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Present and future scientific priorities for NOT

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Abstract. The fundamental mechanisms, boundary conditions, and strategies underlying the development of scientific priorities for the present and future operation and upgrades of the Nordic Optical Telescope (NOT) are briefly discussed. Basically, the availability of powerful new facilities for our user community will accelerate the development of NOT from a general-purpose telescope to a specialised tool, optimised for selected high-priority Nordic research programmes in competitive fields. Carefully planned specialisation of the instrumentation, flexibility and responsiveness in operation, and task sharing between telescopes in the OPTICON network will be the key guidelines for the future.

Key words. User priorities – Instrument specialisation – Flexible operation

1. Introduction

The 2.56m Nordic Optical Telescope (NOT) is operated at the Roque de los Muchachos Observatory on La Palma by the national Research Councils of Denmark, Finland, Norway, and Sweden, and the University of Iceland.

Since its inauguration in 1989, NOT has built a solid reputation for reliability and user-friendliness, excellent image quality, powerful instrumentation within selected fields, and efficient operation by a competent and friendly staff. User demand and satisfaction as well as staff morale are high, and healthy finances currently enable us to renew equipment and hire extra temporary staff to improve our performance even further.

All this is cause for satisfaction, but not for complacency: The world, also the astronomical world, will be a different place in the next decade from what is was in the previous one. Most or all of our users will have access to superior new facilities through ESO (and ESA). Moreover, the basic limitation on the science output of Nordic astronomy is set by human resources rather than any lack of access to observing facilities, including 8m-class telescopes with instruments rivalling NOT itself in cost. Therefore, the question how to balance scarce national research funding between humans and facilities is real, and our contribution to the answer must be prepared carefully and on a realistic basis.

2. Preparing the planning

Accordingly, the preparation of a roadmap for the operation and development of NOT over

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the next several years is the highest-priority action item for the NOT Directorate. This involves formulating and answering key questions like the following:

- *Our users:* Who are our main 'customers'? Which research groups are the most active and competitive, and what do they do? How will their priorities change over the next 5-10 years?

- *Our competitors:* Which facilities are the most powerful for the highest-priority Nordic research projects? What are their characteristics, and what are the strong and weak points of NOT by comparison? Where are the scientific and technical fields where we might compete, and what must we leave to others? Can other high-priority capabilities be made available through exchanges of observing time, rather than building new instruments?

- *Setting priorities:* The Nordic community is small: Neither it nor NOT itself can excel in all fields. Our human and financial resources are also limited. Where, therefore, are the areas where NOT might be developed to support high-profile Nordic science that would not be done otherwise? And how do we achieve this while still fully serving the communities that fund NOT?

- *Finding new tasks:* NOT was established as a front-line research facility. But in a world of 8m-class telescopes accessed increasingly via remote control or service observing, training a new generation of experienced researchers may be well be a globally cost-effective use of a 2.5m telescope. How important is this task for Nordic astronomy, and how may it evolve?

In order to gather the knowledge needed to begin to answer these questions, a conference was held here on La Palma in 2000 (Bergvall et al. 2000). A more detailed, systematic, and comprehensive survey was made in mid-2002 by distributing detailed questionnaires to all research groups in the Nordic astronomical institutes.

The return rate was gratifying and showed that we did indeed reach the great majority of our users, and that they care about the future of NOT. It also showed that the community expects to use NOT as much or even more in the coming decade than in the past – an encouraging message. And we obtained a great deal of detailed information on what our users hope NOT will do for them in the future.

3. NOT in present Nordic astronomy

3.1. Our user communities and their scientific fields

The present main use of NOT by Nordic research groups is in the following fields, listed by country:

Denmark: Gamma-Ray Bursts; galaxy clusters and large scale structure, including Lyα-galaxies; asteroseismology; new studies of Near Earth Objects (NEOs, asteroids and comets).

Finland: Active Galactic Nuclei (AGN) and their host galaxies; cataclysmic variables (CVs); Doppler imaging of active and magnetic stars; studies of NEOs and Trans-Neptunian Objects (TNOs).

Iceland: Gamma-Ray Bursts; galaxy clusters and large scale structure; gravitational lensing and cosmology.

