

OPTICAL ASTRONOMY IN POST-APARTHEID SOUTH AFRICA: 1994 TO 2004

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Abstract. The progress of optical astronomy in post-apartheid South Africa is discussed. Particular emphasis is given to the socio-political climate which embraced the idea of a 10-m class telescope as a flagship project that would lead to widespread development in science, technology and education - not only in South Africa, but across the subcontinent.

1. Introduction

This account of optical astronomy in South Africa starts where Feast (2002, hereafter Paper I) left off, in 1994 with the first democratic elections and the start of a new era. The end of apartheid offered vastly increased opportunities for international collaborations among individuals and institutions, which the astronomy community was quick to take advantage of. Nevertheless, while the historical strength of astronomy laid a firm foundation for growth and success, the reasons why the discipline thrived and grew in the following decade were complex and essentially political.

In the following I attempt a brief description of the policies and socio-political climate that have nurtured astronomy in South Africa, while acknowledging that no two individuals will see this in the same way and that any such account will be incomplete and probably idiosyncratic.

The government-funded facilities available for optical and infrared astronomy in South Africa are described with an emphasis on the 10-m Southern African Large Telescope (SALT), due to be commissioned in early 2005. No attempt is made to describe detailed scientific projects or results, but it is worth noting that productivity remained high throughout the decade, with the South African Astronomical Observatory (SAAO) annual report,

for example, recording well over 100 publications per year from its user community. A detailed account of research at the beginning of the period can be found in the compilation edited by Warner (1995). The challenge for the future is to redirect these efforts towards making effective use of SALT.

Two significant transformations were initiated in South African astronomy during this decade: one involves the change to big telescope astronomy and is only just starting; the other is a broad “Africanization” of activities which is far from complete but well underway. Prior to 1994 the main interactions had been with the international community (excluding Africa), particularly that in the UK. Most of the local optical astronomers had been born, and many of them trained, outside of Africa. The post-1994 investment in astronomy came with the assumption that this would change - that astronomers would find ways to interact with and influence South African science and that a cohort of indigenous astronomers would be trained and nurtured. The challenge has been to do this in such a way that these young scientists are the peers of their international contemporaries and not merely tokens to fill quotas. Interestingly this challenge is being met through strengthening collaborations and partnerships, both nationally and internationally.

2. National Science and Technology Policy

The 1994 government created, among other things, a new Department of Arts, Culture, Science and Technology (DACST). While there were hopes that these unlikely bedfellows might encourage a society with a strong culture of science and technology, the marriage proved unworkable and the 2002 divorce left the Department of Science and Technology (DST) on its own. DACST (and latter DST) was a low budget department with a Minister from a minority party (Inkatha Freedom Party) within the Government of National Unity, which was led by the African National Congress. Nevertheless, the existence of DACST, and later DST, as a government department with a specific mandate for the sciences has had a profound effect on the science policy, and on the astronomical facilities in particular.

In September 1996 DACST issued its first white paper on science and technology: *Preparing for the 21st Century* (DACST 1996). Although sometimes criticized as not being sufficiently transformational this document clearly stated the goals then seen as central to South Africa’s young democracy - an improved and sustainable quality of life for all, a competitive economy and a democratic culture. Considerable emphasis was put on the challenge to participate in global activities while addressing the specific needs and aspirations of South Africans. At the core of the new policy was a vision of a national system of innovation and a clearly perceived need for

capacity development.

In addition to the immediate requirements of society there was an articulated view of the role of pure science: “*Scientific endeavour is not purely utilitarian in its objectives and has important associated cultural and social values. It is also important to maintain a basic competence in “flagship” sciences such as physics and astronomy for cultural reasons. Not to offer them would be to take a negative view of our future - the view that we are a second-class nation, chained forever to the treadmill of feeding and clothing ourselves.*”

In 2002 the newly created Department of Science and Technology published its *Research and Development Strategy* (DST 2002). The main thrusts have not changed fundamentally: innovation, human resource development for science and technology and an effective government science and technology system. Interestingly within the present context, astronomy is specifically mentioned in several places, e.g. “*One way to achieve national excellence is to focus our basic science on areas where we are most likely to succeed because of important natural or knowledge advantages. In South Africa, such areas include astronomy, human palaeontology and indigenous knowledge.*” There is also specific mention of the importance of “*Flagship projects such as the Southern African Large Telescope ...*”

Significantly DST (2002) also points out that South Africa’s spending on science and technology, at 0.7 percent of GDP, is significantly lower than it should be to ensure national competitiveness in years to come. Although there is a commitment from DST to increase the fraction of the GDP that goes to science, it is not yet clear how this will be achieved.

