Nordic Optical Telescope

Development Plan 2008–2010

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1 Preface

As 8-10m telescopes, notably the ESO VLT, have entered astronomy, it is clear that NOT cannot remain competitive in all areas. A complement of telescopes of different sizes is still needed, but specialisation is necessary. At NOT, the effort has focused on increasing flexibility in scheduling and instrumentation, with the aim to be competitive in fields where Nordic groups are strong and accepting restrictions elsewhere.

Following an initiative to define a more specific scientific and educational strategy for NOT, a common plan was debated and finalised through a meeting of all Nordic groups in Copenhagen in November 2006. The agreed strategy (see *http://www.not.iac.es/news/reports/NOT_StrategyReport_Fin.pdf*). contains a number of quite non-trivial elements: Encourage much larger projects than have been costumary up to now; increase flexible scheduling and service observing; specialise in transient and variable sources, and compress the instrumentation into a single, fixed set defined and provided in open competition. A similar approach was recommended in order to define a single, coherent Nordic educational programme based on NOT.

The strategy was approved by the Council and is thus official NOT policy, and we are proceeding with the implementation. The overall strategic framework for the future of NOT in research and education is described in a separate report by the Director. This document describes our detailed development plan based on this strategy for the period 2008–2010, as seen from perspective of the telescope operations.

2 Introduction

From the submission of a proposal, via the specific movements of the telescope, detector and instrument, to the final resulting images is in principle one 'data flow' system. This includes things like the reception and processing of the proposals which are used for the scheduling and execution of observations, but also the operation and maintenance of the telescope and calibration plans for the instruments and detectors. The final product is the data from the instruments which, together with proper header information, the observing logs, the operational logs of the telescope and data acquisition system (i.e., instrument plus detector), and the proposal and scheduling information provide a complete system to fully define what is needed to reduce the data or retrace what happened in case there is a problem.

Over the past few years a significant amount of work has been done on the different pasts of our 'data flow' system. This includes the development of a new proposal system and its related database system, the development and implementation of calibration plans for nearly all instruments and observing modes, the development of our data acquisition systems to provide proper data format and keyword information, and also the upgrade and modernisation of the Telescope Control System (TCS) needed to allow the integration of this part with the rest of our system.

Within this framework, the aim is to increase the amount of service and queue scheduled observing, provide a more automatic and integrated operation of the telescope, instrument and detector, and improve our quality control and data archiving. To provide such a modern, fully integrated observing system many things are needed to be developed (further) and below I outline the plan for the coming few years to achieve this.

3 Development plan for the period 2008–2010

The different tasks have been grouped together by their direct purpose, not under which specific system each task falls. In Sect. 4 a time-line is given in which approximate dates are given when we plan to have a specific part ready. Of course, much of the development work will be done in parallel and in stages, which I have tried to reflect in the time-line by indicating dates for intermediate goals for the different tasks. Sect. 5 gives our detailed estimates for the resources need to complete the programme.

3.1 Observing system

In general, this concerns the practical side of operating the telescope, instruments and detector. It includes a large variety of sub-systems which are controlled by the TCS and the data acquisition systems. This is the main part related to improving the efficiency and reliability of the observations and consist of various rather specific projects.

We estimate to require a total of 1.75 FTE per year for the projects outlined below. We do not provide estimates for each separate project as they are all more or less strongly inter-connected, but overall the main effort is aimed at the general objective to increase flexible scheduling and service/queue observing.

1. **The Sequencer**

   A system is being developed to provide the option to fully manage observations through the control of all the sub-systems from one 'observing' script. The general aim is to improve the efficiency and reliability of the observations. A first version is in operation for FIES and a version will be soon implemented for ALFOSC, but the system needs to be developed further for use with other instruments and to fully include the complete capabilities provided by the observing system.

2. **Script generator**

   We have a facility which provides a way to make simple observing scripts. This 'script generator' needs to be expanded and developed further to include the possibilities provided by the Sequencer. This is especially essential if the level of service/queue observing is to be increased to limit the amount of (extra) work to things which can not be automated. The increased complexity of scheduling and executing observations with different requirements (including different instruments) also makes it necessary to develop the system that checks the validity of the scripts (as for the combination of telescope instrument and detector set-up) to avoid mistakes, and allow for an optimal set-up of the telescope and the different instruments to be defined in advance.

