Astronomy in the Netherlands

Mid-term update of the
Strategic Plan 2001-2010
and
forward look to 2015

NCA
on behalf of
NOVA, ASTRON, SRON

June 2006

Figure on cover

A three-color composite image of the small sky field observed with the ISAAC multi-mode instrument at VLT ANTU obtained during the Faint InfraRed Extragalactic Survey (FIRES) project. The photo is a combination of one HST WFPC2-camera exposure (in the I-filter at wavelength 0.814 µm; here rendered as blue) and two ISAAC exposures (J_s; 1.24 µm; green - K_s; 2.16 µm; red). A large number of red galaxies at redshifts $z > 2$ was found: these sources are hardly visible in the HST observations. The FIRES program is led by Franx.

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Strategic Plan 2001 – 2010
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forward look to 2015

Nederlands Comité Astronomie - NCA
on behalf of
Nederlandse Onderzoekschool Voor Astronomie - NOVA
Stichting Astronomisch Onderzoek in Nederland - ASTRON
Netherlands Institute for Space Research – SRON

June 2006

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Executive summary

Dutch astronomy currently operates successfully under its Strategic Plan 2001-2010, issued in October 2001. The purpose of the current document is to provide a mid-term update for the strategy of astronomical research in the Netherlands, and to extend the planning horizon to about 2015. A number of the goals set out in the 2001 plan have already been accomplished, but several important ones have not yet been attained, and these recur in the goals for 2006-2015.

Harvesting the scientific results of the instrumental projects completed during the past several years, as well as finishing those that are still underway, are important themes in the plans for the coming period. In addition, new exciting developments in astronomical research worldwide necessitate concerted national efforts in order for the Netherlands to stay at astronomy's cutting edge.

Astronomy

The goal of astronomical research is to understand the Universe and all its constituents in terms of the laws of physics. Key questions include: What are the fundamental physical laws governing the Universe? How do the structures we observe in the universe (such as planets, stars, galaxies and the cosmic web) form, and how do they evolve? How did life develop in the Universe, and where do we fit in?

These are amongst the most fundamental questions in science and appeal to deep human motivations to understand the world around us and, ultimately, our origins. These questions motivate the Netherlands' national astronomy program, which specifically focuses on:

- i Formation and evolution of galaxies
- ii Birth and death of stars and planets
- iii Physics of neutron stars and black holes

These three main research areas are dynamic and interrelated. Scientific progress causes the research within each area to evolve, for example towards (exo)planet and gamma-ray burst research in areas (ii) and (iii) respectively, and cross-links between them and with other areas to spring up, such as astroparticle physics, (bio)chemistry and prebiotic biology, computer science, geophysics, laboratory astrophysics, and solar system exploration, which provide further exciting opportunities for new directions.

Organization

The universities of Amsterdam, Groningen, Leiden, Nijmegen and Utrecht each support PhD granting astronomy research institutes. Together these comprise NOVA, the Netherlands Research School for Astronomy, which carries out a joint strategic research and instrumentation program funded through the Ministry of Education, Culture and Science (OCW). The Netherlands Organisation for Scientific Research (NWO) supports the institutes ASTRON (ground-based instrumentation and operator of radio facilities) and SRON (development and exploitation of instrumentation for space observatories and liaison with the European Space Agency ESA). Through its Board of Physical Sciences (GBE) it funds research projects in astronomy, and also supports the Dutch participation in the Joint Institute for VLBI in Europe (JIVE, hosted by ASTRON), and in international observatories on La Palma and Hawaii. Finally, OCW also funds the

