APPENDIX

Department of Science and Technology

A National Key Research and Technology Infrastructure Strategy

July 2004

National Research Foundation

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Acknowledgements

This strategy was developed by way of a two-stage process. An initial draft was the product of a wide consultation process facilitated and written by Dr Anthon Botha of Technoscene. This process, convened by the responsible member of the NRF Executive, Dr Prins Nevhutalu, resulted in a draft strategy submitted to the NRF Executive in June 2003. It was subsequently revised by the NRF Executive on the basis of more recent developments regarding the implementation of policies such as the National R&D Strategy.

The NRF wishes to acknowledge the following who were instrumental in the developing this strategy:

- The members of the reference group:
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- All Vice Chancellors who appointed contact people at higher education institutions
- All presidents, directors and heads of research institutions who appointed contact people in their organisations
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EXECUTIVE SUMMARY

Introduction

Our nation's mission to create wealth and thereby to create jobs and eradicate poverty hinges largely on our ability to develop new products, technologies and services through research and innovation. This can only be achieved in a highly competitive world if the nation has at its disposal the required human capital capable of generating new knowledge and technologies through research in an environment with quality infrastructure that includes state-of-the-art research equipment. The maintenance of state-of-the-art research equipment and infrastructure linked to the development of highly skilled people and the generation of knew knowledge and technologies, is globally recognised as being a core responsibility of the state, and hence the funding of research equipment, particularly in higher education and the science councils, should primarily be from public funds.

Context and Background of the Strategy

No coherent strategy for the renewal and placement of research equipment exists. Funding of research equipment was done much on an ad hoc basis, with the NRF and its predecessor the FRD having funded and placed some equipment in higher education in a loosely coordinated manner to ensure some means of regional accessibility and capacity building. In more recent years, several policy instruments of government are making provision for the placement of some research equipment, albeit within the confines of these instruments, e.g. the Innovation Fund, THRIP and the Biotechnology Strategy. Industry, NGOs and Trusts have also contributed to the placement of research equipment, particularly in higher education. All of this falls way short of what is required to maintain the research equipment infrastructure necessary to produce cutting edge research to remain internationally competitive in science and technology and thereby to meet the growth and development needs of the nation. This was highlighted in the National Research and Technology Audit of 1997, on the basis of which it is estimated that the present day replacement value of the research equipment infrastructure is R3.7 billion, and that only 10% of this can be regarded as being state-of-the-art, with the remainder being outdated.

This National Key Research and Technology Infrastructure Strategy has been developed in response to the National Research and Technology Strategy wherein the concerns regarding the country's state of research and technology infrastructure is highlighted. A macro-environmental scan was conducted where the strategies, policies and funding methodologies in selected countries were researched to establish their approach to research facility and equipment management and support. This scan was followed by a thorough analysis of the strategy and policy environment in South Africa that influences the development of a National Key Research and Technology Infrastructure Strategy.

Strategic objectives

The following strategic objectives are defined and recommendations are made to each of these objectives:

- Prioritising types of research equipment and the purpose of such equipment
- Differentiating between categories of research equipment for planning and funding purposes
- Creating a long range planning culture around research equipment
- Assigning responsibilities for the funding and management of research equipment
- Establish guidelines for economic models required to sustain the research infrastructure
- Introducing proper quality management of research equipment
- Identifying appropriate funding categories for research equipment
- Ensuring optimal use of world-class research equipment in a sustained manner
- Assuring access to research equipment by providing grant funding for mobility of researchers

Scenarios supporting the strategy

Scenarios were generated for the South African research infrastructure situation. The scenarios allow for possible outcomes of:

- **Local Focus:** Research aimed at primarily solving local priorities and demands. The context of "local" is national (as in South Africa) and may be extended to include sub-regional (as in SADC)
- **Global Focus:** Research aimed at making South African industry and knowledge globally competitive

This is supported by certain strategic options that can be exercised in the placement and management of research infrastructure:

- **Well-found Laboratory:** minimum level of (usually departmental) equipment and facilities that an external sponsor would expect to find in place
- **Infrastructure for world-class science:** major items of equipment, which are too costly to acquire through research project grants, usually for multi and interdisciplinary research.

The most likely scenario that underwrites the strategic framework that was developed is:

> The strategy should be to strengthen both the well-found laboratory situation and the world-class infrastructure simultaneously. This dual approach is required since the installed base of equipment is ageing and very little attention has been given in many institutions, particularly higher education, in maintaining and modernising the well-found laboratory environment.

Strategic framework following from the scenario

Given the wide spectrum of research equipment, six categories are identified, clustered into three broader categories for the purpose of developing a strategy

- Equipment of the well-found laboratory
- World-class multi-user equipment, consisting of
  - Multi-user within institutional context (several users within one institution)
  - Multi-user in regional or national context (several institutions as users in a region or nationally)
- Big, expensive facilities
  - National Facilities, declared as such and managed by the NRF, as well as facilities such as the NLC, SAFARI, SAC
  - International Facilities such as SALT, SKA
  - Foundation Facilities, e.g. NREN

Funding considerations for a National Key Research and Technology Infrastructure

It is proposed that in the renewal of the Key Research and Technology Infrastructure three different, yet coordinated approaches are adopted for the three broader categories of research equipment.

The well-found laboratory, i.e. the basic research infrastructure that is expected to be in place to conduct research, to train research students and to access research funding/contract research on a competitive basis, should be the responsibility of the institutions concerned and should be funded from the parliamentary core grant to science councils or the government subsidy to higher education and supplemented from any contract income they may receive. Institutions must take full responsibility for the planning, capital investment in, maintenance and upgrading, expansion and

management of equipment for well-found laboratories. However, given the run down nature of the well-found laboratory in higher education, a once off allocation should be made by Treasury to the DoE for the refurbishment of the well-found laboratory in higher education institution on the basis of motivated requests aligned to their respective research and research training strategies as contained in their three year rolling plans.

Big, expensive equipment facilities are normally planned and motivated for on an ad hoc basis as and when the needs and opportunities arise. Such initiatives are spearheaded by the DST and are of a magnitude that requires Cabinet approval. Funding of these is normally provided for by way of a special allocation from government.

Several principles should guide the renewal and placement of world-class multi-user equipment development of this strategy, viz.:

- Support to be provided on a competitive nature
- Criteria for selection to include
  - Appropriateness in terms of national/regional priorities and needs
  - Multi-users and accessibility
  - Potential for innovation and elevating quality and competitiveness of research
  - Technical support infrastructure
- Shared approach to funding
- Provision for support to ensure optimal and sustained serviceability
- Placement in most appropriate environment
- Contractual agreement with host institution

Funding should be available for:

- Recurrent funding required for sustainability
  - Salaries
  - Maintenance and repair
- Remedial funding requirements
  - Funding required for upgrades
  - Funding required for replacement
- Funding required for expansion (new acquisitions)
- Funding required for radical interventions to equip the science and technology missions
- Funding the Mobility of Researchers

Funding requirements for world-class, multi-user equipment

Funding should be made available by government for a well co-ordinated National Key Research and Technology Infrastructure Programme and be managed by a national agency. This grant should make provision for the following separate, but related sub-grants:

- Remedial grant for research equipment and facilities (upgrade and replacement)
- Grant for the expansion of research equipment and facilities
- Annual grants to cater for shared costs of salaries, running and maintenance for the duration of the life cycle of the equipment as negotiated in a memorandum of understanding.
- Mobility Grant Fund

The proposed budget for the systematic renewal of the world-class infrastructure based on the audit as well as other considerations is R100 million per annum. To this R10 million needs to be added per year for ten years to R100 million to make provision for the recurrent grants to sustain optimal serviceability, as well as R2 million in the initial year for mobility grants, which need to grow gradually to R5 million in year ten. On this basis the National Research and Technology Infrastructure Grant Fund will require R112 in year one and ideally grow to a maximum of R205 in year ten.

Within the MTEF this implies an amount of R112 million for 2005/06 and increasing to R133 million for 2007/08 (non-inflation adjusted).

Key recommendations

The key recommendations of the strategy are that a ***National Research and Technology Infrastructure Programme*** be established.

The **vision** of the National Research Infrastructure Programme should be:

Equipping South African science and technology for local relevance and global competitiveness

Mission

To provide an effective planning, funding and management system for a research infrastructure in South Africa to:

- Make the research base more internationally competitive through a planned approach of supporting world-class research infrastructure, that is responsive to new extensions in science and technology.
- Provide a top class equipment infrastructure for the training and development of the human capital essential for the generation of new knowledge and innovation.
- Involve research institutions in long range planning of their own research environments and how to equip these with appropriate research infrastructure.
- Support national science and technology missions as defined among others by the National Research and Development Strategy.
- Support institutional and regional missions as defined by provincial and institutional strategies

and thereby support economic growth and the provision of quality of life and well-being of all citizens in South Africa.

It is recommended that this strategy becomes the responsibility of the Department of Science and Technology as a supportive strategy to the National Research and Development Strategy. The Department of Science and Technology should negotiate with National Treasury for the funding required for research infrastructure. This approach will imply a coordinated and centralised management of policy and funding for research infrastructure.

It is recommended that the Department of Science and Technology appoints the most appropriate existing national agency to manage the planning and granting environment for research equipment and facilities in a dedicated and well-staffed National Research Infrastructure Programme. The National Research Foundation is suggested as the agency that should be tasked with this responsibility.

1 The Context of and Background to the Proposed South African National Research Equipment Strategy

South Africa lacks a national strategy for the replacement and renewal of research equipment of an expensive capital nature. Individual institutions plan establishment of their own facilities based on internal priorities and this planning often leads to duplication of effort and sub-critical support for such facilities.

The National Research and Technology Audit developed a database of research equipment and generated a scenario of the status of such equipment in 1998. The equipment infrastructure for research was characterised as old, not enabling South African researchers to compete effectively internationally. The recommendation from the audit calls for a major injection of funds to replace, renew and introduce state-of-the-art equipment, which will improve the quality of both the research outputs and research skills. Audit recommendations are, however, based more on prevailing overseas research environments and replacement practices of the research equipment base, rather than on a firm strategy of equipment renewal in support of a national research agenda.

The National Research and Technology Foresight project followed and pointed out a few areas where South Africa should excel, also in research leadership. These areas are being explored further in road mapping exercises and some have led to the development of national strategies, such as for biotechnology and advanced manufacturing technology.

Since 1986 the National Research Foundation (NRF) (and its predecessor, the Foundation for Research Development - FRD) has only managed to spend a total of R 53 million to address the acquisition of expensive research equipment in the higher education sector in a dedicated capital investment programme. This type of equipment was usually acquired in partnership funding with the higher education institution, and contributions from these institutions since 1996 amounted to R 38 million, whilst the NRF grants totalled R 22 million for the same period. The NRF further invested about R 46 million in smaller research equipment for the period 1996 to 2003, as well as a further R11,5 million for repair and upgrades of expensive equipment in 2002 and 2003 . Since 2000 no substantive targeted capital programme exists in government to address the crisis in research equipment that is evolving, particularly in the higher education sector.

The allocation of capital grants for the purchase of research equipment in the past has to a large extend been ad-hoc. Budgets were made available based on recognition of the need but the size of the budgets was often so sub-critical, that the purchase of capital equipment was limited. These capital budgets were part of the budget cycles of higher education institutions, the science councils and research laboratories. Funding was allocated either as part of a broad research programme that was very dependent on research equipment, or as competitive capital grants to higher education institutions through the NRF, and in recent years also directly to the science councils from the Department of Science and Technology.

Proposing and applying for funding for research equipment in such an environment has been, to a large extent, opportunistic. Applicants used every possible opportunity to acquire grant funding and although proposals were developed around the utilisation and sharing of such equipment, the funding organisations never had a long-term view of how this research equipment will benefit research foci and how the equipment will be managed over the life cycle. Although institutions that benefited from the grant environment were required to co-invest significant portions of the capital acquisition cost, budgets for sustaining and maintaining the equipment were not declared. Although a memorandum of understanding was formed between funding agencies and these institutions for the upkeep and maintenance of this equipment, this was often neglected to such an extent that very expensive equipment introduced into the system was inoperable after periods as short as three years.

Some ad hoc mechanisms for the placement of equipment exist at present.