3. **Service scheduling tool**

   To do service/queue observing a system is needed to manage the observing descriptions, the schedule of the observations, and the execution and administration of the observations. In the current system we only have a limited number of observing programs active at the same time, while we use a limited number of simple selection criteria and it is simple to keep an overview. With an increasing level of service/queue observing it will be essential to develop this system to keep an overview and manage the many different observing programs and optimise the selection of observing programs, and as much as possible minimise the required extra effort. The development of this system is closely linked to the Script Generator where there is a specific issue regarding the validity of observing scripts and the required instrument set-ups.

4. **Detector controller upgrade**

   One of the limiting factors on the efficiency of observations are the current slow, outdated detector controllers. An upgrade to more modern, state-of-the-art controllers is needed. This will also require an upgrade of the data acquisition system (see Sect. 5 for more detail).

5. **Remote observing**

   The facilities to allow remote operation of the telescope and instruments (e.g., to allow for tests from the sea-level office, or for observing by off-site training courses) need to be significantly expanded and improved. Specifically, the system should as much as possible allow for unassisted operation (which requires a reliable and complete monitoring and safety system), and should be made such that no part of the system (e.g., guide star acquisition, placing a star of a slit, etc) provide a major bottleneck for remote observing.

6. **Observing system set-up**

   Switching operations between different instruments involve various sub-systems that have to be set. We plan to develop a system that simplifies this. The aim is to make operations more flexible and reliable, specifically for ToO and monitoring program observations to be executed with a different instrument than is used for the regular observing program (e.g., a FIES observer that needs to do ToO observations with ALFOSC, a NOTCam observer that needs to do observations for a monitoring program with FIES, etc.), and to improve the efficiency and reliability of service/queue observing in general.

7. **Target acquisition and pointing**

   An important aspect for remote observing and for the general efficiency of observing is the precision in the way the target acquisition works (which is effectively equivalent to improving the pointing). We plan to develop a system that automates this process as much as possible, increasing the efficiency and reliability of the observations.

3.2 Quality control and data management

In general, this concerns things which are not directly related to the execution of observations, but concerns the quality of the observations, the description of the data and the archiving of the data. Specifically, this includes procedures to check and optimise the set-up of the telescope and instrument, keep track of the state of the instrument and telescope, and define the quality of the resulting data. Together with the headers included with the data, this information provides a full description of the data taking process and the resulting data which can be used as direct input to a data archive and is needed to be compatible with the requirements for inclusion in virtual observatories.

We estimate to require a total of 0.75 FTE per year for the projects outlined below.

1. **System status logging facility**

   Both the new TCS and the Sequencer have a more extensive logging capability then existed before. We plan to develop this system to include all the relevant parameters and provide an interface to analyse the content of the logs, e.g., for troubleshooting.

2. **Quick-look reduction and analysis software**

   Currently a post-processing system exists that allows for a simple quick-look reductions and analysis of the observations. We plan to develop this system and expand it further as a quality control tool. This will include things like analysing the seeing and focus measurement with the aim of providing a direct check on the quality of the data that are being acquired. This provides both a tool to look for possible improvements and a tool to ensure that the best data quality is obtained (e.g., warning if the telescope is not properly focussed).

3. **Calibration data analysis**

   As part of the different calibration plans we are regularly obtaining efficiency measurements for the different instruments and observing modes. We plan to develop and automate the system to reduce and analyse these data, and collect all the results in our data-base system. These data will provide a tool to monitor the longer-term health of the telescope and instruments. The reduction and analysis software will also be offered to the community as tools for the pipeline processing of regular observations.

4. **Weather station**

   We plan to upgrade and modernise our weather station. This will allow the full integration of the weather data in our observing system. A system will be developed to include this data in our data-base system and allow for a proper correlation with, e.g., quality control data.

5. **Data saving and archiving**

   We are implementing a system to automatically save data to DVDs. We plan to develop this system further to an automatic archiving system, and combine the information in the data headers, the system status logs and the results from the data quality control to provide a full description of the data in a searchable archive.

