VLTI Science Operations at Paranal

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ABSTRACT

The VLTI now has performed three years of science operations using the VINCI instrument since the first fringes on a star were obtained on March 17, 2001. Since December 5th, 2001, shared risk science observations have been performed with VINCI. In April 2004 (period 73) we have started science operations with the MIDI instrument. Subsequently both the AMBER instrument and the Auxiliary Telescopes (ATs) will be also running under the science Operations at Paranal and offered to the astronomical community.

We will present how the VLTI Science operations currently are performed and integrated into the general Paranal Science Operations scheme, using the extensive experience of Service Mode operations performed by the Paranal Science operations group. We focus on the execution of the Service mode operations, how they are planned, performed, evaluated, and processed and the data finally sent to ESO Garching. The near future developments are also presented and how the new instruments and telescopes will be integrated into the Paranal Science Operations.

Keywords: VLTI, VLT, Science Operations, Paranal, ESO

1. INTRODUCTION

The ESO *Very Large Telescope Interferometer* (VLTI) located at Cerro Paranal in northern Chile is part of the ESO *Paranal Observatory.* The VLTI is a general purpose interferometric instrument that offers various instruments to the general astronomical community: VINCI[1] (now no longer in use in science observations), MIDI[2] (a two beam mid infrared instrument, with spectroscopic capabilities from R=30 to 230), and, in 2005, AMBER[3] (a three beam JHK band instrument with spectroscopic capabilities from R=30 to R=10000). These were/are offered in either *Visitor Mode* (VM) or *Service Mode* (SM), using either the Siderostats (for VINCI), the 8.2 meter *Unit Telescopes* (UTs), or the 1.8 meter *Auxiliary Telescopes* (ATs[4]). The siderostats and ATs can be freely relocated on any of the 30 telescope locations (see figure 1). Siderostat baseline changes were made every few months, and with the ATs it is planned to have telescope relocations every few weeks depending on the user requests.

After the *First Fringes*[5] on March 17, 2001, with the VLTI+VINCI using the siderostats (16 meter baseline), the development has been rapid and the astronomical community has been able to obtain the *Shared Risk* science data taken with VINCI+VLTI from the start.[6] A few key dates are:

- October 30, 2001 - First light with UTs (103 meter baseline).
- January 2002 - Data release of the first commissioning data and this was followed by regular *Shared Risk* data releases. These data releases have been made quarterly with all the data taken with VLTI+VINCI.

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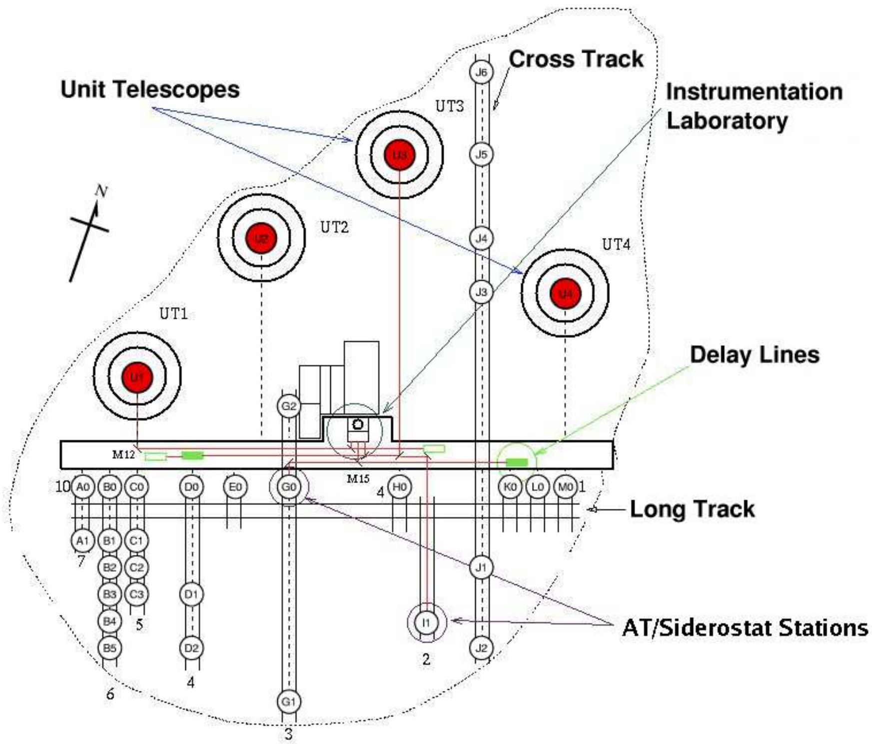

Figure 1. A schematic view of the VLTI where the telescope pads for Auxiliary Telescopes (ATs) and siderostats are visible, as well as the four UTs. In the center are also shown the delay line tunnels, VLTI control building and the interferometric lab.
The MIDI observations are currently using combinations with two UTs simultaneously, AMBER will be using up to three UTs or ATs simultaneously. Of the ATs one is currently being commissioned at Paranal and the remaining three ATs will be installed in 2004/5.