The DST operates through a number of science councils to which it provides government grants via the National Advisory Council for Innovation. One such research council, the National Research Foundation (NRF), is directly involved with astronomy. The NRF provides research funding and evaluation for tertiary education institutions through its Research and Innovation Support Agency. It also administers the National Facilities (the largest of which are physics-based) including SAAO and the Hartebeesthoek Radio Astronomy Observatory (HartRAO). The NRF and its predecessor, the Foundation for Research Development (FRD), have been very influential in astronomy in South Africa during the decade under consideration, due largely to the direction provided by the FRD/NRF President, Khotso Mokhele, and his vision for science in Africa¹.

Resources devoted to higher education are inadequate and the support of university research by DST and the Department of Education remains a huge challenge both in terms of retaining talent and in attracting young

¹www.news.cornell.edu/Chronicle/02/2.28.02/Mokhele.html

Figure 1. SALT Ground Breaking Ceremony: Dr Ben Ngubani, Minister of Arts Culture Science and Technology (left) and Mr Manne Dipico, Northern Cape Premier, are “digging”.

people into postgraduate training and academic careers. This is a problem that should be solved in parallel with the financing of “flagship” resources.

3. Astronomers in South Africa

In reading this account it is worth keeping in mind that the astronomy community in South Africa is very small - no more than 25 in optical/infrared astronomy and only about 40 PhDs across the spectrum, including radio and gamma-ray astronomers and theoretical cosmologists. In early 2004 most of the active astronomers were based in the two observatories (National Facilities) with 14 researchers at SAAO and 5 at HartRAO; the rest were spread thinly among various universities. The number of research students is disturbingly small, but a strategy is in place to change this (see section 6.1).

Ten of South Africa’s 21 universities employ astronomers within physics, mathematics or astronomy departments, but typically only one or two astronomers per institution. The University of Potchefstroom has a somewhat larger group engaged in astronomy and space physics, who, among other things, collaborate in the High Energy Stereoscopic System (H.E.S.S.) gamma-ray experiment in Namibia². The University of Cape Town has cosmologists, as well as theoretical and optical astronomers spread amongst their mathematics, physics and astronomy departments. The University of South Africa, a distance learning institution, provides the only astronomy undergraduate course in South Africa. The University of the Free State runs Boyden Observatory with the recently refurbished 1.5-m (60 inch) telescope³ (see also Paper I). At the time of writing various tertiary institutions are due to merge, but it is unlikely that this will significantly affect astronomy.

There are also two planetariums in South Africa. One is part of the Iziko Museum of Cape Town and the other is run by the University of the Witwatersrand in Johannesburg. The Astronomical Society of Southern Africa is an organization of amateur and professional astronomers⁴ who publish an annual astronomical handbook for Southern Africa (Slotegraaf 2003) and a journal, *Monthly Notes of the Astronomical Society of Southern Africa*.

²www.mpi-hd.mpg.de/hfm/HESS/HESS.html

³www.geocities.com/assabfn/spacetides/boyden.htm

⁴www.saaو.ac.za/assa

4. South African Astronomical Observatory (SAAO)

SAAO is the National Facility for optical/infrared astronomy. Its prime function is to advance fundamental research in astronomy at a national and international level through the provision and use of a world-class astronomical facility. The establishment of SAAO was described in Paper I. SAAO contributes to the development of South Africa by providing training in a scientific and high-tech environment, by stimulating young people to follow careers in science and technology through a science education programme in schools and for teachers and by helping to create a culture of science and technology amongst all communities through a vigorous science awareness programme.

Most of the current planning and activity at SAAO revolves directly or indirectly around SALT. SAAO's *vision* for the immediate future is *to operate SALT as a first-rate international facility with a major impact on the science and education system of South Africa*. SALT is described in section 5 and here we look briefly at the other facilities located at SAAO's Sutherland site, 360 km north-east of Cape Town.

