Evaluation of the Nordic Optical Telescope

Prepared for the Joint Committee of the Nordic Natural Science Research Councils (NOS-N)

Copenhagen, March 2006

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Cover picture:
View of Observatorio del Roque de los Muchachos on the island La Palma. The Nordic Optical Telescope is seen to the left and the William Herschel Telescope to the right.

Presentation

In May 2005 the Council of the Nordic Optical Telescope Scientific Association (NOTSA) addressed the Joint Committee of the Nordic Natural Science Research Councils (NOS-N) with a request to review the role of the Nordic Optical Telescope (NOT) (La Palma, Spain) in Nordic astronomy in the next 10-20 years.

The NOS-N discussed the inquiry at the June meeting in Oslo and decided on the November meeting in Tallinn (Estonia) to initiate an evaluation of the Nordic Optical Telescope (NOT) with the Danish Natural Science Research Council (FNU) to be responsible for the implementation of the review.

The review panel on NOT was set-up following the recommendation of NOS-N and its main scope is:

Advise on suitable strategies for achieving a scientifically valuable and operationally cost-effective role for NOT over the next 10-20 years.

Members of the review panel made a site visit to the optical telescope on La Palma on the 6-7 February 2006 and the review panel met with representatives of NOTSA on the 21-22 of February 2006 in Copenhagen, Denmark.

The composition of the review panel

Chairman:

- Poul Erik Nissen, University of Aarhus

Panel members:

- Gerry Gilmore, University of Cambridge
- Roberto Gilmozzi, European Southern Observatory
- Esko Valtaoja, Tuorla Observatory

Executive Secretary for the review panel

- Anders Kjær, Danish Research Agency

Material received by the panel

For the purpose of the evaluation of NOT the panel received the following material from NOTSA in December 2005:

- The Nordic Optical Telescope - Status and Perspectives (December 15, 2005) by NOT Director, Johannes Andersen with the following appendices
    1. NOTSA - Results of the user group survey
    2. The Rationale for the Common Northern Observatory (CNO)
    3. NOTSA - Final budget for 2006
    4. NOTSA - Fallback plan for operating NOT on a flat budget
    5. Refereed publications in 2002-2005 from data taken with NOT
    6. NOTSA - Annual reports 2002-2004

- Reports from NOT Observing Programme Committee (OPC)
    1. On allocation periods 32 and 33 by OPC chairman, Jan-Erik Solheim
    2. Additional report about use of NOT in periods 32-33 by OPC Chairman, Jan-Erik Solheim

- Reports from Nordic Town Meetings on the mid- and long-term future of NOT held in November and December, 2005

Introduction to NOT

History of NOT

The decision to build the NOT was taken in 1984 after discussions in NOS-N. The Nordic Optical Telescope Scientific Association (NOTSA) was formed in 1984 as a consortium of the four Nordic Research Councils for the purpose of constructing and operating the 2.5m Nordic Optical Telescope (NOT). The telescope is located at the Spanish Observatorio del Roque de los Muchachos (ORM) on the island of La Palma, Canaries, Spain and was inaugurated in 1989. In 1997 the University of Iceland joined the NOTSA. The Associates contribute to the budget in the proportions 20: 30: 1: 20: 30 for DK, FIN, IS, NO and SE.

The present legal basis for the creation, development and operation of the ORM on the island of La Palma is a set of international agreements established in May 1979. The agreements and protocol have an initial duration of 30 years. These agreements define the main principles underlying the co-operation between the host country (Spain) and Instituto de Astrofisica de Canarias (IAC) and the partner countries and the user institutions.

NOT organization

The governing body of the NOTSA is the Council, which determines overall policies, approves the annual budgets and accounts and appoints the Director and the Astronomer-in-Charge. A Scientific and Technical Committee (STC) advises the Council on the performance and plans for the telescope and other scientific and technical policy matters. An international Observing Programmes Committee (OPC) of independent, experienced scientists appointed by the Council, performs peer review and scientific ranking of the observing proposals submitted. Based on the ranking by the OPC the Director prepares the actual observing schedule. The draft schedule is again reviewed by the OPC before it is finalized and posted on the web. Proposals are invited in May and November for the semesters beginning the following 1 October and 1 April. The call for proposals is announced widely, and all necessary forms and information are available on the web. The agreements establishing the observatory specify that 20% of the time is reserved for Spanish astronomers and 5% for international projects allocated by an International Scientific Committee, the CCI.

The Director has the overall responsibility for the operations of the NOT, including staff, financial matters, external relations and long-term planning. The staff on La Palma is led by the Astronomer-in-Charge, who has authority to deal with all local and urgent matters related to the operation of NOT.

Recent development

NOTSA is formally a Swedish non-profit foundation funded by Nordic public funds. In 2004 it was discovered that NOTSA had some unfortunate administrative shortcomings in personnel management practices covering previous years' contracts. These have been corrected to comply with current Spanish and EU regulations. The administrative scrutiny clarified that NOTSA is legally not a Swedish governmental organization, meaning that NOTSA staff must be employed under Spanish law and labour regulations. Accordingly, new contracts were signed and in effect from 1 January 2005. The result is that the staff are now protected by the Spanish social security system, but implies considerable extra expense in order to cover the mandatory taxes and social charges compared to the costs corresponding to the status which had previously been believed to be relevant, namely as tax-free international staff. The new contracts strictly preserve the net income earned by each staff member after deduction of taxes and social charges. Altogether, a 25% increase in the total budget for 2006 compared to 2005 has been necessary to cover these charges.