- The Technology and Human Resources for Industry Programme (THRIP) which is a joint venture between the government (the DTI) and the private sector has contributed just short of R 108 million (R 34 million (government) and R 63 million (industry) for equipment more expensive than R 200 000 per item) in 3 years up to 2002.
- In the Innovation Fund, research equipment determined to be necessary for the project is funded as part of the project. The equipment belongs to the Innovation Fund until the project is completed, at which point the Innovation Fund will normally pass it on to the consortium if the project milestones have been achieved and the project enters the commercialisation phase, or to the higher education partner if the project is terminated.
- In accordance with the big science approach of the National R & D Strategy, placement of state-of-the-art equipment within the context of the biotechnology programme and Centres of Excellence has now also become a new funding source for equipment.
- Donations from the private sector, estimated to have contributed a further R25 million annually towards the acquisition of new research equipment of >R100 000.00 per item over three years prior to 2004 in higher education.

These ad hoc contributions are but a fraction of what is required, and at this rate the research infrastructure base is ageing at an alarming pace with researchers finding it extremely difficult to stay competitive. In addition, the training of human resources with adequate skills, particularly in the natural sciences, engineering and technology is suffering under the lack of adequate and state-of-the-art equipment.

A lack of coherent planning and a clear identification of responsibilities and roles for continued funding has led to a situation where the funding authorities do not have a clear view on long range planning in equipping science and technology in the country. The lack of such a vision leads to uncertainty in whether any funding is applied productively and whether planning supports the longer term strategic objectives of government such as the National Research and Development Strategy.

This strategy considers other national visions, policies and strategies. It firstly acknowledges the government's Micro-economic Strategy and Economic Vision[1], which states:

"By 2014, following the successful implementation of the microeconomic reform strategy and complemented by continued macroeconomic stability and a process of sustainable social development, South Africa will have a restructured and adaptive economy characterized by growth, employment and equity, built on the full potential of all persons, communities and geographic areas."

This vision is supported in national government by an "integrated economic cluster" of departments that are responsible for growing the economy. The focus is on increasing competitiveness, growing economic sectors, addressing infrastructure, human resource development, technology and access to finance and identifying key performance areas such as economic growth, employment, SMME creation, black economic empowerment and competitiveness.

These priorities have led to the formulation of a National Research and Development Strategy. It is this cabinet approved strategy, which recognises the urgency of a major intervention in the renewal of research equipment and which in turn led to the development of this National Research Equipment Strategy proposal.

[1] http://www.dti.gov.za/publications/publications.htm

Some of the other national policies and strategies that informed the formulation of this proposed Research Equipment Strategy are:

- National Biotechnology Strategy
- Integrated Manufacturing Strategy
- Advanced Manufacturing Technology Strategy
- National Plan for Higher Education[2]
- Advanced Institute for ICT
- SAITIS[3] – the South African Information Technology Industry Strategy (taken up in most of the above strategies)
- NEPAD[4] (not as a national strategy, but as a regional development strategy)

This document proposes a National Key Research and Technology Infrastructure Strategy, as well as proposals on implementation and funding investigations. It is supported by the study of similar strategies in selected overseas countries. An analysis of major items of research equipment that were acquired after completion of the National Research and Technology Audit was done and the value of the installed equipment was updated and is used in the calculations of the financial impact of this strategy. A series of regional workshops were held to develop this strategy and to assess in the light of national missions and regional missions what type of research equipment may be required. The following supporting documents are available:

- An investigation into international models for research equipment support
- A survey of research equipment purchased since the National Research and Technology Audit
- An analysis of research focus in national and regional research missions and its impact on research equipment in South African research institutions

[2] http://www.education.gov.za/Policies%20and%20Reports/2002_Reports/he/transrestructuring/transformation_and_restructuring.htm

[3] http://www.dti.gov.za/saitis/

[4] http://www.nepad.org

2 Overview of Policy Studies and Interventions relating to Research Equipment

2.1 Review of Research Equipment in South Africa, 1992

The status of research equipment in South Africa was assessed in 1992[5]. The following conclusions were made:

"South African universities are under-equipped in comparison with universities abroad. The average replacement value of equipment at our universities is approximately $3 million per university. In Canada, the corresponding amount is $10 million and in the USA, $7 million. The top 20 universities in the USA, in terms of R&D spending, have research equipment valued at an average of $28 million. South African universities have only one third of the value of equipment available at Canadian universities and only one ninth of that at universities in the UK.

The age profile of research equipment in the country is indicative of the financial constraints that the universities have experienced in the last five years. Only one quarter of the research equipment in the country has been purchased within the past five years. Internationally, the average half-life of obsolescence of research equipment is estimated at 6.6 years. International comparisons show that South Africa is seriously lagging behind Australia, the USA and the UK. In Australia, more than 60% of the research equipment is younger than 5 years; the respective figures for the USA and the UK are 53% and 41%.

Funding of research equipment in South Africa is seriously neglected by the appropriate authorities. At the beginning of the 1990s, the average annual funding for research equipment was reduced to 30% of that spent annually during the previous 10 years.

Funding for research equipment not only trickles down, but is also disproportionately dependent on sources which are not legitimately responsible for supporting the infrastructure. Industry in South Africa provides approximately 20% of the funding for research equipment at universities, whereas the figures for the USA and the UK are 4 % and 5 % respectively. The high level of private sector involvement in matters of infrastructure at universities makes the tertiary education sector vulnerable to fluctuations in the business cycle. A protracted economic recession, or a withdrawal of support by the private sector would have serious negative consequences for the research infrastructure".

[5] "Equipping South African Science", A Pouris & A Pouris, March 1993

The recommendations made at the time included:

"The research equipment at South African universities is on the verge of obsolescence. Shrinking university budgets, the inability of university administrations to maintain a proper balance between academic salaries and investment in equipment, and the commercialisation of the CSIR, which used to act as a depository of equipment, and the devaluation of the Rand, are the main forces which have to be counterbalanced if we wish to reverse the present situation.

A different funding model to the one currently used for research equipment, is required. A Research Council such as the FRD, should be allocated an investment budget earmarked for new equipment. The budget may be implemented using the various approaches adopted by the Swedish programme for purchasing expensive scientific equipment, the DFG funding scheme for university equipment, and the Korea Basic Science Centre.

An amount of R40 million per year for a five-year period, will be required if we wish just to update the existing infrastructure. Assuming that an approach similar to the one used by DFG is used, providing a 50 % incentive to universities to update their infrastructure, an amount of R20 million per year should be allocated from central government funding for research equipment.

It should be emphasized that the recommended amount will permit the upgrading (or replacement) of equipment in hand, but will not allow for the purchase of supplementary equipment, or for the shortage of these facilities to be addressed".

2.2 National Research and Technology Audit, Research and Training Equipment, 1998

This audit, which aimed to collect, organise and analyse data related to training and research equipment in the country, was part of the broader National Research and Technology Audit (NRTA). The exercise had two main objectives: firstly, to collect data for inclusion in the NRTA database and, secondly, to cast light on policy and management issues related to research and training (R&T) equipment at a national level in South Africa.

The report "Research and Training Equipment", found the status of the research and training equipment in South Africa to be as follows:

- There are 2 168 items of equipment in the database with a total replacement value of R1.79 billion.
- Most of the equipment is to be found at the science councils that declared that they own 966 pieces of equipment valued at R1.12 billion.
- Universities declared 884 items of equipment with a replacement value of R376 million.
- Technikons are the third largest equipment-owning group. They declared that they have 202 items of equipment with a replacement value of R40 million.
- Museums and government departments declared 118 pieces of equipment with a value of R256 million.
- Two pieces of equipment alone are valued at more than R100 million each. These are the National Accelerator Centre (NAC) (now iTemba LABS) with a declared replacement value of R500 million and the CSIR's medium-speed wind-tunnel with a replacement value of R125 million.

The report concluded that:

- the technical *sophistication of the stock of equipment* was below international standards, and that only 290 items of equipment, with a replacement value of R174 million, was characterised as state-of-the-art, i.e. less than five years of age. ***This represented only 13 per cent of the stock of equipment in terms of number and 9.7 per cent in terms of value at the time***. This is also a reflection of its age profile, which indicates that only 13 per cent of the equipment was acquired in the last five years, compared with 40 per cent of research equipment abroad.
- The financial requirements for supporting the stock of equipment appear to be substantial. Survey respondents indicated that equipment valued at R512 million will have to be replaced in the next five years (until 2002). A further R224 million is required to upgrade the equipment infrastructure to meet the research and training needs of institutions. The latter amount increased to R429 million when respondents were asked to identify the two most important instruments on their wish list that they would buy if money were available.
- *Equipment policy and management* in the country appear to differ considerably from best international practice. Some institutions follow normal *accounting practices* in the depreciation of their equipment, others attempt to keep equipment budgets separate from budgets for other needs, while the regional cooperative initiatives provide incentives for the development of some form of equipment recording. None of the institutions surveyed was found to have a coherent approach to the planning, procurement and management of equipment throughout its life-cycle. More importantly, however, is that the institutions receive no guidance on the appropriate management of teaching and research equipment.

The present replacement value of research equipment can be recalculated on the basis of earlier estimates as follows:

"In 1996, South Africa was estimated to have scientific equipment with a *replacement value* of R 1.79 billion[6]. At year 2000 prices, this equipment was assumed to be worth R 2.5 billion"[7]. Given this trend, the 2002 value will be R 3.2 billion.

A database[8] was created with classification of the data in terms of technique and practical and logical grouping of equipment. The approach used for arriving at the classification system was from a user perspective. The database is static and no efforts have been made in updating it since the audit.

This database is available on the Internet at the given URL.

2.3 National Research and Technology Foresight

The National Research and Technology Foresight project[9] that was conducted during 1998 and 1999 and published in 2000, came forward with nine recommended key technology areas.

The focus of the National Research and Technology Foresight (NRTF) study was 15 to 20 years into the future, and delivered a suite of technologies with potential to impact positively on the socio-economic needs of our country. It became necessary, however, to focus on a shorter term, and develop roadmaps[10] in three technology areas namely Information and Communication Technologies (ICT), Advanced Materials, and Biotechnology and Bioinformatics, to realise the immediate potential inherent in these.

The objective is to formulate, in all three sectors, the linkage between technology resources that need to be developed, and the exploitation of future market opportunities. The provision of the appropriate research infrastructure is an integral component of the implementation of these roadmaps.

[6] (Audit: National Research and Technology: Research and Training Equipment, 1998, Executive Summary, p 3).

[7] (Evaluation of the Programmes and Activities of the Former Centre for Scientific development (CSD) and Foundation of Research Development (FRD) Report of the Review Panel aimed at stimulating and informing the discussions regarding the way forward for the NRF, April 2000, p 47).

[8] http://dacstweb.pwv.gov.za/nrtad/index.html

[9] http://www.dst.gov.za/reports/forsight_reports.htm

[10] http://www.dst.gov.za/programmes/technology_development/tech_dev_directorate.htm

2.4 The Agency Review of the System Wide Review of SETI's

The position of the review panel responsible for the evaluation of the programmes and activities of the former Centre for Science Development (CSD) and Foundation of Research Development (FRD) (the two institutions that merged to form the NRF) regarding equipment renewal can summarised as follows:

- The NRF, through its enhanced brokering role with other funding sources, should increase its equipment budget to at least R50 million per annum to maintain the current infrastructure. Under these conditions, a separately managed, centrally co-ordinated equipment programme, to handle equipment of all disciplines, including the humanities and social sciences, is justified.
- In the event that the funding level of the equipment programme is not substantially increased, the programme should be disbanded and applications for multi-user equipment should be considered in other programmes.
- Before the NRF awards funds to an institution for the purchase of equipment, the recipient institution must make a tangible commitment to the support, maintenance and running costs associated with the equipment and operating personnel, if required.
- Regional co-operation between institutions should be encouraged and facilitated by the NRF with the clear objectives to:
  - Co-ordinate the purchase and funding of expensive equipment especially at the tertiary institutions as well as statal or parastatal institutions
  - Promote the sharing of facilities by institutions
  - Compile and maintain an inventory of available (research) equipment
  - Evaluate and facilitate application to the NRF for regional (national) equipment
  - Regardless of the establishment of an equipment programme, a mobility fund to promote use of shared equipment should be maintained and expanded.

