White Paper on Science & Technology

Preparing for the 21st Century

Department of Arts, Culture,
Science And Technology
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LETTER FROM MINISTER B.S. NGUBANE

Science and Technology (S&T) are essential components of the government's strategy for creating the South Africa of the future. The importance of S&T is recognised outside government as well, by other political parties, by business, the higher education sector, the science councils, labour, NGOs and civil society.

The vision for South African Science and Technology presented in this White Paper has been developed by a consensus process between all these sectors. This vision is one where, on the one hand, South Africa uses S&T to become economically competitive on a global scale, and on the other hand to provide essential services, infrastructure and effective health care for all South Africans. We believe that this is best done by embedding our S&T strategies within a larger drive towards achieving a winning National System of Innovation. In such a System, institutions such as universities, technikons, science councils, private sector research laboratories and market intelligence divisions would cooperate in a nationally optimal way towards solving real problems, whether these occur in industry, agriculture, defence or basic research.

The changes proposed in this White Paper follow two broad themes. Firstly, they serve the need to promote cohesion between South

African S&T institutions and the programmes they form part of, in the interests of our National System of Innovation. Secondly, they support the creation of a system of output measurements for these institutions, so that the taxpayer can demonstrably be given value for money.

I would like to thank all those who contributed to the production of this White Paper, whether by participating on the task team, by responding to the Green Paper, or by consulting with my Department during the drafting process. We received well over a hundred substantial responses to the Green Paper, and we have taken considerable care in ensuring that the 83 issues raised in the Green Paper are addressed in this White Paper.

Yours sincerely,

B.S. Ngubane

LETTER FROM DEPUTY MINISTER B. MABANDLA

Technology has been a determining factor in human history since time immemorial and in the 21st Century this will be so to an even greater extent. It is imperative that South Africa makes the right choices, sometimes difficult, to enhance our adoption and mastery of the technologies which will assist us in becoming a competitive nation. Basic science also has a crucial role to play in our country, not just because it is the platform on which applied science and technology are based, but because it has cultural and intellectual foundations as profound as those underpinning music, literature and other products of the human mind.

This White Paper endeavours to promote the full spectrum of science and technology within the context of problem solving in service of national needs, currently best expressed by the Growth and Development Strategy (GDS) of the government. To achieve an optimal configuration of science and technology institutions, it is proposed that the Ministers Committee on Science and Technology embarks on a major study of the missions and governance structures of these institutions. Also absolutely essential in the implementation of the GDS are human resources and skills in science and technology. Currently the race and gender disparities in S&T are unacceptably high. We need to address this imbalance pro-actively, not just because it is right to do so, but because if we do not we will simply not have adequate human resources to deal with our problems.

I have every confidence that the White Paper on Science and Technology puts South Africa on a firm course to enable us to make

better use of our national resources and capabilities. This is the first policy document of its kind in the history of our country, and even the processes which led to its completion have served to focus debate on the importance of science, technology and innovation for our future.

Yours sincerely,

Brigitte Mabandla

Preface

My Government's commitment to create a people-centred society of liberty binds us to the pursuit of the goals of freedom from want, freedom from hunger, freedom from deprivation, freedom from ignorance, freedom from suppression and freedom from fear. These freedoms are fundamental to the guarantee of human dignity. They will therefore constitute part of the centrepiece of what the government will seek to achieve.....

President Nelson Mandela in his Inaugural Address to a Joint Sitting of Parliament, 24 May 1994.

South Africa has begun, for the first time in its history, to undertake the task of the equitable development of the life opportunities of all its citizens. It has a unique opportunity at this time to transform the means and the methods [of] through which its social goals are to be achieved.

RDP White Paper, 23 November 1994

PART ONE

CONTEXT AND SUMMARY

CHAPTER 1 The Context

Preamble Vision and Goals for an Innovation Policy for South Africa

The White Paper is based on a view of the future where all South Africans will

- enjoy an improved and sustainable quality of life,
- participate in a competitive economy by means of satisfying employment and
- share in a democratic culture.

In order to attain this vision, the following three goals pertinent to the creative use and efficient management of innovation will have to be achieved :

- The establishment of an efficient, well co-ordinated and integrated system of technological and social innovation within which
- stakeholders can forge collaborative partnerships and interact creatively in order to benefit themselves and the nation at large
- resources from engineering, the natural sciences, the health sciences, the environmental sciences and the human and social sciences are utilised for problem-solving in a multidisciplinary manner
- stakeholders, especially those who were formerly marginalised, are part of a more inclusive and consultative approach to policy decision-making and resource allocation for science and technology (S&T) activities.
- The development of a culture within which the advancement of knowledge is valued as an important component of national development.
- Improved support for all kinds of innovation which is fundamental to sustainable economic growth, employment creation, equity through redress and social development.

The concept of innovation

This White Paper is built upon the twin concepts of "innovation" and a "national system of innovation" (NSI). As an introduction to these concepts, we quote below a series of extracts from a discussion on innovation in the 1994 Report of the Auditor General of Canada, which captures a particular spirit which we would like to see suffuse through the proposed policy:

Innovation has become a crucial survival issue. A society that pursues wellbeing and prosperity for its members can no longer treat it as an option.

Innovation tends not to arise by itself; it is generated and sustained through the efforts of people: innovation is where the spirit is. It cannot be legislated, or brought about by edict. It comes from individuals and from creative and interactive communities. Like happiness, innovation wilts in a climate of criticism and repression yet thrives in an environment of encouragement and support.

Government therefore needs to work hard at creating an environment that is supportive of innovation. Otherwise innovators will either not innovate - they will "play safe" - or they will leave for more encouraging societies.

In an innovative society, individuals, groups, organizations, government and Parliament recognise that they are partners, rather than opponents, controllers or contenders. The ideas of community, networking, collaboration and common purpose

of playfulness, fun and excitement, but also of healthy competition, openness and accountability need to be guiding principles.

An important element of innovation is resolving dilemmas, that is, reconciling apparently competing values. Truly innovative societies can, at the same time, meet real needs and control costs, address individual choices and satisfy societal priorities, considering both economics and compassion.

To survive and prosper, that is, to achieve and maintain a high standard of living for its members, a society must do four things well:

- *First, it must build and sustain social, legal and economic structures and processes that support innovation, that are competitive while sustaining the natural environment, and that lead to wellbeing for the greatest number of people.*
- *Second, it must ensure that its members develop and continually update the knowledge, competencies, abilities and skills that are required to produce innovative products and services.*
- *Third, it must nourish and support the effective potential of its members [and their] commitment to a common purpose, trust, collaboration, enthusiasm, caring and loyalty; this includes defining meaningful roles for those who are outside conventional work structures.*
- *Fourth, it must build and sustain relationships, within itself and with other societies, that enable it to interact productively, both for its own and for mutual benefit; and it must do so with a long-term view, considering spans of generations.*

Furthermore, an innovative society is willing and able to discuss and examine openly all issues, even controversial matters and "sacred cows"; it retains the suppleness to explore and experiment; and it has the wisdom and persistence to pursue selected options in the quest for desirable results. It is able to envision a desired future, examine its possibilities, select preferred results, and pursue its choices vigorously.

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1. **Introduction**

   The development and application of science and technology within a national system of innovation (NSI) in South Africa will be central to the success of the Growth and Development Strategy (GDS) of the Government as it seeks to address the needs of all South Africans. In keeping with a variety of political, constitutional, social and economic changes introduced by the government, the NSI[1] as an enabling framework for science and technology is intended to support the six pillars of the Growth and Development Strategy.

   The stimulation of a national system of innovation will be central to the empowerment of all South Africans as they seek to achieve social, political, economic and environmental goals. The development of

innovative ideas, products, institutional arrangements and processes will enable the country to address more effectively the needs and aspirations of its citizens This is particularly important within the context of the demands of global economic competitiveness, sustainable development and equity considerations related to the legacies of our past. A well-managed and properly functioning national system of innovation will make it possible for all South Africans to enjoy the economic, socio-political and intellectual benefits of science and technology.

2. The Global Context

The setting and realisation of national goals cannot be undertaken without due regard to the implications of global imperatives. Social and economic systems "globalised" by world market forces, the information revolution and new communications technologies require constant innovative planning and monitoring in order to function optimally in the interests of their constituencies. The political transition in South Africa has projected us into the global arena, exposing us to pressures and challenges that require innovative and flexible responses to a rapidly changing global environment. The major challenge will be to integrate successfully into global systems and communities while addressing the local needs and aspirations of South Africans.

Some of the dominant trends and developments at a global level that will affect planning and resource allocation in South Africa are:

The knowledge-based transformation of many of the world's societies as a result of the increased flow of information made possible by ever-improving global communications technologies. The world is in the throes of a revolution which will change forever the way we live, work, play, organise our societies and ultimately define ourselves. Unlike previous revolutions which were focused on energy and matter, this fundamental change involves our experience of time, space, distance and knowledge. Although the nature of this information revolution is still being determined, its implications, which are global and inescapable, are being felt with increasing force. In the world-wide race for competitiveness the finishing line keeps moving away. The ability to maximise the use of information is now considered to be the single most important factor in deciding the competitiveness of countries as well as their ability to empower their citizens through enhanced access to information.

The competitive pressures on the South African economy as it opens up to global market forces. The opening up of trade opportunities in global markets in general and the requirements of the World Trade Organisation Treaty on Technical Barriers to Trade in particular pose both opportunities and dangers to the developing economy of this country. Identifying niche markets in which international competitiveness can be improved, increasing technology

investment and enhancing productivity become imperative. Policy choices about investing in infrastructure, education and training, and in research and development (R&D) will all have to be located within a framework where there is an appropriate balance between opening up the economy to global competitiveness and nurturing local initiatives. Government will have to play a key role in creating a macro-economic environment within which innovation to support both competitiveness and the quality of life can flourish.

Increased co-ordination of innovation policies and strategies in response to the complex challenges generated by global social and economic changes. A national system of innovation that addresses the needs and aspirations of its citizens, while maintaining a competitive edge, must have a high measure of strategic and creative interaction among its constituent elements. The promotion of a national system of innovation as a framework for social and economic policy maximises the possibilities for all parts of the system to interact with each other to the benefit of individual stakeholders or groupings of stakeholders and the advancement of national goals. For example, the close co-operation between government, industry and research institutions is a prerequisite for projects designed to produce growth and development in accordance with national goals. Increasingly, the co-ordination of innovation strategies and initiatives within a national system of innovation will extend beyond the boundaries of national states as regional imperatives grow stronger. The development of a national system of innovation in South Africa will have to take into account social and economic developments in neighbouring countries with a view to eventually developing a regional system of innovation as a crucial long-term guarantee of regional stability and upliftment.

A problem-solving, multi-disciplinary, partnership approach to innovation as a mechanism of growth and development. Traditional ways of producing knowledge within single disciplines and institutions are being supplemented by knowledge generated within various applied contexts. This is knowledge that is collaboratively created within multidisciplinary and transdisciplinary research programmes directed to specific problems identified within social and economic systems. A national system of innovation benefits from "knowledge practitioners" being located in multiple knowledge generating sites and institutions such as higher education institutions, government and civil society research organisations, and private sector think tanks and laboratories. It is also strengthened by adopting a problem-solving approach that seeks to draw on multiple resources that span the natural sciences, the human sciences, and the medical and health sciences. Setting up a national system of innovation in South Africa that will stimulate such collaborative, multidisciplinary, applications-based research will require new policy, funding and organisational arrangements, including provision for training new generations of scientists and technologists oriented towards the solving of real problems.

3. The White Paper in the Government Context

Science and technology (S&T) are considered to be central to creating wealth and improving the quality of life in contemporary society. To facilitate this function it is accepted that government has a prime responsibility in creating an enabling policy environment in terms of regulatory and funding mechanisms. This White Paper presents government's vision for S&T within the overall framework of the Reconstruction and Development Programme (RDP) , its later and more detailed specification through the Growth and Development Strategy (GDS) and the Macroeconomic Strategy presented by the Ministry of Finance.

The core vision of the White Paper is the conceptualisation of a national system of innovation which seeks to harness the diverse aspects of S&T through the various institutions where they are developed, practised or utilised. No government can order innovation to take place, but government can ensure that a competent pool of expertise from which innovation can spring is grown and maintained. This is where the White Paper strongly addresses one of the pillars of the National Strategic Vision in recognising the need to invest in people at all skill levels. The policy thrusts of this White Paper are in harmony with the White Paper on Education and Training in its identification of investment in mathematics, science and technology as a fundamental goal.

More widely, the White Paper addresses another of the strategic pillars in stressing the role of technology in meeting basic needs as set out in the White Paper on Urban Strategy, and that on Rural Strategy. In essence, this document seeks to highlight the relationships between the different mechanisms of delivery of services to our people, and to outline the way the Department of Art, Culture, Science and Technology (DACST) can play a co-ordinating role in effective and efficient implementation of interventions.

The need for transformation has given rise to a series of policy initiatives which have both explicit and implicit impacts on what this White Paper refers to as "the national system of innovation". Given the many initiatives currently being pursued, there is a clear need for an ongoing "conversation" among those initiatives. Other White Papers with obvious interests in and implications for our national investments in S&T include those on the Small Businesses Support Strategy, Education, and Telecommunications. The lead departments responsible for each of these areas will have to work together closely in the implementation of these policies in order to make the most efficient, effective and economic use of the available resources.

4. Promotion of Technological Change

There is a need to define a sustainable path for South African social and economic development and the relationship between this path and technology investment. In order to do so, we must be aware of relevant global trends. In recent years, industrialised countries have devoted considerable attention to improve their understanding of the economic implications of rapid technological change. Of importance, at the political level, was the Declaration issued at the conclusion of the Organisation for Economic Co-operation and Development (OECD) Ministerial meeting[2] in June of 1990. The assembled Ministers had agreed that technological change was a fundamental source of economic growth in the OECD economies. The acceptance of the contribution of technological change to economic growth underlies the attempts of many industrialised countries to develop policy frameworks for the promotion of innovation as a primary route to drive continuous processes of technical change throughout their economies. This drive to master the effects of technological change has also been the key element of the policies pursued by the newly-industrialising countries of South East Asia. As international trade becomes increasingly free and more globalised, South African firms are going to face mounting competition, both at home and abroad, from firms whose home countries have espoused these new theories. Much work remains to be done in South Africa, however, to make the promotion of technological change a central tenet of national policy.

CHAPTER 2

Requirements underlying South Africa's Science and Technology Policy.