- September 15-17 2002 - Light beams from all four VLT 8.2-m Unit Telescopes (UTs) were successively combined, pairwise, to produce interferometric fringes .
- December 15, 2002 - First Light with MIDI and two UTs (102 meter baseline).
- September 2003 - Scientific Data from MIDI Science Demonstrations made publicly available.
- January 2004 - First *Auxiliary Telescope* for the VLTI installed at Paranal
- March 20, 2004 - First Light with AMBER and siderostats on a 64 meter baseline.
- April 2004 - First MIDI observations as part of normal science operations. Observations done in both *Visitor Mode* (VM) and *Service Mode* (SM).

This paper focuses on the Science Operations for the VLTI and in Section 2 we discuss the principles of SM[7] and how these are used to plan and execute the night observations. In Section 3 we describe the staff involved in executing the SM and VM operations and who are fundamental to the successful science operations, in Section 4 we discuss the particular issues differentiating the *VLTI Science Operations* (VLTI SO) from the standard Paranal Science Operations (PSO), and, finally, in Section 5 we present a view of the VLTI SO from an observers point of view.

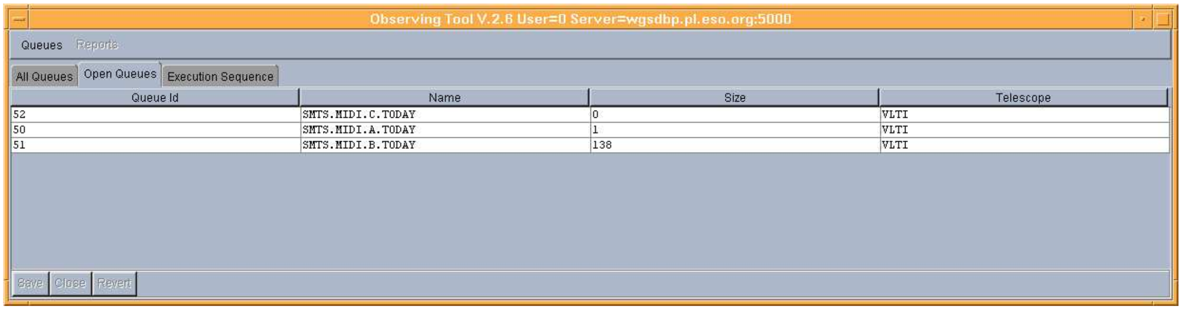

Figure 2. Here are shown the three MTS queues, class A, B and C, from which the astronomer constructs the STS queue. The selection of which OBs to execute are depending on the current baselines, weather and *Local Siderial Time* (LST).

2. GENERAL SERVICE MODE PRINCIPLES

The Service Mode (SM) Operations are guided by many rules that are used as criteria to plan and execute each night of observations. The basic objectives[8] for the SM operations are:

- The fulfillment of the scientific objectives of an observing run are heavily depending on that all the OBs in the run are completed. Thus SM operations are aimed towards completing a smaller number of runs rather than having all runs incomplete.
- An execution of an OB should not be scheduled unless it has a high probability of completion.
- Observing conditions permitting, runs with higher scientific priority as defined by the OPC should be completed preferentially to lower-priority runs.

These basic premises are then used in the three types of scheduling used in the execution of Science Operations. The three types are:

- *Long Term Scheduling* (LTS)
  - The LTS contains all the *Observation Blocks* (OBs) created from all the accepted proposals covering the observing period.
  - The LTS manages *Right Ascension* (RA) space, not nights. A range of RA is available on any given night. Conversely, any given RA is observable on many nights. For Service Mode, it is more appropriate to manage coordinate space than calendar space.
- *Medium Term Scheduling* (MTS)
  - The MTS is created and maintained by the *User Support Group* (USG) in Garching, and is updated daily to adjust to the pertinent RA constraints. Typically three queues are created for each instrument, these are the A, B and C class queues. For MIDI in the current period (P73) only the B queue is used. From these queues the NA selects the OBs which are then inserted into the STS queue. In figure 2 the three MTS queues are opened and ready for preparing the STS queue. An example of the Class B queue for MIDI observations is shown in Figure 3.
- *Short Term Scheduling* (STS)
  - The STS is created and maintained by the *Night Astronomer* (NA) and is dynamically created and updated to adjust to the observing conditions. An example of the STS for MIDI observations are shown in figure 4.