The common-user facility comprises telescopes with apertures of 1.9, 1.0, 0.75 and 0.5m, as well as a 0.75-m automated telescope doing photoelectric photometry. Although the median seeing, 0.9 arcsec, is not exceptional, Sutherland is among the darkest and best photometric sites in the world and SAAO is well known for photometric standards and high precision photometry of variable stars - at optical and infrared wavelengths. A considerable variety of techniques are supported, from high speed photometry to long-term monitoring covering decades. The astrophysics studied encompasses a range of binary and variable stars including: rapidly oscillating Ap stars, blue subdwarfs, cataclysmic variables, symbiotic stars, Be stars, asymptotic giant branch stars, novae, supernovae etc. as well as detailed studies of Galactic Structure, the Magellanic Clouds and the cosmic distance scale.

An Infrared Survey Facility (IRSF) was opened in November 2000. This 1.4-m telescope is operated jointly by Japanese (Nagoya and Tokyo Universities) and South African astronomers. Its primary mission is a deep survey of the Magellanic Clouds using *SIRIUS*, a simultaneous three-channel imager operating in the near-infrared *JHK'* bands, with a $7' \times 7'$ field⁵.

In 2002 YSTAR, a 0.5m automated telescope constructed by Yonsei University, South Korea, started operations at Sutherland. It performs all-sky time-series observations in order to identify and monitor various transient

⁵www.saaoo.ac.za/facilities/irsf/irsf.html

Figure 2. Cut-away diagram showing SALT in its enclosure; the tower houses the Shack-Hartmann wavefront sensor at the centre of curvature of the primary mirror array.

phenomena, including variable stars, near-earth objects and gamma-ray bursts⁶.

Since 1990 Sutherland has been home to one of the six remote solar telescopes that make up the Birmingham (UK) Solar Oscillations Network (BiSON). BiSON is monitoring low-degree oscillation modes of the sun for the purpose of solar seismology⁷.

Currently under construction is a 1.2-m telescope; one of two such instruments that will comprise MONET - a collaboration between the University of Göttingen, SAAO and the McDonald Observatory Texas. The other telescope is sited next to the Hobby-Eberly telescope in Texas. Between them the two MONET telescopes cover the entire sky. The programme has a very large educational component and was funded by the Krupp Foundation⁸.

5. Southern African Large Telescope (SALT)

At the time of writing SALT is nearing completion at Sutherland in the Northern Cape Province. The telescope will have in essence two primary missions:

1. **International Mission:** To provide a state-of-the-art facility that will permit Southern African and international astronomers to perform cutting-edge research on the southern skies that will complement the research carried out using telescopes sited in the northern hemisphere.
2. **South-African Mission:** To play a major role in overcoming and redressing the consequences of the policies of past governments that excluded the majority of South Africans from education, training and careers in science, engineering and technology.

It was very clear by the 1980s that South Africa needed a large telescope for optical astronomy to be competitive on international terms (Paper I). A great deal of debate ensued among astronomers as to how large the telescope should be and of what design, with a minority taking the view that more small telescopes were to be preferred over a large one. The broad scientific community, in particular the Royal Society of South Africa and the South African Institute of Physics, were strongly supportive of astronomy and appreciated the need for a large telescope (e.g. Ellis 1994). As

⁶csaweb.yonsei.ac.kr/~byun/Ystar/

⁷bison.ph.bham.ac.uk

⁸alpha.uni-sw.gwdg.de/~hessman/MONET/

apartheid ended and it became clear that the new government was looking for visionary projects - a window of opportunity opened.

5.1. BACKGROUND TO CABINET APPROVAL

In 1996 it was suggested that a copy of the 10-m class Hobby-Eberly Telescope (HET), then nearing completion at McDonald Observatory in Texas, would make the ideal large telescope for South Africa. The design of the HET is particularly cost effective in that it gives access to 70 percent of the sky for around 20 percent of the cost of a conventional telescope. A 10-m class telescope had both scientific and political appeal; this model was adopted by DACST, FRD and the astronomy community who prepared a motivation to be presented to the South African government (Stobie 1998).

In addition to the strength of astronomy in South Africa at the time and the very exciting challenges at the frontiers of scientific knowledge, there were various factors that made a large telescope attractive to government and/or to international collaborators.