1. Introduction

In this chapter the basic requirements for a S&T policy, which is consistent with a vision of innovation in South Africa, are laid down. This vision embodies a co-ordinated effort to achieve excellence in serving the national goals. It is a broad vision in that it focuses simultaneously on maintaining cutting edge global competitiveness and on addressing the urgent needs of those of our citizens who are less able to assert themselves in the market. These requirements will be treated under the following five broad interrelated themes which are regarded as fundamental to the expression of a sound S&T policy:

- Promoting competitiveness and employment creation
- Enhancing quality of life
- Developing human resources
- Working towards environmental sustainability
- Promoting an information society.

In addition to these crucial areas for government involvement, there are three important dimensions of science and technology which inform our strategies in South Africa :

- The importance of knowledge generation
- The role of the human sciences in innovation
- Finance, management and performance.

2. **Promoting Competitiveness and Employment Creation**

The most important requirements for promoting competitiveness and employment creation are listed below:

In the face of the growing globalisation of the world economy, technological innovation and support for South African enterprises need to be encouraged as central to the above goal. Recognising that business is the driving force behind the economy, government must provide the leadership, incentives and support that the business sector needs to meet the new challenges posed by highly competitive markets. This will involve developing a shared vision of South African innovation.

South Africa's support structure for creating and sustaining micro-enterprises and small businesses will require a strong technology component.

Public investment in R&D needs to be redistributed away from the support of activities within the government's own facilities and towards more comprehensive support of R&D executed in the private sector. Nevertheless, this long-term need must be seen in the light of the government's current responsibilities, namely to take a lead

- in pre-competitive research, until a culture develops in the private sector where such research is seen as a business imperative
- where entry barriers related to equipment and human resources are high
- in areas where the activity is considered to be a service which the government has a duty to provide, and
- in areas of public good in which, to achieve the greatest benefit, the research results and technology transfer need to be placed in the public domain.

A prime objective of the NSI is to enhance the rate and quality of technology transfer and diffusion from the science, engineering and technology (SET) sector by the provision of quality human resources, effective hard technology transfer mechanisms and the creation of more effective and efficient users of technology in the business and governmental sectors.

The development of entrepreneurship needs to be fostered throughout South African society, particularly among those historically excluded from the formal economic sector, and this entrepreneurship needs to be linked to the promotion of innovation.

Government, via the Growth and Development Strategy and the Macroeconomic Strategy, is seeking to achieve an annual economic growth rate of 6%. In a country which is currently underinvesting in S&T and innovation, this target will require a greater than 6% per annum growth rate in the national investment in these activities. In particular, those sectors destined for export growth will not achieve their targets if this investment does not occur.

3. **Enhancing Quality of Life**

The means to ensure that the governmental research portfolio gives due attention to those areas of R&D with the capacity to affect quality of life must be established, and specifically in domains where market failure is high such as the following :

- environmental sustainability
- health care provision
- meeting basic needs at the community level
- reducing the total cost of infrastructure provision
- providing safety and security to all who live and work in South Africa.

The government has a duty to ensure that an appropriate portion of the money it spends on science is utilised in these areas.

Urban and rural communities need to be assisted and encouraged to adopt social and technological innovations to assist them in decision-making and to enhance their ability to make informed choices.

4. **Developing Human Resources**

In step with a dynamic vision for innovation-assisted economic growth, greater equalisation of income and economic opportunities needs to be facilitated and the legacy of apartheid-based disempowerment of individuals and institutions needs to be addressed within a national system of innovation.

The lifelong processes of scientific and technical education, training and learning among the workforce and among South Africans in general need to be promoted as an essential response to the forces created by the dynamic changes of the global economy. This is a necessary response to enable those made redundant in one circumstance by these changes to continue making an active and creative contribution to the economy, their own well-being and that of society.

New approaches to education and training need to be developed that will equip researchers to work more effectively in an innovative society. This will require new curricula and training programmes that are comprehensive, holistic and flexible, rather than narrowly discipline-based. Education and training in an innovative society should not trap people within constraining specialities, but enable them to participate and adopt a problem-solving approach to social and economic issues within and across discipline boundaries.

5. **Working towards Environmental Sustainability**

Growth of the South African economy must be reconciled with considerations of environmental impact, resource constraints and conservation, and must further be determined by human needs and safety.

Sound regulatory mechanisms need to be implemented to ensure that the positive aspects of technology introduction, transfer and diffusion are maximised and the negative aspects minimised.

Environmental research, monitoring and control require ongoing support and encouragement, as do the development and improved availability of environmental technologies. Economic and environmental efficiencies are interrelated, thus innovative practice must include environmental management. It is important that South African enterprises are able to adopt and implement best-practice technologies for environmental management and waste minimisation.

A national strategy is required to implement the terms of agreement on environmental sustainability adopted at the United Nations Conference on Environment and Development in Rio de Janeiro in 1994 (Agenda 21), and specifically to develop an understanding of the problems of climatic change, desertification and loss of biodiversity.

6. **Promoting an Information Society**

The development of a South African vision of the information society is urgently required, one serving our own needs rather than echoing those of other nations.

A South African vision of the information society should seek to ensure that the advantages offered by the information revolution reach down to every level of society and achieve as best a balance between individuals and social groups, communities and societies as is practically possible. In developed countries, even where social issues are taken into account, the bias tends toward individual advancement via personal universal access and, at a public level, toward competition between firms and nations. This vision would seek to ensure the creation of an equitable information order nationally, regionally and internationally. It would therefore take into account the undoubted

potential of communities at various levels to co-operate, to bridge differences, to work for mutual upliftment and the meeting of basic needs, and to redress the social imbalances of underdevelopment. The development of such a perspective would aim to ensure that the information revolution benefits society as a whole.

The potential of information technology (IT) needs to be captured to serve people issues such as supporting education, providing household services and enabling social development. As a developing country, South Africa needs to ask certain questions with respect to the information revolution:

- What should we do to prevent being marginalised by the accelerating rate of innovation in information technology in the world?
- How can we participate globally without merely throwing open our markets to foreign products, thus increasing our dependency on the developed world?
- How can we empower ourselves with a capacity for IT innovation?

7. **The Importance of Knowledge Generation**

The well-being of scientific activity in South Africa is intimately linked to material factors. World-wide there is a clear trend for curiosity-driven research to increase as a function of national per capita income. Nevertheless, there is a danger of adopting too economistic a viewpoint. Even at our current stage of development, there is a need to recognise the importance of the knowledge-generating function of research, particularly in the higher education sector. Human wonder and curiosity and the ability to recognise serendipitous discovery account for much of scientific progress. Basic enquiry, as opposed to a formula-driven approach, is absolutely essential, particularly at the universities and technikons, which deal with young minds. It is important that fundamental research activity not be regarded as impractical, because it is the preserver of standards without which, in the long term, the applied sciences will also die.

Scientific endeavour is not purely utilitarian in its objectives and has important associated cultural and social values. It is also important to maintain a basic competence in "flagship" sciences such as physics and astronomy for cultural reasons. Not to offer them would be to take a negative view of our future - the view that we are a second class nation, chained *forever* to the treadmill of feeding and clothing ourselves.

8. **The Role of the Human Sciences in Innovation**

The importance of the human sciences in South African society need to be recognised. Four of its important roles in the context of innovation need to be highlighted:

- in the understanding of social processes and problems and as a source of social innovation
- in facilitating appropriate technological change within society and within the economy
- in providing the basis of policy analysis; and
- as a source of new knowledge and informed critique of the transformation of South African society and its economy.

9. **Finance, Management and Performance**

The limitations imposed on research, technology development and technology transfer by the fiscal problems of the day need to be overcome. This will require a carefully co-ordinated approach, which recognises in general the less wasteful nature of a simpler fiscal policy, while appreciating the absolute necessity of encouraging innovation in the private sector.

Frameworks to promote linkages between universities, science, engineering and technology institutions (SETIs) and the private sector are needed with a view to sharing risks, resources and insights with respect to precompetitive research.

Finally, there is a need to meet the internal challenges of governing a healthy S&T system. This includes managing the problems of big science, fundamental research and service-oriented science and their relationship with technology development, infrastructure, basic needs provision and human resource development. It also includes the comprehensive measurement of the inputs and outputs of S&T research and development, and its impact on the goals of national policy objectives, both in S&T and other fields.

CHAPTER 3

A National System of Innovation for South Africa

1. **Innovation and National Systems of Innovation**

Innovation is the application in practice of creative new ideas, which in many cases involves the introduction of inventions into the marketplace. In contrast, creativity is the generating and articulating of new ideas.

It follows that people can be creative without being innovative. They may have ideas or produce inventions, but may not try to win broad acceptance for them, put them to use, or exploit them by turning their ideas into products and services that other people will buy or use.

Similarly, people can be innovative without being creative. For example, if they apply or implement ideas or inventions that were made elsewhere, they are being innovative, even though the inventions or creative ideas were not their own.

Some innovations are truly revolutionary, while most represent modest improvements in the way we do things. Competitive companies, for example, are continually introducing incremental innovations to improve the products they sell or the processes they use in production. Only rarely will they introduce something radically new into the market place.

The aim of this White Paper is to try to create the conditions that will support both creativity and innovativeness throughout our society. For the purpose of this Paper, such an environment would consist of all individuals and organisations involved in creating and using a knowledge base in order to build a better South Africa and would thus constitute a national system of innovation. Such a system, in its broadest conception, is the means through which a country seeks to create, acquire, diffuse and put into practice new knowledge that will help that country and its people achieve their individual and collective goals.

One submission in response to the Green Paper on Science and Technology[3] cogently argued that

"Science creates conditions for economic and national development, and raises the prestige of a country in the modern world. The most important goal of SET policy is to achieve results which in the near future will support the process of social and economic transformation, and in the long run will ensure economic growth and social development of the country, by making the most of resources set aside for scientific research and development. To reach this goal, it will be essential to link science effectively with other areas of social and economic activity, and with education in particular."

The Green Paper distinguished between a strategy for science and technology and a strategy for strengthening a national system of innovation in the following way:

- *"A national S&T system focuses attention on the outputs of that system; that is new knowledge and new technologies. A strategy for S&T is aimed at ensuring that there is a sufficient supply of these outputs. A strategy based on a national system of innovation includes, but goes beyond that, seeking in addition*

to promote changing the ways in which society and the economy do things. It is specifically concerned with supporting and promoting the attainment of national objectives by the creative use of the outputs of the S&T system".

Thus, a national system of innovation can only be judged as healthy if the knowledge, technologies, products and processes produced by the national system of science, engineering and technology have been converted into increased wealth, by industry and business, and into an improved quality of life for all members of society.

Both the Green Paper and the White Paper are based on the analysis of how well South Africa ensures the fulfilment of six sets of functions of its national system of innovation, the first two sets of which are the exclusive domain of government, while all of the others are the domain of activity of many stakeholders.

The six sets of functions are:

Government functions

- Policy formulation and resource allocation at the national level
- Regulatory policy-making

Shared functions

- Performance-level financing of innovation-related activities
- Performance of innovation-related activities
- Human resource development and capacity building and
- The provision of infrastructure.

The use of the concept of a national system of innovation as a framework for policy is an attempt to signal a radical departure from the current situation and understanding in South Africa, introducing a new view of the role and status of the sciences, engineering and technology in national development. The acceptance by many countries that technological change is the primary source of economic growth means that economic and S&T policies have to recognise as central concerns the two processes - innovation and technology diffusion - which are the agents driving that technological change.

The rate of technological change in a country depends not only on the amount of R&D done in the country, but also on important factors such as the ways in which available resources (including skills) are organised, at both the company and firm level, and the availability of technologies from both domestic and foreign sources. In this context the process of technology diffusion is of cardinal importance. The policies set out in this White Paper see the promotion of the effective distribution of available knowledge as a critical function of a national system of innovation. A well-functioning process of technology

diffusion could boost progress in South Africa through appropriate combinations of domestic and imported technologies, but this in turn will be highly dependent on the ability of South African firms to absorb such technologies.

To summarise, a national system of innovation can be thought of as a set of functioning institutions, organisations and policies which interact constructively in the pursuit of a common set of social and economic goals and objectives.

Government's three key interests, then, can be thought of as being:

- to ensure that South Africa has in place a set of institutions, organisations and policies which give effect to the various functions of a national system of innovation
- to ensure that there is a constructive set of interactions among those institutions, organisations and policies and
- to ensure that there is in place an agreed upon set of goals and objectives which are consonant with an articulated vision of the future which is being sought.

We have adopted the concept of a South African national system of innovation as the basic framework for policy analysis within this White Paper for three principal reasons:

- It affords an opportunity to think of means for the promotion of coherence and integration among national activities, two factors which have been sorely neglected in the South African S&T system of the past.
- It offers a means of identifying what needs to be done without automatically tying the necessary functions to any particular institution or organisation which is currently in place.
- It focuses attention on *innovation* - on doing new things in new ways - rather than simply on the production of knowledge.

In South Africa the Growth and Development Strategy, enunciated in November 1995, provides government's goals and objectives and the Macroeconomic Strategy of June 1996 the associated modalities. This White Paper attempts to ensure that there are in position the institutions, organisations and policies and an environment in which the necessary "constructive interactions" between them can flourish in order to promote the successful implementation of the broader policies referred to.

While much of the emphasis in this White Paper is on technological innovation and on its role in promoting industrial competitiveness, the concept of innovation is a much wider one. At this point in South Africa's history it will be particularly important to recognise the great national need for social innovation, as our country tries to redefine itself and to create a brighter future for all of its citizens. Innovation in

the design of South Africa's social and economic institutions, and in its system of governance, is needed equally as much as innovation in the products and production processes of its economy.

2. Research for Innovation

The White Paper proceeds from the view that innovation is an encompassing notion that is based on the continuous production of new knowledge and its creative applications in a number of spheres. This viewpoint holds that the promotion of research, both applied and basic, in the natural sciences and in the social sciences, is crucial to innovation and hence to both social and economic development.

Applied research

Applied research, particularly in the natural sciences, has time and again proved its worth in ultimately delivering goods, services and conditions which improve the lives of individuals and societies. This is generally accepted despite the unwise choices research has made possible for humanity, particularly during the 20th century.

The provision of clean drinking water, electricity, houses and water-borne sewerage all depend to an extent on ongoing scientific research. Research is also critical for a healthy industrial environment. Here, even if the breakthroughs are not made in South Africa, a research mindset is essential in order to optimise the benefits of technology transfer from abroad.