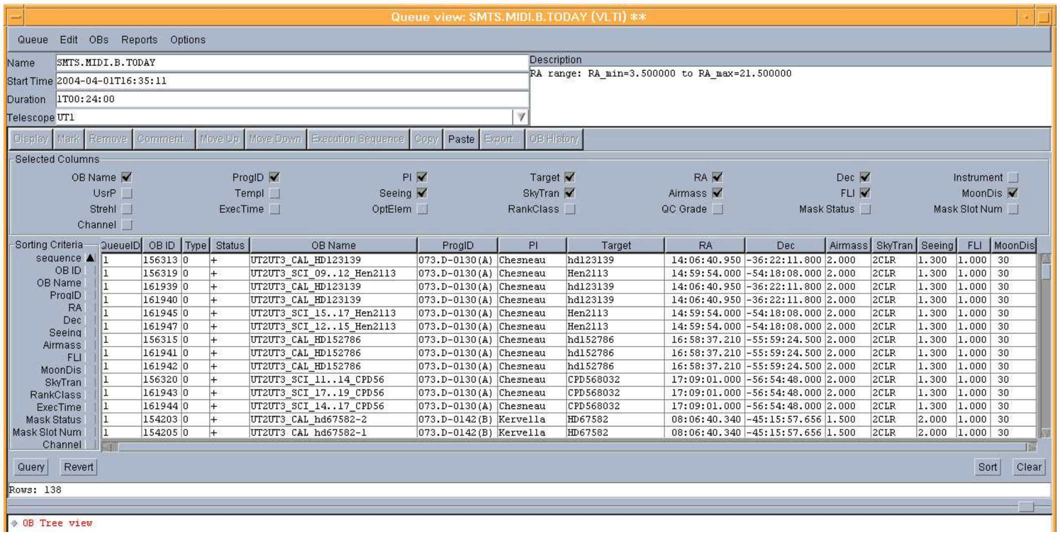

Figure 3. The MIDI Class B MTS queue. We can see that the OB names include information on the requested baseline (UT2-UT3) and whether it is a science target or a calibrator for a science target. A complete MIDI observation always includes the execution of a science OB and an execution of a calibrator OB. The successful execution of the observation requires that both observations fulfill the requested criteria.

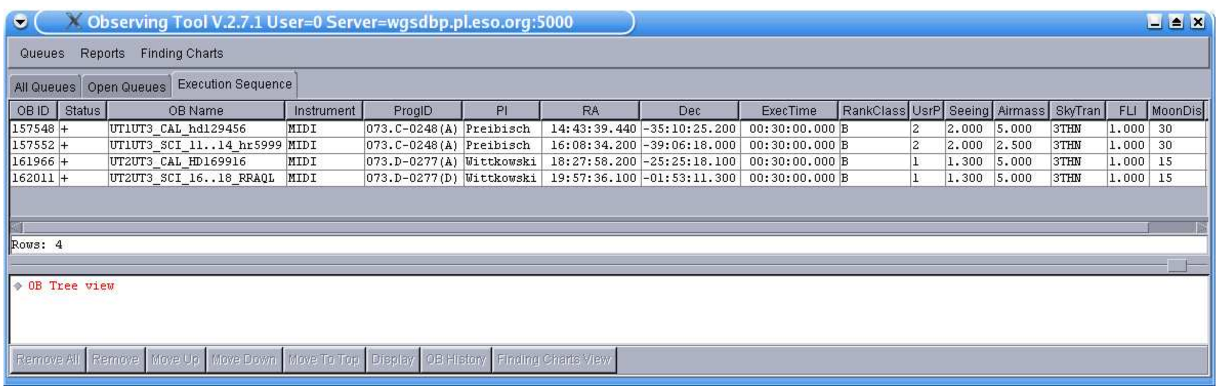

Figure 4. Shown is an example of the *STS* (the *Execution Sequence*). This queue contains a few OBs that will be executed within the next few hours. Each complete science observation consists of a science OB and a calibrator OB, where the science OB is executed and directly followed by the calibrator OB.