Although these recommendations were accepted by the NRF, the National and Regional (multi-user) Equipment Programme had to be disbanded because of a lack of resources. The Mobility Grant fund, which enable researchers to make use of expensive or unique equipment not available at their own research location continued. More recently the NRF again set aside some resources (R4.5 million in 2002/03 and R7 million in 2003/04) exclusively for equipment repairs and upgrades to ensure that the available equipment infrastructure in higher education remains serviceable for a little while longer.

2.5 Equipment support through THRIP, the Innovation Fund and the National Laser Centre

2.5.1 THRIP

Under the THRIP conditions of grant research equipment can either be acquired on an in-kind contribution or purchased directly from the grant. THRIP matching funds for contributions in-kind are, however, only provided for projects based at historically black universities (HBUs) or at technikons and only contributions of equipment (including computer software) and/or materials that are transferred to the HBU or technikon are regarded as in-kind contributions.

Any *research equipment* acquired with THRIP support becomes the property and responsibility of the HEI/SETI concerned. Where it is more practical for the research equipment to be located at some place other than the institution, an agreement must be entered into stating that the equipment will be re-located to the institution within the project duration period. In the three years up to the end of 2002, R 108 million was invested in research equipment of more than R200 000.00 per item in higher education. Of this R34 million was contributed by government through the programme and R63 million from industry.

2.5.2 Innovation Fund

Equipment determined to be necessary for the project is funded as part of the project. The equipment belongs to the Innovation Fund until the project is completed, at which point the Innovation Fund will pass it on to the consortium if the project milestones have been achieved and the project enters the commercialisation phase. However, if the project is unsuccessful and the Innovation Fund will pass on the equipment to the higher education partner. Innovation Fund beneficiaries are expected to keep an asset register.

There is no upper limit currently on the equipment costs permitable, and decisions regarding equipment are purely based upon assessed need if the project is deemed a worthy investment. However, there is an annual cap of R 5 million for the total project costs, so equipment has to fit into this limit. There is no specific policy for equipment application.

2.5.3 National Laser Centre equipment rental pool-scheme

The National Laser Centre has at its disposal an array of laser equipment which it rents out to researchers in higher education for specified periods of time linked to an approved research proposal. The rental pool scheme is funded by the NRF with the aid of a ringfenced grant of R3 million per annum from the DST. This scheme also makes provision for researchers to use some expensive state-of-the-art equipment at the National Laser Centre.

2.5.4 Regional Innovation Centres for Biotechnology

In line with the Cabinet approved Biotechnology strategy, three Regional Innovation Centres (BRICs) were established by the DST in 2003 each with an annual budget of about R30 million. Provision within this strategy is made for the purchase of expensive research equipment that is shared by different groups within a BRIC. Research equipment within the context of this strategy can either become part of technology platforms, i.e. enabling infrastructure for researchers to develop products and services, and or within the context of individual research proposals. There is no upper limit to equipment items that can be acquired within the framework of this programme.

2.5.5 DST/NRF Centres of Excellence

Effective and comprehensive funding has been recognised as a key factor of success of such centres, the first ones of which are presently being established. Ready access to state-of-the-art equipment is considered part of the critical success factors of such centres. The present funding ceiling of R5 million per annum for such centres implies that few such centres will be in a position of purchasing expensive research equipment should the need arise.

2.6 Regional Planning

Some regions have responded to the crisis in research equipment acquisition by planning regionally. This regional planning has also fitted in well with the former National and Regional Equipment Programme strategy of the NRF. These regions have been very successful in facilitating regional collaboration on research equipment matters and such collaboration has been rewarded by the former NRF Equipment Programme by co-funding large and expensive pieces of research equipment in the region to be shared by all the participants in the proposal.

2.6.1 esATI (Eastern Seaboard Association of Tertiary Institutions)

The institutions in KwaZulu-Natal agreed to work together to determine a regional priority for regional equipment, rather than each putting in an own view as to what the region most needed[11]. Since the NRF equipment programme has been under review, the institutions have not done anything in this regard - the agreement is “on hold”. A Working Group, appointed by the Vice Chancellors, will prioritise all esATI projects, including those that are not presently active. A regional strategy for research equipment and graduate studies will get some priority. In theory, any new venture in the region is supposed to start as a joint venture (according to the esATI mission statement).

[11] Prof John Butler-Adam, Chairperson, esATI

2.6.2 REEP (Regional Expensive Equipment Programme)

The REEP committee comprises representatives from the five Western Cape tertiary institutions (University of Stellenbosch, University of the Western Cape, University of Cape Town, Cape Technikon and Peninsula Technikon) as well as iThemba LABS, the ARC Infruitec Nietvoorbij, and CSIR.

Each has one representative and the priorities for major expensive research equipment required at the various institutions are discussed. The needs are carefully prioritised with a view to avoid duplication, and where a shared item is agreed upon, a robust management structure is compiled which will ensure that the instrumentation is shared by all institutions that require it. Before making a recommendation to the NRF it is also ensured that the institution concerned has the appropriate infrastructure to operate and maintain the equipment concerned.

Only a few meetings took place, and the committee is now dormant because the NRF has had no equipment money in the last few years. However, the meetings that took place have been successful in that they were carried out in a spirit of cooperation and mutual goodwill.

It is clear that regional planning regarding equipment is only dependent on the NRF having funds to establish such equipment. The regional committees did not continue their work to strategise independently to uphold equipment funding in the regions from other sources. This has to be recognised as a weakness in planning approach.

2.7 National Facilities and Other Models for Producing "Critical Mass" In Relevant Research Areas

2.7.1 National Facilities in South Africa

The criteria for establishing a new national facility have been developed by the SETI Review. The current national facilities in South Africa are:

In Nuclear sciences and nuclear medicine

- iThemba LABS (Laboratory for Accelerator Based Sciences)

In Astro-, space- and geo-sciences

- SAAO (South African Astronomical Observatory), incorporating SALT (South African Large Telescope) Foundation (Pty) Ltd
- HartRAO (Hartebeesthoek Radio Astronomy Observatory)
- HMO (Hermanus Magnetic Observatory)

In Bio-diversity/Conservation

- SAIAB (South African Institute for Aquatic Biodiversity)
- The National Zoological Gardens

The National Facilities Review[12] states that a national facility must be seen as the top of a hierarchy of groupings of researchers to produce a critical mass of people and *equipment* for tackling problems in areas of national benefit either through advancement of science or application of technology. There are several other models for creating such groupings, such as:

2.7.2 Centre-based research at universities

In a number of countries, the most productive research at universities is being carried out in centres, which are multidisciplinary and team-based. By bringing together researchers as teams of varying size and different disciplines to produce the critical mass required to address problems in selected areas.

Instrumentation centres exist at various universities where electron microscopes, microprobes, etc. are grouped together to form a common facility and where a critical mass of researchers can be brought together in a field, e.g. materials science.

2.7.3 Regional research centres

A logical extension of university research centres is regional research centres linking researchers at a number of universities within a geographical region. Thus in a specialised discipline critical mass is created by such an approach when there are insufficient researchers within any one university. This approach is also useful where specialised facilities or items of equipment are too expensive for any one university to afford – particularly at a time of budget stringency.

The recently announced DST/NRF Centres of Excellence would constitute such centre-based and regional groupings.

2.7.4 Co-operative research centres

The need to bring together universities, industry and government agency researchers to address problems of national interest or development of new processes and products for wealth creation has been recognised in many countries. Different approaches to setting up co-operative research centres (CRCs) have been adopted in different countries – some preferring close university–government agency links, others close university–industry links, and others a linkage of all these.

[12] http://www.dst.gov.za/SET_institutes/set_institutes.htm

There is no substantive reason why a major national facility should not be associated with a CRC. However, the objectives of the two programmes need to be borne in mind. A national facility provides a research service without which large numbers of programmes could neither achieve their objectives nor match international research, while a CRC addresses problems in a focused area of national interest.

2.8 Private sector investment in research equipment for public gain

Given the limited resources available for research equipment in higher education for many years now, the higher education sector has had to rely very heavily on the goodwill of industry and, in more recent year also on private foundations and trusts, to assist with the purchase of expensive research equipment. In many instances the funding of such equipment is directly linked to the field of interest of the funder, e.g. analytical equipment for geochemical research by the mining industry, equipment for medical research by the Wellcome Trust etc. Although an attempt was made to ascertain the amount spent by the private sector on research equipment in higher education over the past few years, it was difficult to extract exact information for this purpose. From the limited data that was readily available from some of the higher education institutions, it is estimated by way of extrapolation, that contributions from the private sector for the purchase of expensive research equipment in excess of R100 000.00 must be at least R25 million annually.

2.9 Risks in Capital Funding for Research Equipment

The problem with addressing the situation around research equipment lies in the fact that budgets are put under pressure in higher education and in government departments responsible for supporting and promoting research in higher education. The need for research equipment has grown to such an extent that it can no longer be addressed from existing budgets, particularly from the Science Vote. In the past, higher education institutions did their utmost in sharing research equipment and facilities and planned intensively on a national and regional level. Although this approach should continue, sharing of research equipment across institutions and regional and national planning alone cannot realistically improve the situation any more; additional funding is required.

Alternatives to the widespread placement of research equipment and facilities in the higher education sector could include the opening of more national facilities where equipment is grouped according to application and where skilled staff is appointed to operate and maintain this equipment. This solution, however, only applies to research equipment that is not used on a routine basis for training and

research. A few very expensive types of equipment could be addressed in this way. Additional to state funding for renewal, maintenance and purchasing leading edge equipment, higher education institutions should develop financial disciplines based on capital depreciation to provide for equipment replacement funds in their own environments. Whatever the alternative, equipment funding should remain a partnership between the state and higher education; research equipment must be seen as part of the essential infrastructure of higher education and hence a justifiable expense from the public purse.

3 New Policies and Incentives

3.1 The National Research and Development Strategy

Several departments sponsor research and development in South Africa in support of their respective missions of delivery for the benefit of the nation and hence also have an interest in research equipment as part of their strategy of delivery. However, overall direction to government funded research is provided for by the National Research and Development Strategy of the DST which was approved by Cabinet in 2002. As in many other countries, two basic principles underpin government's support for scientific programmes, viz.

- The programme could potentially contribute towards addressing social or economic goals
- The programme is potentially world class and could contribute to leading-edge global knowledge

The new R&D Strategy[13] is indicator based and rests on three pillars:

- Innovation
- Science, engineering and technology (SET) human resources and transformation
- Creating an effective government S&T system

3.1.1 Technology missions

The innovation "pillar" involves the establishment and funding of a range of technology missions that are critical to promote economic and social development. These are:

- the two key technology platforms of the modern age, namely Biotechnology and Information technology
- Technology for manufacturing
- Technology to leverage knowledge and technology from, and add value to, our natural resources sectors
- Technology for poverty reduction

[13] http://www.dst.gov.za/legislation_policies/strategic_reps/sa_nat_rd_strat.htm

3.1.2 Basic research

Includes areas of scientific focus where South Africa should be leading and at the cutting edge of new knowledge through its research contributions. Two approaches are adopted in the R & D Strategy to identify such areas:

Scientific areas where there is an obvious *geographical advantage*. Examples are:

- Astronomy
- Human palaeontology
- Biodiversity
- Antarctic research
- Other examples of possible phenomena or systems e.g. the Kaapvaal Kraton (geology) and the South Atlantic Magnetic Anomaly (geomagnetism and space science)

Scientific areas where there is an obvious *knowledge advantage*, e.g.:

- Indigenous knowledge
- Technology for deep mining
- The high incidence of diseases of poverty has placed the South African medical research community at the cutting edge of technology development in these areas
- Micro-satellite engineering (although large multinational consortia now dominate the communication satellite market, South Africa has retained a niche competence in micro-satellites deriving from a fusion of defence spin-offs and university research)
- The African integrated approach to HIV/AIDS vaccine development
- Encryption technology (spin-offs from State investment in the defence sector have generated significant foreign exchange recently)
- Fluorine technology (high entry barriers mean that the competence developed in the uranium enrichment programme could be turned to South Africa's advantage)

3.1.3 Centres or Networks of Excellence

In promoting research and development in a national system of innovation, the South African government has identified through its national research and development strategy that centres of excellence are an important mechanism of establishing critical mass. It is envisaged that such centres will stimulate sustained distinction in research while simultaneously generating highly qualified human resource capacity in order to impact meaningfully on key national and global areas of knowledge[14]. Centres of excellence are physical or virtual centres of research which concentrate existing capacity and resources to enable researchers to collaborate across disciplines on long-term projects that are

[14] The NRF Framework for Centres of Excellence in the South African System of Research and Innovation, www.nrf.ac.za

locally relevant and internationally competitive in order to enhance the pursuit of research excellence and capacity development. As already indicated above, such centres are now being established.