Basic research

The important role of basic scientific research in knowledge generation and in maintaining educational standards has been mentioned in section 2.7. South Africa has a proud record of quality basic research and it is important to sustain this. In particular, the bridge that such research provides to the international scientific environment must be preserved. It is the quality of our science rather than the number of international agreements we are party to which will ensure this. Therefore our scientists must be given incentives to continue publishing in high impact journals and testing their ideas against international best practice by presenting their ideas in international fora. This tested process of bench-marking against the best in a field is no less important for South African science and technology than it is for our sport.

The skills and respect for rigour learned in service of cutting edge basic research are transferable to almost any environment where high level analytical and problem solving competence is required. It should not be forgotten that the World Wide Web was developed by particle physicists at CERN in Geneva, as a *by-product* of the Nobel prize-winning scientific programmes undertaken there. Similar equally

productive transfers of skills have occurred in the field of financial risk management. The ability to make leaps such as these lies at the heart of an innovative culture and it would be short sighted to underestimate the role of basic research in achieving this culture.

Social Science research

The dramatic political changes in South Africa over the last few years provide a unique opportunity for social renewal in respect of our value systems, the role of the individual in society and with respect to the state. We will need new knowledge to assist us consolidating democracy, the protection of human rights and the accountability of public authorities in South Africa. Ongoing policy research in areas such as health care, education and employment creation, which are central to improving the quality of life of millions of poor South Africans will also require the active and continuing involvement of social scientists. South Africa needs to clarify the relationship between central and provincial levels of government in practice. Resolving the inherent tensions in any such system will require creative thinking about mechanisms and processes for which there are few, if any, existing models. Human and social scientists play a vital role in providing critical analyses of national goals, choices about development policies and strategies, and other national issues pertaining to the transformation of South African society. Their involvement is crucial to a deeper understanding of social issues and to stimulating public debate that could lead to a reconsideration of chosen paths. Equally important to any society that seeks to be innovative in its response to the demands of global change is social research that identifies and explains global trends and their implications in areas of political and economic life, communications and lifestyle changes. Research in the social sciences is therefore of fundamental importance particularly at this point in our history.

Research activity also strengthens the national system of innovation through the general production and transmission of knowledge, and the training of new generations of academics and researchers. Scientists engaging in basic research contribute to the intellectual vibrancy of society as part of a strong R&D base needed not only for understanding and applying new technologies but also for participating in, and in some areas leading, a global scientific community. It is important to assert, in this climate of pressing social and material needs, that research, which generates long term benefits should not be downplayed. The corollary of this is that researchers and research managers need to think very fundamentally about what their aims are and to articulate these clearly to decision makers and to the public at large.

3. Stakeholders in South Africa's National System of Innovation

South Africa's national system of innovation "consists of all individuals and organisations involved in creating and using a knowledge base in order to build a better South Africa". The Green Paper enumerated a wide range of stakeholders - in government, business, education and training institutions, in multipartite bodies and in organised civil society, even including a number of interested outsiders. The principal institutional stakeholders in government and their respective roles are described below.

Central policy departments

The central policy departments are those departments which have a cross-cutting function, that is they are responsible for determining policy across all or many government departments and do not have a specific line management function. The President's Office and the Department of State Expenditure are examples of such departments. Some functions of DACST are also of a central policy nature. In many national systems, such departments play a crucial role in determining policy, establishing priorities and allocating resources from government coffers to the line departments and SETIs (see section 4.1).

Government line departments

The line departments are those government departments which manage a specific portfolio within government, such as the Department of Education and the Department of Defence. These departments do not have a cross-cutting function, but are often subject to policies determined in other departments, such as the Department of Public Service and Administration. Very often, their SET requirements are fulfilled by outsourcing to performers who are better equipped to handle the research. This outsourcing of performance by line departments follows the international trend. The practice of outsourcing is however not followed in cases where government accountability is politically desirable. The crucial requirement of the line department is that they retain the capacity for "intelligent buying" of R&D and SET services.

Agencies

The agencies are those government bodies which are tasked to allocate funds from central government to performers of R&D within all sectors of the economy, and especially within those sectors where government has a line responsibility such as water affairs and national education. There are two types of agencies:

- *General agencies*, whose main function is capacity building and human resources development within the higher education sector (such as the Foundation for Research Development).

- *Specialised domain agencies*, whose task is to fund long-term R&D aimed at knowledge generation (as opposed to short-term contract research) and whose finances are exclusively derived from industry levies (such as the Water Research Commission).

SET institutions (SETIs)

For the purposes of the White Paper, the term SET institutions refers to all the dedicated institutions performing R&D or related scientific activities, including those that are incorporated in the directorates and subdirectorates of a government department where a clear mandate to perform SET is a core function.

SETIs are an important component of the overall R&D framework. They have played a powerful role in enhancing the competitive technological strengths of our industry. They are crucial in generating results that lead to innovation in those areas which are not easily or appropriately undertaken in the private sector, for instance, in the areas of pre-competitive research, support of small, medium and micro enterprises (SMMEs), development of high-risk technology, the provision of a national innovation infrastructure, and the support of innovation in the public sector which leads to improvements in professionalism, efficiency and effectiveness.

State Corporations

State corporations developed as part of a general model of government initiatives for various mission-oriented or policy-related reasons. This was consistent with the post-colonial and international political trends, prevalent in the 1950s to 1970s, of retaining high government involvement in this domain. They are usually constituted by an Act of Parliament and operate as autonomous institutions within their mandates.

There are also many other stakeholders in the NSI such as

Business

Firms, enterprises, industries, the private sector, business of whatever description, there is general agreement that the collective organisations in the private sector are fundamental to the financing and implementation of innovation in society. The prime engine for economic growth is located in a country's firms - a nation's competitiveness depends upon the ability of its firms to innovate, and thereby provide sustainable output and employment growth.

However, innovation is not a trivial process. It is costly, often high risk, and generally operates on a longer time frame in years than the traditional quarterly periods or annual periods over which a company's performance is evaluated. Investors in innovation programmes require

vision, strategic thinking and confidence. Very often they require to be driven by external competitive pressures and threats. Amongst other factors, to innovate successfully often means that a nation must be prepared to probe the unknown and to take calculated risks.

Government has an important role to play in the sharing of this risk and in its attempts to provide an enabling environment for innovation. Mechanisms for this are discussed in section 8.3.

Higher education sector (HES)

The higher education sector is characteristically only a recipient of funds for R&D, with which it is required to provide talented human resources, meet local needs in knowledge generation related to scientific progress, create and sustain centres of excellence in the social and physical sciences and engineering, and participate in consortia and other joint research programmes.

With some notable exceptions, the HES is poorly connected to the business sector and the government SETIs. This Paper proposes mechanisms to improve this linkage (see section 8.3). A further problem is the comparative absence of multi-disciplinary and problem-oriented institutes. Some specific proposals have been made to fund larger scale projects of a multi-disciplinary nature which are intended to address problems of national concern.

Non-government organisations (NGOs)

There are a large number of S&T-oriented NGOs in South Africa, ranging from those performing research (for example S&T policy centres) to those providing scientific services and others involved in education and training. Traditionally, NGOs have been left out of national S&T planning and policy making in South Africa. The introduction of the Innovation Fund, which is intended to reach beyond those institutions eligible for parliamentary funding, will hopefully better enable this group to contribute to the NSI.

These stakeholders all play a variety of roles in the system - they may be policy makers or advisors, financiers, regulators, performers of R&D or other related scientific activities, educators or trainers, or providers of infrastructure. Some will play single roles while others will be engaged in more than one way. Each may be the dominant participant in some sector of economic life. In particular, government recognises that enterprises are the primary sources of industrial innovation while our institutions of higher education are the dominant actors in education and training. Government plays many roles in the national system of innovation, but is the dominant player only in those areas described in the Green Paper as the "core functions" of government, that is in policy setting, resource allocation at the national level, and in legislating regulatory frameworks.

Since the White Paper is a statement of government policy, it can contain only commitments and initiatives on behalf of government. The fact that specific initiatives which should be taken by, for example, enterprises or universities are not mentioned, does not mean that such initiatives would be unimportant - in fact, the opposite is true. The White Paper, however, deals exclusively with policies and initiatives of government.

CHAPTER 4

A Guide to the Initiatives in this White Paper

This chapter deals with the functions of a national system of innovation as listed in Chapter 3 as well as in the Green Paper and discusses initiatives in the areas of:

- Policy Formulation and Resource Allocation
- Regulatory Policy
- Performance-Level Financing
- Performance
- Human Resource Development and Capacity Building
- Science and Technology Infrastructure

These principal policy initiatives are summarised and specific references are made to the location in Part II of this White Paper in which individual initiatives are spelled out in greater detail.

1. **Government Functions**
    1. **Policy Formulation and Resource Allocation**

        Government performs its role in a national system of innovation by means of a set of functions which enables it to influence an environment, within its jurisdiction, in which innovation is being promoted. In the process of consultations leading up to the drafting of this White Paper, there have been many calls upon government to stimulate an enabling environment.

        The tools at a government's disposal are the right

        - to establish laws and regulations
        - to allocate public resources according to a set of priorities which it establishes and
        - to initiate and implement programmes related to these functions (such as the Research and Technology Foresight and Audit exercises).

This White Paper proposes a revamping of the methods used to develop policy options for government's consideration as they relate to innovation in general and to SET activities in particular. To this end the role of the Department of Arts, Culture, Science and Technology (DACST), as the central policy formulating and co-ordinating body within government, is articulated in the next chapter (section 5.1.1). A major investigation of the governance of science, engineering and technology performing institutions is proposed under the auspices of the Ministers Committee on Science and Technology (section 5.1.1) and a new policy advisory body, the National Advisory Council on Innovation, is to be created by legislation (section 5.1.2). All line departments will be encouraged to submit proposals for the new council to investigate.

In order to arrange for the co-ordinated implementation of policies relating to innovation, and in particular to the government's own role in R&D and in the provision of scientific services, a new management and budgetary system for all SETIs will be introduced (section 8.1.1). This system will incorporate a regular process of external review of all government SETIs (section 8.1.3).

Since government spending plays an important role in the functioning of a national system of innovation, a new Science Budget, displaying all S&T spending by government SETIs, will be developed in order to permit Ministers to better assess relative priorities, on a multi-year basis, across the full spectrum of government's activities in support of innovation (section 5.4.1).

To make the national system of innovation a reality, the promotion of innovation, and the support for SETI activities in general, will need to permeate the actions of all parts of government. It will be a responsibility of DACST to promote such an integration of innovation-oriented thinking throughout government. This paper looks at practical means of having DACST interact with other departments, for example, with Trade and Industry and with Education, on S&T issues raised in the Green Paper (section 5.3.2). Equally, the national innovation policy must be carefully articulated with other overriding policies of government, such as the Growth and Development and Macroeconomic Strategies (section 5.3.1).

A national system of innovation needs to have a means of assessing the likely directions of technological

change and of assessing its own capacity to respond. In South Africa government will avail itself of the outputs of the Research and Technology Audit and the Research and Technology Foresight projects (already under way) in a timely and effective manner (sections 5.2.1 and 5.2.2).

Some of the most significant, pervasive and profound technological changes taking place in the world today are those which spring from the rapid development of information technologies. These technologies have literally the potential to affect every facet of life - in effect they are already able to affect every facet of government. However, the ability of government in South Africa to respond to the opportunities and challenges presented is currently hampered by the lack of a national policy. Government has decided that it will set in motion extensive consultations on the impact of information technologies on South Africa's economy and society by means of a Green Paper, which will subsequently lead to the development of a government policy and the publication of a White Paper on the Information Society (section 5.2.1).

2. **Regulatory Policy**

   Government will move to ensure that its regulatory system, as it deals with South Africa's intellectual property regime (section 6.1), is fully aligned with international practice, in order to assist firms and individuals in the global market place. It will also initiate consideration of the adequacy of existing legislation to ensure the protection of health, safety and the environment (section 6.2).

2. **Shared Functions**

The matters discussed above represent the core functions of a government in a national system of innovation; they are functions about which government alone is empowered to take final decisions. All of the other crucial functions of a national system of innovation are shared, often among many stakeholders, and stakeholders may act either alone or in many different combinations. In fact, one of the most important features of a system of innovation is that the participants should interact positively and creatively.

In what follows, the White Paper concentrates on government's intentions with respect to its participation in these "shared functions".

1. **Performance Level Financing**

A major initiative of this White Paper is the establishment of an Innovation Fund (section 7.2) which will promote large-scale projects, involving participants from throughout the national system of innovation, and which will focus attention on the major themes of government pertinent to this White Paper, namely competitiveness, quality of life, environmental sustainability, and on harnessing information technology to the needs of our society and economy.

The principles underlying government funding for research and capacity building in the higher education sector are dealt with, as are moves to ensure that this funding is delivered through an appropriately co-ordinated system (see section 7.3).

Government will also act to optimise the distribution of the resources which it allocates to SETIs within government to ensure that it is financing activities which are appropriate to government and that the sectoral distribution adequately reflects the overall priorities of government rather than being the product of "historical incrementalism" (section 8.1.1).

With respect to government support of private sector innovation, policies are set out for procurement programmes, for harnessing the purchasing power of the state to serve as a spur to innovation (section 7.4.1) and for the way in which other existing financing programmes, such as the Support Programme for Industrial Innovation (SPII), should relate to the new Innovation Fund (section 7.4.2). Given the current tax environment, this White Paper pursues direct rather than indirect incentives. (section 7.4.3). Government, however, will always be a minority source of funding of innovative activities at the national level, consequently the White Paper outlines some expectations of what the private sector could do (section 7.4.4).

2. **Performance**

A primary goal of a national system of innovation is the active promotion of a whole range of interactions among performers of all sectors, private, academic and governmental (sections 8.2.2, 8.3.1, & 8.3.3). Government recognises that the national system of innovation needs to incorporate processes designed to facilitate and accelerate the diffusion of technology throughout our economy, and particularly among small, medium and micro enterprises (SMMEs). Measures to

enhance technology diffusion and the technology support activities of our strategy to support and promote SMMEs are outlined (section 8.3.4).

There is a need to be precise in determining the range of specific SET functions which should be carried out in governmental SETIs. Accordingly, this White Paper elaborates on the new management system for SETIs (section 8.1.1). It establishes an evaluation approach to SETIs which emphasises "output" rather than "input" criteria (section 8.2.1), and it sets out policies with respect to the core functions and best-practice criteria which should be applicable (section 8.1.3). Guidelines under which departmentally-based SETIs could be given administrative flexibility are set out (section 8.2.2) and the relationships between science councils and their corresponding line ministries are outlined (section 8.2.3). The Paper also proposes steps to avoid "unfair competition" between SETIs and the private sector (section 8.2.4) and contributes to depicting a vision for role of the science councils with respect to industry. It also sets out objectives for the improved linkage of defence R&D to civil innovation (section 8.2.5) and outlines the steps it will follow to arrive at an evaluation of the role of the Atomic Energy Corporation (section 8.2.6).