The current plans for the operation of NOT extend until 2009, when the original contract with the Spanish authorities on the use of the observatory site on La Palma comes up for renewal.

Status of NOT

Telescope

After more than 15 years of use, NOT is still a very competitive optical telescope in the 2-3 meter class. The optics is excellent, which in combination with the good seeing conditions on La Palma makes it possible to obtain high-quality images and spectra of celestial objects with NOT. Recent upgrades of the telescope include a new cooling system and a much more efficient auto-guider system. Later in 2006 a new telescope control system will be implemented.

Instrumentation

NOT has three "core" instruments of which ALFOSC is in operation for about 70% of the available observing time. It is used for UV-optical imaging and low- to medium-resolution spectroscopy in a field of 6x6 arcmin. ALFOSC is remarkable for its high efficiency, polarimetric capabilities and its fast readout mode of windows around selected objects. The second most used instrument is NOTCAM, an infrared imaging and low- to intermediate-resolution spectrograph, which is used 10-15% of the time. The last available core instrument, MOSCA, consists of a mosaic of four CCD detectors that delivers a field of 7x7 arcmin with a 0.1 arcsec sampling and a superb near-UV sensitivity. It was commissioned in 2001 but has not been much used until now, which is a bit surprising given that it seems to be the natural choice for programmes requiring high image resolution and a stable Point Spread Function (PSF).

A fourth core instrument, FRED, originally planned to be constructed at the Tourla Observatory several years ago, has so far not been delivered. It is a Schmidt-type, wide-field (17x17 arcmin) imaging instrument with low stray light and ghost image levels. It would have been very useful for the completion of several NOT programs, e.g. weak gravitational lensing studies of galaxy clusters and studies of Near Earth Objects.

In addition to these core instruments, several visitor instruments are being used at NOT, most notably SOFIN, a high-resolution echelle spectrograph from Oulo with interesting possibilities for spectro-polarimetric studies of active stars, and TURPOL, a nearly unique instrument from Turku for single object UV-optical polarimetry used e.g. for studies of dust distribution in our Galaxy. Recently, NOT has installed a fiber-connected high-resolution spectrograph (FIES), constructed at Aarhus University, in a new thermally stabilized building close to the NOT dome. This instrument may eventually replace SOFIN and, as a more stable and flexible instrument, it will add new possibilities, e.g. monitoring of stellar oscillations and search for exoplanets.

Mode of operation

Most of the observations at NOT are carried out by visiting astronomers using the telescope for scheduled periods of a typical length of 3-5 nights. Over the last few years, NOT has in addition introduced an increasing amount of Target-of-Opportunity (ToO) observations as well as service observations dealing with short programmes that may be given time through a fast-track application procedure. The ToO observations of transient objects like supernovae and Gamma-Ray Bursts have led to a number of high-impact publications. The service observations are scheduled on fixed nights, on the average two per month, which means that the chance to get the good seeing conditions often required by the service programmes is quite low.

Staff

Apart from the Director, NOT has presently a staff of four astronomers, three technicians/engineers, four software technicians and about two FTE administrative assistants. In addition, there are presently five M.Sc. students from the Nordic countries working on La Palma 25% of their time on NOT projects and a visiting Ph.D. student from Uzbekistan. The staff works

in a very enthusiastic way to keep the telescope and instruments running with a minimum of downtime. They also take care of night duties on the mountain, introduction of visiting astronomers and service observations. A major part of their time is used for upgrading the telescope and the instruments, such as improving the active optics system, the pointing of the telescope and the instrument control systems. A considerable amount of work has recently been devoted to establishing a more modern data system, which includes software scripts to control the observation procedure, pipe-line reduction of the data, and archiving. Altogether, it is the impression of the panel that the staff works in an efficient way.

Major observational programmes

The observing programmes at NOT cover nearly all fields of astronomy and astrophysics. As examples, we mention a few ongoing projects with Principal Investigators from the various Nordic countries. These programs have all led to well-cited publications in major, refereed journals;

Denmark:

- Nature of Gamma-Ray Burst sources.
- Investigations of stellar structure by asteroseismology.

Finland:

- Physics of Active Galactic Nuclei.
- Monitoring of stellar magnetic activity.

Iceland:

- Physics of Gamma-Ray Burst sources.

Norway:

- Structure of clusters of galaxies from gravitational lensing.
- Photometric and astrometric studies of Near Earth Objects.

Sweden:

- Physics of nearby supernovae.
- Doppler imaging of stellar surface structures.

It should be emphasized that in all of these projects there is collaboration between astronomers from two or more Nordic countries, and there is also extensive collaboration with scientists outside the Nordic countries. Furthermore, many of the projects involve observations with other telescopes such as the ESO VLT, HST and space instruments.

The interest for obtaining observing time on NOT has been somewhat decreasing over the last ten years, from a pressure factor of 2.3 (the ratio between the number of nights applied for and the number of observing nights available) ten years ago to an average pressure factor of 1.8 over the last three years. To some extent this development can be ascribed to the fact that Denmark and Sweden got access to the ESO VLT in 1998 and that Finland became a member of ESO in 2004. There are, however, sufficient good programmes to ensure that all Nordic countries get a number of observing nights that corresponds to the financial contributions to NOT.