- **Location:** The latitude and longitude, climate, good infrastructure, geological stability and the relatively low cost of skilled labour all contribute to making Sutherland an attractive site for a large telescope. In addition, Sutherland is located in the Northern Cape, a province which is under-resourced in terms of scientific infrastructure.
- **Focus for competence:** A developing country needs broad scientific and technical competence, but cannot afford to invest across the board. Astronomy provides a focus for such an investment in that it draws on other natural and mathematical sciences, including physics, chemistry, applied mathematics and computer science. SALT, as a particularly high-tech telescope, would afford unique technical and engineering training opportunities.
- **Science education:** International experience has shown that astronomy provides a strong draw card into science and SALT could provide an inspiration to young and old.
- **Science Awareness:** A visitor centre associated with SALT would attract visitors not only to SALT, but also to Sutherland and to the Northern Cape.
- **African flagship:** There was much to be gained by an endeavour in which Africans led, or at least competed on an equal footing with, the rest of the world. Astronomy and SALT had the potential to do this at modest cost.
- **Benefits to industry** Over 50 percent of the cost of the telescope would be spent within the country providing a stimulation to the engineering industry. Furthermore, the transfer of cutting-edge technology

from European and North American industry would potentially improve local competitiveness.

Education, particularly science education, is crucial to the success of South Africa. Black people were systematically excluded from serious science and mathematics education during apartheid, and the legacy of this is enormous. Although an obvious area for redress under the new dispensation progress has been limited - in 2000 less than one percent of the black Africans taking the school leaving exam passed mathematics at the level required to proceed with science or engineering studies at university level (DOE 2001). There is no doubt that the situation is better than it was in 1994, but given that education is the key to all the national priorities including health, poverty alleviation and employment, vastly more might have been done. The issues are too complex to go into in the space available, but many identifiable problems are identical to, although worse than, those experienced in North America and Europe, e.g. shortage of properly qualified teachers. SALT, astronomy and space science will help, but only as part of a coherent and holistic programme.

On the science awareness front its worth noting the "impact" of Comet Shoemaker-Levy 9 (SL9). Contrary to accepted folklore this particular comet foretold a very positive future for South African astronomy when it crashed onto Jupiter in 1994. The impact of one fragment of SL9 was televised live from Sutherland to the world, and drew an extraordinarily large South African and international audience. One young South African paid it the ultimate tribute in our sports crazed society: "*The TV coverage ... was very exciting, a bit like a football match*" (Whitelock & Flanagan 1998). South Africans, like everyone else, are drawn to science by the spectacle of astronomy and no better demonstration could have been orchestrated.

When the issue was taken to Cabinet, the SALT project was championed by the then Deputy Director General for Arts, Culture Science and Technology, Dr Rob Adam, himself a physicist by training and one of the architects of the national science policy.

On 1 June 1998 the Minister of Arts, Culture, Science and Technology, the Hon. Lionel Mtshali, announced in Parliament that the South African Government would fund 50 percent of the total cost of SALT, estimated as R100M (or US\$20M at the time of the announcement), *provided* that the balance could be raised from international partners. The announcement was greeted with enthusiastic applause and the decision was strongly supported by all political parties.

In late 1999, after several international partners expressed strong interest in contributing to the project, the Cabinet gave SALT the *green light* to proceed, although the telescope was at that stage only about 80 percent funded. On 1 September 2000 a ground breaking ceremony was held on the

SALT site with representatives from all of the major SALT partners at that time.

The time-table for completion involves commissioning during 2004 and anticipates operations commencing early in 2005.

5.2. INTERNATIONAL PARTNERSHIP

At the time of writing the SALT consortium comprised 11 partners (including the HET Board; see section 5.6) from 6 countries, listed here with their shareholding as of 2002 (the detailed shareholding will change as the telescope was not fully funded at this stage):

– National Research Foundation (South Africa)	34.4 %
– University of Wisconsin-Madison (USA)	15.1 %
– KBN and CAMK (Poland)	11.0 %
– Rutgers University (USA)	10.8 %
– Dartmouth College (USA)	9.4 %
– Göttingen University (Germany)	4.9 %
– United Kingdom SALT Consortium	4.1 %
– University of Canterbury (New Zealand)	3.9 %
– University of North Carolina (USA)	3.1 %
– Carnegie-Mellon University (funds not yet committed)(USA)	3.1 %

The total budget for SALT estimated in 1999 US\$ was 30M, divided as 18.12M for the telescope, 4.8M for instruments and 7.08M for 10 years of operations. Few of the partners committed to escalating their contributions with inflation, and as of January 2004 there was a shortfall of between \$2M and \$3M in respect of the telescope and instruments, for which an additional partner is being sought.