A set of principles defining an appropriate participation by government SETIs in postgraduate education is included (section 8.2.7).

The White Paper sets out relevant principles to guide South Africa's international, intergovernmental relations in science and technology (section 8.4).

3. **Human Resource Development and Capacity Building**

The quality and motivation of the country's trained human resources are of crucial importance to any national system of innovation. Just as human resource development is the first pillar of the Growth and Development Strategy, it is also a keystone of this innovation policy (section 9.2). While human resource development and capacity building present challenges to all countries, the legacy of apartheid in South Africa has multiplied the challenge and its restitution requires urgent attention. Accordingly, this paper sets out a policy of equity by redress (section 9.3) and research capacity development at historically disadvantaged institutions (HDIs) (section 9.4) which will operate

within the government's activities as a stakeholder in the national system of innovation.

Human resource development is too often construed as meaning solely tertiary level education. Government looks at the issue in a much broader light and we set out policy approaches for human resource development and capacity building at the national level (section 9.5) in ways that take into specific consideration the needs of adult education and training (section 9.6) and of technology education (section 9.7). The White Paper also sets out a set of principles for government financing of training in the context of the national system of innovation (section 9.8). At an even broader level, the White Paper proposes an approach to the promotion of public understanding of SET (section 9.8).

4. **Science and Technology Infrastructure**

Attention is paid to South Africa's communications and information technology infrastructure (section 10.1.1), to libraries and museums, (section 10.1.2) and to the availability of statistical information (section 10.1.3).

At present most of the technical services provided by government in support of its regulatory role with respect to standards, metrology and calibration are provided by the South African Bureau of Standards while research relating to some of these issues is carried out in the Council for Scientific and Industrial Research (section 10.2).

The major national facilities for research which government establishes are important elements of the infrastructure for innovation in any country. The facilities dedicated to "big science" - those large scale ventures into the unknown - are particularly subject to debate. In response to the concerns of the science community, this White Paper sets out criteria which government will use in evaluating the need for national facilities and it announces the process which will be used to decide on future support for South Africa's programmes in "big science" (section 10.4) The White Paper also proposes that the SAFARI nuclear research reactor, located at the Atomic Energy Corporation premises at Pelindaba be declared a National Facility. A further concern of the scientific community, addressed by the White Paper, is that of the provision and optimal use of expensive research equipment (section 10.5).

PART TWO

SPECIFIC INITIATIVES

CHAPTER 5

Policy Formulation and Resource Allocation

1. **Institutional Mechanisms**
    1. **Responsibilities of the Ministers Committee, the Minister and of DACST**

Government initiatives relating to the stimulation of South Africa's national system of innovation are spread throughout the structures of government in ways which are poorly co-ordinated and frequently overlooked in policy debates - a heritage of the past. To rectify this situation and to ensure that concern for promoting the national system of innovation remains prominent among the list of governmental priorities, the government has established

- A national ministry responsible for science and technology, namely the Ministry of Arts, Culture, Science and Technology
- A Department of Arts, Culture, Science and Technology (DACST) to support the Minister
- A Ministers Committee for Science and Technology (MCST).

The Minister will be responsible for the following bodies to be established pursuant to this White Paper:

- The National Advisory Council on Innovation
- The National Research Foundation, which will be responsible for support to research and research capacity building.
- The Innovation Fund
- The National Facilities for Research.

In the light of the proposals contained in this White Paper, government has decided that the terms of reference of DACST shall be:

- to promote coherence and consistency in the government's approach to stimulating South Africa's national system of innovation in general, and in its commitment to the support of science, engineering and technology development in particular
- to promote and co-ordinate interdepartmental and government-wide initiatives relating to the support of innovation and technology diffusion
- to direct the preparation of a government-wide Science Budget, in order to permit ministers to assess relative spending priorities, on a multi-year basis, across the full spectrum of government's activities in support of innovation
- to design and present to Ministers a comprehensive system for the management of government science, engineering and technology institutions, in order to ensure that their roles within the national system of innovation are clearly defined, that they have clearly defined and understood objectives, and that they undertake their mandate with efficiency, economy and effectiveness
- to ensure that the management system referred to above includes adequate arrangements for evaluation of performance against international best practice, and that output measures are in place to indicate the nature of the contribution being made by government SETIs to South Africa's development
- to manage the process of evaluation and review created within the management system described above and to recommend to Ministers any actions necessary as a result of assessments carried out
- to represent the government in formal international, intergovernmental negotiations dealing with science, engineering and technology and with the promotion of innovation
- to provide a link between government and the activities of the National Advisory Council on Innovation
- to commission or conduct any policy research necessary to the fulfilment of the responsibilities set out above.

The MCST is a Committee composed of all Ministers whose portfolios encompass a significant Science and Technology component and is the principal policy

coordinating and information disseminating body for science and technology matters across government.

This White Paper proposes that the MCST embark on a fundamental investigation into the governance and management structures of government-funded science and technology performing institutions. The terms of reference for this investigation will be drawn up by DACST and submitted to the MCST for ratification. The investigation will aim to establish how these institutions, either individually or as components of the National System of Innovation, could be re-structured or reconfigured to meet broad national goals. This process will precede the implementation of the institutional review system described in section 8.1.3.

2. **Creation of a National Advisory Council on Innovation**

Government has a constant need for informed advice about the problems and opportunities facing our country, and in no area is this more true than in the concern for the stimulation of innovation in the pursuit of our national vision. Accordingly, a National Advisory Council on Innovation (NACI) will be created by legislation. The Council will be charged with carrying out enquiries, studies and consultations with respect to the functioning of our national system of innovation, as requested by the Minister.

The Council will

- consist of up to 22 individuals, appointed in their own capacities by the Minister, and drawn from the many different stakeholder groups in our national system of innovation
- conduct enquiries, studies and consultations consistent with its legislated mandate and initiated on the request of the Minister
- take steps to ensure that the subjects and terms of reference of its activities are made public
- be provided with a small independent secretariat and a budget administered by DACST, with which to commission relevant activities, including policy research, in support of its programme of work.
- play an advisory rather than an operational role.

DACST will be mandated to provide NACI with terms of reference for studies relating to outstanding issues

raised in the Green Paper, in consultation with other relevant government departments.

In addition, NACI will be invited to advise DACST on an overall framework for the proposed reviews of government-financed SETIs and will have a continuing role in providing commentary on completed reviews to DACST.

The establishment of NACI will not reduce the important role of the National Science and Technology Forum (NSTF). Although the NSTF has a strong government sector within it, it is essentially a non-governmental body which has full powers to decide on its own role and functions. Government will look forward to continuing the pattern of dialogue with the NSTF which has developed in recent years.

2. **Inputs to Policy Making**
    1. **The Information Society**

South Africa currently lacks a national policy to facilitate the country's optimal integration into the global information society and outlining clear responsibilities, goals and targets. This is a serious defect in our overall innovation drive and must be remedied as soon as possible. Information society planning must now take place at the highest levels within South Africa to develop a national vision, policy and strategy for meeting our specific needs. Government has decided to embark on process leading to a national policy on the Information Society, including the drafting of a Green Paper. This will attract responses from the public and other stakeholders. The national consensus elicited will allow for the drafting of a White Paper as soon as possible.

The public policy process on the South African Information Society should consider, among others, the following policy issues, which are all relevant to the NSI:

- How can an Information Society policy facilitate the more intense and widespread use of information by all those participating in the development process, and particularly by the government, which is managing the process, and the communities, which are driving it?

- How can the policy encourage to the greatest possible extent the use of local knowledge, expertise and technology?
- How should copyright and intellectual property issues be addressed?
- What opportunities does the Information Society present to improve government operations? How can the information society be used to improve government services to the public?
- How can we ensure that South African information industries take full advantage of the R&D and technological development opportunities presented by the information community?
- How can the Information Society best be used to improve the growth and competitiveness of all South African businesses, especially SMMEs, throughout South Africa?

2. **Utilisation of the Results of the Research and Technology Audit**

   DACST is in the process of carrying out a comprehensive Research and Technology Audit, among whose principal outputs will be:

   - An assessment of existing government interventions in science, engineering and technology
   - An innovation survey of the South African science, engineering and technology system
   - A research and technology inventory of the South African economy.

   The information gathered by the Audit is to be entered into a publicly-accessible electronic data base and it will be a responsibility of DACST to ensure that this data base is maintained and updated regularly.

   With the introduction of a Science Budget process set out later in this chapter, the outputs of the Audit should become an important source of information for Ministers as they seek to make important allocations to SET activities.

   The Audit will also provide a critically important instrument for government in generating data on the distribution of national scientific capacity so that the investigation on the structure of the government funded

elements of the national system of innovation described in section 5.1.1 can be properly informed.

3. **Utilisation of the Results of the Research and Technology Foresight Exercise**

   DACST announced its intentions to conduct a Research and Technology Foresight Exercise in 1995. This process is currently under way and involves detailed consultations concerning potential technological trends and trajectories of significance to the social and economic development of South Africa. The expectations of the results of this important exercise need to be kept in perspective and the potential implications of the outcomes considered.

   It is widely accepted that much contemporary technological advance comes from two broad sources - from totally unpredictable discoveries made by researchers with deep insight into the workings of nature and the physical world, and, more often but less spectacularly, from increasingly extensive and co-ordinated research programmes based upon a matching of technical insight with objectives derived from some identified need. Without denying the importance of the former route, the present Foresight Exercise has been embarked upon to inform R&D investments by the public and private sectors in this country. However, apart from the specific technological insights expected from the Foresight Exercise, the process of conducting such an exercise has in itself paid dividends in other countries by enhancing certain characteristics among the groups who participate. Referred to as the six C's of research foresight, they are

   Communication bringing together people in a novel forum so that they can interact

   Concentration on the longer term, so that participants can look further into the future than they might otherwise

   Co-ordination so that people not accustomed to working together can form productive R&D partnerships

   Consensus so that a clear picture of likely future scenarios is generated

Comprehension so that those involved gain an understanding of changes that are happening in their businesses or professions, at a global level, and attempt to exert some control over these events

Commitment so that people participate fully and are able and willing to implement changes in the light of the foresight exercise.

These characteristics are all conducive to fostering an efficient and effective national system of innovation. Government is therefore optimistic that innovative activity will be stimulated by the process of the Foresight Exercise as well as by the outputs.

Government intends to use the results of the Foresight Exercise as important inputs into its investments in R&D, within the Science Budget. The Foresight Exercise will also inform the management of both the proposed Innovation Fund and the system of support for research capacity building in the higher education sector. These structures would call for research proposals in directions identified by the Foresight Exercise as the most promising.

3. **Interaction with Other Policies**
    1. **Other Major Policy Influences**

The principal blueprint for action adopted by government is the Growth and Development Strategy, adopted by Cabinet in late 1995. The six pillars of that strategy are:

- Investing in people as the productive and creative core of the economy
- Creating employment on a large scale while building a powerful, internationally competitive South African and southern African economy
- Using enhanced investment in household and economic infrastructure both to facilitate growth and improve the quality of life of the poor
- A national crime prevention and security strategy to protect the livelihood of our people, secure the wealth of the country and promote investment
- Transforming government into an efficient and responsive instrument of delivery and empowerment, able to serve all South Africans while directing government resources primarily to meet the needs of the poor majority

- Using a system of welfare "safety nets" to draw the poorest and most vulnerable groups progressively into the mainstream of the economy and society.

The policy proposed in this White Paper is specifically designed to reinforce the pillars of the Growth and Development Strategy.

2. **Getting SET on the Agenda of Other Policies and Legislation**

Governments of the industrialised countries recognised, at the beginning of the 1980s, that one of the challenges of promoting technological innovation was in devising means to ensure that government actions across all fields - in trade, education, labour laws, environmental protection, to name but a few - be taken with due consideration of how these actions would affect the climate for innovation. It has been easier to state this challenge than to meet it, but it remains a task which demands attention.

DACST will contribute to meeting this challenge by:

- to promote coherence and consistency in the government's approach to stimulating South Africa's national system of innovation in general, and in its commitment to the support of science, engineering and technology development in particular
- to promote and co-ordinate interdepartmental and government-wide initiatives relating to the support of innovation and technology diffusion.

In Parliament, the Portfolio Committee on Arts, Culture, Science and Technology (ACS&T) and its Subcommittee on S&T have a special function. It is their responsibility to place S&T issues within the context of the broader national debate and to pursue concerns of the public with respect to S&T. They also consult widely within the parliamentary system among groups informed about S&T questions. DACST will continue to be active in its regular communications with the Portfolio Committee on all issues affecting or affected by S&T activities.

4. **Resource Allocation**
    1. **The Need for a Science Budget**

At present, budgetary decision-making within government concerning expenditures on S&T is done on a partial basis, and only with a single year perspective. The basis is partial since the so-called Science Vote encompasses proposed spending only for DACST, the eight science councils, and the three national facilities; the perspective is short term since government still operates on an annual budgetary cycle.

A Science Budget will be an important tool for Ministers to use as they allocate resources to competing priorities and will also provide Parliament with a better overview of the range of government allocations in support of SET activities. In pursuit of this goal, DACST will review the government spend on S&T. The aim of this exercise will be to maximise the benefits from departmental budgetary allocations.

If Ministers are to make considered and multi-year commitments to expenditures on S&T, and government is committed to doing so, then two things need to happen:

- An annual Science Budget document, constructed using data drawn from departmental budgets, must be prepared which displays all governmental S&T expenditures including specifically

    - science councils and national facilities
    - departmental intramural expenditures and transfer payments on S&T
    - transfers in the Defence Sector for S&T
    - other departmental transfers for S&T, including, in particular, the support offered by the Department of Education to institutions in the higher education sector.

- The Department of Finance's proposed multi-year fiscal framework for general government budget expenditures needs to be adopted and applied to the Science Budget.

The first steps to be taken will involve DACST and the Department of State Expenditure reaching agreement on

the definitions of activities to be covered by the Science Budget and on the necessary questionnaire to be used to collect the data from departments during the budget preparation process. It is the intention of government that a document setting out the Science Budget will be available for the 1998-99 fiscal year.