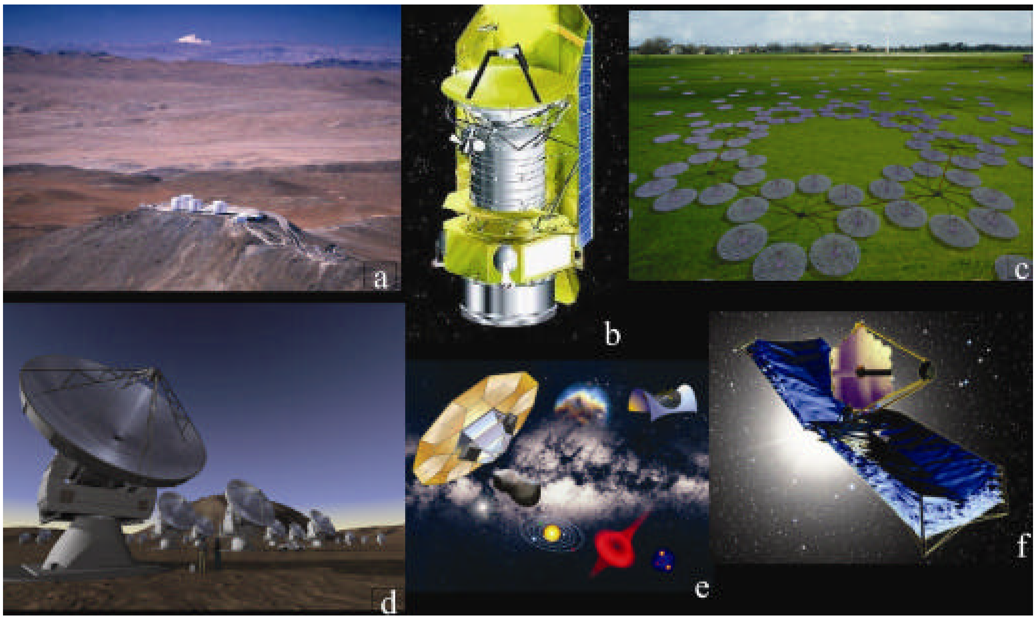

Figure 1: Observational opportunities for the coming decade:

a. ESO's Very Large Telescope and Interferometer, together with the VLT Survey Telescope and VISTA, on Cerro Paranal.
b. The Herschel Space Observatory, to be launched in 2009.
c. The international Low Frequency Radio Array, with its core in The Netherlands, operational in 2009.
d. The Atacama Large Millimeter Array, on Llano Chajnantor, fully operational in 2012.
e. ESA's next cornerstone mission GAIA, to be launched in 2011.
f. The James Webb Space Telescope, to be launched in 2013/14.

national membership in the European Southern Observatory ESO, and part of the national involvement in ESA.

The universities, NOVA and NWO each have their own strategic planning cycles, as do ESA and ESO[1], but have a long tradition of coordinating their planning of astronomical research and instrumentation. The Netherlands Committee for Astronomy NCA (which represents the Netherlands in the International Astronomical Union, but does not itself fund any scientific research) comprises representatives from all these bodies and is instrumental in developing the joint strategy.

Each field of modern astronomical research relies on observations covering the entire wavelength range from gamma rays to radio (with important new, non-electromagnetic windows currently opening up). ESO, ESA and NASA provide Dutch astronomers with access to international facilities including the Very Large Telescope (VLT), the VLT Interferometer and the survey telescopes VST and VISTA, the Hubble and Spitzer Space Telescopes and the high-energy space observatories Chandra, XMM-Newton, and Integral. NWO ensures access to the UK/NL/E optical telescopes of the Isaac Newton Group on La Palma, the UK/CND/NL submillimeter James Clerk Maxwell Telescope (JCMT) on Mauna Kea, and to the Westerbork Synthesis Radio Telescope (WSRT) and JIVE, both located in The Netherlands.

[1] References to plans for astronomical research and instrumentation are listed on page 11.

Implementation of the 2001 strategic plan

In the past five years, Dutch astronomy has strengthened its already prominent international position. Research has flourished, with considerable scientific progress in the three focus areas, and several fundamental breakthroughs (Fig. 2-4 plus cover). Astronomy PhDs trained by NOVA compete successfully for the best postdoctoral positions world-wide. Dutch astronomers are frequent users of leading facilities where telescope time is obtained in strong international competition; they actively participate in advisory and governing bodies of organizations such as ESO and ESA, and serve on international task forces planning future frontier facilities.

