EUROPEAN ORGANISATION FOR ASTRONOMICAL RESEARCH IN THE SOUTHERN HEMISPHERE

For Recommendation

SCIENTIFIC TECHNICAL COMMITTEE

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Guidelines for decommissioning of VLT instruments
**Introduction**

The planning of the future VLT instrumentation has been presented to the STC as part of the Science Priorities for ESO into the 2020s (STC-551 and STC-560) and in a programmatic planning (Cou-1625). In the coming years several VLT instruments will need to be decommissioned to make space for new instrumentation and this document presents the guidelines to decide on which instrument should be removed from the telescope. A separate document describes the specific situation with the return of CRIRES+ to the VLT in the first quarter of 2018 (STC-570).

The VLT instrumentation covers a wide range of observing capabilities. All 13 foci will be occupied by late 2016, when ESPRESSO will be mounted at the incoherent combined focus.

Only two VLT instruments have been decommissioned so far: FORS1 in 2009 and ISAAC in 2013.

**Guidelines**

In a steady state situation, the instrument planning will proceed through an analysis of the future scientific needs, the status of the current instrumentation and the available resources. Decommissioning is a natural part of such planning.

Removing an instrument from the telescope will always be connected to some loss of capabilities. We list here criteria to consider when assessing the decommissioning of an instrument.

1. **Scientific relevance**
   - Instruments that are no longer scientifically competitive should be decommissioned. Typically, an instrument will be superseded by a new instrument at an ESO facility.

2. **Operations costs**
   - In some cases the operational costs for an instrument may increase to the point that the scientific return may be either jeopardised or no longer affordable.

3. **Maintenance costs**
   - Maintaining an instrument at a scientifically interesting level may become too expensive and require too many resources. Instruments should not be maintained at all costs. Rather a replacement should be envisaged in such cases, if the scientific value is considered important enough. Exceptional science cases may warrant exceptional efforts.

The list is ordered in level of importance. Often a combination of the above criteria will lead to the decision to decommission an instrument. In all cases, a careful evaluation of the different criteria is needed.

A regular assessment of the operating instruments to evaluate a combination of the above factors is recommended.
Planning the future instrumentation
The science priorities of the VLT have been laid out in STC-551 and STC-560.

Science relevance of current instruments
The requested time per period for the current instruments is displayed in Figure 1. There are versatile instruments, which serve many different science cases and typically are in high demand others serve specific and important science cases. Instruments of the first kind at the VLT are currently FORS2, XSHOOTER and MUSE. UVES, NACO, SINFONI and HAWK-I provide capabilities for many astrophysical applications. Their versatility is not necessarily reflected in the demand. Instruments with more specific science cases include FLAMES, VISIR, SPHERE, VIMOS, KMOS and in the past CRIRES. They typically serve smaller communities and are not demanded as much. Of course, the demand is also influenced by how competitive an instrument is compared to similar instruments at other observatories.

In the following we give a very brief summary for each instrument grouped according to the ranking in the previous paragraph

FORS2 remains the most demanded VLT instrument and covers some of the basic observational parameter space. It is the deepest imager and low-resolution spectrograph in the optical ESO offers at the moment and in the foreseeable future. The simultaneous spectroscopy in the UV, optical and near-infrared provided by XSHOOTER has been in high demand. XSHOOTER is a very popular
instrument and its versatility has proven beneficial for many science topics. It is a critical instrument for stellar astrophysics. **MUSE** has a wide application to many science cases. It is a very popular instrument right after it started operations. It is the largest integral-field and the most efficient spectrograph ESO offers in the optical. With the AOF it will become the only optical AO-assisted integral-field instrument world-wide.