3.1.4 Financing R&D Equipment

The R&D Strategy document recognises the need to provide substantial resources for the financing of research equipment and states in this regard that:

"New financing for large R&D equipment was requested a number of years ago. A small allocation (R14 million) was given for this purpose. Although the Department of Science and Technology has introduced stringent conditions for these equipment grants (large equipment, multi-institutional support, high potential for training and research, and use in a limited set of focus areas) the scheme is heavily over-subscribed. It is necessary to significantly increase this programme, as most equipment is sourced overseas (usually purchased in Dollars or Euros), equipment is a critical success factor in both biotechnology and ICT research as well as the chemical and physical sciences, and the ability of our scientists to be excellent globally is linked to quality of equipment."

The commitment by the DST to increase the support for research equipment in accordance with the R&D Strategy was the impetus to initiate this strategy document.

3.2 Integrated Manufacturing Strategy

The Integrated Manufacturing Strategy[15] of the South African government is in effect its industrial strategy. It involves beneficiation, manufacturing, production, infrastructure and ICT as an enabler for industrial development. Many research programmes that are research infrastructure intensive will be aimed at realising the integrated manufacturing strategy.

3.3 Technology Mission Driven Strategies

3.3.1 National Biotechnology Strategy for South Africa[16]

The Biotechnology strategy has been designed to stimulate and to derive optimal benefit from local advances in biotechnology, specifically in the areas of human health, food security and environmental sustainability, including the successful commercialization of publicly funded research and development in this area. A key element in the strategy is the development of Regional Innovation Centres where technology platforms can be established consisting of capital equipment and specialized expertise that can be shared by participants in research projects and industry. See also 2.5.4 above.

[15] http://www.dti.gov.za/publications/publications.htm

[16] A National Biotechnology Strategy for South Africa. Department of Arts, Culture, Science and Technology, December 2001

3.3.2 Advanced Manufacturing Technology Strategy[17]

The Advanced Manufacturing Technology Strategy has been developed in response to the National R&D Strategy and the Integrated Manufacturing Strategy. Both of these have recognized the importance for international competitiveness and growth to move from raw material intensive manufactured goods towards increasingly knowledge-intensive goods and services. The strategy envisages a variety of different activities and projects located in Centres, Networks and Initiatives, funded from a variety of different existing funding sources. The strategy does, however, recognize the importance of dedicated funding, amongst others for infrastructure development to be essential for success.

3.4 Department of Education – A New Framework for Funding of Higher Education

The Department of Education recently introduced a new funding framework for higher education.[18] This framework goes hand-in-hand with the National Plan for Higher Education and is based on the realisation that the current funding framework, which was introduced in 1982/83, is not suitable as steering mechanisms to meet the policy goals for the transformation of higher education.

The new model represents a major change in focus. It emphasises that the primary purpose of higher education is to teach, research and play a pivotal role in the improvement of the social and economic conditions of the country. The new funding framework is seen as a distributive mechanism and as a way of allocating government funds to individual institutions in accordance both with the budget made available and the government's policy priorities. The new approach is intended to rather pay institutions for delivering the teaching-related and research-related services specified by government-approved plans.

The main element of the new funding framework is the splitting of block grant into two earmarked grants, one for teaching and the other one for research. Teaching funds will be based on teaching inputs and teaching outputs. Research funds will be based on research outputs (research masters, doctorates and publications) although provision is also being made for a teaching input at master's and doctoral level, with weighting factors strongly favouring postgraduate students in disciplines requiring expensive infrastructure such as the natural, life and health sciences and agriculture. Research funds will no longer be "blind", with the block grant component based on research outputs of institutions. Research output will be based on publication units, on research masters graduates and

[17] A National Advanced Manufacturing and Logistics Technology Strategy for South Africa. Prepared for the National Advisory Council on Innovation, December 2002

[18] Government Allocations to Public Universities and Technikons. Ministry of Education, August 2003

on doctoral graduates weighted on a 1:1:3 ratio. Historically about 10.5 % of the education vote was earmarked for research, but the actual proportions of the block grants will in future be determined by the Ministers of Education and Finance.

A major influence on the Proposed National Key Research and Technology Infrastructure Strategy will be the fact that fewer universities will do research according to the National Plan for Higher Education. It is estimated that only 8 – 10 universities will be full research universities. They will thus get more funding than they get currently. The important implication of the weighting factors in favour of postgraduate students and the more expensive disciplines is the principle that such funds from the education vote should enable research active institutions to provide for the well found laboratory, i.e. the fundamental infrastructure, including some basic equipment required, to be active in research.

4 A Proposed National Key Research and Technology Infrastructure Strategy

Following the background information on the research equipment support environment in South Africa given thus far, which is at best fragmented, uncoordinated and lacking sufficient funding, it is clear that a national strategy is required to address the situation of research equipment in South Africa.

4.1 Type of research covered by the National Key Research and Technology Infrastructure Strategy

It is necessary that research to be supported by research infrastructure should be defined as wide as possible. In this respect, research is considered from four perspectives:

- Research targeting by government
- Research in response to market demand
- Research for the purpose of teaching and training
- Research for the purpose of knowledge proliferation

Given these different perspectives on research, it is quite logical that different constituencies will have responsibilities for the guiding, funding and equipping of such research. This is taken into account in this strategy.

Research targeted by government is covered in this strategy by focusing on the national science and technology missions as reflected in the National R&D Strategy, but also to be responsive to regional and/or institutional missions. This is one of the most important areas addressed by this strategy, since it provides an indication of where research funding will be spent according to national priorities. A research equipment strategy needs to be aligned with such priorities.

This strategy does not address ***research in response to market demand*** in great detail, apart from the priorities reflected in the targeting at national or regional level. This is because such research is normally on a contract basis between the client and the research institution. The equipment purchased for such research is often dedicated to the specific project. Nevertheless, such equipment may also be used wider, or after the conclusion of the project it may form an important part of the installed research equipment base in the research institution. The long-range strategic planning at institutional level should take such equipment into account and introduce it into the general research environment once the projects where this equipment has been purchased are concluded. The same

situation may apply for research equipment purchased under THRIP or the Innovation Fund environments. These types of public-private partnerships in research funding will remain an important way of equipping the science and technology base.

Research for the purpose of teaching and training is included in the strategy. One of the main purposes of academic research is to train highly skilled human resources capable of using research equipment for the purpose of generating and applying knowledge through research for socio-economic advancement of the nation. All research institutions operating under the National System of Innovation have a priority in teaching and training of human resources.

Research for the purpose of knowledge proliferation refers to that research done to become globally competitive in the knowledge society. It does include the notion of 'basic research'. This strategy does not distinguish between 'basic' and 'applied' research. Both forms of research are included in the Proposed National Key Research and Technology Infrastructure Strategy. No preference is given to the one above the other.

4.2 The strategic objectives

The following are strategic objectives to be addressed by a Key Research and Technology Infrastructure Strategy:

4.2.1 Prioritising types and purpose of research equipment

The type of equipment in terms of research use and focus should be addressed and possible paths of arriving at a desired research infrastructure base should be given on this basis. From such an analysis the priorities for establishing a research equipment infrastructure base for the country should be provided.

4.2.2 Differentiating categories of research equipment

Research equipment covers a broad spectrum from small items of a few hundred Rand to tens and even hundred of millions of Rand. It is therefore necessary to classify research equipment into different categories for the purpose of ownership, management, funding and collaborative usage.

4.2.3 Creating a long range planning culture

It is evident that very few institutions have a long range research plans that include research equipment. The establishment of such a planning culture will assist greatly in assessing future equipment requirement scenarios for the country.

Well-defined collaborative models may also cut down on the amount of research equipment required in the research base and lead to a more productive research infrastructure.

4.2.4 Assigning responsibilities for the acquisition and management of research equipment per type of research environment

Currently no distinction is made between equipment requirements of the well-found laboratory and expensive, state-of-the-art equipment that will enable researchers to compete globally. It is therefore necessary to differentiate between the well-found laboratory and world-class equipment and the responsibility of funding and managing these.

4.2.5 Establishing guidelines for economic models required to sustain the research infrastructure

Currently very few research institutions employ economic models to support the long-range sustainability of their research infrastructure base or research equipment. Such models based on depreciation or replacement funds, sustainability funding and whole life-cycle costing will need to be introduced.

4.2.6 Introducing proper quality management

Proper quality management of research needs to be in place. This needs to support proper research management, intellectual property management, sustainability planning and financial planning.

4.2.7 Specifying funding categories for research equipment renewal and maintenance

Currently a variety of research equipment capital funding is dealt with in single grant environments. The splitting of grants and budgets into new acquisitions, upgrading, replacement, maintenance and repair will be necessary.

4.2.8 Ensuring optimal use of research equipment in a sustained manner

A critical component of research equipment is the human resource base and knowledge pool associated with it. Research equipment cannot be operated and used by researchers who are not properly trained to optimise the use of the equipment. It is not only the ability to operate and to maintain the equipment that is important, but also the ability to interpret the research results and thereby to maximise the use of the equipment. In addition, proper support in terms of technical back-up and maintenance to ensure optimal functioning is essential

4.2.9 Assuring access to research equipment

Research equipment of an expensive nature cannot be duplicated when utilisation to full capacity cannot be effected. In such cases research equipment will have to be shared over large distances or in central facilities. Researchers should have access to a grant environment where such mobility is supported.

5 Scenarios for South African research equipment and facilities

Simplified scenarios can be generated for guiding the equipment strategy. Such scenarios are based on a two-dimensional view of the environment and some Political, Economical, Social and Technological (PEST) vectors. In general, the technological issues are the ones under most control by a research community and are handled as key factors and forces influencing the research equipment scenarios. The political, economical and social vectors are key uncertainties, but the major aspects can be highlighted and taken into account in the scenario planning.

5.1 Key Technology Trends

In developing a scenario for research equipment in South Africa, the key factors and forces to be considered when the technology dimension of research equipment is taken into account are:

- Research equipment ages faster because of computer integration and software upgrades.
- New technology is embedded into equipment at a faster pace, following the technology life cycle of mainly electronic components.
- Technologies developed using the equipment place higher demands on resolution (e.g. nanotechnology, microstructures), accuracy (e.g. qualitative analysis), magnification (e.g. microscopy and telescopes) and complexity (e.g. genomics).
- Data processing takes place in real time and experiments are tuned while being conducted
- Data can be shared world-wide through the Internet in almost real time.
- Data volumes for processing and storage increase drastically (e.g. astronomy, bioinformatics).
- Economies of scale are not achieved in the case of the most expensive equipment categories (e.g. NMRs, telescopes, sequencers, etc) since many are custom-built or built on order only.

5.2 Key Uncertainties

The key uncertainties arise in the vectors of political, economic and social aspects of the environment that will guide the strategy development. These are seen to be:

Political

- The political will exists in South Africa to address science and technology, research and development (e.g. the National R&D Strategy, National Biotechnology Strategy, Advanced Manufacturing and Logistics Technology Strategy, the creation of a separate Department of Science and Technology, and the prominence given to the importance of Science and Technology in the first state-of-the-nation address by the President after the elections).
- Political priorities are many and wide-spread and competitive environments exist for obtaining funding for research and development and higher education.
- The challenge is to increase the size of the science and technology and education budgets and not only to re-prioritise existing budgets.
- A dual focus will be used in planning, that of national priorities in science and technology, a debate led by the Department of Science and Technology and that of human resource development and knowledge development, led by the Department of Education, with obvious existing overlaps.
- The South African government's leading political role in NEPAD will lead to research collaboration on the continent, which in turn will require a well-equipped research base in South Africa.

Economical

- The macro-economical situation in SA is stable, with a focus on micro-economical development to enhance competitiveness (supported by the Micro-economic Reform Strategy and Vision 2014 of the government).
- Improvements in the exchange rate, growth rate and inflation all bode well for more stable pricing and affordability of state-of-the-art imported research equipment.

Social (institutional context)

- The South African higher education sector is going through radical transformation (mergers, new missions, e.g. comprehensive institutions) as the National Plan for Higher Education is implemented. The resulting rationalisation within HEIs will not only create economies of scale but foster collaboration in the purchase and usage of research equipment.
- The funding formula for HEIs is being adapted to have two, largely output based streams of funding for education and research.
- A new investment culture is emerging in some HEIs reducing the reliance on state funding. This represents a modern academic entrepreneurial culture, yet many institutions insist on using old models of funding, where the state is seen as the main provider.