The NOVA program has led to the establishment of vigorous inter-university thematic research networks, and a strong national program of instrument development together with ASTRON, SRON, and GBE. This has considerably strengthened the participation of the Netherlands in the ESO program: Dutch astronomers are now involved in many first and second generation instruments for the VLT and the VLT Interferometer and Survey Telescope, and in designing and building the high-frequency receivers for the Atacama Large Millimeter Array, which uniquely exploit its 5000 m elevation. The program also supports a thriving laboratory astrophysics effort, enabled participation in the instrument program for the successor to the Hubble Space Telescope, the James Webb Space Telescope (JWST), provided a state-of-the-art pulsar capability (PuMa II) for the WSRT, and supports software development for the Low Frequency Array (LOFAR). The NOVA Program also made it possible to attract top scientists to the Netherlands, including instrumentation experts, and to improve the age distribution of the university staff: 40% of the tenured (track) staff has been appointed in the past six years. Continuation of the NOVA program beyond 2003 was accomplished, and NOVA is currently funded through 2008. Many projects require funding beyond this date.

University support of astronomy has been fairly stable overall, but the growth of the new program at Nijmegen and of structural staff positions in Leiden and Amsterdam was offset by declining support for university-funded PhD positions in Amsterdam and Groningen. OCW support of astronomy remains strong.

All of the five major priorities in astronomical instrumentation (participation in ALMA, instrument development for the VLT and its Interferometer, participation in the mid-infrared instrument MIRI for JWST, realization of LOFAR and preparation for the Square Kilometer Array SKA, and development of real-time VLBI) succeeded in raising substantial funds, and are well underway or have even, in some cases, already been achieved. LOFAR construction was funded through the BSIK scheme, work has started successfully and several further sources of funding have since been secured, but the project needs additional resources to finance software development and operations. An international SKA design study led by ASTRON received significant funding from the EU FP6 Program. All major radio observatories in Europe were connected by wideband glass fiber to JIVE in Dwingeloo, enabling real-time VLBI.

Support of the observatories on La Palma and Hawaii has been satisfactory, and several new instruments were funded by GBE. The NWO-M funding line for smaller instrument initiatives and software development has been very effective, but its budget is now under threat. Oversubscription rates for the annual GBE Open Competition (OC) for funding of graduate students and postdocs have increased to factors above seven, and the critical goal to double the number of temporary research positions

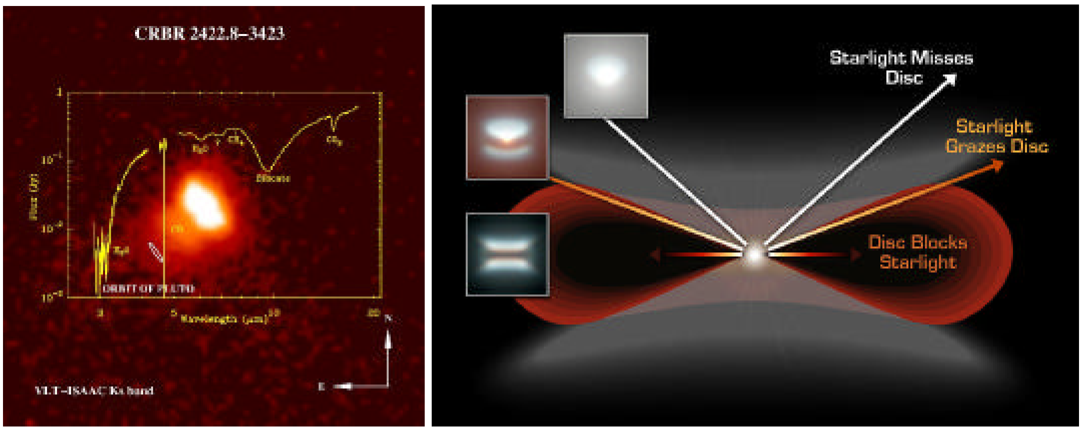

Figure 2: Studies of proto-planetary disks around forming stars revealed major new insights into the formation and early evolution of our Solar system. The edge-on disk CRBR 2422.8-3423 in Ophiuchus shows deep absorption features due to ices, such as water, CO and CO_2. While much of the ice observed along the line-of-sight is located in a foreground molecular core, a significant fraction of the ice likely resides in the outer disk. Left: Spitzer-IRS and VLT-ISAAC spectra of this disk, superposed on the VLT near-infrared image of the source. A fraction of the deep ice absorptions arises in the warm surface layers of the disk. Right: model images of the CRBR 2422.8-3423 disk viewed under various inclinations (Pontoppidan, van Dishoeck et al. 2005).

available through the OC on a structural basis has not yet been reached - in fact, at the time of writing money is so tight and demand so high that GBE decided to curtail the 2006 competition in favor of a less under-funded 2005 one; a very worrying development.