The large wavelength coverage of **UVES** remains unique and will be important for many future stellar abundance studies. **NACO** had been foreseen to be decommissioned in 2014, but was moved to UT1 to provide wide-field AO infrared capabilities including the L and M bands. It is needed for the observation of the passage of S2 near the black hole at the Galactic Centre and should be operated until 2019. The near-IR integral-field instrument **SINFONI** is very versatile and has been used for many different projects. It is the only ESO instrument that can provide spectroscopy of the stars in the Galactic Centre. IR integral-field spectroscopy has been extremely useful for dynamical studies of distant galaxies. SINFONI maintains the advantage of AO support and hence an improved image quality over KMOS and will remain competitive for individual object observations. **HAWK-I** is the only wide-field imager on the VLT. The demand for HAWK-I has not been very high recently. With the AOF it will become a ground-layer AO instrument with an image quality of 0.2”. Together with its wide field this will make HAWK-I an interesting IR imager.

**FLAMES** is the only high-resolution multi-object spectrograph currently available at ESO. The follow-up of ongoing and future sky surveys requires multiplexed high-resolution spectroscopy. FLAMES currently still is among the few instruments of this type world-wide. The multiplex of FLAMES will be superseded by other instruments soon. It remains competitive at the moment, mostly because there are only few high-resolution multi-object spectrographs on 8m telescopes. New instruments, (e.g. HERMES, WEAVE, MOONS, 4MOST) typically have a 10-fold increase in multiplex compared to FLAMES. **VISIR** provides European astronomers access to the mid-IR from the ground. After its upgrade with burst mode, sparse aperture masking and coronographs it provides important access to disk and exo-planet science. **SPHERE** offers extreme AO in the infrared and parts of the optical and will be the instrument of choice for high-contrast observations with bright reference sources. It is important for the study of disks and exo-planets. Surveys with **VIMOS** are ongoing. Past redshift surveys have provided several high-level cosmology results. This is a classic survey instrument and is predicated on large data samples. **KMOS** has opened the near-infrared spectroscopy of faint (extended) sources. It is an important instrument for the study of galaxy evolution at intermediate redshifts and several Large Programmes are making use of it.
The publication statistics in Figure 2 show the scientific productivity of all instruments. The versatile instruments UVES, FORS2 and X-SHOOTER produced the highest number of publications in 2015. Instruments with a more specific application tend to produce fewer papers. Of course, there is also an age effect and instruments typically reach a steady publication rate about 5 years after the start of operations. Survey-type instruments tend to take a little longer to reach equilibrium. Hence, the numbers for KMOS and MUSE cannot be used for a direct comparison. Decommissioned instruments (FORS1 and ISAAC) display a (slowly) dropping publication rate.

The science case for all VLT instruments is still strong and there is no reason to decommission an instrument according to this criterion at this point.

**Operations and Maintenance**

The origin of operations costs is manifold. Operations support for instruments ranges from regular maintenance, which includes replacing expendable items (e.g. masks, cooling liquids). Other items include calibration activities. More complicated instruments tend to have a higher operations costs. Maintenance activities include the replacement of defective components or upgrades (software and hardware).

Both operations and maintenance costs tend to increase with the age of the instruments. An indicator of a combination of operations and maintenance costs is the technical downtime an instrument suffers and the number of problem reports (see Gonté et al., Messenger 157, 17). Instruments with excessive down time (>10%) should be investigated for potential decommissioning. Currently, the downtime is monitored for telescopes only, although there are plans for a future monitoring on an instrument basis. The operational and maintenance load an instrument represents to the observatory can also be measured through problems reports and effort invested. These parameters are tracked. Instruments with a significant operational impact need to have a significant science impact to justify continued operation.

NACO and VIMOS are operationally the most demanding instruments. The maintenance of NACO has become expensive (e.g. detector exchanges, maintenance of objective wheel, real-time computer) and is binding many instrumentation and operational resources. VIMOS was upgraded in 2014 to make it ready for public surveys, except for the grism exchange unit. The operations have

![Figure 2: VLT publication statistics. GIRAFFE is the FLAMES spectrograph.](image-url)
stabilised, but there are still large overheads, e.g. due to stuck slit masks. Most other instruments are in regular maintenance mode. XSHOOTER will have the ADC repaired in 2016.