- External contract funds often do not make provision to cover overheads such as equipment depreciation and hence leave a gap in ensuring an adequate provision of a healthy infrastructure base.
- Adequate costing and financial models such as depreciation and replacement funds are not in place.
- Long range research strategies are not in place.
- The National Research and Development Strategy has identified a crisis in the fact that the average scientist is ageing fast. Apart from having an effect on the transfer of knowledge to the next generation of researchers, it has impacts on utilising and maintaining equipment since the knowledge vested in these scientists is disappearing from the research arena as they retire.

5.3 A Scenario generator

Figure 1 shows a scenario generator to be used in the development of a possible future scenario for research equipment.

Two axes are used, one for possible outcomes and one for strategic options. Two diverging outcomes and options are selected to picture scenarios that may emerge. The present position is then plotted somewhere on the map, followed by possible future positions to be taken, depending on how some of the scenario vectors (key factors and forces and key uncertainties) converge.

The possible outcomes selected are motivated as follows:

- **Local Focus:** Research aimed at primarily solving local priorities and demands (equivalent to the “Frozen Revolution” and “Our Way is the Way” scenarios in the National Research and Technology Foresight[19]). The context of "local" is national (as in South Africa) and may be extended to include sub-regional (as in SADC)
- **Global Focus:** Research aimed at making South African industry and knowledge globally competitive (equivalent to the “Global Home” and “Innovation Hub” scenarios in the National Research and Technology Foresight)

[19] NRTF Scenarios, Dawn of the African Century, ‘A Nation at work through Science and Technology for a better future’, Department of Arts, Culture, Science and Technology 1999

The strategic options that can be taken are qualified as:

- **Well-found Laboratory:** minimum level of (usually departmental) equipment and facilities that an external sponsor would expect to find in place
- **Infrastructure for world-class science:** major items of equipment, which are too costly to acquire through research project grants, usually for interdisciplinary research centres.

The profile of a well-found laboratory includes:

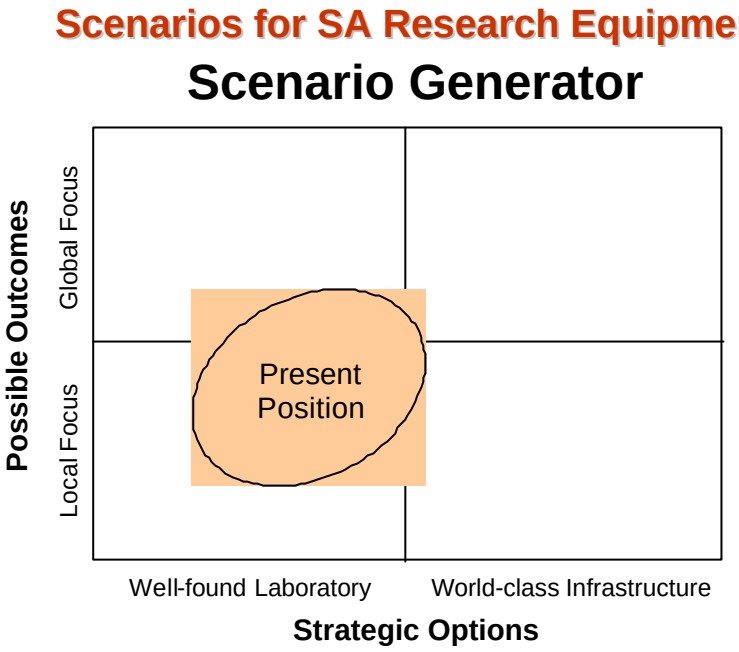
- A well-found laboratory has the minimum level of equipment, at an acceptable quality and quantity available to support research and training in research, which is part of the strategic plan of an individual, department, research group or institution.
- Basic equipment should be available to support a broad range of research projects, or a specific research project.
- Equipment purchases are funded by research grants of individuals or groups, and from research grants to individuals, groups or department's from own institutional funds.
- Long term plans for the sustainability of a well-found laboratory need to exist to ensure the competitive baseline of the individual, department, research group or institution.
- A well-found laboratory is a precondition to host infrastructure for world-class science.

Similarly, the profile of an infrastructure for world-class science involves:

- State-of-the-art equipment for competitive research and research training.
- Equipment to be used by more than one discipline.
- Equipment that is usually funded on a national, regional or inter-institutional level.
- Equipment that fits in with national science, technology and industrial strategies.
- Equipment that often requires specialised operation and management environments where the user does not necessarily operate the equipment.
- Equipment having a long range life cycle.
- Equipment that is usually underpinned by a well-found laboratory environment.

Figure 1 shows the position for the current South African research equipment situation. One should recognise that there are levels of the well-found and of world class status that a laboratory may have. The present position of research equipment on the map of outcomes and strategic options is that existing equipment, including the state-of-the-art equipment of yesteryear, is mostly aged and used for research with a local focus and to fit into the medium and lower levels of well-found laboratory status. Limited research with a global focus is being done in well-found laboratories. The existing, but very limited (10 – 13% of installed base as described by the National Research and Technology Audit), world-class infrastructure is applied mainly for research with a local focus. This equipment is applied to a lesser extend for finding global solutions through research.

Figure 1: Scenario generator illustrating the position for the current South African research equipment situation



The desired strategy should position the South African research equipment and infrastructure base as shown in Figure 2.

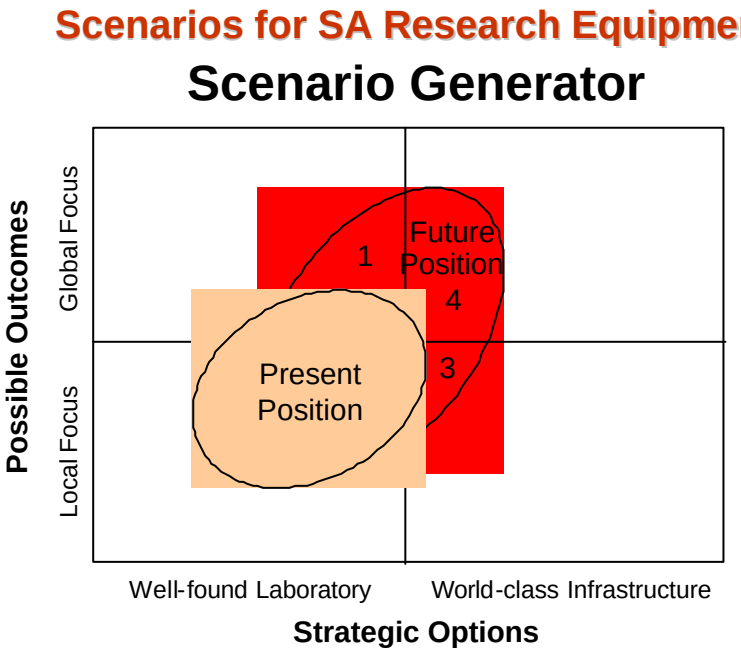


Figure 2: Desired position of South African research equipment and infrastructure base

Expansion options are indicated by the numbers in Figure 2. Under such a scenario the following is required:

1. **Expand the well-found laboratories to support research with a global focus**: Well-found laboratories are a necessity to be globally competitive. This is required for teaching and training, routine work and research support.

2. **Expand well-found laboratories to support research with a local focus**: Well-found laboratories are a necessity to address the local needs. The current situation is probably less than sufficient for this approach and *growth* is required.

3. **Expand infrastructure for world-class science to support research with a local focus:** Infrastructure for world-class science is essential to bring world-class solutions to local problems.

4. **Expand infrastructure for world-class science to support research with a global focus:** Infrastructure for world-class science is essential to be globally competitive. *Significant growth* is required, since it also benefits the local focus. This should be the *main focus of equipment expansion*, since it also benefits the local focus.

A **two pronged strategy** should thus be followed to strengthen the well-found laboratory and to build the world-class infrastructure. This dual approach is required since the installed base of equipment is ageing and insufficient attention has been given in many institutions to maintaining and modernising the well-found laboratory environment.

6 Strategic Framework for Research Equipment and Facilities

6.1 Rationale

The acquisition and placement of key research equipment must happen within a policy framework that addresses national and regional needs and priorities. These have been identified for South Africa and several strategies are in place to address these (Chapter 4). Within this strategic framework, competitive world class research relies on a spectrum of state-of-the-art research equipment, which varies from low-cost, dedicated bench-top laboratory equipment characteristic of the well-found laboratory, to large, expensive research facilities with scientific, technical and administrative support staff with annual budgets of several tens of millions of Rand.

A strategic framework for key research and technology infrastructure must of necessity have a holistic approach to the entire spectrum of research infrastructure needs. It must furthermore also take cognisance of the more recent initiatives to implement policy in line with the strategies referred to above, which make provision for the acquisition and placement of state-of-the-art research equipment. Reference here can be made to the Innovation Fund, the Biotechnology Strategy, THRIP and Centres of Excellence. There are however some limitations of the extent to which these strategic initiatives meet the equipment infrastructure requirements of the nation, viz.

- Limitations in the grant size and hence limitations in the type of equipment that can be acquired within the context of these strategies
- The dedicated nature of the equipment, i.e. very project specific and hence often focused on departmental level within higher education.

The strategic framework for research equipment and facilities to be built on the proposed scenario requires the identification of several categories of research equipment infrastructure which depend largely on the purpose the equipment serves within the framework. Six such levels are proposed,

- Institution based: departmental
- Institution based: centres
- National and Regional equipment
- National Research Facilities
- International Facilities
- Foundation infrastructure

6.2 Categories of Research Infrastructure

6.2.1 Institution based: Departmental

The type of equipment normally part of a well found laboratory. It is used by one or several researchers and students within the department and funded by the institution and or the researcher from his/her research grant.

6.2.2 Institution based: Centres

Part of the institutional research infrastructure utilised by researchers from several disciplines and departments. Examples include electron-microscopy units at universities, SpectRAU, the Schonland Research Centre and expensive equipment located in Centres of Excellence within such institutions.

6.2.3 National and Regional Equipment

This includes expensive research equipment which is normally beyond the means of a single or cluster of institutions. Depending on needs, equipment of this nature may be placed in several regions to serve the needs of researchers within the region, or where only one piece is available in the country to serve the needs of researchers in the country. This type of equipment is placed within the most appropriate environment within universities or SETIs and managed by these institutions on behalf of the region/nation.

6.2.4 National Research Facilities

Includes research facilities which normally require a high capital investment and a substantial annual budget of several tens of millions of Rand to manage and maintain. Facilities of this nature are structured around unique research equipment or collections. Two types of national research facilities can be distinguished, viz.:

- Declared National Research Facilities, are those that are managed by the NRF with the aid of an entrenched budget earmarked for such facilities. Examples are iThemba LABS, SAAO, HartRAO, HMO, SAIAB and the NZG.
- Facilities hosted by other institutions, such as the National Laser Centre, the Satellite Applications Centre, and the SAFARI nuclear reactor.

6.2.5 International Facilities

Mega-science facilities located in South Africa by virtue of e.g. geographical advantage in which South Africa has acquired a share on behalf of local users. These are managed by South Africa on behalf of the international partners. SALT is a primary example. The SKA could be a future facility of this nature.

6.2.6 Foundation Facilities

Foundation facilities are those which constitute the backbone of the research infrastructure and without which all or most of the other categories of the research equipment infrastructure can not function optimally. Prime examples are the proposed National Research and Education Network (NREN), networks of computers to significantly enhance the available computing capacity, and a research information infrastructure to provide access to research information resources and the dissemination of such resources, such as e.g. the Bio-informatics Network.

6.3 Shareholders and stakeholders in equipment categories

The relationship between shareholders and stakeholders in the various equipment categories needs be defined.