As mentioned in the introduction a rather high fraction (25%) of the observing time on NOT is given to Spanish and international programmes in return for the infrastructure services provided by IAC. In addition, there has recently been a remarkable increase in applications from individual PIs outside the Nordic countries, and the number of nights allocated to such proposals now reaches 20-30% of the available observing time. A good fraction of these "international" PIs are of Nordic

origin. Furthermore, some of the non-Nordic nights are paid for through the EU funded OPTICON collaboration (75,000 Euro per year).

Publications

As seen from the attached Appendix F "Metrics of NOT publications 2002 - 2004", the number of refereed publications using data from NOT has reached a very satisfactory level of 60 - 70 papers per year. This is only about 20% lower than the rate of publication from the larger 4.2m William Herschel Telescope on La Palma, and at the same level as the average publication rate for the three ESO telescopes on La Silla, the 3.6m, the 3.5m NTT and the 2.2m, which altogether produce about 200 papers per year. Hence, there is no doubt that NOT is a very efficient telescope in terms of science production relative to expenditure.

As seen from Fig. 1 in the Appendix F, publications from NOT get nearly twice as many citations as the average for all astronomy (including theoretical papers), and NOT is only about 30% below the high impact Hubble Space Telescope. While citation rates cannot always be taken as an indication of high quality (papers with erroneous results sometimes get very high citation numbers), it is reassuring that the NOT papers have a high degree of attention. It should also be noted that the distribution of publications and citations among the Nordic countries (Table 2 in Appendix F) does not show any large anomalies. The lower number of citations for Sweden may to some extent be explained as a statistical fluctuation.

As shown in Table 3 in Appendix F, one might have expected that a larger fraction of the NOT papers had a first author from one of the Nordic countries. On the other hand, one should note that the majority of the papers using NOT data also use data from other facilities like the ESO VLT and HST. Hence, one cannot always expect a Nordic astronomer to be first author. In many cases NOT serves as an "entrance ticket" to an international collaboration that uses data from several world-class facilities.

Scientific context for NOT: ~ 2015

The range of scientific subjects currently addressed by NOT users, and the whole Nordic astronomy community, is extremely broad. Among these topics many will develop significantly over the next 10-20 years, especially as new survey facilities come on-line. Among general surveys which will identify many new examples of the types of object appropriate for NOT observations are the major surveys, UKIDSS (near IR, first data release to the ESO community 2/2006), VST (ESO), VISTA (ESO), PanStarrs (US) and LSST (US). AstroF and Herschel will provide IR sources in the near future.

All these are area-complete deep imaging surveys whose purpose is to identify targets for further study. Also of specific Nordic interest is GLAST, which will extend the study of Gamma-Ray Bursters, a field in which Nordic astronomy and NOT makes a major contribution. In another high public-interest field, extra-solar planetary systems, the Kepler satellite will identify very large numbers of sources for study. CoRoT will develop and extend the science of astero-seismology, another field with internationally leading Nordic expertise. Planck, a major ESA mission with substantial Nordic involvement, will discover large numbers of “foreground” sources, clusters of galaxies discovered from the Sunyaev-Zeldovich effect among them, which will motivate imaging and other follow-up analyses, some appropriate for NOT imaging.

Perhaps the largest impact will come from Gaia. Gaia, an ESA cornerstone mission, will be launched in late 2011. Gaia will survey every object in the sky to V=20 with HST spatial resolution, providing spectrophotometry of each on the order of 100 times over five years. Real-time data processing and an ‘alert’ system will feed discoveries for community study during the

mission, in addition to the mission-end astrometric catalogue. These real-time discoveries will include ~500,000 quasars – one every few minutes – and several hundred thousand supernovae. These SNe, perfect for detailed study of Dark Energy, will require more detailed imaging and spectra with telescopes such as NOT, to provide well-sampled light curves.

The requirement to have an appropriate capability to study these sources is a major motivating factor for the UK telescopes – INT, WHT – to be available for use through the CNO.

Other facilities available in the 2015 era include ALMA – the Large Millimetre Array in the Andes Mountains with major Nordic involvement through ESO, and Grantecan the 10 meter optical telescope on La Palma for which NOT imaging is a powerful part of source selection.

Operational modes in which NOT will contribute importantly to this science context include imaging, spectroscopy of brighter targets, monitoring and rapid reaction/response observing.

NOT as a researcher training facility

Medium-sized telescopes such as NOT have an important role in the training of the future generation of astronomers. The most efficient use of observing time at large telescopes, and even the ability to write successful proposals for them, requires previous hands-on experience with smaller telescopes. As a real international observatory with a variety of instruments - as opposed to a simple student telescope at a university - NOT provides excellent possibilities for this. The demand for various forms of researcher training time with NOT is likely to increase in the future. It should, and can, be accommodated considering the present demand for observing time.

NOT has a research studentship program for astronomy and engineering students at either the M.Sc. or the Ph.D. level. The level of satisfaction is very high among the present students, who consider the NOT traineeship a great asset for their future careers. The students also participate in the operations, spending about three nights per month at the telescope. An increase in the number of students might make feasible an increase in the service mode observations, for which there is a strong demand among the user community. However, to maintain the high quality of the student training program, the number of senior staff astronomers must remain sufficient.

Nordic-Baltic Summer Schools in astronomy, financed by NORDFORSK (previously NorFA), are held every 1-2 years. Typically, ~20 students use NOT for 6 nights, either on-site or through remote observing as in the August 2005 course at Moletai Observatory in Lithuania. These highly successful summer schools also help the Baltic countries to strengthen their astronomical research, important for the development of a strong long-term astronomy community in these countries. The EU-sponsored Network of European Observatories in the North (NEON) Observing School program now also involves NOT. Through NEON and other collaborations, NOT may also be able to obtain more EU funding in the future, by selling observing time.