Stable and adequate baseline funding of R&D at SRON and ASTRON, allowing these organisations to attain their strategic goals in the areas of radio, submillimeter, optical/ infrared and high-energy astrophysics has not yet been realized.

Opportunities

The scientific opportunities for the next decade are tremendous (Fig. 1). By 2009 a complete arsenal of first-generation instruments and the first second-generation instruments will be operational on the VLT (with strong Dutch involvement), as will the survey telescopes VST (NOVA PI on its camera) and VISTA. By that time, the WSRT may have new focal plane arrays, LOFAR will be fully operational, and Herschel will have been launched, with major Dutch investment in one of its three instruments, HIFI (SRON PI). If all goes well, the Hubble Space Telescope will have been refurbished once again. Furthermore, the Icecube neutrino detector in Antarctica will be fully operational, and the Auger Observatory in Argentina will enable study of extremely energetic cosmic rays.

By 2013, the full suite of second-generation VLT instruments will be complete (with the Netherlands participating in three of the five), ALMA with its 50 antennas will have just come on line at Chajnantor, Europe and the United States will be ready to start construction of Extremely Large Telescopes for the optical/infrared regime, and the SKA Design Study will have paved the way for the construction of the 10% SKA

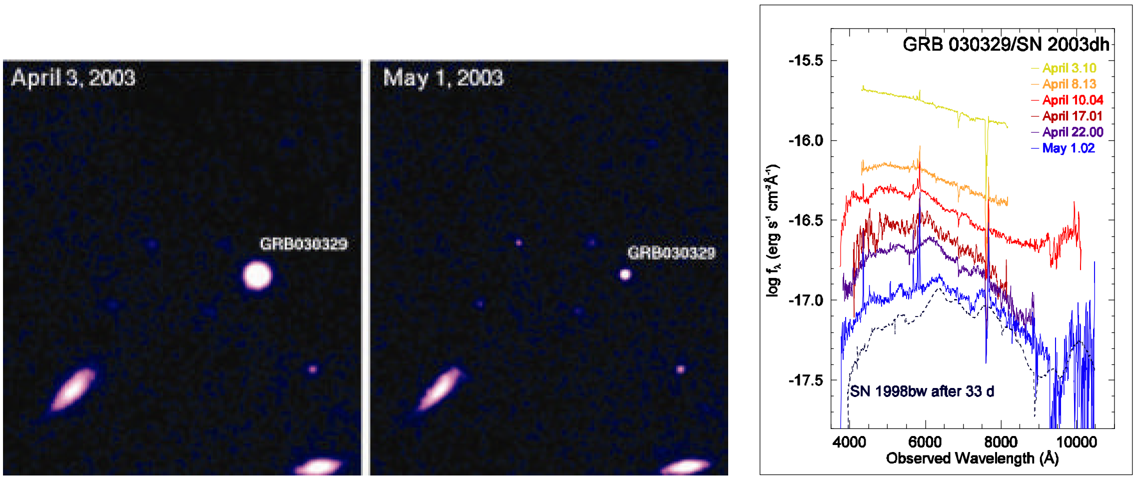

Figure 3: Studies of gamma-ray bursts demonstrated that some of them are caused by the deaths of very massive stars. Left: ESO-VLT images of the afterglow of the gamma-ray burst of 29 March 2003 and its supernova SN2003dh, at redshift 0.17, taken on 3 April 2003 and on 1 May 2003. Right: Discovery spectra of a type Ic supernova in the afterglow of the same gamma-ray burst: the spectra are shown in real intensity, the brightest and earliest ones on top, and the fainter ones downwards as time proceeds from four days after the burst to more than one month later. In the early measurements, one sees the fairly smooth and featureless spectrum of the fast explosion that produced the gamma-ray burst. As this fades, another spectrum becomes apparent, which is identified as that of a very energetic type Ic supernova, caused by the explosion of a massive star.

Pathfinder at radio wavelengths. The GAIA Observatory will have started taking data, ESA will have initiated construction of (one of) its Cosmic Vision missions, and soon after, the James Webb Space Telescope will be launched, with on board MIRI with a unique spectroscopic capability contributed by the Netherlands (NOVA PI). The gravitational wave observatory LISA should follow in about 2015.