Furthermore, while the budget for the telescope was probably a reasonable estimate, that for the operations is certainly an underestimate. The situation is further complicated by the fact that the budgeting is done in US\$ while most of the operational costs will be in South African Rand; the Rand has been very volatile during the last five years.

5.3. THE TELESCOPE

The SALT project started as a copy of HET. The only significant change originally envisaged was a slightly larger altitude tilt, 37° compared to 35° for HET, that would give SALT access to the whole of the Small Magellanic Cloud. As HET went into operation it became clear that optimal performance would only be achieved with further modifications and the SALT project team made a critical systematic analysis of the possible options. In

Figure 3. SALT Dome; inserts (from bottom left to top right) NASSP students learn from an expert; unemployed people in Sutherland making eclipse viewers; children learn optics while constructing their own cardboard telescopes with plastic lenses.

this regard the project benefited hugely from the experience at HET and from the insight of those working directly with HET.

HET and SALT both have primary mirrors comprising 91 identically shaped spherical mirror segments in a fixed altitude structure. The telescopes rotate in azimuth to acquire their targets, but remain stationary during an observation. Compensation for the earth's rotation is achieved by means of a mobile optical payload which, in the case of SALT, comprises a spherical aberration compensator and atmospheric dispersion corrector, a moving pupil baffle and four focal stations including an acquisition camera.

SALT, its instruments and its progress were described recently by Meiring et al. (2003) - including the detailed modifications to the HET design - and by Buckley et al. (2003). The major modifications include:

- A redesigned spherical aberration corrector (SAC) giving much better image quality, a larger field of view ($8'$ diameter *vs* $4'$ for HET) and a larger pupil size (11m *vs* 9.2m for HET).
- Mirror coatings for the SAC that have particularly good ultraviolet response (> 90 percent reflectivity) without compromising the visible/infrared performance.
- Capacitive edge sensors on the primary mirror segments and a centre of curvature alignment sensor, that uses a Shack-Hartmann wavefront sensor, will allow the alignment to be maintained for days at a time and will support a possible future phasing of the mirror array.
- A variety of modifications to minimize dome seeing.

5.4. INSTRUMENTATION

While the HET design makes it possible to build a low cost telescope, there is no way to achieve comparable savings on the instrumentation packages without compromising the overall performance. The intended suite of first generation instruments included SALTICAM, PFIS and HRS. However, as of early 2004 the design for the High Resolution Spectrograph (HRS) has not been finalized and its funding is still uncertain. In view of the importance that the SALT partners place on such an instrument we anticipate good progress by the time this article is printed.

SALTICAM (O'Donoghue et al. 2003) is the acquisition camera and simple science imager for SALT. It is mounted at the corrected prime focus and its wavelength range is 320 to 950 nm. In a simpler form, without re-

imaging optics, it is also being used as the verification instrument to check the telescope performance during commissioning.

PFIS (Kobulnicky et al. 2003) - the Prime Focus Imaging Spectrograph - is a versatile high throughput imaging spectrograph operating between 320 and 900 nm. Resolutions of $1500 < R < 8000$ will be provided by volume-phase holographic gratings, while the Fabry-Perot mode will allow imaging at resolutions up to $R=12500$. Any of the spectroscopic modes can be paired with the polarimeter to enable linear, circular or all-Stokes polarization measurements. It will also be possible to use PFIS at time resolutions anticipated to be up to 10Hz. An infrared arm to PFIS is likely to be provided as a second generation instrument.

All of the first generation instruments are being designed to support seeing limited observations.

5.5. SCIENCE WITH SALT

Two workshops have been held to discuss possible science projects with SALT and HET, both in Cape Town (Buckley 1998, 2004). The first of these was held in 1998 prior to finalization of the telescope and instrument designs and provided relevant input to the final specifications for the instrumentation.

The second workshop was held in 2003 and attended by more than 100 delegates from 16 countries. Most participants were from SALT partner institutions, but there was gratifying interest from Africa including representatives from Nigeria, Kenya, Uganda, Ethiopia and Mauritius. Workshops for educators and for students were held in parallel to this meeting as part of the collateral benefits activities (see section 5.7).