Stockholm Observatory has since 2003 had an annual university course in observational astrophysics, involving five nights of observations with NOT. Extremely popular with the students, the course provides an example which other Nordic universities should consider following in the future, with either on-site or remote observations by students.

However, possibly the largest influence of NOT in researcher training has been the fact that young astronomers in all the Nordic countries have a relatively easy opportunity to use a world-class telescope for their research. The attractiveness of NOT for young researchers considering their career alternatives is well attested. The true impact of NOT is hard to quantify, but one can note the constantly increasing number of Nordic Ph.D. theses involving NOT observations, reaching a

record of 8 in 2004. Since 1990 there have been 49 Ph.D. theses and 44 M.Sc. theses using data from NOT (*www.not.iac.es/news/publications/theses.html*)

Finally, NOT can in many respects be compared to NORDITA in providing a focus, a meeting place, for young - and not so young - researchers, thus creating a previously lacking foundation for Nordic collaborations in astronomy.

The Common Northern Observatory, CNO (2009-)

One possible long-term future proposed by the NOT Director is to consolidate the capabilities of the NOT with other telescopes at the same site into an integrated single observatory. Preliminary discussions with the Directors of the ING and of the TNG have resulted in a discussion paper (Appendix 2 of the "NOT: Status and Perspective" report by the Director) outlining the rationale for such merging.

We support this option, although it should be clear that it does not represent an answer to the short term financial problems and in fact will need some initial investment (e.g. in standardization) before the long-term benefits can be realized. It is however the only way we can see for the NOT to maintain a competitive edge (through scientific specialization and reduced running costs) at the time 8- to 10-m telescopes will be in their maturity, and Extremely Large Telescopes will begin operations. We recommend that a working group including all potential participants in a CNO be set up as soon as possible to develop a detailed implementation plan for a CNO to assess which instruments are best suited for NOT to have a major role in a CNO, ensuring access for NOT community astronomers to a suitably wide range of instruments.

We identify two main advantages in the CNO option. One is the synergy between telescopes due to a rationalization of the consolidated instrument package whereby each telescope will have the instrumentation best suited to its characteristics.

In the case of NOT we see as potential instruments ALFOSC (with perhaps an increased field of view) and LuckyCam (given the ideal size of the telescope for this imaging technique). It is not clear to us that FIES would be competitive enough to remain in the merged observatory: in any case, even if its efficiency were improved, another telescope may be a better choice for it than NOT. Some of the visitor instruments may still be of interest, especially if operated by external groups. We stress that historical investments should not influence the discussions on the rationalization of each telescope, which should be driven only by the scientific uniqueness identified for the 2010+ time frame.

The second advantage is savings on personnel, which will be significant if a single management structure is established and if common standards are achieved (in particular in software, detector control electronics, and preventative maintenance).

The main disadvantage of CNO will be less control on the allocation of observing time, especially if a common time allocation committee (which we recommend) is established. Clearly, the current Spanish position of having an independent Telescope Allocation Committee (TAC) needs to be addressed.

We support the creation of a CNO board as soon as possible, including Spanish representation, to start negotiating the parameters, plans, schedule and possibly a progressive implementation of this option.

We strongly recommend that the following be included in the CNO negotiations:

- Identification of the unique scientific capabilities of a merged observatory
- Single management structure
- Clear policy for visitor and test instruments
- Use of at least one telescope focus as a test bench for innovative instrument concepts
- High priority to training of new observational astronomers
- Common TAC for all available observing time
- High fraction of observing time (50%) in service mode
- Significant fraction of time (10%) devoted to Access Programs (this may provide extra funding from e.g. the EU).

The natural time frame for the creation of the CNO would be the coming renegotiation of the current agreement in 2009, so the CNO Board will have about two years to reach agreement on the structure of the integrated observatory. We note that the maximum advantage of this option would be achieved if all the telescopes at the site were part of it. Exploratory discussions with all potential partners should therefore also take place.

Short-term (2007-2009) developments

The short-term horizon is dominated by the 300 K€ shortfall. We note that this shortfall is entirely due to the historical misunderstanding of the NOT legal status, and consequent inappropriateness of staff employment contractual procedures.

The NOT is a high quality telescope, efficiently operated at costs comparable with (if not lower than) those of similar facilities. Its strong points are the flexibility and the rapid response time to urgent new observations. It is therefore difficult to suggest options to maintain the current level of funding that do not significantly reduce the quality of the telescope or its operations, with the consequent damage of seriously undermining the possible negotiations for a common observatory by bringing into the discussion a less attractive package. We note that the creation of a CNO would achieve savings both in manpower and running costs, but only after 2009-2010.

We see three options to address the shortfall:

1. Increase the contributions
2. Find new partner(s)
3. Make operations cheaper

We strongly urge the Associates to consider option 1 at least until the negotiations for a CNO are concluded, starting at the same time the search of new partner(s). We cannot identify any possible new partner at this time, however.

If options 1 and 2 cannot be realized, the only option to reduce costs is a reduction in staff complement. We have identified no possible savings in other budget entries.