Shareholder: The research institution owns or co-owns the research environment where the collaborative model is applied
Stakeholder: The research institution is a participant in, but does not own or co-own the environment where the collaborative model is applied

According to Table 1, Institutional and Regional/National equipment are owned or co-owned by research institutions as shareholders, which implies that they have invested money in the establishment and upkeep of such equipment. National Facilities do not belong exclusively to research institutions such as HEIs or Science Councils, are mostly funded and operated by Science Councils or agencies on behalf of the state, whereas for International Facilities the state has made an investment on behalf of the users. In such facilities the institutions, higher education and SETIs can be considered as stakeholders as such facilities are, by implication only available to stakeholders. Both a shareholder or a stakeholder model can apply in case of Foundation Facilities. For a network such as NREN universities and science councils would be stakeholders, whereas for an advanced computing facility or research information network such institutions can be shareholders depending on the computing capacity/research information databases their respective own institutional infrastructure contributes to the facility.

Table 1: Shareholder/Stakeholder relationship viz. different equipment categories

Equipment category	Shareholder	Stakeholder
Institution: Departmental	X	
Institution: Centre	X	
Regional/National	X	
National Facility		X
International Facility		X
Foundation Facility	X	X

6.4 Research strategies and equipment category requirements

Table 2 provides a matrix which could to be used for planning current and future research equipment placement strategies. Equipment will be linked to the national science and technology missions as per the National Research and Development Strategy and to missions that have been identified as either institutional or regional. Given the multiplicity of departmental research, one could be tempted to remove this from national strategic planning. It needs to be acknowledged though that these activities generally contribute to the maintenance of the strategic knowledge base of the country and are supported through the research funding subsidy from the DoE to higher education. It should be noted that many well-found laboratories are positioned and managed at departmental level.

Table 2: Research Equipment Categories for Specific Strategic Missions

	National Science Missions		National Technology Missions		Institutional Research Strategies	
Infrastructure Categories	**Well-found**	**World-class**	**Well-found**	**World-class**	**Well-found**	**World-class**
Departmental-based research *(One department, one or many researchers)*						
Centre-based research *(One institution, several departments)*						
Regional/National equipment *(One per region or country, several institutions)*						
National Facilities *(One institution nationally, many participants or national network of institutions, one management centre)*						
Foundation Facility *(backbone without which others can not function optimally)*						
International Facility *(Country a shareholder on behalf of many local users)*						

New research equipment needs to be strategically classified according to a matrix of this nature in future and specified whether it is considered to be part of the well-found laboratory or world-class in nature.

During the regional consultation phase of the development of this strategy, the institutional centre-based research and the regional needs for world-class infrastructure for research collaboration were identified.

A summary of this preliminary survey is available in a separate document: "An analysis of research focus in national and regional research missions and its impact on research equipment in South African research institutions." A breakdown per region (geographical, taking the changing face of higher education into account) of such collaborative foci and the types of world-class research equipment employed or needed in future are given in this analysis. The content presented, however, is based on interpretation of the concept 'world-class' by the institutions that responded which may differ at this early stage of introduction of the notions 'well-found' and 'world-class'.

6.5 Research Infrastructure Database

The implementation of any Key Research and Technology Infrastructure Strategy will require the creation of a national database, within which information on equipment is recorded according to the types of criteria listed in 7.2 above, the purpose for which it has been acquired, the location of the equipment, replacement costs and other information criteria that may be decided on. Such a database is essential in deciding on the acquisition and placement of new equipment within the context of this strategy. The focus of such a database will, by implication, be on all categories apart from equipment that constitutes part of the well found laboratory. Such a database will need to be a live database where new acquisitions are added and obsolete equipment is deleted on a continuing basis. The management of such a database will have to be the responsibility of the agency with the responsibility of implementing any equipment funding component of this strategy.

7 Strategies for handling and funding National Key Research and Technology Infrastructure

By its very nature, research equipment which constitutes the national equipment infrastructure varies in cost and maintenance from small, desk-top operated systems of a few hundred Rand to large, expensive instruments of several hundreds of million Rand. No single funding scheme can accommodate such a spectrum and hence several different funding and management models are required.

7.1 Foundation Facilities, International Facilities and National Facilities

These categories of infrastructure normally require very high capital investments of a nature that often necessitates long term planning and implementation. Such mega-science (in South African context) initiatives require special motivation to Cabinet for support prior to implementation. Examples are SALT, SKA and NREN; initiatives spearheaded by the DST on an ad hoc basis as and when opportunities or needs arise. Long term, sustained funding of such facilities for management, maintenance, etc., is normally by way of special grants from the parliamentary science vote, whilst management responsibility is assigned to an agency. National research infrastructure such as research vessels and research bases in Antarctica would also fall under this category. In such instances the DST would need to liase very closely with the responsible line departments concerned.

7.2 Strategy for Well-found Laboratories

The strategy suggested for dealing with well-found laboratories is that institutions take full responsibility for the planning, capital investment, maintenance and upgrading, expansion and management for equipment for well-found laboratories. The decision on what should be placed in a well-found laboratory thus remains an institutional matter. By implication, funding for the well-found laboratory is largely derived from the parliamentary core grant to the two types of institutions under consideration in this strategy:

7.2.1 Science Councils and state owned science based enterprises

These institutions, including National Research Facilities, would normally sustain their fundamental infrastructure from their parliamentary grant, but subsidised by income derived from contract research.

7.2.2 Higher Education Institutions

The same principle applies to higher education institutions which, ideally, should be able to maintain the fundamental research infrastructure of the well-found laboratory from the recently introduced subsidy grants they earn on the basis of teaching inputs for masters and doctoral students, and the research outputs linked to research publications as well as graduated research masters and doctoral students. These subsidies are in turn linked to the three year rolling plans of the institutions which are approved by the Minister of Education on the basis of among others the high level skills requirements of the nation.

Interaction with the higher education sector in preparation of this strategy has shown that the infrastructure of the well-found laboratory is not up to standard and requires a once off injection for refurbishment so that it can be maintained at the required levels under the new funding formula in future.

Such a once off capital injection to upgrade the well-found laboratory is primarily the responsibility of the Department of Education and should be motivated as such by this department to Treasury with the support of the DST. Allocations under such a scheme should be managed by the DoE. Submissions by higher education institutions to access these funds must be aligned to their research and research training strategies as outlined in their respective three year rolling plans, which in turn should be aligned to the National Research and Development Strategy.

7.3 Strategy for World-Class Research Equipment of National, Regional and Institutional Nature

Under these categories all research equipment is included that is not catered for under sections 8.1 and 8.2 above.

It is the intention of this strategy not to deal with this type of equipment on a disciplinary or type basis, but to look at the equipment requirements within the context of research that has been identified as of national, regional or institutional priority and where significant collaboration already takes place or should take place where such collaborative efforts do not exist.

Four strategic areas of research are considered:

- The national science missions based on the geographical advantages for South Africa
- The national science missions based on the knowledge advantage for South Africa
- The national technology missions
- The institutional and regional missions

The strategy for funding world-class research infrastructure to support these missions would be to map the activities of major users of research equipment on the national and local science and technology mission spectrum according to the long range research and equipment plans that will be supplied by research institutions. Future planning can then take place according to these declared interests and applications from these areas can be done to a future capital grant-funding scheme. A preliminary mapping of research on this mission spectrum and collaboration models that exist, or that are planned, is contained in a supporting document to this strategy document: "An analysis of research focus in national and regional research missions and its impact on research equipment in South African research institutions", which is available in a separate document.

For the funding of such equipment it is proposed that a National Key Research and Technology Infrastructure grant fund be established to cover the requirements for world-class equipment in the National/Regional and Institutional Centre categories. Such grants should be disbursed on a competitive basis, taking priorities in support of *national, regional and institutional missions* into account. Funds for this purpose should be made available from the DST in line with the status of the national missions as determined by the National Research and Development Strategy priorities. In this context it needs to be emphasised that such a National Key Research and Technology Infrastructure grant fund will also be available for world-class equipment needs that can normally not be covered fully from grants made available directly from mission driven strategies such as e.g. the Biotechnology Strategy and the DST/NRF Centres of Excellence.

For these categories of equipment, funding should be available for:

- Recurrent funding required for sustainability
    - Salaries
    - Maintenance and repair
- Remedial funding requirements
    - Funding required for upgrades
    - Funding required for replacement
- Funding required for expansion (new acquisitions)

7.3.1 Recurrent funding required for sustainability

Research equipment funding will have to be planned over the entire life cycle of the equipment. Before any grant funding is made available for the acquisition of new equipment, such a life cycle plan needs to be prepared. This life-cycle plan should include:

- Human resource costs (salaries)
- Maintenance costs
- Expected upgrade schedules and costs
- An exit or replacement strategy for the equipment

Salaries - The human resources and skills levels required to operate and maintain the equipment, should it require specialised input, should be included in the costing. The main costs are salaries and overheads over the full life cycle of the research equipment. The host institution should commit to provide some funds for salary and overhead costs to ensure sustainability of human resource support.

Maintenance and repair - The maintenance contracts that are offered by suppliers at purchase, or that are purchased separately to the acquisition cost, as well as any maintenance budgets required for a scheduled maintenance cycle should be calculated and declared. Maintenance budgets should include provisions for repair. The institution where the equipment is hosted should commit for some maintenance support.

7.3.2 Remedial funding requirements

Remedial funding includes costs of upgrades, and cost for replacement of defunct equipment with newer equipment.

Funding required for upgrades - Upgrades include any new addition of a component of research equipment or new equipment to a research facility to improve the research infrastructure. Upgrades of world-class equipment should be proposed in a competitive grant-making environment. The need for upgrades should be reflected in the long-range research and research equipment strategic plans of the institutions. A separate grant should be available for upgrades.

Funding required for replacement - Replacement is understood to include the full replacement of an item of research equipment with a newer, often more advanced model. The need for replacement must be reflected in the institutional research and research equipment strategy and be visible to the funding authorities over at least a period of three years. Not all equipment that exists will be replaced. It may also be that equipment that is bought as part of a grant-funding scheme for world-class equipment in a specific national or regional mission may not be replaced after it has served its goal. The need for replacement should as far as possible be made clear when that equipment is motivated for the first time. Such equipment may be replaced under the well-found laboratory scheme, should the institution require continuing research that may have moved out of the domain of one of the

missions with time. The institution will then be responsible for funding the replacement of such equipment.

7.3.3 Funding required for expansion (new acquisitions)

New acquisitions refer to equipment that is totally new to the field of research or to the research community on a national basis. This type of equipment does not represent a replacement of any existing research equipment. Research equipment that is funded under this grant type will be required because of new research directions or new technology or techniques that develop in a specific research field. Although requests for new equipment will normally be on an open call for proposals, the need may arise from time to time for directed calls, i.e. where the research community is not responsive to development needs and priorities of the nation.

7.3.4 The placement of new specialised equipment

The placement of new specialised equipment often also requires specialised environments that are capital expensive. Examples include very specialised sample preparation facilities and ultra-clean environments for sample preparation and homing of the equipment. Such special needs must be disclosed and vested fully in applications.

7.4 Placement

Consideration for the placement of equipment of the regional or national category depends on various considerations. In principle, though, equipment of this nature can be hosted by higher education institutions, Science Councils, National Facilities or other government owned research laboratories such as e.g. NECSA. Placement considerations include whether the institution is actively pursuing research in a priority area, either on its own or in collaboration with researchers from other institutions and has taken the initiative, what financial contribution is it prepared to make, support from other potential users, guaranteed accessibility to users from other institutions, maintenance support infrastructure, etc.

Under certain circumstances, e.g. where several institutions have an equal claim to access of equipment, consideration can be given to placement in a neutral environment that can provide a service to all.

Wherever equipment of this nature is placed, the host institution and the granting agency will be required to sign a memorandum of agreement in which the conditions for placement are clearly outlined. Such an agreement needs to spell out the details of the respective contributions to the capital investment, salaries for support staff, maintenance costs, running expenses, access by and

costs to other researchers, duration of support by the granting agency, and the host institution respectively.

7.5 Funding and different granting categories for world-class equipment

Three different granting categories are envisaged on the basis of the above expenditure scenarios, viz.:

- Competitive funding for new acquisitions
- Competitive funding for the upgrade and the replacement of existing equipment.
- Annual grants to cater for salaries, running and maintenance for the duration of the life cycle of the equipment as negotiated in the memorandum of understanding referred to in 8.4.

The resources for funding for these categories of equipment should primarily be from new monetary sources allocated to the DST in accordance with the provision of the National R&D Strategy. Other sources of funding could come from other government departments that make provision for research and development in support of their own respective missions.