The continuing exponential increase in computing power makes it possible to harvest the massive data streams from these new observational facilities. At the same time it allows the direct computation of astrophysical problems of vastly increased complexity, essential for our understanding of the Universe and its constituent structures.

Coherent national strategy in an international context

Astronomy is a global and highly competitive endeavor, with new players entering the field to join the currently leading nations. Thanks to the application of new technological capabilities to astronomical instrumentation as well as the rapid progress in information technology, astronomy worldwide is currently going through a golden age of discovery. Major advances are typically based on observations done with a new instrument opening up a new window in parameter space, and involve follow-up observations with telescopes across the electromagnetic spectrum, and the intensive use of state-of-the-art networks, storage, computation and algorithms for data processing and interpretation. Unique expertise, deep theoretical insight coupled with a capability of rapid interpretative follow-up, and a stimulating research environment that attracts the best scientists, are all crucial.

The ambition of the Dutch astronomical community is to maintain its current forefront position in international astronomical research. The strategy is to continue the successful approach where most of the observational/interpretative and theoretical research and part of the conceptual instrument development occur at the university institutes, funded by GBE, NOVA and the universities, and technology development and instrument construction take place predominantly at ASTRON and SRON, in a coordinated program of sufficient critical mass.

A growing concern is the retention of unique expertise in an increasingly dynamic environment: an increasing fraction (now up to 80%) of scientific group members are employed on temporary contracts and 'permanent' staff is becoming increasingly mobile as well. A successful national astronomy program must offer competitive opportunities to retain its key researchers, and to attract new talent. Groups require dedicated support for maintaining expertise in instrumentation, software development, state-of-the-art data reduction, simulation and theory, with a horizon exceeding that of a graduate student or postdoc contract.

Top priorities for the coming decade

1. Structurally extend NOVA funding beyond its present horizon of 2008, for a program of similar scope as the current one, at an estimated cost of about 6-7 M€/yr. This is *the* key priority for maintaining the international position of Dutch astronomy as it is essential for the continued viability of the university institutes, which form the heart of the Netherlands' astronomical research effort. It will allow:

    a. To continue carrying out front-line research across the full spectrum from instrument development to theory in inter-university networks of researchers in the three focus areas, to bring in the harvest of new observational facilities, particularly those with substantial Dutch investments (which include ESO instruments, HIFI, and LOFAR), while continuing to support participation in the next generation of instrumentation and the development of technical and software expertise required for this. All this as part of a strong national program of training young astronomers to the highest international level and improving the demographic composition of the university institutes' tenured staff.

    b. To continue the strong involvement of the Netherlands in the ESO program which includes the development of an Extremely Large Telescope on a competitive timescale. The way forward is to be involved from the start in instrument design and development, building on the strong Dutch track record at mid-infrared wavelengths (ISO, VISIR, MIDI, MIRI) and in (adaptive-optics assisted) integral-field spectroscopy (SAURON, OASIS/GLAS, SINFONI, MUSE, SPHERE), with a recent revival of expertise in polarimetry, all with strong links between NOVA, ASTRON and SRON.

    c. Maintain strong university support of astronomy at Amsterdam, Groningen, Leiden, Nijmegen and Utrecht, including funding of PhD positions.