There are only two positions that we think may be suppressed. One is that of the Director (by merging his/her responsibilities with those of the Astronomer in Charge). This would have the advantage that all NOT staff would be at the site, but has the disadvantage that the workload of the new Director would be substantially increased (to the detriment of his/her scientific productivity,). Moreover, the Director's interactions with European activities would have to be dropped or assumed directly by the NOT Council.

Once the upgrade to the control software has been completed, a second position that may be suppressed is one of the software positions.

Enhanced Service Mode

Flexibility and rapid response were identified by the NOT communities as strategic requirements for the continued operation of the telescope. We have identified a cost neutral improvement to the operations that would enhance these characteristics while at the same time providing a better use of the telescope time, especially in winter (but not confined to it).

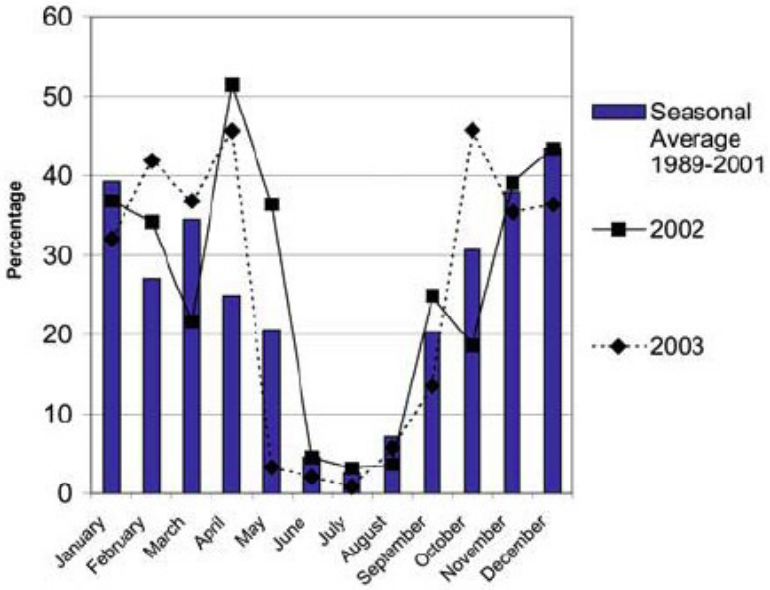

Figure 4. WHT monthly weather downtime.

The figure above shows the average monthly downtime at La Palma (from the WHT telescope statistics). It is clear that during the winter months only about half of the time is suitable for observations, which means that several observers travel to the NOT for little or no scientific return at all.

We propose to increase the fraction of service mode (including the advantages of queue scheduling – i.e. matching observations to the sky conditions) offered to the users by increasing the number of students present on the mountain. The expense for three additional students (30.000 Euro per year) would correspond to the savings in the travel cost for visiting astronomers, which savings might be transferred to an increase in the NOT budget.

We understand that the number of students has increased in the recent past, and an aggressive plan of advertising for "operational astronomer" positions would probably further increase the number of candidates interested in spending about one year at La Palma learning how to operate a telescope and its instruments.

We see several advantages with this scenario:

- Enhanced role of NOT in training the observational astronomers of the future
- Enhanced flexibility (adapting the observing programme to the existing conditions)
- More service mode (50% of the time), in line with modern observatories
- Better reactivity to targets of opportunity

We recommend that the NOT Director prepare a plan to implement this option.

Executive Summary – the five questions

1. Review the needs of Nordic astronomy for access to 2-4m optical telescopes in the northern hemisphere.

There is a demonstrated requirement for a level of access, comparable to that available at present, in the near future. Given the astronomical context in 5-15 years, especially the range of forthcoming space missions, it is probable that Nordic astronomy will require at least as much as at present, and possibly greater, access to facilities in this class, rather than a decrease, even if there is no increase in the size of the Nordic astronomical research community.

2. Review and advise upon suitable strategies for providing access to competitive northern hemisphere facilities in a cost-effective manner. In particular, the role which NOT could play in this regard, either as a self-contained operation, or in a broader context, such as OPTICON and the proposed CNO.

We see no strong case for NOT to continue as an independent self-contained facility. Rather, as part of a co-ordinated group of facilities (CNO), sharing infrastructure and operational costs, we perceive significant economies of scale, together with improved access to a wider range of optimised and complementary instrumentation. In this context, present (and probable future) EU funding will be valuable to support relevant technology developments, to provide cash support through an Access program, and to support the highly valued Research Training Role of NOT. This development from the present NOT to the CNO is by far the most cost-effective route to Nordic access to competitive Northern astronomical facilities.

3. Based on the specific strengths of the NOT, make recommendations regarding the scientific priorities for the services that could be delivered by NOT in the near and mid-term future.

The scientific drivers for the future use of NOT must be set by peer-review of community proposals. In that context, we note that there is a possible near-term operational change, which could be cost-neutral, and which would significantly enhance community scientific return from NOT. This involves using more student support to operate NOT in service mode through the winter months, if financially necessary by phasing out one astronomer post in favour of several student posts. A very much expanded service program would allow approved programmes to be matched to best observing conditions, ensure timely completion of high ranked projects, and save visiting observer travel costs and time. Other priorities include the importance of NOT for rapid access, research training, and its potential to allow rarely-used instruments to be supported by visiting teams.

4. Within those priorities, identify the most cost-effective ways to run the telescope and to look into future management, staff structure and level of service.