In short:

The basic premise of the *Short Term Scheduling* (STS) at the telescope during *Service Mode* (SM) observations is to comply with the priorities and assumptions used during the preparation of the *Long-Term Schedule* (LTS) of the given observing period.

2.1. Service Mode Run Priorities

When preparing and updating the STS during the night the NA has to keep the observing priorities in mind. These can be summed up as:

1. Target of Opportunity (ToO) programs / Time critical programs
2. Guaranteed Time Observations (GTO) programs
3. Large programs (LPs)
4. Chilean programs
5. Carry Over programs
6. Normal programs

Note: this ranking is a priori independent of the rank class of the program (A,B,C), see below. In general, runs with priorities 1-5 must only appear in rank class A.

To every accepted SM run a rank class is assigned according to its *Observing Programmes Committee* (OPC) priority:

- Above OPC cut-off line:
  - Class A (highest priority)
  - Class B (medium priority)
- Below OPC cut-off line (but grade better than 3) requiring relaxed conditions (seeing >1", transparency Thin/Thick etc.):
  - Class C (filler runs), to populate the LTS for bad conditions which usually would leave the telescope idle.

3. GENERAL SCIENCE OPERATIONS STAFF

The Science Operations Staff focuses on the telescopes and not on the particular instrument, as every astronomer should be capable of performing and evaluating the observations done with any of the instruments mounted at the telescope that he/she is supporting. For each telescope PSO allocates a *Night Astronomer* (NA) and a *Telescope and Instrument Operator* (TIO) which is responsible for operating the telescope and the instruments, during the day there are two *Day Astronomers* (DA) for day time duties, and there is one Shift leader (SL) who coordinates the work off all NAs, DAs, and TIOs, and, being the interface to the Paranal Engineering group.

3.1. Paranal Science Operations Shift leader

The Shift leader is coordinating the work of all the Science Operations Staff. His/her duties include among others:

- Follow up on problem reports done during the night's observations and plan/arrange for their solution.
- Coordinate the work of telescope and instrument engineers, and software support so that maintenance and repairs can be planned and executed with a minimal interruption of the night time observations.
- Plan and follow-up of non standard queue requests (Target of Opportunity Requests (ToOs), Directors Discretionary Time Proposals (DDTs), etc).
- Supervise and support the DAs and NAs.

3.2. Paranal Science Operations Day Astronomer (DA)

The DA is focused on the day time support of the previous night's observations, this includes:

- Follow up on the previous night's observations and possible problems.
- Check the quality of the night's observations and calibrations, and execute the necessary day time calibrations.
- Coordinate the daily work with the Engineering Department after instrument calibrations are completed.
- Check that the instruments are in a safe daytime state after the calibrations are finished. Before the start of the night prepare the instrument so that it is ready for the night time operations.
- Introduce any *Visiting Astronomer* (VA) to the VLTI and the pertinent instrument in question.

3.3. Paranal Science Operations Night Astronomer (NA)

The NAs main task is the planning and execution of the STS.

- Follow-up and check that the problems and tasks reported the previous night have been solved.
- Prepare OB execution sequence for the beginning of the night (including twilight calibrations etc).
- Check the MTS queue for OBs that can be executed during the night (including twilight).
- Check the weather situation and the weather prognosis for the next few hours so that a most effective STS queue can be made from the MTS. If there are changes in weather update the STS.
- Check the quality of the observations and subsequent calibrations so that they fulfill the requested observational criteria. This is done by checking both the raw data and the pipeline data.
- In case of problems try to solve the problems with the help of the *Telescope and Instrument Operator* (TIO), if not contact the VLTI manager and SL.
- Report problems and time losses.
- Update the Night report using *Paranal NightLog tool* (PANL) with the performed observations and calibrations and their classification.

In the case of *Visitor Mode* Observations (VM) there are a few additional tasks:

- Study the visitor's observing program; discuss with shift leader and visitor observation strategy.