A principal aim of the proposed Science Budget is to enable Ministers to consider appropriate budget reallocations within the system in accordance with government priorities, after having availed themselves of the results of the reviews of government SETIs (announced in this White Paper) and of the Research and Technology Audit. While some adjustments in relative levels of spending have already been implemented, and will continue next year, it is only realistic to conclude that well-informed choices about significant reallocations will only be introduced in the budget for fiscal year 1998-99. These choices will include relative allocations to specific policy objectives; allocations to core and non-core activities as determined by the reviews; allocations to R&D compared to investments in other related scientific activities such as the provision of infrastructure services; and the balance of government support among government in-house activities and support to activities in the private and higher education sectors.

It must be stated that the purpose of the Science Budget is to *inform* departments of the S&T portfolio across government. The rights of individual departments to decide on their own budgets will be unaffected.

CHAPTER 6

Regulatory Policy

1. Aligning Patenting Regulations with International Norms

One of the issues brought to the fore by treating innovation as a national priority is that of intellectual property rights. Intellectual property is a collective term for four types of intangible property, namely patents, trademarks, copyrights and trade secrets. The awarding, recording and protection of intellectual property refers to the set of systems and laws designed to administer and regulate the registration and copying of all forms of intellectual property, including inventions, unique symbols and creative expressions. The current trend world-wide is towards harmonising the relevant laws, although such

property is protected on a national basis. Clearly, the aim behind this trend is to give the inventor protection in a globalised world economy.

Although no specific legislation will be proposed here, the DACST will work with the department of Trade and Industry (DTI) to establish how South African patenting regulations should be revised to best promote innovation.

Issues to consider in establishing or modifying patenting regulations are:

- The value to the inventor of the patenting system. Adequate protection fosters investment and stimulates innovation. The rights of South African inventors need to be rigorously protected.
- The issue of not being a patent examining country. This can be addressed by doing the examining in South Africa, which is costly. A much less costly alternative is to permit provisional registration of patents pending confirmation by the patenting system of a country which does examine patents. This approach has been adopted by Saudi Arabia.

The basic approach should be to align our intellectual property regulations with international norms, rather than opt for a regional or purely national system.

2. **Promoting the Protection of Safety, Health and the Environment (SHE)**

As economic development proceeds, it becomes more imperative to provide for the protection of people and the environment in the face of new stresses and demands. In the area of SHE, the whole nation is a stakeholder. Thus human and environmental health must be seen as essential partners in development. Development decisions should not be taken before the whole range of impacts, including employment opportunities, health and environmental implications, have been taken into account. To fulfil this requirement without generating expensive and time-consuming litigation, the regulatory framework needs to be relatively simple and consolidated. A tendency exists for SHE regulations to be dispersed through a multiplicity of Acts, probably because SHE has often been a legislative afterthought rather than a primary concern. Future SHE legislation must therefore take the following principles into account:

- comprehensiveness
- efficiency and streamlining
- adequate penalties.

In this regard, initiatives by the Departments of Labour, Environmental Affairs and Tourism, Health and Mineral and Energy Affairs need to be supported. DACST will initiate discussions with these departments

to establish in what way the National Advisory Council on Innovation (NACI) could contribute.

CHAPTER 7

Financing (at the Performance Level)

1. Financing and Innovation

In chapters 5 and 6, detail was provided about core government functions *vis-a-vis* the national system of innovation (NSI). A separate component of the NSI are those functions which are essentially shared functions, comprising the implementation functions such as financing, performance, human resource development and infrastructure provision. Financing of innovation at the performance level and the subsequent management of that performance are clearly crucial to the effective functioning of the NSI. These two aspects of the NSI are covered in this and the following chapter.

Throughout the White Paper, the theme of innovation, as opposed to S&T itself, has been made central to the determination of policy and strategy. This is a crucial focus - excellence in S&T does not necessarily translate into innovation. The transformation of new ideas into commercial successes, which are so important to the nation's ability to achieve economic growth, employment creation and competitiveness, requires that attention be given not only to R&D and the technological factors of innovation, but also the social, institutional and market factors such as adoption, diffusion and transfer. In some cases, these non-R&D costs may account for as much as 60% of the total innovation cost. In the past, policies designed to improve the S&T output of a nation have not recognised the importance of non-technological factors to the innovation cycle. As a result S&T initiatives have often failed to deliver consistently and coherently against promises of economic growth and employment creation.

In order to incorporate the new demands of innovation, firms and government must make an organisational effort to adopt new methods of production, management and distribution. Government, in its efforts to provide infrastructure and health care, and to guide sustainable development and environmental management, must pursue new approaches to technology management. In this respect, many firms and enterprises are already leading the way. Market intelligence capacity within R&D departments is now more the rule than the exception. Product development takes place within small, flexible, multi-disciplinary teams, which are able to speed up the introduction of new ideas to the market place. In the forthcoming sections, many of the functions of government, industry associations and firms connected to

the implementation of innovation programmes, and strategies for improving the efficiency and extent thereof, are discussed.

The Green Paper defined the "financing functions" of the NSI as the "management of financing systems appropriate to the implementation of the other functions of the system", and the "use of Government's purchasing power as a stimulus to innovation in the production of goods and services which it requires". Within each of these functions, the White Paper is proposing several initiatives which are outlined in the sections below.

2. The Innovation Fund

Throughout the White Paper, the proposed policy initiatives have emphasised the need for measures to give effect to the concept of innovation, as opposed to S&T or R&D and wherever it may be taking place. This is especially true of the proposed Innovation Fund, which will offer a new lead in encouraging and enabling longer-term, large innovation projects in the higher education sector (HES), government SETIs, civil society or the private sector.

The principal objectives of the initiation of the Innovation Fund are:

- to permit a reallocation of resources from the historical patterns of government science towards the key issues of competitiveness, quality of life, environmental sustainability and harnessing information technology
- to increase the extent to which funds for the activities of government SETIs are obtained via competitive processes and
- to promote increased networking and cross-sectoral collaboration within South Africa's national system of innovation.

The Innovation Fund will initially obtain its income from reprioritisation of the science allocations across government. Final details of the procedures for raising revenue from the Fund, receiving applications, determining criteria for eligibility and monitoring progress of supported programmes, will be developed by DACST in consultation with NACI. The guiding criteria for the Innovation Fund are:

- Initially, at least 50% of the funding will be allocated to projects directly dealing with the needs of disadvantaged populations.
- Preference will be given to larger and longer-term proposals. This will allow for significant initiatives to be undertaken by larger groups or consortia and to reduce the overheads associated with processing and managing the funding of many small projects.

- Applications will be considered from groups whose members may be drawn from any combination of government SETIs, HES, private sector, public sector or civil society.
- Particular priority will be given to applications which indicate close relationships between those conducting the activities foreseen and those who would be expected to diffuse and make practical use of the results of those activities.
- A common framework for proposals, costing and output measurement will be provided in view of the different cost structures in the organisations from which the applications will be received. The Innovation Fund will not finance the salaries of principal researchers.
- The programme created to administer the Fund will be mandated to define a mechanism for developing and updating thematic priorities on a biennial basis. Ideally this process should also be supplemented and updated by a technology foresighting exercise. NACI will also advise on the setting of these priorities.

DACST will create a mechanism to administer the Innovation Fund. To make the Fund a useful and credible programme, it is essential that it establish a process of assessment of proposals capable of evaluating the technical, economic and social implications of proposals. This will involve the use of qualified external reviewers. The management of the Fund should draw on the experience of the Support Programme for Industrial Innovation (SPII), the Water Research Commission, the Safety in Mines Research Advisory Committee and the Energy Policy Projects (both supported by the Department of Mineral and Energy Affairs), and the Directorate of Technology Development of the SANDF in designing appropriate processes of review and follow-up.

In view of the potential for overlap between SPII and the Innovation Fund, DACST and DTI have agreed to work together to manage these two programmes optimally.

3. Principles for Funding R&D in the HES

Government has decided that a ***co-ordinated system*** of grant financing of research in institutions of higher education will be instituted. The principles on which the system will operate will be the following:

- All areas of research will be eligible for support, as will basic and applied research and activities of technological development.
- The system will pay particular attention to the introduction of processes to facilitate the financing of problem-oriented research involving participants from many disciplines.
- The system will develop and implement a policy of peer review for all areas of research which will incorporate the following procedures:

    - panels of peers will include researchers of international stature where possible, especially in areas of basic research
    - peers for applied activities will include representative users of the potential outputs
    - special measures will be taken to provide for appropriate review of proposals in emerging or poorly developed fields in South Africa in which there may at present be an inadequate supply of appropriately qualified South Africans to judge such proposals.
- A progressive effort will be made to achieve economies through sharing of support facilities among the organisations involved in allocating this support. The support to research in higher education will be allied to the government's primary support for human resource development in this sector.
- The system will be responsible for promoting individual and institutional capacity for research within tertiary education.
- In general, the organisations providing this support (that is, the agencies) will not themselves engage in the performance of research. The intention of this proscription is to avoid potential conflicts of interest between granting and performance responsibilities and to ensure that all research meeting agreed standards has the possibility of being funded. Nevertheless, this principle is not intended to impede the implementation of other government-funded research programmes if it is deemed inappropriate for these programmes.
- The primary criteria for support will continue to be the quality of the research proposed, the relevance of that research to the goals and objectives of South Africa's vision for the future, and the contribution the activity will make to redressing the human and institutional imbalances of the past.
- A regular schedule of evaluations will be instituted for all programmes.

The principal institutional system *initially* engaged in delivering this support will have the following structure:

There will be four Agency Divisions:

- Division for Natural Sciences and Engineering, formed essentially from the present FRD.
- Division for Social Sciences and Humanities, formed essentially from the Centre for Science Development of the present HSRC.
- Division for Health Sciences, encompassing the medical and health support thrusts of the current FRD and HSRC and any other current programmes deemed appropriate by government.
- Division for Agricultural and Environmental Sciences, including the agriculture thrusts of the current FRD, but essentially a new component of grant funding.

The NRF will also be responsible for administering the National Facilities for Research (NFs), such as the National Accelerator Centre. This White Paper proposes that experiment time at the NFs be allocated according to the same principles as those outlined for grant funding. This will ensure that these facilities become truly national in character. A more detailed exposition of the role of the NFs is given in section 10.4.

The four Divisions will be co-ordinated through the National Research Foundation (NRF), which will have the following structure:

- A chief executive officer, known as the President, and appointed by the Board of the NRF.
- A management echelon immediately below the President, consisting of the Heads of each of the four Divisions and a Head: Interdisciplinary Grant Funding.
- A Board with the following membership composition:

    - A Chairperson (appointed by the Minister),
    - The President (appointed by the Board),
    - Corresponding to **each** Division, one member with experience in the scientific domains spanned by that Division (four members in total, appointed by the Minister),
    - Three members with appropriate experience (appointed by the Minister) making a total of nine members.

It is intended that the new system for grant funding be a flexible one and that it should develop the capacity to adjust the array of programmes which it supports in a timely manner. In addition, the National Research Foundation should keep under review both the number and terms of reference of the Divisions. The Minister may request that new Divisions be added to the NRF, or existing ones be amalgamated. Any additional Divisions will carry with them one additional Board member with appropriate professional experience. Adjustments at this level, although infrequent, should certainly be possible, in the light of experience.

The dispensation for the administration of grant funding presented in this White Paper represents an important departure from the present arrangement in that

- it prescribes a separation of agency and performing functions,
- it aims at reducing overheads by consolidating grant funding, while promoting the independence of different areas of SET,
- it creates a mechanism to ensure support for interdisciplinary R&D.

The NRF is intended to replace and augment current granting mechanisms in the FRD, the HSRC and the MRC, but its existence will not in any way proscribe the operations of specialised domain agencies (see section 3.3) such as the Water Research Commission and the Department of Defence's Directorate for Technology Development. However, the emphasis placed on economies of scale and multidisciplinary work in this White Paper is considered to be valid, even in respect of the specialised domain agencies.

Each Division of the NRF will have its own Advisory Panel, which will assist in promoting synergy between the programmes of the Division and the research and human resources needs of the relevant sector. In the case of the Division for Health Sciences, for example, the Essential National Health Programme now being established by the Department of Health would provide an important reference system.

The primary functions of the NRF will be to ensure the support of research and research capacity building within the HES. The terms of reference, to be drawn up by DACST in consultation with line departments, will contain detailed objectives, to be spelled out in legislation, and will include, among others

- developing a policy framework for the NRF which will envisage a set of common policies applicable throughout the NRF, complemented as necessary by additional policies relevant to specific parts of the NRF
- developing processes and programmes for promoting, evaluating and financing multi-disciplinary research
- promoting inter-Divisional approaches to budgeting and advising government on the allocation of financial resources to the NRF
- developing appropriate measures for sharing information between Divisions.

The NRF should create an ongoing dialogue with its stakeholders in the tertiary education sector on the issues of research support and capacity building.

The Department of Education is an important source of financing of research in tertiary education institutions; it provides this support both through funds included in its general formula for financing tertiary education and it operates a grant programme based on publications in peer reviewed journals.

DACST will enter into discussions with the Department of Education to seek means of ensuring that the general formula financing of research is supporting the objectives set out in this White Paper. The present 15% allocated by the Department of Education from the subsidy received for each full time equivalent student in order to support research represents an amount of money substantially larger

than that currently made available by government for grant funding via the FRD, the HSRC and the MRC. The Universities must be able to account that this money is spent on research.

As far as the research funding based on peer reviewed publications is concerned, a new policy is being developed by the Department of Education, in consultation with stakeholders.

4. **Private Sector Funding**

The private sector is able to raise funds for its R&D activities from five main areas:

- internal cash flow
- loan and equity financing
- government incentive schemes
- industry levies (such as those applied in the sugar industry)
- aid and donor organisations.

In addition to the above, careful attention must be given to the needs of SMMEs, which are typically at the cutting edge of commercialising novel products or processes (that is, the products of innovation), but have limited resources both for financing internal R&D and for transferring technology to or from SETIs and international technology vendors. Government policy in this regard has already been stated in a separate White Paper.

1. **Procurement Policy**

The pro-active application of the purchasing power of the broad public sector is an important policy instrument for government in order to promote technology and industrial development. A selective procurement policy has been applied in the past to give preference to local producers in selected industries and to provide measures to encourage local product design and development. Unfortunately, the policy did little to encourage the development of technological capabilities in industry and in some ways both limited and distorted product development.

The Ministry of Finance is constantly engaged in reviewing the procedures on government procurement. These reviews address many key areas, including the simplification of tender documentation and procedures, access to tendering information, the unbundling of big contracts into small, more manageable contracts, control mechanisms and risk management, counter trade regulations (in itself an important means of enhancing and initiating local technology development and

diffusion), life cycle costing in tender adjudication, and procurement guidelines.

