS system.

After discussions with all stakeholders, it was decided to reduce the preliminary upgrade of SPIFFI in 2015/16 to the replacement of

- Pre-optics
- Instrument optics (4 mirrors)
- Sky-baffle
- J- and K-band filters incl. filter wheel

Since SINFONI with SPIFFI is an instrument in operation at Paranal, there will be a formal change request to LPO. The preliminary planning foresees January 2016 for the implementation of all changes.

It was also decided to postpone a number of modifications to 2019:

- Replacement of IRACE with NGC
- New Hawaii (H2RG) science detector
- J-K High resolution grating
- New electronics (incl. PLC and cryo control)

Several discussions and meetings on the ERIS concept took place at all levels providing the Consortium with detailed information on ESO’s mechanical and optical design. At the next progress meeting in May, the concept shall be finalised.

Final drafts of the Top-level Requirements, the Statement of Work and the Technical Specifications are under discussion, as well as the Finance Committee document.

In addition to the large progress meetings, regular meetings on a bi-weekly base between the ERIS PI and the ESO core team have been established.
6. New VLT Instruments

6.1 Multi Object Optical and Near infrared Spectrograph (MOONS)

MOONS is proposed as a fibre-fed, multi-object, 0.8 to 1.8 micron spectrograph for the Nasmyth focus at the VLT. Spectral resolving powers of 5000 and 20000 will be available with a capability of simultaneously measuring over 500 targets within the 25 arc minute diameter VLT patrol area. UK-ATC will act as the Consortium lead institute and the PI is M. Cirasuolo. The other members of the consortium are the Observatorio Astronomico de Lisboa (PT), the Observatoire de Paris (F), INAF Arcetri, Bologna and Roma (I), the Pontificia Universidad Católica de Chile (Chile), the University of Cambridge (UK) ETH Zürich, Institute for Astronomy (CH), the University of Geneva (CH) and ESO.

The kick-off meeting was held in October 2014 and PDR is scheduled for September 2015. The MOONS team has been working to develop the instrument, in particular, the definition of the detector specifications, analysis and definition of the calibration strategy, development of the operational concept, improving the optical and mechanical design of the spectrograph and improving the design of the fibre positioner and rotating front end. Prototypes are being developed for the fibre positioner and metrology system.

6.2 4-meter Multi Object Spectroscopic Telescope (4MOST)

4MOST will be a world-class facility for fibre-fed multi-object spectroscopy for the VISTA Telescope. Its unique capabilities result from large field of view (> 3 deg²) spectral resolutions for both galactic and extragalactic applications. The instrument will have a high multiplex with more than 700 low-resolution fibres operating between 400 - 885 nm and more than 700 high-resolution fibres operating in the ranges 393 - 435 nm, 521 - 571 nm and 610 - 675 nm.

In response to comments submitted by ESO after the review of the "M3" (incremental CoDR) documentation package three documents were updated and the Phase A study has now been closed.

The SOW and the Technical Specification (both as draft versions) were submitted to the 4MOST project office. The TRLs have been reviewed further between ESO and the Consortium, with good progress. Science operations are also the subject of ongoing iterations.

The Science Kick-off meeting was held in November in Potsdam. The meeting was very productive and progress was made in defining the structure of the 4MOST Science Organization. Science policies, Survey Management, Infrastructure Working Groups, Calibration and QC were extensively discussed.

The 4MOST Science Coordination Board is now meeting on a monthly basis and Joe Liske has been appointed as the chairman. The Survey Teams are progressing with development of Survey Management plans. Simulation catalogues for the WAVES survey were submitted. A first run of the Facility Simulator with all consortium surveys will be made in the near future.
The new consortium partner, MPIA Heidelberg has taken responsibility for the Instrument Control Electronics. In addition, the Project Office entered into negotiations with other potential partners in an effort to secure further support and funding.

For the detector cryostat cooling system, after careful engineering and programmatic trade-off studies, it was decided to select the standard ESO CFC cooling system. A comprehensive comparative study of the two conceptual designs for the Wide Field Corrector is well underway. The baseline designs for both HR and LR spectrographs have been further refined to gain confidence that requirements can be met.

Productive discussions with ESO regarding the interfaces between the VISTA telescope and the instrument were held. ESO has entered an effort to consolidate the VISTA solid model so that opto-mechanical interfaces can be defined. Furthermore, progress has been made in defining the interface for the guide probes and active optics.