Norway: Cosmology and large scale structure (weak and strong gravitational lensing); cataclysmic variables; minor solar-system bodies (NEOs, TNOs, planetary satellite dynamics).

Sweden: Supernovae (explosion physics and use as cosmology probes); galaxy clusters and Blue Compact Galaxies; Galactic chemical evolution; Doppler imaging and spectroscopic analysis of chemically peculiar and active stars, including RS CVn binaries; star formation, interstellar matter and circumstellar envelopes; planets, comets, and asteroids.

Foreign: Throughout is existence, NOT has allocated 10-15% of the Nordic observing time to proposals from outside the Nordic community, providing healthy competition from the best researchers throughout the world. In addition, 25% of the time is contractually reserved for Spanish and international (CCI) projects. These 'foreign' projects cover all areas of astronomy and astrophysics.

Foreign (including Spanish) use of NOT will be a continuing (and within the OPTICON framework probably increasing) feature at NOT; but planning will, of course, be based on the wishes and priorities of Nordic astronomers.

3.2. Our competitors

In each of the Nordic countries, competition for the attention and funding of the astronomers comes from other astronomical facilities as well as from other factors. They can be briefly summarised as follows:

Denmark: ESO and ESA facilities; the Danish 1.5m in Chile; declining scientific staff numbers at university institutes.

Finland: Radio astronomy and space research; membership of ESO is expected on a relatively short time scale.

Iceland: With no technique-specific research groups in Iceland, NOT effectively competes with the rest of the world.

Norway: Strong space Solar physics programme; other space projects.

Sweden: ESO; radio astronomy including ALMA; space research projects (ESA and ODIN); Solar physics.

In summary, most Nordic astronomical communities are small and struggling valiantly to make best use of the many excellent facilities available to them. This is the background on which future developments of NOT must be considered.

3.3. Our strong and weak points

In planning for the future, one must take a realistic view of the strong and weak points of the facility. Some may be improved with money and work, others are fundamental. A quick summary of the most salient points follows:

– *Strong points of NOT:*
  - Modern, fast, reliable telescope (downtime only 1-2%)
  - Excellent site and image quality
  - Northern location (complement to ESO telescopes)
  - Good CCD and NIR detectors
  - User-friendly, hands-on operation; excellent staff support
  - Adequate and stable funding.

– *Weak points of NOT:*
  - Small by today's standards (2.5m)
  - Image quality not unique in the future
  - Only 75% of the time available
  - Northern hemisphere only (for non-ESO members)
  - Limited technical support capacity
  - Associates are free to redeploy funds with 2 years' notice.

Most of these items will remain fundamental boundary conditions for whatever scientific and technical plans may be developed for the future. It is useful, therefore, to list and consider them explicitly.

3.4. Present priorities

NOT is currently equipped with a suite of relatively conventional instruments for imaging and spectroscopy in the optical and near-IR regions. Up-to-date information on available instruments, their performance and status is maintained at the NOT web site (http://www.not.iac.es) and will not be repeated here.

The standby CCD camera is always available for direct imaging, regardless of what other instrument may be mounted at the main focal position. Other instruments are scheduled in blocks of time, and most observations have been carried out in the classical "visitor mode" according to a schedule established semester by semester.

The option is maintained for visitors to mount their own special instruments at NOT. Notable successes include the fast-readout CCD camera "LuckyCam", where frame selection on good nights has produced diffraction-limited images rivalling those obtained with the *Hubble Space Telescope* (see NOTSA (2003)).

Within this general framework, operations have been organised according to the following set of priorities:

- Provide good service to as many major Nordic user groups as possible
- Deliver the best images possible with classical scheduling
- Offer maximum capabilities with minimum instrument changes
- Provide limited scheduling flexibility for individual programmes with blocks of time in the same instrument configuration (e.g., mix and other programmes over 1-2 weeks)
- Allow instant override authority for highly-rated Target-of-Opportunity projects (e.g. Gamma-Ray Burst alerts), with immediate data transfer
- Provide quick-look data reduction.

Within this framework, a great deal of valuable science and several outstanding results have been achieved over the last decade. However, the most modern large telescopes will beat NOT on all of these accounts in the future; NOT must develop qualitatively new areas of strength to remain competitive.