Meanwhile, the Department of Trade and Industry (DTI) has implemented procedures for determining the effect of price preferences as a result of the tender system on industrial development, monitoring the participation of SMMEs in government procurement, studying the application of trend analysis to the potential development of technology needs, and developing guidelines and directives for contracts with firms to develop particular new products.

In view of the extensive treatment of this form of government financing elsewhere, the White Paper will not attempt to formulate any additional guidelines or policy initiatives with regard to government procurement.

2. **The Innovation Fund and SPII**

As described in the Green Paper, the Support Programme for Industrial Innovation (SPII) supports innovation in firms on a matching grant basis and has recently been broadened to include support for patent registration for products/processes developed with SPII support. The fund is administered by the DTI through the Industrial Development Corporation (IDC).

Despite some advantages, the use of indirect incentives to stimulate R&D expenditure has been ruled out by capacity problems within the revenue collection services and the recommendations of the Katz Commission (see section 7.4.3). Direct subsidy of such expenditure via the Innovation Fund and an expanded SPII therefore remains the only realistic option if incentives for private sector innovation are to be increased.

With the addition of the Innovation Fund, the total money available for direct subsidisation of R&D will be increased, a positive development given that it is currently low by international norms. An inter-departmental committee will be established in order to align the objectives of SPII and the Innovation Fund. To undermine the existing efficacy of SPII or attempt to replicate its administrative structures would be counter-productive. The combined resources of DTI and DACST will be more influential in supporting innovation within the NSI.

3. **Tax Incentives**

Present legislation covering the treatment of R&D expenses for tax purposes is covered in section 11 of the Income Tax Act of 1962, which outlines two ways in which expenditure can be offset against taxable income. If costs of a revenue nature are concerned, expenditure incurred for the purpose of scientific research undertaken for the development of the business or by way of contributions to research performing institutions, is considered to be legitimate business expenditure and is deductible from taxable income. Whereas contributions to institutions are deductible only if the CSIR certifies that it approves the research proposal and that it is satisfied that such contributions will be used in the research undertaken.

Costs of a capital nature can be deducted from taxable income as a tax allowance consisting of 25% of the expenditure over a four-year period subsequent to the initial purchase. Similar conditions apply as for costs of a revenue nature, namely that the taxpayer must have incurred the costs for the purpose of scientific research undertaken for the development of the business, and that the CSIR has certified that the research was performed during the year of the assessment and was financed by such expenditure.

Although widespread use is made of the above allowances, the use of the CSIR as a certifying body presents a problem to some firms because of a clear conflict of interest. At the time the Act was passed, the CSIR was wholly government funded, and was not perceived as a potential competitor to private sector enterprises. This situation has changed very significantly since then and this White Paper therefore proposes that the use of the CSIR as a certifying body be re-examined.

A growing number of countries, particularly advanced countries and the newly industrialised countries, are adopting fiscal incentives to support R&D in private firms. These supply-side measures are effective in encouraging innovation investment, but require extensive administration and regulation. In general the Katz Commission is strongly opposed to using the tax system to deliver incentives for the private sector, because such indirect measures erode the tax base, are hard to administer by the revenue collection officials (who are not scientists) and do not provide accurate data

about the use of the system. These recommendations have for a large part been accepted by government.

Despite the obvious advantage of indirect incentives, which is that it is able to reach a larger number of firms, the White Paper accepts that government is better equipped to administer direct subsidies such as those delivered through SPII. Details as to how this may be achieved and the levels for which government support of SPII should be increased, are covered in section 7.4.2.

4. **An Imperative for the Private Sector**

Government can play an enabling role in the encouragement of an innovation culture within the private sector. It is then the responsibility of the private sector to recognise the importance of innovation spending from the point of view of competitiveness. By international norms, the South African private sector underinvests in innovation activities (comparative figures were given in the Green Paper), and over the past seven years, the tendency has been for the levels to decrease rather than increase. This trend does not augur well for the country in the long term, especially in view of the rising R&D expenditure amongst our trading partners and competitors. The White Paper therefore proposes that organised business develop a policy for building innovation capacity and supporting innovation within the country's enterprises.

CHAPTER 8

Performance

1. **Management and Financing of Government SET Institutions**

The current management and financing system for SETIs in South Africa has some desirable features which should be retained or extended. Nevertheless, it does not meet many important criteria and needs to be amended in such a way that the new mechanisms do not obstruct their effective functioning. Such mechanisms, as they relate to management and financing, are now discussed.

1. **A New Management System for SETIs**

The scientific and technological activities of government SET institutions, discussed in the White

Paper, go beyond mere "support for R&D", but also encompass activities such as natural resource surveys, the development and management of technical libraries and data bases, and the introduction and administration of technical standards and regulations. In most governments, as much is spent on such "related scientific activities" as on R&D.

From the perspective of governance, there are three distinct types of government owned or funded SETIs in South Africa. These are:

- *State owned corporations (SOCs)*. The SOCs are each mandated by an Act of Parliament and fall under the jurisdiction of the Companies Act. Eskom and Telkom are examples of SOCs. As outlined in the Macroeconomic Strategy document, government's intention with respect to SOCs may involve the total sale of the asset, a partial sale to strategic equity partners or the sale of the asset with government retaining a strategic interest. The government does not stipulate what the salaries of the employees of SOCs should be and these are fixed solely by their boards. There are SETIs within a number of state owned corporations. However, the new management system is not envisaged to apply to these SETIs.
- *Science Councils (SCs)*. Each SC has been established by an Act of Parliament, defining its mandate, and is headed by a governing board. There are currently eight SCs, two of which have been established within the past four years. The Agricultural Research Council and CSIR are examples of SCs. The relationship between government departments and SCs is currently defined by the system of Framework Autonomy (FA) adopted by the previous government in 1987. Prior to this, the SCs were administered in a similar way to department-based institutes (see below). Framework Autonomy is administered financially via the budgetary allocation for Science Councils and National Facilities for Research (NFs), currently the responsibility of the Minister of Arts, Culture, Science and Technology. This financial envelope incorporates only the SCs and NFs.
- FA has several positive features. For example the system allow s SCs a degree of management flexibility consistent with a government

directive that they generate their own income from contracts, hence reducing their dependence on a parliamentary grant. However, FA has been criticised because it has led to a situation where individual SCs shape their own agendas independent of national priorities. Under FA, the budgetary allocation is determined from a baseline formula established in 1987. The new management system *will* apply to SCs.

- *Department-based Institutes (DBIs).* The DBIs are embedded within government departments and have staffing structures and employee remuneration schemes which are controlled by the Department of Public Service and Administration. The budgets of the DBIs are contained within the budgets of the relevant departments. The National Institute of Virology (Department of Health) and the National Botanical Institute (Department of Environmental Affairs and Tourism) are DBIs. The decision as to whether individual DBIs should fall under the new management system will be left to the relevant line ministries.

It is now the intention of government to put in place a new management system for all SETIs, whose goals will be the following:

- To ensure that the activities undertaken within government SETIs serve to advance national goals and priorities.
- To ensure that the administrative structures within which scientific and technological activities are pursued are not uneven, and are conducive to promoting a favourable climate for innovation; this will include changing the nature of some of the constraints currently applied to science councils and putting in place means of assessing whether or not some additional departmentally-based SETIs should be given the same legal status, structure and operating flexibility as will be enjoyed by science councils under the new system.
- To develop and apply a system of performance measurement by establishing a formal system of peer review, stakeholder input and efficiency auditing into government SET institutions. This system will be linked to output and performance measurement criteria, and it will urge the adoption of "best practice".

- To implement a funding and financing system in which public money is handled according to generally accepted accounting practice and in which public money is spent transparently to achieve the desired outputs.
- To reduce the fragmentation of the existing system by introducing improved systems of co-ordination, thereby aligning sectoral distribution to reflect the overall priorities of government as opposed to being a product of "historical incrementalism".

Over the past decade SCs have moved steadily towards greater financial independence from the state. Indeed, in the case of some, the parliamentary grant accounts for less than 50% of their operating budgets. Although there is some criticism (see section 8.2.4) concerning unfair competition with private sector industry, this can be addressed by structuring the parliamentary grant appropriately and without reverting to a situation of total or near total state funding.

Nevertheless, both DBIs and SCs currently face strong competition for staff from the private sector. In the case of SCs, salaries paid for equivalent jobs are typically below private sector rates and the disparities are sharper for DBIs. The maximum average (MA) and public service remuneration systems are blamed by SETI managements for this state of affairs. In particular, the MA system can result in absurdities as SCs attempt to satisfy technical prescriptions while recruiting the staff they want. It even sometimes happens that averages are exceeded as a result of resignations rather than additional recruitments.

Attempts at attempting to establish a new management system for SCs and DBIs are subject to several tensions, as described below. A good system will have to harmonise these tensions or run the risk of being paralysed in attempting to resist them.

Firstly, there is a requirement to move away from a formula-based funding system to a "budgeting-from-zero" system, where each programme is motivated and budgeted for. This requirement, which is based on the need to demonstrate the wise expenditure of public money, must be balanced against the need of SETIs for financial stability. Research and development activities customarily have fairly distant time horizons and it is inappropriate to expect planning to take place within an

annual expenditure framework. The tension here can best be resolved by multi-year budgeting. DACST will work with the Departments of Finance and State Expenditure to develop a multi-year budgeting process for SETIs within the Medium Term Expenditure Framework now being developed.

Secondly, a process to arrive at a set of performance criteria needs to be defined which will enable the effective deployment of public resources in the performance of core SET functions and promoting innovation (see sections 8.2.1 and 8.2.2).

Thirdly, the process of budgeting from zero can result in attempts by government officials with limited knowledge of the actual R&D activities to manage SETIs at the micro level. This can be avoided by applying the system of institutional review (see section 8.1.3.)

2. **Policy Principles for Funding of Government Funded SETIs**

A new policy for the funding of SETIs needs to accommodate several of the many requirements stated in Chapter 2. For instance, the government has a duty to ensure the adequate financing of R&D performance in cases of market failure (such as low purchasing power of the target market, extremely high risk research or issues relating to national security) and/or where it is beneficial that the results be in the public domain. Government policy also has a duty to address the many historical problems and specifically the problems of fragmentation and lack of transparency of the existing system.

Arising from the above and the objectives of a new management system outlined in section 8.1.1, the White Paper proposes that government support of R&D in SETIs be considered under three headings:

- *Budgetary support* for research within governmental institutions, that is, the core support of R&D performed in government SET institutions or corporations.
- *Contract support* for the purchase of scientific or technological inputs into the functioning of government programmes and departments in which the terms, conditions, objectives and outputs are specified by the funding institution.

- *Grant support* for research allocated on a competitive basis in which the objectives of the research are set by the performers, not by the funders.

Grant funding is the traditional vehicle for support to research and capacity building in the tertiary education sector. The White Paper (through the Innovation Fund) will introduce means of allowing all R&D performers access to such funding.

In the proposed system, every SET performer potentially operates on the basis of two forms of funding, namely "core funding" and "competitive funding". Core funding for government SET institutions is provided in the annual budget of the government, either as a Parliamentary Vote or a transfer payment. Such funding will be "ring-fenced" to ensure that it is not diverted to other uses and could include the longer-term funding of bottom-up initiatives and core national research infrastructure. The extent of core funding required by tertiary education institutions for their R&D activities is provided by government either through the agency funds administered by NRF or through transfers from the Department of Education.

Government will provide competitive funding, which will be open to any performer, through two routes. It will support activities leading to outputs which it, as government, needs, via contracting, and it will support the functioning of the national system of innovation through grants allocated via an Innovation Fund (see section 7.2).

3. **The Process of Institutional Review**

An investigation by the Ministers Committee on Science and Technology into the governance and management of SETIs has been proposed in section 5.1.1. It is equally imperative to develop a dynamic system in which the *outputs from* and *outcomes of* SETI activities are assessed within the context of current and projected future national needs and benchmarked according to best-practice criteria. Further investigations need to be performed as to whether

- the core activities carried out by SETIs are appropriate
- the resourcing of the core activities is adequate

- the SETIs measure up to appropriate international standards for similar institutions.

The answers to these questions will be of great use in integrating SET planning into general development planning at government level.

To establish the most suitable vehicle for an intensive periodic review of a South African SETI it is necessary to be more specific about what is required of such an institution. Broadly speaking, there are three categories within which assessment should take place:

1. **The contribution of the output of the SETI to the realisation of national goals or international commitments.** This would be best carried out by a panel consisting of line department and DACST officials and "end users" from the sector serviced by the SETI.
2. **The scientific quality of the outputs.** The knowledge required to perform this part of the review is of an expert nature and government officials, whose skills are usually at a policy or an administrative level, would not be able to do full justice to the process. Rather, a team consisting of appropriate peers selected from similar SETIs in other countries, augmented by local experts, will provide a better mechanism.
3. **The quality of the management of the institutions.** An efficiency audit of management practice in the SETI should be conducted by appropriate professionals.

Reviews will take place at intervals determined by the Medium-Term Expenditure Framework. DACST will manage the review process and be responsible for making any recommendations to Ministers as a result of these reviews. This will involve establishing the terms of reference and the composition of the review team in consultation with appropriate line departments and the SETI involved.

Terms of reference would contain a generic part applicable to all SETIs, as well as clauses applying to the domain and the medium-term planning of the specific SETI being reviewed. The financing of individual reviews will be negotiated among DACST, the line department and the SETI to be reviewed, on a case by case basis.

Government will need to provide the review process with macroscopic guidelines embodying its overall vision for science and technology. These will be informed by the results of the Audit and Foresight exercises and by NACI and as well as relevant line departments. This would entail giving an indication of the importance of different sectors in the overall plan for the National System of Innovation of the future.

The National Research Foundation will also be subject to review, as will the National Facilities for Research.

2. **Operational Issues of Government Funded SETIs**
    1. **The Replacement of Input Criteria with Output Criteria**

SCs are currently subject to the system of maximum averages (MA), which can be viewed as a set of input controls. Outputs, which should be, after all, the *raison d'être* of any SETI are monitored in terms of the Reporting by Public Entities Act.

The MA system has become a source of justifiable dissatisfaction in the SCs. The relevant statistics, namely average remuneration packages within three broad and very dated occupational staff classes, are poor indicators and do not serve the purpose for which they were designed, namely to ensure that taxpayers' money is not spent profligately. The government will therefore act to ensure that the MA system is scrapped with respect to SCs and replaced with a mechanism, linked to the review process, which embodies both accountability and flexibility for the institutions.