The possible science projects⁹ discussed were as far ranging as one might expect, from searching for planets around nearby stars to surveys of distant quasars. There was consensus that observers should look for projects in niche areas where SALT might be particularly efficient, rather than try for direct competition with general purpose 10-m class telescopes. SALT's special characteristics allow for:

1. Ultraviolet sensitivity down to the atmospheric cut-off at 320nm;
2. Multi-object spectroscopy over the 8' field;
3. Time variability studies: from 0.1s up to one or two hours, or greater than one day;
4. A wide range of polarization studies;
5. High spectral resolution imaging over a few arcmin.

⁹www.salt.ac.za/content/downloads/stobieworkshops/one/default.htm

Figure 4. The first of the 91 SALT mirrors being hoisted into position.

Obviously SALT will not be ideal where high spatial resolution or high precision absolute photometry are required.

There had been some hope that the workshop might identify first-light key-programmes, to which all or most partners would contribute. However, no consensus could be reached on the desirability for this and no obvious specific projects were identified. Nevertheless, many interesting ideas were exchanged and new collaborations were started. There was complete agreement that rapid proof of SALT's potential to deliver first-rate scientific results was essential to the telescope's ultimate success. This must be achieved before serious consideration could be given to funding development work for the telescope, e.g. for phasing the primary mirror array, or for the next generation of instruments.

5.6. SALT BUSINESS MANAGEMENT

The SALT Foundation (Pty) Ltd. is a South African registered private company, formed with the purpose of advancing science and training through the promotion of astronomy in the Southern Hemisphere. The SALT Foundation is run through a Board of Directors and the SALT Shareholders Agreement specifies their relationship with one another and to the company. The company owns the telescope and partners are shareholders in the company. The articles of the company specify that its activities shall not be for the profit of its shareholders and the shareholders enjoy limited liability in that they are not exposed to the liabilities of the company.

Partners purchase shares in the SALT Foundation (Pty) Ltd. which gives them access to the telescope in direct proportion to their share. The HET Board, though not a shareholder, has the right to 10 percent of the observing time for the first 10 years in exchange for providing HET documentation and technical assistance. South Africa, through the National Research Foundation, is the major participant and shareholder in SALT (see section 5.2) and has two seats on the SALT Board while all other partners have one each. The first chairperson of the SALT Board was Bob Stobie (Director SAAO), who died in 2002 and was succeeded by Khotso Mokhele (President of NRF).

To the best of our knowledge this is a unique arrangement with respect to the construction and operation of a telescope. During the construction phase the SALT Project Manager and the SALT Project Scientist report directly to the Board. After commissioning is complete the Shareholders' Agreement specifies that SAAO will operate the telescope under contract

to the SALT Board.

5.7. SALT COLLATERAL BENEFITS

While SALT is an inexpensive project by international standards, it is a huge undertaking for South Africa - committing scarce resources that some might argue were better invested in solving the obvious and debilitating problems that plague southern Africa, which include health, education, unemployment and poverty (see also Section 6). The fact that the South African Government chose to invest in SALT must be seen as an expression of faith in the long-term prospects for the subcontinent and in the role that science and technology will play in that future.

The level of commitment to astronomy is such that much is expected in return. The SALT Collateral Benefits Plan was established to ensure that SALT became more than a research tool for a handful of privileged scientists and that it produces tangible benefits to the people of South Africa. The plan has five main thrusts:

1. **Industrial empowerment:** aimed at ensuring that South Africa derives the maximum from the SALT project in terms of technology transfer and benefits to the economy.
2. **Educational empowerment:** to provide educational and training opportunities, particularly for individuals from historically disadvantaged communities, during the 5-year construction and 10-plus year operational phases of SALT.
3. **Public outreach and direct educational empowerment:** to enhance science education and awareness throughout South African society, inspiring young people to take up careers in science and technology; helping to create a South African society that is scientifically and technologically literate.
4. **Science education Visitor Centres:** to develop science and technology infrastructure, edu-tourism and educational facilities, particularly in the Northern Cape.
5. **SALT as an African facility:** to extend the benefits of the space sciences to the rest of the African continent through collaboration and the widening of training and scientific development opportunities. These should allow South Africa and the continent to participate meaningfully in relevant international scientific endeavours in space and allied sciences.

Developing the collateral benefits in parallel with the telescope and its instruments has been a major thrust at SAAO over the last five or six years. Aspects of this are discussed elsewhere in this document and more details are available on the SALT web page.

It is worth briefly looking at item 5 above and specifically at the name *Southern African Large Telescope*. Clearly South Africa sees its future as intimately linked with that of the subcontinent. The New Partnership for African Development (NEPAD) provides a broad strategic framework for addressing the development needs of the region¹⁰ and SALT should be seen within that context - as a potential icon of the African Renaissance.