- Review with the visitor the first OBs at beginning of the night
- Execute nighttime observations, support visitor in decisions
- Let the TIO drive the telescope and instrument
- Introduce the visitor to the use of the offline machines
- Support the visitor in the use of the raw data and the pipeline products on the offline machines.
- Request data release from data handling administrators in first night

At the end of the night:

- Finalize the night report (in the PANL)
- Print and send night report
- Prepare and start daytime calibrations
- Keep the daytime team informed

3.4. Paranal Telescope and Instrument Operator

The TIO is allocated to night time duty and is responsible for operating the telescope and with the NA to operate the instruments. In particular his/her duties are among others:

- Check that the telescope started up correctly and is functioning properly during the night.
- Park and leave the telescope in a correct mode at the end of the night observations.
- Help the *Weather Officer* (one specifically nominated TIO that keeps an eye on the weather conditions and has the authority to stop the current observations if the weather conditions reach an unacceptable level) to monitor the current weather situation.
- On the VLTI the TIO is also controlling the performance of the delay lines and the optical train leading up to the instrument.
- When using the UTs there is one TIO allocated to each of the UTs.

4. VLTI SCIENCE OPERATIONS PARTICULARS

The aim of the VLTI operations is that it should be working seamlessly within the standard Science Operations frame in use for the normal VLT UT instruments. In particular there are a few constraints added in the case of VLTI Science Operations:

- With the siderostats the baselines were changed on the average every six months to allow sampling of different requested uv-spacings. The MIDI operations are currently (P73) limited to the two available baselines UT1-UT3 (102.4 meter baseline) and UT2-UT3 (46.6 meters). In the future when the ATs are installed the telescope array configuration will change every two weeks (the actual timescales will have to be revised depending on the user requests). With four ATs in operation it will also be possible to make fast (<one hour) array reconfigurations by selecting which subset of two (for MIDI) or three (for AMBER) telescopes are used by the instrument in question.
- The projection angle of the baseline on the sky is another constraint that is requested by the user. This is specified by the user giving an LST range within which his/her OB is to be executed.

- The VLTI Science Operations differs also by the need of having a calibrator OB executed very close in time with the science OB, used to determine the transfer function. Thus the science OB and the calibrator OB are observed and judged as a single observation *i.e.* both of the OBs have to fulfill the specified criteria for the observation to be classified as a success. For MIDI operations this means that each calibrated *uv*-point takes a total of one hour.

- An internal criteria for classifying the observation is that the fringe quality determined from the pipeline, or later day time post processing in the case of MIDI has to reach a sufficient level above the noise. This is not a user specified criteria but an internally determined factor from the experience of three years of operations. This is independent from the user criteria as the weather and sky conditions can be excellent but the detected fringes are weak due to, e.g., the source being to extended, the source having too low a flux or problems caused by delay line tunnel seeing effects.

5. USING THE VLTI, A USER'S PERSPECTIVE

An in depth discussion of the VLTI seen from a user's point of view is discussed in these proceedings,[9] and here we will only make a brief overview.

The aim of the VLTI Science Operations is to make the VLTI with its selected instrument (MIDI or AMBER) completely transparent to the user. He/she can stop worrying about the functioning of either the telescopes or the instrument, and instead just concentrate on achieving the scientific goals of his/her project. The *Science Operations* with both VINCI and MIDI have shown that this goal has been achieved.

5.1. Service Mode

In the case of SM observations the user only has to concentrate on:

- In the Phase II give the right observing constraints so that the observations are executed under the proper conditions, and with the proper telescope array configuration.
- Select a suitable calibration star.[10]
- Prepare a correctly edited OB that properly configures the instrument so that the observations yield the desired data.
- Use the *External Verification Module*s scripts (EVMs) to check the OBs so that they are compliant with the available instrument modes.
- Provide a finding chart of the target region.
- Submit the OB to the *User Support Group* (USG) in Garching.
- Wait for the OB being executed, and after receiving the data, properly reduce them.

5.2. Visitor Mode

In the case of VM the user will travel physically to Paranal Observatory to execute his/her OBs. The preparations where the user prepares his observations are similar to the SM mode. The difference is that the user needs not to submit his/her OB to the USG. He/she will arrive at the observatory 48 hours before the start of the observations and will have support from the *Day Astronomer* to correctly finalize the OB preparation. While at the Paranal Observatory the user has to consider the following:

- Have backup targets in the case of wind constraints. The UTs cannot point into too strong wind, thus the backup targets should be located in the opposite sky quadrant.
- Have finding charts available so that target acquisition can be smooth and clear.

- Have a clear plan for the available time so that the telescope time can be used efficiently by making quick and informed real time decisions.
- If requested, the *Night Astronomer* can give support in the reduction of the data and will give suggestions on the observing strategy.

As in the case of SM observations there is NO need for the user to worry about the control of actual telescopes or the instrument. His/her only action is to select the proper OBs to be executed and analyze the result of the executed OBs.

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