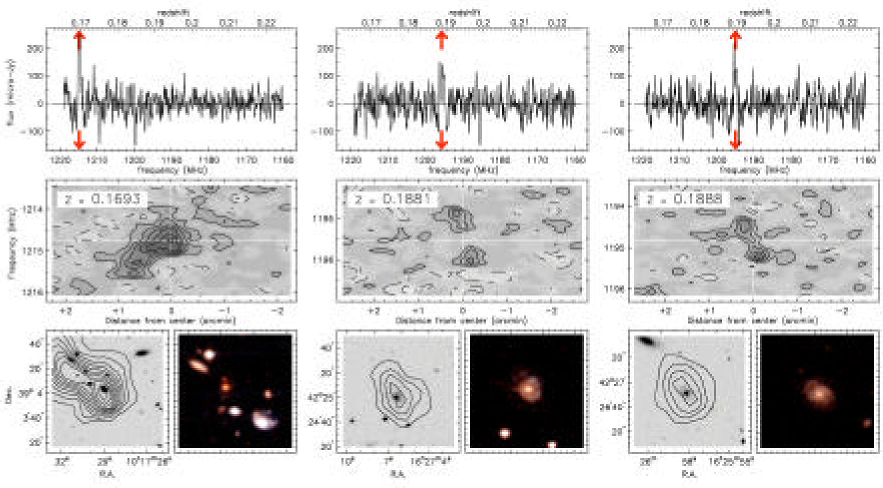

Figure 4: Examples of three galaxies at redshifts around z = 0.2 detected in HI with the WSRT. These galaxies are members of the Butcher-Oemler clusters Abell 963 and Abell 2192. So far a total of 20 galaxies have been detected with masses exceeding $7.6x10^9$ M?. For each galaxy, the upper panel shows the entire HI spectrum with red arrows indicating the redshift and frequency of the HI signal. The middle panel shows the position-velocity diagram along the major axis of the galaxy. The lower left panel shows the integrated HI map on top of an optical image. The lower right panel shows a blow-up color image of the HI detected galaxy. Note that many optical counterparts show disturbed morphologies.

2. Increase NWO-GBE astronomy funding to allow GBE to support the harvesting of the results from Dutch instrumental investments, to seize opportunities in interdisciplinary research (a natural NWO role), and to capitalize on the unique aspects of the NWO-supported observatories. This will make it possible to:

   a. Double the number of research positions funded in the annual Open Competition to 12 fte/yr (a goal from the previous plan that was not yet attained on a structural basis), structurally set the level of the NWO-M investment subsidies to that of 2003 (1.5 M€/yr), and grant Vernieuwingsimpuls positions to astronomy at a rate commensurate with the number of excellent researchers in the field (approximately 1 VICI, 3 VIDI, 3 VENI per year). Stimulate cross-disciplinary research by reserving means for exploratory projects at the 5 fte level among the areas of astroparticle physics, astrobiology/chemistry, and computer science.

   b. Provide continued access to the William Herschel Telescope on La Palma. This will soon be one of the first telescopes worldwide with laser-guide-star adaptive optics at optical wavelengths. It is also a unique platform for visitor instruments, and as such provides Dutch university groups with opportunities to carry out key science programs and to test instrument concepts for the larger telescopes to come. Access to the WHT until well beyond 2009 is of prime importance. The initiative to bring the WHT under an international organization responsible for operating all the leading telescopes on La Palma, the 'Common Northern Observatory', should be supported.

c. Provide access to the JCMT for a few years beyond 2009, until ALMA is up to speed. This will help position Dutch astronomy for the optimal science exploitation of ALMA by use of eSMA and SCUBA2. In the longer term, assure that the current budget lines for both the WHT and the JCMT are preserved for new investments in challenging international projects that require long lead times.

d. Continue JIVE to allow its successful incorporation into the larger radio astronomy schemes emerging in a European context.

3. Provide ASTRON and SRON with the means to maintain a leadership role in the European arena. The programs and goals of both these institutes received excellent ratings from international review panels in 2005. Both require adequate funding to:

   a. Complete the construction of LOFAR, and operate it successfully. LOFAR is an international sensor network which in its application as an astronomical observatory opens up a new low-frequency radio window, and provides an essential pathway towards SKA. Funds need to be found to finance the completion of the astronomy key instrument software and to cover the operations costs. Savings will be realized by operating WSRT and LOFAR jointly, but it is currently estimated that an additional 3 M€/yr will be needed.

   b. Explore the opportunity to develop ASTRON further into the main European Center for Radio Astronomy. This would build on the science legacy of the WSRT, the Dutch leadership in JIVE, successful deployment of LOFAR, and leadership of the SKA design stu.dy. For this the organizational structure and optimal location of, and the connections between, these various projects, as well as of the optical/infrared instrumentation development program currently being carried out at ASTRON, need to be clarified both within a Dutch and a European context.

   c. Ensure involvement of SRON in a substantial space mission once HIFI is completed, in order to retain SRON's leading position in Europe, which is important for Dutch astronomy. ESA's Cosmic Vision 2015-2025 plan identifies possible cornerstone class missions for high energy astrophysics and for the characterization of extrasolar planets. Dutch astronomers are involved in studies for both, and wish to participate in their development, exploiting the links between SRON and NOVA. A PI role in one such mission will require 2.5 M€/yr of additional funding for at least a decade.

   d. Start up interdisciplinary programs supported by SRON at the level of approximately 1 M€/yr which explore the links between exoplanet atmosphere studies, comet/interstellar medium relations, and astrobiology on the one hand, with ESA's solar system science program and space exploration initiative Aurora, and Earth observations on the other.