Finally, it may be interesting to note that the name - *SALT Collateral Benefits* has proved problematic. This is particularly so in the USA where the word *Collateral* seems to be inseparably linked to *Damage*, so the expression *Collateral Benefits* is perceived as an oxymoron, even worse than *Military Intelligence*. Alternatives are under discussion and the name *SALT Science Foundation* has been used, although it is not ideal.

6. Strategic Planning and New Developments

In February 2001 the National Research Foundation began a process of strategic planning for astronomy and space science in South Africa with a meeting attended by all the significant role players from around the country. This was followed by more intensive discussions within the Astronomy National Facilities, SAAO and HartRAO, over the course of 2001. The discussions were far ranging covering possible scientific goals, future needs in terms of human resources and new equipment, and the broader requirements of organizational infrastructure.

One factor driving the planning was the fact that SALT, or at least some sort of large telescope access for South Africa, had been motivated more than a decade before, but would be operational only in 2005. The time was ripe to plan for SALT's successor, and perhaps more urgently, to plan a future for South African radio astronomy. There was also a clearly articulated desire on the part of government to see a move away from the past where isolated centres of excellence interacted with the outside world, but had relatively little impact on the science system of the country, or even on each other. In this connection mergers and partnerships were discussed at length.

The following were major outcomes of this process:

1. South African participation in, and bid to host, the Square Kilometre Array (SKA)¹¹.
2. South African Participation in the World Space Observatory (WSO), an ultraviolet space mission¹².

¹⁰www.nepad.org

¹¹www.ska.ac.za

¹²wso.vilspa.esa.es

3. The establishment of the National Astrophysics and Space Science Programme (NASSP).
4. The establishment of an African Institute of Space Science (AISS).
5. The establishment of an African Virtual Observatory - it is essential that African astronomers have access to the international virtual observatories currently being established if they are to use SALT and other facilities effectively.

The SKA and WSO are outside of the scope of this paper. NASSP and AISS are making progress and are discussed briefly below, while South Africa's links to the Virtual Observatories remains a challenge for the future.

6.1. NATIONAL ASTROPHYSICS & SPACE SCIENCE PROGRAMME (NASSP)

The 2001 strategic planning process identified the lack of appropriately qualified local scientists, particularly black scientists, as the single biggest threat to the future of astronomy in South Africa, as well as to the country at large. The expertise in South African astronomy and space physics would be quite significant if concentrated in one place rather than spread thinly through a dozen universities and National Facilities.

NASSP is a training programme that takes students through the honours and masters degrees¹³. It is based at the University of Cape Town (UCT), but the lecturing staff are drawn from the entire South African astronomy and space physics community, whereby scientists not located at UCT teach intensively for short periods of time. The students are drawn from all over the country and from elsewhere in Africa. Graduates in physics, engineering, mathematics and computer science are accepted provided they have done physics to the requisite level. One of the fundamental objectives of NASSP is to create an African network of astronomers who are bonded by the common experience of schooling and interlinked both professionally and personally.

NASSP was made possible through the generous sponsorship, initially from the Ford Foundation and the NRF, and later from the Canon Collins Educational Trust and the UCT Vice Chancellor's Fund. Their support made it possible to pay students realistic bursaries - a crucial factor when poverty is commonplace among the families of many prospective students.

The first NASSP honours class produced 11 graduates at the end of 2003. There had been no honours graduates in astronomy anywhere in South Africa over the previous 3 years and only 2 MSc and 1 PhD graduate

¹³In SA, students typically do a BSc in 3 yrs, a 1-yr honours degree and a 2-yr MSc before starting a PhD - the efficacy of this is debatable and changes are under discussion.

Figure 5. Sutherland landscape; inserts: (left to right) a young technician trains in the mechanical workshop; SALT mirror support structure with central 7 mirrors and NASSP students; student fills cryostat with liquid nitrogen.

over the same 3 year time period. In 2004 15 students have registered through NASSP for honours and 14 for MSc. This was a very satisfactory start.

NASSP graduates who do not continue in research will go into industry or commerce - taking with them practical skills in problem solving, data analysis, computer programming and science communication that will serve them well in any challenging career.