The Reporting by Public Entities Act indicates a shift in government thinking towards the application of output monitoring measures to institutions receiving public money. Compliance with the Act involves the institution demonstrating to the Director-General of its associated line department, acting on behalf of the Auditor-General, that the parliamentary grant portion of its operating budget was spent according to measures consistent with its mandate. However, output measures for SCs need to be further refined, particularly in the light of the recommendation that input controls be removed. It is believed that this can best be done by implementing a system of institutional review (see section 8.1.3).

    2. **A uniform framework for SETIs**

Given concerns that science councils are disadvantaged with respect to the payment of market-related salaries, the plight of the department-based institutes is even more severe. The current two-tier system in which SCs and DBIs are governed differently, is based largely on the criterion that SCs are deemed able to exploit a niche market and so increase their operating budgets by means of contract income, whereas DBIs would do this less successfully. Nevertheless, during the past five years, both the Agricultural Research Council and the Council for Geosciences have made successful transitions from DBI status to SCs and are demonstrably increasing the share of their income obtained from contracts. The view of the government is that DBIs should be encouraged to become SCs or part of existing SCs where their scale or scope of activities would warrant this. This will increase the overall level of SET funding, while simultaneously facilitating the remuneration of SET personnel at market rates.

The concern that conferring SC status on DBIs will draw them away from serving the needs of government is unwarranted within the context of the new management system. Here outputs will be defined and monitored by the institutional review process, the terms of reference for which will be drawn up by DACST and the relevant line department.

Nevertheless, a cautionary note needs to be sounded with respect to the ownership of data acquired using public funds. Such data should ideally be in public domain, and government will need to devise creative ways of reconciling the enlarging of the knowledge pool with the imperatives of contract income generation.

3. **The Role of Line Departments**

It is not envisaged that the new management system for SETIs will substantially alter the current relationship between SCs and their line departments. The line departments will be closely involved in drawing up the terms of reference for the reviews of the institutions, and will still be responsible for ensuring compliance with the Reporting by Public Entities Act. Relevant information will flow to them via the Ministers Council on Science and Technology.

Line departments will play an extremely important role, together with the Audit, the Foresight and NACI, in assisting DACST in arriving at a set of broad

macroscopic funding guidelines to enable the realisation of the National System of Innovation. It is imperative that there is a well-understood government vision about the relative emphasis of different sectors over time.

4. **"Unfair Competition" with the Private Sector**

   It has been government policy since 1987 that science councils should derive an increasing share of their operating budgets by means of contract income obtained directly from the market. The purpose behind this is threefold.

   - Firstly, the councils will tend to become increasingly market-aligned - an undoubtedly positive trend.
   - Secondly, overall national spending on S&T will increase.
   - Thirdly, increased contract income for the science councils will make them less dependent on the parliamentary grant.

   However, the fact that SCs are both budgetary-funded as well as income earning often makes them liable to allegations of unfair competition. Given the exhortation from government for SCs to increase own-income, it is in fact the responsibility of government to devise a system which minimises the potential for such accusations. Any grounds for complaint from the private sector will be removed upon implementation of the following programme:

   - making a portion of SC funding (determined by the review process) conditional upon partnerships with the private sector
   - strict monitoring of auditable systems for financial management within SCs to ensure that cross-subsidisation for revenue-earning projects does not occur and that grant and budgetary funds are spent with economy, efficiency and effectiveness
   - in particular, within one year of publication of this White Paper, all SCs will be required to establish the overhead costs of their activities, and will be required to charge full direct costs plus overheads on all SET contracts. Any exemption from this prescription will need to be approved by the MCST.

5. **Defence Research**

Although our industries are spending on R&D, our balance of trade in medium and high technologies remains negative. A notable exception is the armaments industry, which currently has a positive annual balance of trade, although this statistic needs to be seen in the light of relatively high state investment in this industry. The defence sector in general is a repository of considerable skills in instrumentation, control and advanced materials handling. Extending or converting these skills to civil use could broaden our industrial skills base considerably. It is therefore imperative that the new strategy of the SANDF be examined in the context of the NSI.

The essence of the new strategy of the SANDF is to convert the current force into a smaller but technologically more capable one. The reliance on quality intelligence will be high, to allow the timely scaling up of the force to meet potential threats, as will the dependence on a broad technology base. The result of the Department of Defence buying less hardware will be that less attention will be paid to manufacturing. Insurance against threat will take the form of maintaining small but sophisticated forces which can be mobilised quickly and which rely on technology to increase the flexibility and responsiveness of a smaller military establishment. In this scenario, the defence R&D effort will be a forum for technology assessment, rather than the first stage in large scale production of weapons. This approach is not dissimilar to post cold war military strategic thinking.

The maintenance of a strong technology base is therefore a prerequisite of the new SANDF strategy and must serve a number of purposes:

- maintaining the capability to detect threats
- being aware of trends in military technology and their implications for the SANDF
- being capable of producing technology demonstrators that can rapidly be turned into military technology if necessary
- being capable of providing expert advice for procurement purposes
- providing test and evaluations services
- supporting upgrade and maintenance activities.

After the UN arms embargo on South Africa was introduced in 1978, the emphasis in military technology development moved to local production of weapon

systems. Now that this requirement is diminishing, it is appropriate to examine the foundations of military R&D in South Africa. The classic model of defence research, where the research institutes exist to fulfil roles rather than to follow the market, is less appropriate in our country. Most of our defence technology is acquired from the private sector, with statal and parastatal institutes such as Protechnik, Mechem and CSIR's Aerotek playing a lesser role. Nevertheless, in the 1980s South Africa's defence industry emerged as one of the major sectors of the economy, employing around 130 000 people (about 10% of the total manufacturing employment). Although about half of these jobs have now been lost and domestic arms production is at a much lower level than in the 1980s, South Africa has had a positive trade balance in arms in the past two years due to new markets opening up.

The central issue in the defence technology debate in South Africa has recently been whether sufficient spin-off can occur for the Defence Research and Development budget to have a positive effect on high technology development in the civilian sector. The spin-off paradigm focuses on the ways the military develops or nurtures through procurement products, processes and organisational innovations, including national technology infrastructures, human resources development, equipment and indeed whole sectors and firms that transform and enhance the civilian economy. Products such as kevlar, insecticides and telecommunications satellites are examples of spin-offs. However, history is also filled with instances of "spin-on" technologies, that is technologies developed in the civil sector which have found military applications. Examples of recent spin-ons are stealth and multispectral technologies.

Some reasons for the increasing predominance of dual use technologies in the defence arena are:

- Performance requirements for commercial markets have caught up with military specifications.
- The large and increasing development costs can now be supported as easily by the volume of sales of consumer products as by the guaranteed markets of military procurement.
- Product life-cycles in competitive markets are considerably shorter than those for military systems. In this sense, the civilian economy has

proved itself an even more voracious consumer of technology-intensive products than the military.

It is clear, therefore, that the future of the South African defence industry cannot be seen as distinct from that of its civilian manufacturing counterpart and that dual use concepts should be understood and applied. The view that defence technology should be phased out in favour of civilian technology, or converted into it, is not tenable. Instead, the defence industry must make special efforts to leverage spin-offs in the civilian sector and to develop relationships with civilian institutions in the NSI to promote spin-ons. It is via this partnership route that our defence industry will achieve its rightful place in the mind of the public, and shake off negative perceptions associated with its role in the South Africa of the past.

The Department of Defence, DACST and the Department of Trade and Industry should co-operate closely to develop a strategy for optimal promotion of the local defence industry. The Defence Research and Development Committee budget should be displayed in the government SET budget, as well as in the Department of Defence budget. This would give government and the public the opportunity to evaluate the entire SET spend in an unfragmented way.

6. **The Atomic Energy Corporation**

The principal roles of the Atomic Energy Corporation have been to manufacture nuclear fuel for the reactor at Koeberg power station, to participate in the discontinued nuclear weapons programme and to perform research which supported these functions. Since 1990, following its new 2000 Plus Plan, the AEC has re-directed its role from a largely strategic to a largely commercial one. This process resulted in large scale rationalisation (notably the closing down of the enrichment programme in 1995) and in a re-focussing of its core competency areas, which now include irradiation processes, fluorine based chemicals and applications and laser-based isotope separation technology.

Fundamental research still takes place at the AEC using the SAFARI research reactor, which was acquired from the United States as part of the Atoms for Peace programme in 1965. The SAFARI is currently widely

utilised by researchers in the higher education sector and has a number of years of useful life left. This White Paper proposes that the SAFARI reactor be administered as a National Facility for Research (see sections 7.3 and 10.4).The detailed modalities for this will be agreed upon by the Minister of Mineral and Energy Affairs and the Minister of Arts, Culture, Science and Technology. The use of SAFARI as a National facility will promote its optimum use by university and technikon researchers and enable vocational training to a much greater extent.

The AEC also receives government funding for technology development and industrialisation activities. An evaluation of the role of the AEC should be conducted according to terms of reference drawn up by the Ministers of Mineral and Energy Affairs, of Arts, Culture, Science and Technology and of Trade and Industry.

7. The Linkage of Government SETIs to Postgraduate Education

Throughout the system of government SETIs, there are researchers and facilities with unique capacities some of which can be seen as valuable resources for the enhancement of postgraduate education in our country. However, any policy in favour of using these resources should not create a system in which SETIs are in competition with universities or other institutions of tertiary level education. Mindful of this condition, government will encourage the involvement of SETI staff or facilities in postgraduate education provided that the following principles are observed:

- SETIs can become involved in postgraduate education and training only within the context of formal agreements with universities or other tertiary level educational institutions.
- Either party should be able to initiate negotiations of such agreements.
- All staff operating costs related to research activities undertaken in the SETIs own facilities and involving postgraduate students will be borne by the regular budget of the SETI concerned, with the exception of payment of stipends for postgraduate students or salaries for academic faculty who are jointly supervising students.

- Tertiary level education institutions involved in such agreements should grant to SETI staff involved an adjunct appointment at an appropriate academic level, and such staff should be eligible to receive additional remuneration from the institution involved for any activities (for example lecturing) which are additional to the normal duties of the SETI staff member as a researcher. Similar arrangements in the other direction, involving academic staff taking on additional duties on behalf of the SETI involved, should also be made.

This policy will apply to all SETIs and in the majority of these, it is hoped that some SETI staff will become participants in the linkages envisaged.

In the case of the National Facilities for Research, most research staff should become involved in such arrangements since the country cannot afford to maintain expensive basic research facilities which do not have extensive involvement in postgraduate training. The terms of reference of proposed reviews of NFs will include the requirement that each individual facility's attempts to give effect to this policy be evaluated.

3. **Promoting linkages between sectors and between stakeholders**

    1. **Key linkages**

    The following key aspects can only be addressed in the context of linkage, for example, the linkage between the higher education sector (HES) and the business sector, between the business sector and the science councils, and between firms and institutions themselves:

    - Wasteful duplication of activities
    - Fragmentation of effort
    - Lack of co-ordination between institutions
    - Diffusion of best-practise technology
    - Increasing R&D investment in the private sector
    - Lack of leadership to achieve national SET objectives
    - Promotion of a performance culture
    - Focus of activity (making use of the Research and Technology Audit and Foresight results)
    - Making full use of the social sciences in the NSI
    - Making full use of information technology in the NSI.

Especially important, too, is the linkage between basic and applied research with respect to real problem solving.

2. **Provision of Mechanisms to link R&D Output to Practical Use**

   Whilst South Africa has many examples of good R&D work, it has only managed to effectively commercialise and exploit the research results in a few instances. Part of the problem is undoubtedly the absence of mechanisms to ensure that industry benefits maximally from the SET output of the HES, SETIs and other basic and/or applied research performers. Equally important has been the absence of effective programmes to keep R&D performers in touch with the needs of industry.

3. **Linkages between Firms**

   The capacity of firms to innovate is to some extent determined by both horizontal and vertical linkages between firms. For instance, the differentiation of a product line is often informed and driven by customer feedback, whereas close co-operation with suppliers may well result in economies of production realised through shorter delivery times, improved packaging, etc.

   The Department of Trade and Industry is currently involved in several studies which are designed to result in concrete and sector-specific measures to enhance inter-firm linkages.

   The new management system will be administered in such a way as to promote the linkages discussed above.

4. **Technology Diffusion**

   From a technological perspective, economic growth has proved to be intimately linked to the process of technical change in individual firms and in the economy as a whole. In turn, technological change in an economy is strongly linked to innovation and to technology diffusion. While the main thrust of this White Paper deals with the fostering of innovation, that thrust must be strongly allied to facilitating the diffusion of useful new technologies, whether domestic or foreign, throughout the economy. Government has a particularly important role to play in stimulating such diffusion among the small, medium and micro-scale enterprises

(SMMEs), a sector representing great expectations for employment creation.

Efforts to support SMMEs around the world has led to programmes responding to five generic needs of those enterprises, being access to

- finance
- markets and market information
- improved management
- skills upgrading for members of the work force of the SMMEs
- best-practice technology

where best practice is determined by the existing capacity of the individual SMME to manage the technical change involved in moving from existing to new practices. Successful upgrading of the technical performance of most SMMEs is much more likely to come through a consistent succession of incremental changes rather than through single, dramatic leaps in technical capacity.

In March 1995, government published a White Paper outlining a Support Strategy for Small and Medium Scale Enterprises and has since been putting in place most of the key institutions needed to provide much needed assistance to SMMEs in this country. However, to date, most of the attention has been focused on the first four needs listed above. The time has now arrived to put significantly increased emphasis on addressing the technological needs of SMMEs.

While much can be learned from overseas experience in providing technological support to SMMEs - and South African delegations have conducted extensive visits to gather and analyse that experience - the system introduced here must place greater emphasis on supporting entrepreneurs from the informal sector than would be necessary in most other countries.

The proposal to conduct a series of pilot experiments to develop a South African model of manufacturing technology is an important initiative. The model should emphasise two important tasks, namely that of reaching micro-entrepreneurs and that of tapping into the existing technological expertise to be found in this country, including the government SETIs.

DACST will work with DTI on a range of relevant issues related to technology diffusion in SMMEs. Of particular importance in this collaborative activity is the need to define the best available means of financing technology development for SMMEs.

4. **International Agreements**

Since the April 1994 elections, and following the re-entry of South Africa into the international community, several bilateral technology agreements have been signed with our main trading partners. At the international level, these agreements are intended to facilitate joint R&D; at the regional level South Africa has a special responsibility to facilitate innovation within our neighbouring countries.