6. **Archive interface**

   To give full access to the information in the archive and make it fully compatible with virtual observatories, we plan to develop an interface program which allows to search and query the archive.

3.3 Upgrades

A more general task will be to implement upgrades to improve the various parts of the observing system. This is not fully defined, but our general experience is that on a regular basis improvements are identified that will provide significant improvements, but require some (typically limited) development work on some parts of the observing system. Below I list a few examples.

We estimate to require a total of 0.5 FTE per year for these limited upgrades similar to the examples given below.

1. **FIES reduction software**

   We plan to develop the existing FIES pipeline reduction package in order to simplify the preprocessing of the calibration data and to allow for observations with interleaved ThAr spectra.

2. **Skewed readout mode**

   A specific upgrade to the FIES detector control system would be the option to allow for the skewed readout mode allowing for the resolution of the spectra to be 'tuned'. The main issue is for this system, which exists in prototype form, to be properly developed, tested and implemented.

3. **Active optics**

   In the current set-up the active optics system in the TCS allows only for a fixed setting. From wave-front sensing tests we know that the optimal settings vary as a function of telescope position, and the TCS needs to be upgraded to include these higher order corrections.

4 Time-line for projects

Below I provide the more detailed time-line we have planned for the completion of the different projects. In many case, the general items given above are sub-divided in more detailed steps (e.g., separated by instrument) to more clearly show the planned order and progress of the developments. The guide line for the general order is mostly determined by the interdependence of many items (e.g., the Sequencer → the script generator → the scheduling tool, or; automatic archiving → TCS and sequencer logs → calibration data base → archive query and interface tool). As the varying work load for normal operations is intrinsically unpredictable, goals are only specified per trimester with the aim of completing them within the trimester indicated.

The upgrade projects mentioned in Section 3.3 have not been specifically included as they are not completely defined for the whole period, but this can be considered as a varying background activity to the main program outlined below.

Table 1: Project goals

2008	Q1	Complete Sequencer for NOTCam, Automatic data saving system
	Q2	Complete Sequencer for MOSCA, Complete observing system set-up
	Q3	Improvement remote observing, Start detector controller upgrade program, Start developing scheduling tool, Integration new weather station
	Q4	Script generator for FIES and StanCam, Commissioning archiving system, Complete TCS logging system, Complete optical photometry reduction and analysis tool
2009	Q1	Script generator for ALFOSC and MOSCA, Target acquisition system
	Q2	Script generator for NOTCam, Complete optical spectroscopy reduction and analysis tool
	Q3	Complete Sequencer logging system, Commissioning scheduling tool
	Q4	Complete upgrade data acquisition software, Complete IR reduction and analysis tool
2010	Q1	Commissioning detector controller ALFOSC, Integrated system log analysis tool
	Q2	Commissioning detector controller FIES+StanCam, Complete calibration data analysis and query tool
	Q3	Commissioning detector controller MOSCA+NOTCam
	Q4	Commissioning archive interface and query tool

5 Resources

5.1 Manpower

Most of work is related to software development, where ∼70% of the effort is provided by our software staff, but the work is for a significant part shared with the astronomy staff (and to a more limited degree the students), as they typically define the requirements and do the testing and commissioning, but can also write some of the software.

The main part of the development work for the 'Observing system' (Sect. 3.1) will be centred on the service/queue observing (sequencer, script generator, scheduling tool) and the detector controller upgrade, and for the 'Quality control and data management' (Sect. 3.2) it will be centred on getting a data archiving system (system logs, calibration plan, data saving and archiving, Query tool) that will compatible with accepted Virtual Observatory standards.

We are applying for NORDFORSK support for a two-year post-doc position at NOT to assist in making NOT more flexible, efficient, and to develop its role as part of an integrated optical/submm training programme for Nordic/Baltic PhD students. Apart from his/her own research, the post-doc will provide scientific supervision for two additional PhD students. The remaining ∼0.25 FTE per year over the 2 years of his/her contract will be spend on assist in planning, testing, and implementing increased queue and service observing, and assist with the planning, test, and implementation of remote observing.