The present operation of NOT is highly efficient and cost-effective. We noted in point 3 that an enhanced service observing mode will significantly enhance community scientific return. Otherwise, some small natural saving will be possible as current projects are completed, the system reaches full maturity, and economies of scale across the CNO are implemented. The only significant efficiency savings which are realistic require economies of scale, which requires that

NOT become part of an integrated Common Northern Observatory. This may imply some transition costs as systems are made compatible, but will provide a context in which NOT has a stable, scientifically productive and viable long-term future.

5. Advise on how to optimise the operation to maximise the scientific value for money in a scenario where the budget is kept at the current level.

The present budget of NOT is dominated by staff and basic operations costs. This budget is constrained so tightly that there are no feasible short-term reductions below the 2006 operational budget. The only possible option for operation at the 2004 cash level is by finding a new partner, and reducing Nordic access. We are unaware of any such partner.

Appendix A - NOT Organization, 2006

Associates	
Denmark	Danish Natural Science Research Council
Finland	The Academy of Finland
Iceland	University of Iceland
Norway	The Research Council of Norway
Sweden	The Swedish Research Council

NOT Council	
Denmark	Dr. Hans Kjeldsen Prof. Jørgen Christensen-Dalsgaard
Finland	Dr. Leo Takalo Dr. Kati Sulonen
Iceland	Prof. Einar H. Gudmundsson Research Professor Gunnlaugur Bjornsson (Chairperson)
Norway	Professor Per Lilje Dr. Bjørn Jacobsen
Sweden	Prof. Claes-Ingvar Björnsson (Vice chairperson) Dr. Finn Karlsson

NOT OPC (Observing Programmes Committee)	
Denmark	Dr. Frank Grundahl Dr. Johan Fynbo (subst.)
Finland	Dr. Kari Nilsson (Chairperson) Dr. Tomas Hackman (subst.)
Iceland	Dr. Vilhelm S. Sigmundsson Dr. Einar Juliusson (subst.)
Norway	Dr. Håkon Dahle Dr. Andreas Jaunsen (subst.)
Sweden	Dr. Sofia Feltzing Dr. Jesper Sollerman (subst.)

NOT STC (Scientific and Technical Committee)	
Denmark	Dr. Hans Kjeldsen
Finland	Dr. Leo Takalo
Iceland	Prof. Gunnlaugur Bjornsson
Norway	Prof. Per Lilje (Chairperson)
Sweden	Prof. Claes-Ingvar Björnsson

NOT Staff	
Director	Johannes Andersen
Astronomer in Charge	Thomas Augusteijn
Astronomer team	Tapio Pursimo Anlaug Amanda Djupvik John Telting
Software team	Ingvar Svärdh Peter M. Sørensen Jacob W. Clasen Ricardo Cardenes
Technician & engineer team	Carlos Perez Graham Cox Peter Brandt
Administrative staff	Loida Fernandez Francisco Armas Eva Jurlander
Student programme	Lars Glowienka Karianne Holhjem Raine Karjalainen Tine Nielsen Danka Paraficz Dmitry Sharapov

Appendix B - National contributions, 2006

	Relative	Basic contribution, Euro	Additional contribution, Euro
Denmark	20%	248,700	58,200
Finland	30%	373,000	58,200
Iceland	1%	12,600	2,900
Norway	20%	248,700	58,200
Sweden	30%	373,000	0
Total	***~100%***	***1256,000 Euro***	***177,500 Euro***

Appendix C - Terms of Reference

Terms of reference as described by NOTSA Council in letter dated 19 August to NOS-N

Terms of reference for the evaluation panel

The evaluation panel should consist of three prominent researchers, at least one of them non-Nordic. The panel will be briefed through a status report from NOT, a visit to the site, and visits to the Nordic countries. Based on its interviews during these visits, the panel would be asked to advise the NOTSA Council on suitable strategies for achieving a scientifically valuable and operationally cost-effective role for NOT over the next 10-20 years. In its report, the panel should address the specific points listed below, but may give any additional comments or advice which it finds pertinent. As a part of its evaluation, the panel should include its assessment of the current operation of NOT and such scientific and financial planning documents as have been submitted to the Council and Committees of NOTSA.

Specifically, the panel should:
1. Review the needs of Nordic astronomy for access to 2-4 m optical telescopes in the northern hemisphere.

2. Review and advice upon suitable strategies for providing access to competitive northern hemisphere facilities in a cost-effective manner. In particular, the role which NOT could play in this regard, either as a self-contained operation or in a broader context, such as OPTICON and the proposed CNO.

3. Based on the specific strengths of the NOT, make recommendations regarding the scientific priorities for the services that could be delivered by NOT in the near and mid-term future.

4. Within those priorities, identify the most cost-effective ways to run the telescope and to look into the future management, staff structure and level of service.

5. Advise on how to optimize the operation to maximize the scientific value for money in a scenario where the budget is kept at the current level.

The cost of the evaluation, up to about 200.000 DKK, will be paid by NOTSA.