**New instruments**

Table 1 lists VLT instruments under construction and their planned dates for start of operations (Preliminary Acceptance Chile, PAC).

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Planned start of operations (PAC)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESPRESSO</td>
<td>3Q2017</td>
<td>Incoherent combined focus</td>
</tr>
<tr>
<td>AOF</td>
<td>2Q2018</td>
<td>UT4 facility feeding HAWK-I, MUSE and SINFONI/ERIS</td>
</tr>
<tr>
<td>ERIS</td>
<td>4Q2020</td>
<td></td>
</tr>
<tr>
<td>MOONS</td>
<td>4Q2020</td>
<td></td>
</tr>
<tr>
<td>4MOST</td>
<td>3Q2021</td>
<td>VISTA</td>
</tr>
<tr>
<td>CUBES</td>
<td>-</td>
<td>Contingent on Brazil joining ESO</td>
</tr>
</tbody>
</table>

There is substantial overlap in the specific capabilities of some of these new instruments with existing ones. **ESPRESSO**, like UVES, is a cross-dispersed high-resolution spectrograph. It covers a smaller wavelength range and is optimised for accurate radial velocities. **ERIS** combines an AO supported infrared (including L and M bands) imager in combination with an upgraded SINFONI. It will make good use of the AOF and replaces almost all NACO functionalities. **MOONS** has a high multiplex (~1000), works at 650nm<\(\lambda<1.8\mu m\) and has a high resolution mode. Amongst its prominent science cases is the follow-up of Gaia sources. **4MOST** is an optical extremely high multiplex (>2000) spectrograph with a very wide field of view on VISTA. Like MOONS one of its science goals is the massive spectroscopic follow-up of Gaia stars. It also has a low resolution mode for galaxy redshifts. **CUBES** fills an important niche in the current VLT instrument complement by providing very high efficiency high-resolution spectroscopy below 400nm. It will serve some very specific science cases, which currently are not accessible with ESO instruments.

Other new instruments are **GRAVITY** (PAC: 4Q2016) and **MATISSE** (PAC: 3Q2017) for the VLTI and **NIRPS** for the 3.6m telescope and **SOXS** for the NTT on La Silla. For planning details on these instruments see Cou-1625.

The only new VLT instrument specifically mentioned in Cou-1625 is an adaptive optics instrument for UT4 to make best use of the AOF, which is also a priority in STC-560.

**Proposed decommissioning of VLT instruments**

There is a clear overlap in capabilities of some existing instruments with the ones under construction. All **NACO** capabilities will be covered by SPHERE, SINFONI and ERIS, when it arrives. **FLAMES** and **VIMOS** will be superseded by MOONS and 4MOST. VIMOS is operationally expensive and it is proposed in STC-570 to make space for CRIRES+ in 2018. NACO and FLAMES should be decommissioned when the new instruments become available. The following schedule is envisaged:

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Decommissioning year</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIMOS</td>
<td>2018</td>
<td>Replaced by MOONS, later 4MOST</td>
</tr>
<tr>
<td>NACO</td>
<td>2019</td>
<td>End of S2 campaign</td>
</tr>
<tr>
<td>FLAMES</td>
<td>2020</td>
<td>Replaced by MOONS, later 4MOST</td>
</tr>
</tbody>
</table>
This means that by 2020 a Nasmyth focus will become available as a visitor focus again, which was proposed in the ESO 2020s Science Priorities (STC-551). The next instrument for possible decommissioning will most probably be HAWK-I when the new AO instrument will be delivered to the VLT (around 2024).

An assessment of the other instruments should be done 2018 to evaluate points 1 through 3 in the guidelines. Instruments with very low demand need to be assessed for their science potential and return. Such an assessment should also include the option to upgrade an instrument or eventually replace its capabilities by a new instrument.