It is anticipated that many of the NASSP graduates will go on to do PhDs within South Africa, or with SALT or H.E.S.S. partner institutions who offer special scholarships for South Africans. Eventually they will obtain positions in African universities and research establishments. They will form the nuclei of research groups who will be users of facilities such as SALT and H.E.S.S., as well as participants in the broader space science activities under discussion in Southern Africa.

The NASSP Consortium includes the following universities and National Facilities:

- University of Cape Town
- University of Natal, Durban and Pietermaritzburg campuses
- University of the Free State
- Potchefstroom University
- University of Zululand
- Rhodes University
- University of the North West
- University of South Africa
- South African Astronomical Observatory
- Hartebeesthoek Radio Astronomy Observatory
- Hermanus Magnetic Observatory

NASSP is a unique collaboration and it is quite remarkable that such a diverse group of institutions have been able to compromises and find common ground with such rapidity. It is a programme very much in the spirit of NEPAD and the new South Africa and we are delighted that astronomers have been able to lead in demonstrating how collaborations can benefit all involved - the whole is vastly greater than the sum of the parts.

More details of NASSP can be found on its website¹⁴.

¹⁴www.star.ac.za

6.2. AFRICAN INSTITUTE OF SPACE SCIENCE (AISS)

The concept of an African Institute of Space Science (AISS) was developed as a way to mobilize the space sciences, including astronomy, in support of the national development agenda. Through their multi-disciplinary and cross-disciplinary nature, the space sciences are in a strong position to capitalize innovation and technological development. AISS will combine various activities around southern Africa to provide a coordinated strategic programme for developing space science in the region. Among other things, AISS can provide a local point of contact for international linkages to southern African space science. By forging partnerships of South African government departments, academia and industry with similar agencies internationally, AISS will be in a strong position to leverage funds and to spearhead appropriate applications of space science and technology to African development issues.

The AISS initiative has been embraced by the NRF and has attracted considerable interest from African space scientists (e.g. UN 2001). It has brought to light the current lack of coordination and consequently the rather disparate nature of South Africa's space science and technology activities that are supported by government. The NRF continues to pursue the AISS initiative through a newly established inter-departmental National Working Group on Space Science and Technology¹⁵ which comprises representatives from the Departments of Communication, of Trade and Industry, and for Administration in addition to DST and a number of other partners in the SA space arena.

7. Conclusion

I want to finish by contextualizing the spending on astronomy in South Africa through comparing expenditure on SALT with that on the Hubble Space Telescope (HST). The cost of HST at launch in 1990 was \$1.5 billion (or \$1.59 billion in 1992 assuming 3 percent inflation) while that of SALT in 2002 terms is about \$25 million. Using data from the World Bank¹⁶ we see that the USA GDP in 1992 was \$6.262 trillion, while that of South Africa in 2002 was \$104.2 billion. The cost of SALT compared to the GDP of South Africa, 0.025 percent, is almost identical to that of HST compared to the GDP of the USA. There can be no doubt that the South African astronomy community is extraordinarily fortunate in having access to this level of support.

¹⁵www.nrf.ac.za/publications/news@nrf/feb2002/africaspace.stm

¹⁶www.worldbank.org/data/countrydata.html

The politicization of science is often problematic for scientists, and much has been written about the inevitability of this process in connection with big science projects (e.g. Enard 2002). The above comparison with HST demonstrates that SALT is big science for Africa; the people of South Africa will have expectations of it that are comparable to those of Americans for HST. We South Africans will do well to follow the example of the Space Telescope Science Institute in ensuring that:

- observing time goes to the astronomers with the best projects,
- those astronomers are fully empowered to do first rate science with SALT
- and that the outcomes of their research are made accessible to the public and particularly to young Africans.

It seems appropriate to give the last word to the President of South Africa, Thabo Mbeki. In opening the South African Pavilion at the 2000 World Expo in Hanover, Germany, President Mbeki said the following:

“Now, in the small town of Sutherland in the semi-desert Karoo region of our country, we are building a gigantic African eye through which we can view the universe. The construction of the single largest telescope in the southern hemisphere, SALT - as it is called - will mean that in this humble home of our earliest humans, we are also building a vast gateway through which we can observe our earliest stars, learn about the formation of our galaxy and the lives of other worlds so as to give us insights into our future. We are proud that SALT will not only enable South African scientists to undertake important research, but also provide significant opportunities for international collaboration and scientific partnerships with the rest of the world.”

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