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Appendix D - Plan for review panel

Panel visit on La Palma, 6-7 February 2006

Monday, 6 February 2006:
09:00 - 10:00 Drive up to observatory
10:00 - 11:30 Visit NOT including coffee and meeting with engineering staff
11:30 - 12:30 Visit TNG
12:30 - 14:30 Lunch and meeting with ING, NOT, TNG directors
14:30 - 15:30 Visit WHT
15:30 - 16:00 Visit Grantecan
16:00 - 17:00 Drive down

Tuesday, 7 of February 2006:
09:30 - 10:00 Coffee with staff at the NOT office in Santa Cruz
10:00 - 11:00 Meet students
11:00 - 12:00 Meet software group
12:00 - 13:00 Meet astronomers
13:00 - 15:00 Lunch and meeting with Prof. Rafael Rebolo, IAC

Panel's meeting in Copenhagen, 21-22 February 2006

Monday, 21 February 2006
09:00 - 09:30 Internal Panel discussion
09:30 - 10:00 Meeting with Gunnlaugur Bjornsson, Iceland
10:00 - 10.30 Meeting with Leo Takalo, Finland
10:30 - 11:00 Meeting with Per Lilje, Norway
11:00 - 11:30 Meeting with Jørgen Christensen-Dalsgaard and Hans Kjeldsen, Denmark
11:30 - 12:30 Meeting with Claes-Ingvar Björnsson, Sweden
12:30 - 13:30 Lunch
13:30 - 14:00 Meeting with Jan-Erik Solheim, Chairman of OPC
14:00 - 15:30 Meeting with Johannes Andersen, NOT Director
15:30 - 16:30 Internal Panel discussion

Plan for 22 February 2006
09:00 – 11.00 Internal Panel discussion
11.00 – 12.00 Exploratory meeting with NOT Director and NOTSA Council's Chairman
12:00 – 13:00 Lunch
13:00 – 18.00 Writing the draft report

Appendix E - Glossary of Acronyms

ALFOSC	Andalucia Faint Object Spectrograph and Camera
ALMA	Atacama Large Millimetre Array
AstroF	Japanese Infrared Space Mission (AKARI)
CCD	Charge Coupled Device
CCI	Comite Cientifico Internacional
CNO	Common Northern Observatory
CoRoT	Convection, Rotation & planetary Transits satellite
ESA	European Space Agency
ESO	European Southern Observatory
FIES	Fibre-fed Echelle Spectrograph
FRED	Focal Reducer
Gaia	ESA's astrometric space mission
GLAST	Gamma-ray Large Array Space Telescope
GRANTECAN	Gran Telescopio Canarias
Herschel	ESA's far-infrared, sub-mm space mission
IAC	Instituto de Astrophysicas Canarias
ING	Isaac Newton Group of telescopes
INT	Isaac Newton Telescope
Kepler	NASA's space mission for finding exoplanets
LSST	Large-aperture Synoptic Survey Telescope
MOSCA	Mosaic Camera
NEON	Network of European Observatories in the North
NOT	Nordic Optical Telescope
NOTCam	Nordic Optical Telescope near-IR Camera/spectrograph
NOTSA	Nordic Optical Telescope Scientific Association
NTT	New Technology Telescope
OPC	Observing Programs Committee
OPTICON	Optical Infrared Coordination Network for astronomy
ORM	Observatorio de Roques de los Muchachos
PanStarrs	Panoramic Survey Telescope and Rapid Response System
Planck	ESA's Cosmic Background Radiation surveyor
PSF	Point Spread Function
SOFIN	Soviet Finish spectrograph
STC	Scientific Technical Committee
TAC	Telescope Allocation Committee
TNG	Telescopio Nazionale Galileo
TURPOL	Turku UBVRI Photopolarimeter
UKIDSS	UK Infrared Deep Sky Survey
WHT	William Herschel Telescope
VISTA	Visible and Infrared Survey Telescope for Astronomy
VST	Visible Survey Telescope

Appendix F - Metrics of NOT publications 2002-2004

Introduction

The number of citations to papers using data from the 2.5m Nordic Optical Telescope (NOT) has been obtained from the NASA Astrophysical Data System (ADS; *http://adswww.harvard.edu)* in late December 2005. All refereed papers in the NOT publication lists for 2002, 2003 and 2004 (as sent to the NOT-panel by the NOT director) were included. For comparison the corresponding bibliometrics was also made for the 3.6m Telescopio Nationale Galileo (TNG), the 4.2m William Herschel Telescope (WHT), and the 2.5m Isaac Newton Telescope (INT). The publications lists of TNG were acquired from *http://www.tng.iac.es* and the lists of WHT and INT from the biennial report 2002-2003 of the Isaac Newton Group (ING). For the two ING telescopes the 2004 publication list was not available in December 2005.

It should be noted that the citation lists in the ADS are not complete; citations appearing in mathematics, chemistry and geophysics journals may not be included. Citations from all astronomy and astrophysics journals and the major physics journals are, however, included. As of March 2005 citations from astro-ph (arXiv) preprints are integrated in the ADS. The statistics given in Tables 1-3 includes these astro-ph citations. A method to remove self-citations is available in the ADS, but is rather cumbersome to use and the figures in Tables 1-3 therefore include self-citations. A few checks suggest that the number of self-citations amounts to 10-20% of the total number of citations.

Publications from optical telescopes on La Palma

Table 1 lists the number of refereed publications from NOT, TNG, WHT and INT. It is seen that the number from NOT is the same as the number from INT in 2002 and significantly higher in 2003. Furthermore, the publication rate from NOT is only about 25% lower than the rate from the larger WHT. The lower publication numbers from TNG may be ascribed to the fact that this telescope only came into regular operation in 2001. As seen from Table 1, the publication rate from this telescope has increased very significantly from 2002 to 2004.

The impact of the papers published may to some extent be estimated from the number of citations. As seen from Table 1, NOT compares very well with the other La Palma telescopes. The average number of citations per paper for NOT (or the median number) is nearly the same as in the case of the INT and only 20-40% lower than the numbers for the larger WHT and TNG telescopes.