The contractual documentation, Statement of Work and Technical Specification are being prepared for Council approval in June 2015. Thereafter, the agreement between the 4MOST Consortium and ESO shall be prepared for signature. The Letter of Intent has been prepared and agreed already amongst the 4MOST partners.
## 7. Glossary of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>4LGSF</td>
<td>Four sodium Laser Guide Star Facility</td>
</tr>
<tr>
<td>4MOST</td>
<td>4-meter Multi Object Spectroscopic Telescope</td>
</tr>
<tr>
<td>AIT</td>
<td>Assembly Integration and Test</td>
</tr>
<tr>
<td>AMBER</td>
<td>Astronomical Multi-Beam Recombiner Instrument</td>
</tr>
<tr>
<td>AO</td>
<td>Adaptive Optics</td>
</tr>
<tr>
<td>AOF</td>
<td>Adaptive Optics Facility</td>
</tr>
<tr>
<td>ASSIST</td>
<td>Adaptive Secondary Set-up and Instrument Simulator</td>
</tr>
<tr>
<td>AT</td>
<td>Auxiliary Telescope</td>
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<tr>
<td>BCI</td>
<td>Beam Combiner Instrument</td>
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<tr>
<td>CCD</td>
<td>Charge Coupled Device</td>
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<tr>
<td>CONICA</td>
<td>Coude Near Infrared Camera</td>
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<tr>
<td>CRiRES</td>
<td>CRyogenic InfraRed Echelle Spectrograph</td>
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<tr>
<td>CTC</td>
<td>Cost to Completion</td>
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<tr>
<td>DDL</td>
<td>Differential Delay Line</td>
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<tr>
<td>DL</td>
<td>Delay Line</td>
</tr>
<tr>
<td>DRS</td>
<td>Data Reduction Software</td>
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<tr>
<td>DSM</td>
<td>Deformable Secondary Mirror</td>
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<tr>
<td>DIMM</td>
<td>Differential Image Motion Monitor</td>
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<tr>
<td>EFOSC</td>
<td>ESO Faint Object Spectrograph and Camera</td>
</tr>
<tr>
<td>ELT</td>
<td>Extremely Large Telescope</td>
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<tr>
<td>EOPS</td>
<td>ESPRESSO Observation Preparation Software</td>
</tr>
<tr>
<td>ERIS</td>
<td>Enhanced Resolution Imager and Spectrograph</td>
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<tr>
<td>ESPRESSO</td>
<td>Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations</td>
</tr>
<tr>
<td>ESPRI</td>
<td>Exoplanet Search with PRIma</td>
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<tr>
<td>FDR</td>
<td>Final Design Review</td>
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<tr>
<td>FEROS</td>
<td>Fibre-fed Extended Range Optical Spectrograph</td>
</tr>
<tr>
<td>FLAMES</td>
<td>Fibre Large Area Multi Element Spectrograph</td>
</tr>
<tr>
<td>FORS</td>
<td>Focal Reducer Spectrograph</td>
</tr>
<tr>
<td>FoV</td>
<td>Field Of View</td>
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<tr>
<td>FSU</td>
<td>Fringe Sensor Unit</td>
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<tr>
<td>FTE</td>
<td>Full-Time Equivalent</td>
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<tr>
<td>GALACSI</td>
<td>Ground Atmospheric Layer Adaptive Corrector for Spectroscopic Imaging</td>
</tr>
<tr>
<td>GRAAL</td>
<td>Ground layer Adaptive optics Assisted by Laser</td>
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<tr>
<td>GTO</td>
<td>Guaranteed Time Observing</td>
</tr>
<tr>
<td>HARPS</td>
<td>High Accuracy Radial Velocity Planetary Searcher</td>
</tr>
<tr>
<td>HAWK-I</td>
<td>High Acuity Widefield K band Imager</td>
</tr>
<tr>
<td>HODM</td>
<td>High Order Deformable Mirror</td>
</tr>
<tr>
<td>ICE</td>
<td>Instrument Control Electronics</td>
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<tr>
<td>ICS</td>
<td>Instrument Control Software</td>
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<tr>
<td>IFS</td>
<td>Integral Field Spectrograph</td>
</tr>
<tr>
<td>IFU</td>
<td>Integral Field Unit</td>
</tr>
<tr>
<td>IR</td>
<td>Infrared</td>
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<tr>
<td>IRDIS</td>
<td>Infrared Differential Imager and Spectrograph</td>
</tr>
</tbody>
</table>
IRLOS  Infrared Low Order Sensor (GALACSI)
ISAAC  Infrared Spectrometer and Array Cameras
KMOS  K Multi Object Spectrograph
LFC  Laser Frequency Comb
LGSF  Laser Guide Star Facility
LTP  Long Term Plan
MAIT  Manufacturing, Assembly, Integration and Testing
MASS  Multi-Aperture Scintillation Sensor
MATISSE  Multi Aperture mid-Infrared SpectroScopic Experiment
MIDI  Mid-Infrared Interferometric Instrument
MOONS  Multi Object Optical and Near infrared Spectrograph
MUSE  Multi - Unit Spectroscopic Explorer
NACO  NAOS-CONICA
NAOMI  Nasmyth Adaptive Optics for Multi-purpose Instrumentation
NAOS  Nasmyth Adaptive optics System
NIR  Near Infrared
NTT  New Technology Telescope
PAC  Provisional Acceptance Chile
PAE  Preliminary Acceptance Europe
PDM  Product Data Management
PDR  Preliminary Design Review
PI  Principal Investigator
PIONIER  Precision Integrated Optics Near-infrared Imaging ExpeRiment
PRIMA  Phase Referenced Imaging and Micro-arcsecond Astronomy
SAXO  SPHERE Extreme AO System
SINFONI  Spectrograph for INtegral Field Observations in the Near Infrared
SLODAR  Slope Detection and Ranging
SOFI  Son OF Isaac
SPARTA  Standard Platform for Adaptive optics Real Time Applications
SPHERE  Spectro-Polarimetric High-Contrast Exoplanet Research
SPIFFI  SPectrometer for Infrared Faint Field Imaging
STC  ESO Scientific and Technical Committee
STS  Star Separator
UT  Unit Telescope
UV  Ultraviolet
UVES  Ultra - Violet Echelle Spectrograph
VIMOS  Visible Multi-object Spectrograph
VISIR  VLT Imager Spectrometer in the Infrared
VLT  Very Large Telescope
VLTI  Very Large Telescope Interferometer
VST  VLT Survey Telescope
WFI  Wide Field Imager
WFS  WaveFront Sensor
ZIMPOL  Zürich Imaging Polarimeter