7.6 Funding the Mobility of Researchers

Some measure of assurance of access to multi-user equipment from researchers outside the host-institutions will have to be provided. The establishment of user-committees, which includes outside users, as part of the governance of such equipment can achieve this. In all instances, though, priority for access to equipment should be given to local researchers or foreign collaborators working on the creation of new knowledge or the development of new technologies with public good resources.

A grant fund needs to be made available to fund the mobility of researchers to use equipment not available in their own institutions. Such a fund should allow for travel and accommodation only, but could include under special circumstances also some of the fees charged for the use of the equipment. Such fees should normally be paid for from an existing research grant. The mobility grant fund will support the sharing models such as regional or national collaboration models and visits to national facilities. It will also support researchers to use equipment that is not available in South Africa by travelling to laboratories abroad to learn how to use equipment of to use equipment that is not available in South Africa.

7.7 Issues of Principle: A Summary

Several principles are addressed in this chapter that need to be highlighted:

- A three pronged approach in addressing the strategy
  - Responsibility for the well-found laboratory vested in the institutions concerned and to be funded form the parliamentary core grants and government allocations to SETIs and higher education institutions respectively.
  - A competitive grant funding for world class research equipment of the institutional, regional and national categories within the framework of priorities linked to the National R&D Strategy.
  - Ad hoc interventions that have a large and radical impact on the research environment and require separate Cabinet approval.
- Optimal utilisation of world-class research equipment needs to be underpinned by well-found laboratories of high quality infrastructure.
- Provision of support for the life cycle of world class equipment
- Shared funding by host institution and granting agency for capital, maintenance and running expenses to be formalised by way of memorandum of agreement.
- Support to be provided by the granting agency to multi-user equipment only
- Access of users outside the host institution to be guaranteed

7.8 Conclusions

New money will have to be added to existing budgets in government such as the Science Vote and the Education Vote to support the establishment of a well-functioning and effective research infrastructure. As this strategy is fully aligned with the National Research and Development Strategy, additional funding from National Treasury needs to be solicited in order to create the research and technology infrastructure required to achieve the objectives of this national strategy.

Additional funding needs to be available for:

- The well-found laboratories, particularly in higher education from the Education Vote
- World-class Research Equipment and Infrastructure from the Science Vote
- Funding the Mobility of Researchers also from the Science Vote

8 Funding required to support the strategy

8.1 Capital Grant Funding

Many estimates have been made in the past to determine the exact amount of funding required to place the South African research infrastructure on par with other countries or to make the country competitive on a global scale. Often the replacement value of the installed base is taken as a point of departure. It is not necessarily taken for granted that the whole stock of equipment in the country needs to be replaced.

The exact need for research equipment funding will become available as the proper long range strategic research and capital plans evolve in the institutions and the collaborative research groups that want to be considered for research equipment funding. These long range plans are by virtue of this strategy a precondition to obtain grant funds for research equipment.

Important pointers in setting a target for a National Key Research and Technology Infrastructure Strategy Programme and grant funding of such a programme are:

- The state of the well-found laboratories in the country
- The global competitiveness of the installed base (only about 10% according to the National Research and Technology Audit)
- The overall size of the budget to support the National Research and Development Strategy
- The size of the research block grant in the new funding formula for higher education
- The amount of new funding that could be made available by National Treasury
- Research budgets in all research supporting government departments
- The scenario adopted in this strategy
- The placement of equipment categories for collaboration suggested by this strategy
- The phasing of the grant scheme as suggested by this strategy

The value of the installed base according to the National Research and Technology Audit (adapted for 2003 values) is approximately R 3.5 billion. Approximately another R 180 million has been purchased since the audit (according to a survey of research equipment purchased since the National Research and Technology Audit for equipment with replacement value larger than R 500 000). This brings the total installed base *replacement value* to about R 3.7 billion. Given the state of the infrastructure it is assumed that most of these more recent purchases are in all likelihood replacements, and hence a replacement amount of R3.5 billion can be assumed as being reasonably representative of the

installed base, both for the well-found laboratory and for world-class equipment. From this the large equipment vested in National Facilities needs to be subtracted as large equipment in such facilities is negotiated and motivated on an ad hoc basis and normally funded from a once off special grant from government, as well as equipment located in government departments, as these are not funded from an equipment grant scheme.

The audit also conducted a survey of replacement needs and concluded from such a survey that R736 million was required at the time over a five year period for replacement and upgrade of the world class equipment infrastructure, i.e. about R145 million per annum. This figure, adjusted for inflation at about 6 % per annum translates to about R230 million per annum in today's terms. If such an amount is required annually to replace the world-class equipment infrastructure every ten years (i.e. ~R2.3 billion), then it follows from the value of the installed base of R3.5 billion, that the ratio world-class equipment to well-found laboratory is in the order of 2:1, and the infrastructure to consist of R2.4 billion worth of world-class equipment and about R1.2 millions worth of equipment of the well-found laboratory type.

It is nigh impossible to assess the split in well-found laboratory infrastructure between science councils and higher education. On the basis of equipment items in the Research and Technology Audit it is about 1:1, and on the basis of replacement value in this audit it would be closer to 3:1 (See section 3.2 above). Indications are therefore that for the upgrade in the well-found laboratory in higher education an amount of between R400 million and R600 million is required. It is therefore proposed that the Department of Education, supported by the Department of Science and Technology, makes a submission to Treasury for a special, earmarked allocation of R200 million per year over three years specifically for the refurbishment of the well-found laboratory in higher education institutions. Allocation of these funds should be in accordance with the proposal in section 8.2.2 above.

The annually estimated amount required from government through a dedicated equipment grant scheme for the replacement of world-class equipment and the acquisition of new equipment can however be reduced from the figure of R230 million referred to above, based on the following considerations:

- New funding strategies such as the Biotechnology Strategy, Innovation Fund, THRIP, Centres of Excellence etc. do make provision for the acquisition of some world-class equipment, albeit not of the more expensive type.
- Donors, such as the private sector, NGOs, trusts and such like, will continue to support the acquisition of expensive research equipment, particularly in the higher education sector.
- Technology advances not only make more and more equipment accessible electronically which obviates the necessity of the physical proximity of the equipment to the researcher, but also

improve the capabilities of the equipment in terms of automation and throughput, so that fewer items of equipment can produce the same or even more volume of results (see also 6.1).

- That institutions will be encouraged to co-invest in this type of equipment from own resources, as in the past.
- The rationalisation in higher education from 36 to 22 independent institutions and the focus on research intensive institutions will create economies of scale and also reduce the demand for duplicating certain types of equipment.
- An increased, dedicated mobility grant to facilitate access to research equipment will ensure that the equipment infrastructure is utilised optimally.

On the basis of these considerations it is considered that an annual equipment grant from government for the replacement of existing world-class equipment and the acquisition of new world-class equipment should initially be in the order of R100 million per annum. Adjustments to this amount may be necessitated as long range institutional equipment plans emerge in accordance with the recommendations under section 8.3.

8.2 Recurrent Grant Funding for Sustainability

As considered in Section 8.3.1 above, funds will have to be set aside to cover the grant-scheme contribution to recurrent expenses for sustainability. A rough guideline amount for salaries of technical support staff, maintenance and other direct costs to ensure sustained operations is considered to be 10% of purchase price of the equipment, i.e. R10 million for every R100 million spent to purchase new world-class equipment. This amount will therefore grow annually by R10 million to a maximum of R100 million as the equipment infrastructure is renewed over a 10 year period. This is based on the assumption that the world-class equipment has an expected life-span of ten years.

8.3 Mobility Grant Fund

It is recommended that a mobility grant fund be introduced at an initial level of R 2 million per annum. As the collaborative environments grow and as the equipment base undergoes renewal, it is expected that demand for access to such equipment will grow. It is therefore proposed that the mobility grant increases to about R5 million in year 10.

8.4 Conclusion

On the basis of the above reasoning it is proposed that two equipment funds be established, viz.:

- A renewal fund for the well-found laboratory in higher education. This, a once off allocation to the Department of Education of R200 million per year for three years, should be accessible to higher education institutions by way of a well motivated application on the basis of
  - their research and research training (masters and doctoral) strategy as contained in their respective three year rolling plans and
  - national and or regional and or institutional research and development priorities.

  After year three the well-found laboratory infrastructure should be maintained from the research subsidy to higher education.
- A National Key Research and Technology Infrastructure Programme replacement and renewal of world-class research equipment in higher education and science councils. Such a programme is to be introduced by the Department of Science and Technology in line with the proposals contained in the National R&D Strategy with new funds negotiated for this purpose from Treasury. This programme should make provision for
  - Capital expenditure for equipment of R100 million annually
  - Recurrent funds in support of sustainability (maintenance and upgrades) of the equipment, at 10 % of the investment in capital
  - Mobility grants to enhance access to the equipment of R2 million and growing to R5 million

The equipment grant scheme should therefore grow ideally from R112 million in year one to R205 million in year ten and stabilise thereafter. It needs to be noted that these are not adjusted for inflation and exchange rate related fluctuations.

Very expensive facilities such as are normally found in National Facilities, foundation facilities such as the proposed NREN, international facilities such as SKA and SALT are not funded as part of such an equipment grant scheme, but are normally planned and motivated for separately. Facilities of this nature normally require sanction by Cabinet and a special allocation from the parliamentary science vote.

9 Management of the Key Research and Technology Infrastructure Funding

9.1 Promotion of the Key Research and Technology Infrastructure Strategy

It is recommended that this strategy becomes the responsibility of the Department of Science and Technology as a supportive strategy to the National Research and Development Strategy. In accordance with this Cabinet approved National Research and Development Strategy the Department has a responsibility in developing a coordinated national R&D policy and to fund research infrastructure. A model should be found to make stable funding for research equipment available on the long term along with the long term strategies that will be required from the research institutions and not to subject this funding to short term financial planning and political fluctuation.

The Departments of Education, of Science and Technology and of Labour, together with the higher education sector play the major roles in the development of high level human resources. Without a solid base in human resources, the operation of an equipment infrastructure will not be achieved. The fundamental building block for research infrastructure is the well-found laboratory. This is the responsibility of the institutions themselves that conduct research, whether that research is used for knowledge generation, human resource development or profit purposes. This strategic component of the research infrastructure plays a major role in the teaching and training and knowledge proliferation environments, and a supportive role in the targeted research and market driven research.

Many government departments fund research in support of their own respective mission. This research needs to be supported by a proper research infrastructure. The Department of Science and Technology, through the White Paper on Science and Technology and the subsequent National Research and Development Strategy positions itself to assume responsibility to coordinate research and development on a government-wide basis. Hence, it also has a central role in ensuring that a top class research infrastructure is in place in order to meet the goals and objectives of government as such. This role has been defined as such in the integrated economic cluster. Together, these departments of in the integrated economic cluster are responsible for stimulating economic growth at a national level. An appropriate world-class research infrastructure therefore needs to be in place for the research sponsored by these departments in support of their missions.

9.2 Appointment of a National Management Agency

The management and granting function a National Key Research and Technology Infrastructure Programme should be the responsibility of a national management agency, reporting to the Department of Science and Technology in its coordinating capacity.

It is recommended that the Department of Science and Technology appoints the most appropriate existing national agency to manage the planning and granting environment for world-class research equipment in a dedicated and well-staffed National Key Research and Technology Infrastructure Programme. The National Research Foundation is suggested as the agency that should be tasked with this responsibility. The function of such a National Key Research and Technology Infrastructure Programme will be the following:

- Apply this strategy to create a healthy research and technology infrastructure environment in the research community in the country.
- Improve on this strategy on a regular basis, taking changing circumstances into account.
- Assist the stakeholders to make the right interpretations of the strategic options (well-found and world-class research infrastructure).
- Assist the stakeholders in research equipment to develop long range strategies for research and research equipment.
- Assist stakeholders to do proper economic and costing plans to support research equipment acquisitions and management.
- Develop conditions of grant according to the grant schemes put forward by this strategy. These conditions of grant should address the nature, quality and standing of researchers that are entrusted with substantial equipment and supportive grants.
- Call for proposals according to this strategy and the conditions of grant for research equipment funding on an annual basis.
- Manage the evaluation of proposals according to criteria that are generated from this strategy and the grant-making environment.
- Continuously evaluate the effectivity of equipment acquisitions and placement.
- Report regularly to the Board of the NRF, the Department of Science and Technology and other stakeholders.
- Expand the funding stakeholders to include other government departments and the private sector.
- Market the National Key Research and Technology Infrastructure Strategy Programme and raise funds to supplement the grant moneys received from the DST.