4. Future priorities

Our questionnaire survey and numerous discussions in the NOT committees and in the community have led to the definition of a new set of scientific priorities for NOT in the future. From these, we derive priorities for the instrumentation and operation of NOT which, in turn, are the basis for specific plans of action. We outline this process in the following.

4.1. Scientific priorities

The overarching scientific priorities will be:

- Sharper focus on top-class science
- Specialise on a few strong instruments
- Greater cooperation and coordination with other facilities (e.g. through OPTICON; see below)
- More flexible and service mode observing to accommodate programmes with "unusual" scheduling needss
- Increased use of NOT in training researchers (up to $\sim$ 10% of the time).

As a consequence, technical developments should focus on:

- *Image quality:*
  - Schedule observations flexibly to match variations in seeing
  - Implement fast-readout CCDs and on-line frame selection
- *Science driven scheduling:*
  - Pursue Targets of Opportunity (ToO) vigorously (GRB, SNe, NEOs,...)
  - Provide for longer-term synoptic programmes (e.g. for Doppler imaging)
- *Niche imaging:*
  - Push sensitivity in the UV
  - Provide diffraction limited imaging as standard option (L3 CCDs)
- *Niche spectroscopy:*
  - Provide high-stability spectroscopy (asteroseismology etc.)
  - Provide high time resolution spectroscopy at low noise
- *Quick-response/standby instruments:*
  - Aim to provide wide-band imaging and low- and high-resolution spectroscopy on a standby basis
- *Data reduction and handling:*
  - Provide pipeline reduction software for facility instruments
  - Structure and calibrate the data to eventually be archived in the Astrophysical Virtual Observatory (AVO).

4.2. Technical priorities

The above wish-list needs to be fleshed out in specific technical terms before the task of implementing the recommendations can be evaluated in terms of hardware investment and man-years of effort.

A first attempt may look as follows:

- *ToO observations:*
  - Upgrade StanCam to 4Kx4K CCDs (two channels possible?)

- *Niche imaging:* Develop L3 CCDs for
  - Diffraction-limited imaging in $\sim 1'$ fields
  - Precision point-source and field polarimetry
- *Niche spectroscopy:*
  - Move the fibre-fed échelle spectrograph FIES to a separate vault
  - Pursue medium-resolution spectroscopy using L3 CCDs as a standby facility
- *Workhorse instruments*:
  - ALFOSC (optical) and NOTCam (near-IR) will remain the workhorses of NOT in the foreseeable future
  - A faster, more versatile array controller is needed for all detectors.

We are currently working with the community to develop these possibilities in greater detail, investigate the possible technical solutions, estimate their cost in money, manpower, and assign priorities. The result will be a specific plan and funding proposal for a well-defined upgrade programme, ensuring that NOT will remain an instrument of choice for many of the best Nordic research teams also in the next decade.

5. Conclusions

This contribution deals more with the planning process itself than with "Results and Conclusions". In part, this is because the process is still ongoing. But in large part it is also to emphasize that an open, transparent procedure for defining plans and priorities is essential to ensure that plans will not only be "right" in a scientific/technical sense, including all the best ideas available, but also that they are accepted by the community - including those whose wishes will *not* be fulfilled.

This process is greatly facilitated by the activities of the EU-sponsored Infrastructure Coordination Network OPTICON http://www.astro-opticon.org). OPTICON provides the natural, Europe-wide framework for addressing many of the issues touched upon above:

- Access to complementary instrument options at other European telescopes
- Coordinated, joint development of key hardware and software technologies
- Common data standards and archiving policies through the AVO
- Even more European collaboration and sharing of experience, and
- With luck, also (partial) EU funding for these activities.

The days of multi-purpose, "one-size-fits-all" telescopes are over. As a music lover, I think of the future role of NOT as that of a fine instrument in the international astronomical orchestra - but one many Nordic astronomers will want to play.

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References

Bergvall, N., Takalo, L.O., & Piirola, V. 2000, The NOT in the 2000's, Univ. of Turku.

NOTSA 2003, Annual Report 2002 (also available at http://www.not.iac.es)