5.2 Hardware

Although the major part of the development program is related to software, several projects do require some investment in hardware. As already noted before, many of the projects are actually more or less strongly related, and below I provide the requirements and related cost divided in 3 parts which broadly cover these projects. A table with an overview of the costs is given at the end of this section.

5.2.1 Detector controller upgrade

Before new detector controllers can be installed and used at the telescope, they of course need to be tested and optimised first. For this we need a test set-up to check the controller and define and optimise its behaviour with a detector (read-out noise, linearity, charge transfer efficiency, etc.). This requires a CCD in a dewar that can be cooled with LN_2, where the dewar might need some modification to be compatible with the controller. The test set-up is also needed for the development of the data acquisition software.

In principle we can use the HiRAC (Loral CCD#4) CCD and dewar we have in store; we expect to be able to do any modifications to the dewar that might be needed at NOT. It would be convenient to use a CryoTiger cooled dewar, which needs no specific maintenance and is always available for tests. Including the modification of the dewar for such a cooler, we estimate the total price for this to be 20 000 Euros. It should be noted that the extra CryoTiger would, at the same time, serve as a spare for the two systems we currently have in use, and can also be used for any new detectors in the future (e.g., in a Stand-By FOSC).

The hardware cost of a new controller system for a given detector consist of the controller, a dewar and a data acquisition computer, plus some miscellaneous smaller items. The cost of a generation-III SDSU (ARC; Astronomical Research Cameras) controller is $ 18,000, and we estimate the total cost to be 18 000 Euros per detector. To cover the planned instrument suite of ALFOSC, NOTCam, FIES, and StanCam, plus a system for the test set-up, we require 5 systems at a total cost of 90 000 Euros. After the development phase, the test system would serve as a spare.

5.2.2 Remote observing

A significantly expanded facility to allow for remote operation of the telescope and instruments from the sea-level office and elsewhere will require hardware investments on basically two fronts; networking and surveillance/safety

At the time of writing, an upgrade of the network capacity between ORM and the local IAC/-GRANTECAN headquarters CALP is imminent. The future network speed of this link will be 10 gigabit/second. The NOT should connect to this at ORM with a speed of 1 gigabit/second, thus providing the initial basis for remote operation. However, the fast network connection (of the order of 1 gigabit/second) must extend all the way to the sea-level office. This requires a connection of the sea-level office to the CALP. The gigabit network equipment that is needed for connecting the NOT to the IAC 10 gigabit/second network is estimated at 6 000 Euros. The hardware required to connect to the CALP will most likely be purchased by the ING and the recurring costs be distributed among the participating institutions. This cost is unknown at this time.

An extended safety system should include a centralised, computer based interface to the existing telescope safety system, possible extended with additional sensors. A video surveillance system based on a few cameras placed strategically in the dome, control room and telescope surroundings is also needed. This system should be capable of issuing alarms based on movements. A complete surveillance solution with software and 4 pan/tilt/zoom network cameras costs an estimated 4 500 Euros. A separate computer can host both the surveillance solution and the extended, computerised safety system and is estimated at 2 000 Euros.

5.2.3 Quality control and data management

As the need for greater computing power increases due to the extensive use of on-line or near-on-line data analysis, the current solution where data storage and analysis are hosted on the same computer will not perform well and these tasks need to be separated. The needs for increased FTP storage capacity as service observing increases also requires changes.

A new data analysis server is needed which is estimated to cost 3 000 Euros. A new main data storage (Network Attached Storage - NAS) server is needed, and a solution scalable from 3 TeraByte to 9 TeraByte starts at a cost of about 7 000 Euros. The current data storage server has a capacity just short of 1 TeraByte and it is planned that this will become the new FTP server.

Table 2: Expenditure in Euros

2008	Safety/surveillance:	6 500
	Test set-up detector controller system:	18 000
	Network:	6 000
2009	Data analysis server:	3 000
	NAS/data storage:	7 000
	Instrument detector controller system (4×):	72 000
2010	No expenditures foreseen as the year is used for commissioning with all hardware purchased.	