9.3 Management Funding

It is recommended that operating funds be made available at 2% of the total grant amount per annum, with escalation for inflation, to staff and to run the National Research and Technology Infrastructure Programme. This amount should be negotiable along with possible future new demands that may develop. The grant and management funds should be ring-fenced within the NRF.

10 Key Recommendations of the Strategy

It is recommended that a ***National Key Research and Technology Infrastructure Programme*** be established. This programme should be supported through a ***National Key Research and Technology Infrastructure Grant Fund***.

10.1 Vision

The vision of the National Key Research and Technology Infrastructure Programme should be:

Equipping South African science and technology for local relevance and global competitiveness

10.2 Mission

The mission of the National Key Research and Technology Infrastructure Programme should include:

To provide an effective planning, funding and management system for a research infrastructure in South Africa to:

- Ensure the remediation of the current state of research infrastructure in the country
- Make the research base more internationally competitive through a dual strategy of refurbishing the well-found laboratories and the renewal of the world-class research infrastructure
- Provide adequate and sustained capital funding for remedial (upgrading and replacement), new extensions in science and technology for research equipment and facilities.
- Involve research institutions in long range planning of their own research environments and how to equip these with appropriate research infrastructure and to focus on research infrastructure for a purpose.
- Support the attainment of national science and technology missions as defined by the National Research and Development Strategy
- Support institutional and regional missions inasmuch as these are aligned with more local and regional needs and priorities
- Support economic growth and the provision of quality of life and well-being of all citizens in South Africa

- Make the South African research environment attractive to researchers from the continent and beyond.

10.3 Recommendations on objectives

The key recommendations are made at the hand of the strategic objectives.

10.3.1 Prioritising types of research equipment and the purpose of such equipment

Objective: The type of equipment in terms of use and the focus of research requiring such equipment should be addressed and possible paths of arriving at a desired research infrastructure base should be provided. From such an analysis the priorities for establishing a research equipment and infrastructure base for the country should be derived.

Recommendations:

- Research equipment to be classified into two categories on the basis of where it is placed and how it is funded and managed, viz.: ***well-found laboratories*** and ***world-class infrastructure***.
- Research equipment to be placed and utilised for ***globally competitive research*** in addressing ***national*** and ***local priorities***, in accordance with the National R&D Strategy and emerging regional and local needs.

10.3.2 Differentiating Categories of Research Equipment

Objective: Research equipment covers a broad spectrum from small items of a few hundred Rand to tens and even hundred of millions of Rand. It is therefore necessary to classify research equipment into different categories for the purpose of ownership, management, funding and collaborative usage.

Recommendations:

It is recommended that the following categories of equipment be distinguished::

- **Institution based: Departmental -** The type of equipment normally part of a well found laboratory. It is used by one or several researchers and students within the department and funded by the institution and or the researcher from his/her research grant.
- **Institution based: Centres -** Part of the institutional research infrastructure utilised by researchers from several disciplines and departments

- **National and Regional Equipment -** This includes expensive research equipment which is normally beyond the means of a single or cluster of institutions. Depending on needs, equipment of this nature may be placed in several regions to serve the needs of researchers within the region, or where only one piece is available in the country to serve the needs of researchers in the country.
- **National Research Facilities -** Includes research facilities which normally require a high capital investment and a substantial annual budget of several tens of millions of Rand to manage and maintain. Facilities of this nature are structured around unique research equipment or collections. Two types of national research facilities can be distinguished, viz.:
  - Declared National Research Facilities, are those that are managed by the NRF with the aid of an entrenched budget earmarked for such facilities.
  - Facilities hosted by other institutions, such as the National Laser Centre, the Satellite Applications Centre, and the SAFARI nuclear reactor.
- **International Facilities -** Mega-science facilities located in South Africa by virtue of e.g. geographical advantage in which South Africa has acquired a share on behalf of local users.
- **Foundation Facilities -** Foundation facilities are those which constitute the backbone of the research infrastructure and without which all or most of the other categories of the research equipment can not function optimally.

This strategy focuses on the type of multi-user equipment infrastructure that is placed within existing research institution on a competitive basis, i.e. the Institutional Centre, Regional and National equipment categories. Departmental research which relies primarily on the well-found laboratory is not covered under this research equipment strategy, since it relies on the basic unit of research equipment which should remain the sole responsibility of the institution. The establishment of National Facilities, Foundation Infrastructure and International Facilities are also beyond the scope of this strategy.

10.3.3 Creating a long range planning culture around research equipment

Objective: It is evident that very few institutions have long range research plans that include research equipment. The establishment of such a planning culture will assist greatly in assessing future equipment requirement scenarios for the country.

Recommendations:

- A prerequisite for being considered for any equipment grant will be a well-developed long-range (5 years minimum) research strategy with emphasis on the equipment requirements of such a strategy
- The capitalisation programme should contain a complete life cycle costing model for research equipment.
- Such a life cycle costing model should point out the responsibility the institution holds for staffing, maintaining, repairing, upgrading and replacing the equipment.
- It should also contain an exit strategy, should the institution wish to replace the equipment at the end of its life cycle or, in case of the research cycle where the equipment will no longer be utilised. A plan should be presented on what to do with such equipment, should it still be in an utilisable state (resell, donate, transfer), or at the end of its life time (write off and dissemble).

10.3.4 Assigning responsibility for the funding and management of research equipment

Objective: To differentiate between the well-found laboratory and world-class equipment and the responsibility of funding and managing these.

Recommendations:

- The funding of ***well-found laboratories*** will be the responsibility of the institution that requires a proper basic infrastructure to sustain research. It thus remains an internal institutional priority. It has to be recognised that an initial injection of funding over and above the current institutional budgets of higher education will be required from the Department of Education to strengthen the status of well-found laboratories in the country. Institutions will be fully responsible for the planning, funding and management of well-found laboratories from their respective primary income streams.
- It is recommended that a Key National Research and Technology Infrastructure Grant Fund be made available to cover the requirements for ***world-class equipment***. Equipment in support of a national mission, as well as regional and institutional priorities should be funded from a grant that should be made available to the institutions on a competitive basis, with capital channelled through DST in line with the provisions for equipment renewal of the National Research and Development Strategy
- It is recommended that a National Research and Technology Infrastructure Grant Fund funds capital equipment where possible on a shared basis. Other funding can be contributions from the host institutions own funds, an industrial partner or equipment contribution from dedicated mission driven budgets such as for CoE, Biotechnology etc. Host institutions will take full

responsibility of staffing, maintaining, repairing and replacing (in some cases) the equipment purchased under the National Key Research and Technology Infrastructure Grant Fund. The Fund will however consider an annual contribution to assist Institutions to fulfil their obligations as custodians of a national equipment asset in this regard. The relationship between the National Key Research and Technology Infrastructure Grant Fund and the host institution in terms of funding, both capital and recurrent will be formalised by way of an agreement.

10.3.5 Establishing guidelines for economic models required to sustain the institutional research infrastructure

Objective: To encourage research institutions to employ economic models in support the long-term sustainability of their research equipment infrastructure base. Such models need to be based on depreciation or replacement funds, sustainability funding and whole life-cycle costing.

Recommendations:

- A policy be adopted by institutions on the depreciation of capital equipment in order to generate a replacement/maintenance/repair fund. Such an institutional fund should make provision for the depreciation of the institutions contribution to the equipment concerned where such equipment is collaboratively placed from different sources. This will ensure the institutions competitive edge to bid for the placement/replacement of world-class equipment in future.
- This replacement fund policy be implemented and a discipline be enforced to build such a replacement/maintenance/repair fund.
- Such funding be obtained from reserving a portion of the research budget of the institution.
- A pricing policy be developed where service work for stakeholders and shareholders is conducted to recover some of the investment and running cost of research equipment.
- Costing and pricing policies must stipulate that the full cost of conducting the work must be determined as accurately as possible, and include both direct and indirect costs.
- Direct costs include (in addition to salary and operating costs) all direct materials and charges for use of research equipment. Indirect costs cover institutional overheads (Corporate and Divisional).
- Proper planning in terms of supporting infrastructure and facilities and services needs to be in place. A clear plan for where research infrastructure will be housed and supported needs to be provided.

10.3.6 Introducing proper quality management of research equipment

Objective: The employment of formal quality measurement and management process such as proper research management, intellectual property management, sustainability planning and financial planning.

Recommendations:

- Institutions that apply for capital grant funding to purchase research equipment should have formalised research offices, intellectual property management processes, financial planning and quality management in place.
- The development of a metric for return on investment for capital equipment, based on recognised research outputs such as research publications, and numbers of masters' students and doctoral students. These outputs should be calculated per equipment unit and the productivity of such equipment should thus be expressed. Measures on the productivity of the environments will have a positive impact on the potential to attract research equipment funding in subsequent applications.
- A defined quality management process will be a prerequisite for consideration for funding under the National Key Research and Technology Infrastructure Programme and be reflected in well-developed business plans to be submitted in the application process for research equipment.
- The creation of user-committees to assist host-institutions in the governance of world-class, multi-user equipment is essential.

10.3.7 Identifying appropriate funding categories for research equipment

Objective: To provide for different grant categories to ensure a sustained high quality equipment infrastructure of the country.

Recommendations: The introduction of the following grant categories

- A renewal fund for the well-found laboratory in higher education. This, a once off allocation to the Department of Education of R200 million per year for three years, should be accessible to higher education institutions by way of a well motivated application on the basis of
  - their research and research training (masters and doctoral) strategy as contained in their respective three year rolling plans and
  - national and or regional and or institutional research and development priorities.
- A competitive National Key Research and Technology Infrastructure Grant Fund for the replacement and renewal of world-class research equipment under the categories Institutional

Centre, National and Regional Equipment in higher education and science councils. Such a grant scheme is to be introduced by the Department of Science and Technology in line with the proposals contained in the National R&D Strategy with new funds negotiated for this purpose from Treasury. This fund should make provision for

- Capital expenditure for equipment of R100 million annually
- Recurrent funds in support of sustainability of the equipment, growing from R10 million in year one to a maximum of R100 million in year 10
- Mobility grants to enhance access to the equipment of R2 million and growing to R5 million.

The National Key Research and Technology Infrastructure Grant Fund should therefore grow from R112 million in year one to R205 million in year ten and stabilise thereafter. Provision needs to be made to adjust these figures for inflation and exchange rate fluctuations from time to time.

The capital component of the scheme should make provision for a Remedial Grant Fund for replacements and upgrades, and for New Interventions to equip the science and technology missions.

10.3.8 Ensuring optimal use of world-class research equipment in a sustained manner

Objective: To ensure that world-class equipment is maintained and supported by a knowledge pool in order to optimise its usage. Research equipment cannot be operated and used by researchers who are not properly trained to optimise the use of the equipment. It is not only the ability to operate the equipment that is important, but also the ability to interpret the research results and to maximise the use of the equipment.

Recommendations:

- Research equipment should only be placed where demonstrated capacity exists in the human resource and skills base.
- The record of accomplishment of the researcher or the research team associated with the equipment is thus important, with specific reference to productivity as measured by the quality management programme on research equipment utilisation.
- That host institutions take up the responsibility for the training of researchers to use the equipment
- That training of operators, maintenance technicians and researchers by manufacturers and suppliers is negotiated as part of the purchase of the equipment. Proof of such training being organised will be a prerequisite for grant application.
- That the appropriate SETA be approached for funding to train operators and post-graduate students in the use of large and expensive research equipment

- That the equipment grant scheme make provision, by way of an annual grant for the duration of the life cycle of the equipment, for the sustained operation of the equipment
- That the respective responsibilities of the host institution and the grant scheme regarding the sustained use for the duration of the life cycle of the equipment be agreed upon by way of a Memorandum of Understanding

10.3.9 Assuring access to research equipment by providing grant funding for mobility of researchers

Objective: Research equipment of an expensive nature cannot be duplicated when utilisation to full capacity cannot be effected. In such cases research equipment will have to be shared over large distances or in central facilities. Researchers should have access to a grant environment where such mobility is supported.

Recommendations:

- That a mobility grant is added to the funding environment of the National Key Research and Technology Infrastructure Programme to cover the costs of researchers travelling and staying over to use research equipment.
- The mobility grant will be primarily for the costs of travel and accommodation. Costs for using the equipment to cover any running expenses should ideally be recovered from the research grant available to the applicant.