Conclusion

Dutch astronomy has the opportunity to remain at the forefront world-wide if it is able to harvest science opportunities provided by earlier investments, to continue instrument development for selected facilities, and to continue to train young astronomers to the highest international level. This requires the implementation of the balanced national strategy outlined above, which includes continued support by OCW of the university-based NOVA Program beyond 2008, by the universities for maintaining the level of their astronomy tenured staff and AIO positions, and strong support by NWO to its Physical Sciences Board for astronomical research and observatory program, and its institutes ASTRON and SRON to allow them to maintain leading roles in EU (and perhaps global) scale astronomy programs.

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4. http://www.hq.eso.org/about-eso/organisation/committees/cou/cou-104th/cou-991/cou-991rev.pdf

List of acronyms

ALMA	Atacama Large Millimeter Array
ASTRON	Stichting Astronomisch Onderzoek in Nederland (Netherlands Foundation for Research in Astronomy)
Aurora	ESA program for exploration of Solar system bodies
BSIK	Besluit Subsidies Investeringen Kennisinfrastructuur
Chandra	NASA's X-ray observatory
ECRA	European Center for Radio Astronomy
ELT	Extremely Large Telescope (for optical - near infrared wavelengths)
ESA	European Space Agency
ESO	European Southern Observatory
EU	European Union
FIRES	Faint InfraRed Extragalactic Survey (research program with VLT)
FP6	Framework Program 6 (EU)
Fte	full time equivalent
GAIA	ESA’s Cornerstone mission on astrometry
GBE	Gebiedsbestuur Exacte Wetenschappen, NWO, Council for Physical Sciences
GLAS	Ground-layer Adaptive optics System (new facility for WHT)
HIFI	Heterodyne Instrument for the Far-Infrared for the Herschel Space Observatory
HST	Hubble Space Telescope
ING	Isaac Newton Group (of the Roque de los Muchachos Observatory on La Palma)
ISO	Infrared Space Observatory (ESA mission)
JCMT	James Clerk Maxwell Telescope (on Mauna Kea, Hawaii)
JIVE	Joint Institute for VLBI in Europe
JWST	James Webb Space Telescope, successor of HST
LISA	Laser Interferometer Space Antenna (ESA mission in preparation)
LOFAR	Low Frequency Array (new radio observatory under construction)

MIDI	Mid-Infrared Interferometry Instrument for ESO's VLTI
MIRI	Mid-InfraRed Instrument for the JWST
MUSE	Multi Unit Spectroscopic Explorer (2nd generation instrument for VLT)
NASA	National Aeronautics and Space Administration
NCA	Nederlands Comité Astronomie (Dutch national committee for astronomy)
NOVA	Nederlandse Onderzoekschool Voor Astronomie (Netherlands Research School for Astronomy)
NWO	Nederlandse organisatie voor Wetenschappelijk Onderzoek (Netherlands Organization for Scientific Research)
OASIS	Integral Field Spectrograph on WHT
OCW	Ministerie van Onderwijs, Cultuur en Wetenschap (Ministery for Education, Culture and Science)
PI	Principal Investigator
PuMa	PUlsar MAchine (for the WSRT)
R&D	Research and Design
SAURON	Spectrographic Areal Unit for Research on Optical Nebulae (on WHT)
SINFONI	Single Faint Object Near-infrared Investigation (on VLT)
SRON	Netherlands Institute for Space Research
UK	United Kingdom
VISIR	VLT Imager and Spectrometer for the mid-Infrared (on VLT)
VISTA	Visible and Infrared Survey Telescope for Astronomy (ESO)
VLBI	Very Long Baseline Interferometry (method to combine radio telescopes)
VLT	Very Large Telescope (ESO)
VLTI	Very Large Telescope Interferometer (ESO)
VST	VLT Survey Telescope (ESO)
WHT	William Herschel Telescope (part of ING)
WSRT	Westerbork Synthesis Eadio Telescope
XMM-Newton	ESA's X-ray multi-mirror spectroscopy mission