To put these citation rates in a larger perspective, we can make a comparison with a bibliometric investigation of publications from the Hubble Space Telescope (HST) and the ESO Very Large Telescope (VLT) published by Grothkopf et al. in the ESO Messenger (March 2005, p. 45). Here the bibliometrics was made in December 2004 and includes citations for papers published in 2003 and earlier. The number of publications from these instruments is much larger than the number of publications from the La Palma telescopes, but the average number of citations per paper is not too different. As seen from Fig. 1, WHT is comparable to HST and NOT is only about 30% lower than HST.

Figure 1 also shows the average citation rate for all refereed papers (about 18 000 per year) in astronomy (including theoretical papers). As seen, NOT papers have on the average nearly twice as many citations as the average in astronomy.

Table 1: Bibliometrics of refereed papers in which data obtained with NOT, TNG, WHT and INT, respectively, is used. The number of publications is listed in col. 2. Total number of citations according to ADS as of December 30, 2005, is given in col. 3. Column 4 gives the average number of citations per paper, and col. 5 the median number of citations.

Year	N_{publ}	N_{cit} Dec. 2005	Citations per paper	Median
		NOT 2.5 m		
2002	72	1064	14.8	11
2003	62	667	10.8	9
2004	66	390	5.9	5
		TNG 3.6 m		
2002	20	314	15.7	11
2003	35	741	21.2	16
2004	47	431	9.2	5
		WHT 4.2 m		
2002	93	1698	18.3	12
2003	82	1333	16.3	9
		INT 2.5 m		
2002	72	1084	15.1	11
2003	44	530	12.0	9

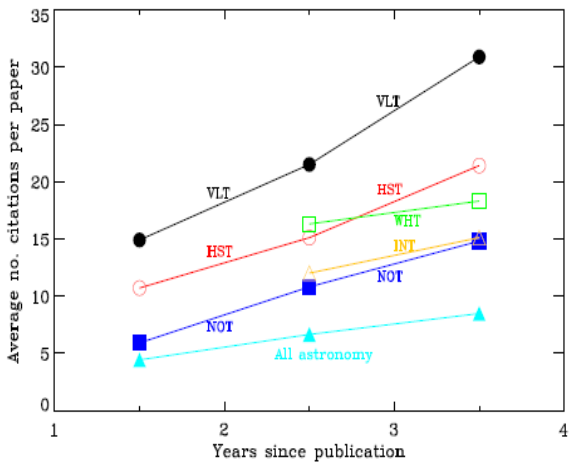

Figure 1: Average number of citations per paper as a function of time elapsed since the year of publication. It should be noted that the HST and VLT bibliometrics was made before astro-ph preprint citations were included in the ADS. The typical ratio between the number of citations with and without astro-ph citations included depends on time elapsed since publication; it decreases from about 1.5 after one year to 1.3 after three years. The HST and VLT citation numbers given in Grothkopf et al. (2005) have been increased with such factors before plotted in the figure.

National distribution of NOT publications 2002-2004

Tables 2 and 3 show the national distribution of refereed papers from NOT in the period 2002-2004. In table 2, a paper has been classified as belonging to a given country if at least one person from that country is co-author of the paper. International papers are those with no co-author from Nordic countries. In Table 3, the papers are classified according to the first author. Affiliation as given in the paper has been adopted, except in the case of Nordic Ph.D. students and post doc.s working abroad (e.g. at NOT, ESO or NORDITA); they were classified according to nationality.

A given paper may have co-authors from several Nordic countries. Hence, in Table 2 the sum of the numbers in col. 2 (n=239) is lager than the total number of publications from NOT 2002-2004 (n=200).

From the average citation rates of NOT papers given in Table 2, we conclude that papers with co-authors from Denmark, Finland, Iceland and Norway, have a very satisfactory impact factor, i.e. at the same level as HST papers. Papers from Sweden and international papers have lower citation rates but are still well above the average in astronomy. The high citation rate of Icelandic papers is due to the participation of Icelandic astronomers in the Nordic Gamma-Ray Burst consortium, which has citation rates well above the average.

Table 2: Distribution of refereed publications from NOT 2002-2004 according to co-authorship.

Country	N_{publ}	N_{cit}	Citations per paper
Denmark	41	687	16.8
Finland	43	622	14.5
Iceland	8	186	23.3
Norway	35	438	12.5
Sweden	34	296	8.7
International	78	683	8.8

Table 3: Distribution of refereed publications from NOT 2002-2004 according to first author.

Country	N_{publ}
Denmark	14
Finland	19
Iceland	3
Norway	10
Sweden	16
International	138

Table 3 shows that out of 200 NOT papers, only 62 (i.e. 31%) have a Nordic first author. Considering that 20% of the observing time at NOT belongs to Spain, 5% is international, and that some additional international time is distributed via OPTICON, one expects of course a substantial number of papers with first authors from non-Nordic countries, but not at a level of 70%. At first sight, one might conclude that Nordic astronomers too seldom take a sufficiently strong lead of observing programs to enable them to become first authors of the resulting papers. On the other

hand, it should be realized that the majority of papers using data from NOT also include data from other facilities such as the VLT, HST and space instruments. Hence, one cannot always expect a Nordic astronomer to be first author. In many cases NOT serves as an "entrance ticket" to a fruitful international collaboration, where data from several world-class facilities is used.