These agreements all entail some commitment in terms of resources. In some cases, the costs can be considerable. These costs may not be significant in view of the net benefits to the economy when participation results in successful technology transfer or collaborative development.

In view of the government's responsibility to fulfil the role outlined above and the limitations on its resources, it is proposed that technology trade or collaborative agreements be considered individually and evaluated according to predetermined criteria. The following factors must be borne in mind when developing these criteria:

- The possible prevention of institutional co-operation between nationals from the two countries in the absence of a bilateral agreement.
- The degree of synergy between the two countries which will promote the productive outcome of collaborative programmes.
- Regional benefits (such as a multilateral agreement with SADC).
- Consistency with broad foreign policy objectives.

Science and Technology attachés deployed by DACST could play an important role in the evaluation of government's and the private sector's requirements for scientific research and for technology acquisition. Nevertheless, a cost-benefit analysis is essential and use must be made wherever possible of existing government infrastructure abroad, for example the network of offices run by the Department of Trade and Industry.

CHAPTER 9

Human Resource Development and Capacity Building

1. **Human Resources as a National Asset**

The Green Paper identified people as South Africa's most basic asset. This position was supported by the comments received in response to the Green Paper. The concepts of human resource development (HRD) and capacity building for the purpose of this White Paper are defined more closely below.

In its most general usage HRD refers to the process whereby people, either individually or collectively, acquire the knowledge and skills necessary for specific occupational tasks as well as for other social, cultural, intellectual or political roles associated with a vibrant democratic society. It also refers to the ability to access and utilise information resources, to give expression to theoretical concepts and their innovative application.

HRD is dependent on a comprehensive strategy outlining coherent and integrated policies in a wide range of related areas, including economic, labour, education and training, and science and technology policy. Central to this approach is the belief that attempts at reforming an element of the system, for example, education and training, in isolation of developments in other policy areas and social institutions will not generate the desired outcomes.

The concept of capacity building covers both institutional capacity and individual capacity. Institutional capacity building in South Africa will involve significant investments in infrastructure development. Such investment would focus on key resources and facilities needed to support the R&D environment such as education infrastructure, science parks, museums and libraries, as well as on "soft" infrastructure such as the facilitation of information flow, intellectual property issues, and other crucial elements in the utilisation of R&D products. However, tending to these needs alone will not provide well-functioning institutions. Developing modern and flexible management systems, geared to the mandate of the institution, and evolving strategic plans for the development of staff skills and competencies are just as important.

Individual capacity involves the development of high-level skills, competencies, values and attitudes required for S&T development. Referred as HRD, individual capacity building addresses training, but also includes curricula and reward systems for a research career and fostering a supportive research culture.

Science and technology performs a dual function in the process of HRD. On the one hand, it provides the knowledge and skills content of HRD programmes - S&T covers a spectrum of subject disciplines from basic numeracy to quantum mechanics. On the other hand, S&T also acts as the medium whereby knowledge and skills are transferred - an

example is the introduction of computer literacy which has positive spin-offs for a range of other knowledge domains.

2. **Links with the Growth and Development Strategy**

The Growth and Development Strategy is premised on six pillars. The first of these argue that growth and development must be based on *"Investing in people as the productive and creative core of the economy*". The government intends to create the following outputs related to HRD through the GDS:

- A *human resource development investment strategy* which would be an integrated and affordable five-year HRD plan.
- A *training strategy* which details sectoral investment programmes for the National Training Strategy, with a priority on immediate investment strategies.
- *Restructuring education* through improving the quality of education within the prevailing fiscal constraints with the priority on skills for employment, growth and democracy and a plan for effective backlog provision.
- *Social partnerships in human resource development* with specific reference to partnerships with the private sector on education, health and training. This also proposes a training investment target of five per cent of the salary bill.

DACST will be responsible for bringing the perspective of S&T to each of these programmes.

As HRD is a developmental strategy which requires a considerable amount of investment in time and hence finance, it can only be successful if based on effective social partnerships. The effective participation in such co-operative ventures is dependent on the constituents being properly organised. On the part of the public sector, this requires co-ordination across departments. Government recognises the need to improve this co-ordination, and has designated specific roles to individual departments within the framework of the GDS.

The most significant social element of HRD is its contribution towards the social emancipation of individuals and to the collective upliftment of society. Individual members' general well-being is improved through their acquiring the skills to deal with the day-to-day challenges of society and also through their personal involvement in the social, political and economic spheres of life.

The projected economic goal is a qualitatively enhanced production process with highly skilled labour and management co-operatively contributing towards growth. Such an achievement, in the context of the new GDS, should promote the institutional basis for co-operation and the required investment.

3. **Equity through Redress**

The most pervasive effect of the system of apartheid is the legacy of inequalities generated by decades of policy interventions specifically designed to exclude the majority of South Africans from participation in social, political and economic spheres of life. Programmes need to redress the inequalities which have excluded black women and men from the mainstream of South African society.

An effective HRD programme in science, engineering and technology is therefore vital to redress this imbalance, to improve our economic performance and to ensure the proper functioning of the NSI. Such a programme will have to address the consequences of past deliberate policies and practices that promoted racial and gender discrimination in HRD. Apart from the human rights issue, there is also the imperative for South Africa to optimise its productivity and economic performance to succeed in the global marketplace. To achieve this goal, South Africa will have to maximise the utilisation of ideas, creativity, ingenuity and innovation from the entire population.

By establishing appropriate enabling S&T policies in South Africa, we could move toward equity. This expectation is rooted in our belief in human rights and the belief that sustainable human development will occur faster where equity exists. Deliberate and affirmative actions need to be implemented. Aggressive promotion of the principle of lifelong learning gives South Africa the best chance, in the long term, of redressing SET-related skills, where the imbalances were most pronounced.

In the short term, DACST is collaborating with the Department of Education in the Students and Youth into Science, Technology, Engineering and Mathematics (SYSTEM) programme, a student recovery programme linked to teacher development. Consultations between government and the stakeholders, including teacher organisations, will be undertaken to promote the success of this strategy. DACST will also network with the Department of Education regarding the Technology 2005 programme.

4. **Research Capacity Development at HDIs**

Historically disadvantaged institutions (HDIs) have very limited research capacity, mainly because these institutions had been created to serve the homelands as part of apartheid policies. The emphasis of their original mission was on teaching and militated against their developing a research focus. Government is committed to improving the HDI's capacity to perform R&D. To facilitate this objective, DACST has a programme to obtain Official Development Assistance funding to establish or strengthen centres of excellence in research in HDIs. The objectives of this programme are

- to stimulate the development of S&T
- to target women and black students in these fields of study and
- to leverage institutional change in keeping with the first two mentioned.

Awarding of grants will be based on

- ability of programmes to deliver in the immediate term
- evidence that programmes promote staff development
- incorporation of a strategy for sustainability
- specification of expected graduate and research outputs and
- gender targets.

5. **HRD and Capacity Building at the National Level**
    1. **Foundations of an HRD policy**

        A national HRD and capacity building strategy must aim at building scientific, technological and managerial abilities and capacities at the individual, institutional and community levels. To achieve this objective would require an approach that promotes flexibility and transsectoral participation, the establishment of standards, accreditation and certification criteria, credit transfer and the redress of inequities. This scheme should also introduce mechanisms to promote efficiency and linkages to elements of the Growth and Development Strategy. It should also provide a framework for sustainable implementation.

        The central enabling mechanism for such an approach is the National Qualifications Framework (NQF) and the statutory body established to regulate its functions, the South African Qualifications Authority (SAQA). The objectives of the NQF are threefold. Firstly, it aims to create an integrated national framework for learning achievements; secondly, it seeks to improve access to, mobility and progression within, education and training; and thirdly, its overarching aim is to enhance the quality of education and training.

    2. **Implementing the policy**

        The relationship among institutions must be organised so as to advance the GDS. This means that government institutions, the private sector and other stakeholders must collaborate in determining the policies, planning and implementation of the HRD programmes. Institutions must be brought into the process of policy making and development, planning, management, implementation and evaluation in a coherent way.

Linkages between these institutions must be determined so that the collective institutional resources are available to develop the HRD process. SAQA will ensure that linkages exist between the various systems, sectors and programmes.

3. **Lifelong Learning**

The concept of lifelong learning has been endorsed by the tripartite discussions of the National Training Board (NTB). The NTB has adopted a holistic approach towards education and training, combining the socio-economic needs of the country and the development needs of the individual. This approach changes the thinking around education and training as separate activities, to one of "lifelong learning". Institutions must therefore move toward structuring themselves to support the creation of learning- and knowledge-centred organisations.

The White Paper on Education and Training of 1995 argues that the present disparities in skills and competencies evidenced in the labour market is a direct product of a segregated system of education and training. The result is the reproduction of inherited racial, ethnic and gender hierarchies in private, parastatal and public employment. This legacy has also resulted in an imbalance in the composition of graduates produced by institutions of education and training. For example, South Africa continues to produce a disproportionately low number of technikon graduates relative to the number of university graduates. In fact, the inherited systems have been designed in such a manner as to discourage contact among institutions at the higher education level.

The White Paper on Education and Training describes the overarching goal of the national education and training policy as being

to enable all individuals to value, to have access to, and succeed in lifelong education and training of good quality. Educational and management processes must therefore put the learners first, recognising and building on their knowledge and experience, and responding to their needs. An integrated approach to education and training will increase access, mobility and quality in the national learning system.

The ever-increasing technological content of competitive modern economies requires a society with lifelong learning as part of its standard norms, ethos and practices. More importantly, policymakers and decision makers in government, business and industry must integrate the lifelong learning ethos into the competitive strategy of the nation.

An integrated curriculum will reflect the norms and values of a non-racial, non-sexist and democratic society. It must ensure that the curricula are relevant to both the needs of the individual as well as to the social and economic demands of society. South Africa needs to move away from static and solely content-driven syllabi towards curricula directed towards problem-solving. This approach will demonstrate the artificiality of the some of the distinctions between academic and vocational training.

4. **Compulsory Mathematics/Science at Pre-tertiary Level**

The comments received in response to the Green Paper have shown overwhelming support for maintaining compulsory mathematics and science up to the exit level (currently Std 7) from the compulsory phase of education and training. These subjects would consequently be contained in the General Education Certificate of the system proposed by the Department of Education. The implementation of this however depends on the availability of the necessary skilled educators and trainers in these fields. The SYSTEM programme is also concerned with this issue.

6. **Adult Basic Education and Training**

For any HRD strategy to be meaningful in the South African context, a comprehensive and affordable adult basic education and training (ABET) programme must receive high priority to ensure the furthering of the skills and career prospects of workers and the unemployed. Adult basic education and training must therefore be provided to redress discrimination and inequality imposed under apartheid as well as to redress the exclusive "youth" focus of schooling.

The future system must therefore make provision for lifelong-learning opportunities to serve a wide range of learners through structures that will be readily accessible and affordable. Concerted interventions in the field of ABET will contribute greatly toward achieving the objective of human resource development through massive expansion and qualitative improvements in the provision of education and training.

ABET is aimed at providing adults with education and training programmes equivalent to exit level in the formal school system, with an emphasis on literacy, numeracy and technological skills. It constitutes a fundamental and crucial step in the GDS. The provision of ABET can be accelerated and expanded by building partnerships between the state, employers, labour, communities, funders and non-government organisations (NGOs). Such collaboration would also assist in establishing a process for funding support of national ABET programmes in S&T, which should be managed at provincial and local levels by relevant stakeholders. DACST will, through engagement with SAQA, contribute to the development of an effective ABET curriculum and policy relating to S&T.

7. **Technology Education**

Based on the general acceptance that technological capability is central to contemporary society, many advanced and developing countries have introduced technology education into the school curriculum. There is considerable debate as to whether technology is a discipline in its own right, whether it should be taught as part of science, or spread across the curriculum. In many countries the implementation of technology as a subject has been undermined by a shortage of resources and teachers, inadequate support, and confusion about its philosophical underpinnings. Currently a national technology education pilot project is being implemented in the General Education phase of schooling with the aim of evaluating the curriculum implications.

Based on the overwhelming support received in responses to the Green Paper for introducing technology education across the General Education system, DACST will assist the Department of Education in developing a technology education programme for schools.

8. **Public Awareness of S&T**

Access to information is empowering, enabling people to monitor policy, lobby, learn, collaborate, campaign and react to proposed legislation. It is also one of the most powerful mechanisms through which social and economic progress can be achieved. The democratisation of society and elimination of poverty can only occur if people have equal access to the services and resources they need to perform their productive tasks. Democracy implies being aware of choices and making decisions. The extent to which this is possible depends largely on how much information is available to the people and how accessible it is.

For the national system of innovation to become effective and successful all South Africans should participate. This requires a society which understands and values science, engineering and technology and their critical role in ensuring national prosperity and a sustainable

environment. This, in turn, requires that S&T information be disseminated as widely as possible in ways that are understood and appreciated by the general public.

Recent history has demonstrated the potential of technology to improve the quality of people's lives. Yet disadvantaged populations in general and women in particular, especially those in rural areas, have little access to information about these technologies. To date, a combination of factors have prevented them from gaining equitable access to the information they need and have thus limited their ability to participate more fully in the transformation process in South Africa.

A campaign to promote awareness and understanding of S&T and of its importance will have two key elements, namely promoting S&T literacy on the one hand, and promoting the power of S&T on the other. These programmes would include

- increasing familiarity with the natural world
- promoting understanding of some of the key concepts and principles of S&T
- demonstrating that science, engineering and technology are social tools and
- fostering the ability to use S&T knowledge in ways that enhance personal, social, economic and community development.

The deficiencies of the current system are multifaceted. The solution of this problem requires an innovative approach in itself. All available SET institutions in South Africa should be actively involved in such an initiative.

Government will institute via DACST the delivery of S&T public awareness programmes in collaboration with consortia of institutions, including societies for the advancement of science, professional associations, academies of science, science museums and libraries, media (printed and electronic), educational institutions and private business.

CHAPTER 10

Science and Technology Infrastructure

In this White Paper the term "science and technology infrastructure" refers to national research facilities and services, to libraries and to regulatory frameworks, as well as to extended physical structures such as telecommunications networks. These systems are part of the overall public investment programme in infrastructure recently outlined in the government's Macroeconomic Strategy document.

1. **Establishment, Operation and Maintenance of Information Services**

    1. **Communications and Information Systems**

    However, when almost the entire nation can be viewed as strong stakeholders in a particular infrastructural facility such as information services, government needs to be active also at the regulatory level, applying flexible and responsive structures to deal with such a rapidly changing environment. Moreover, it is vital for government to ensure acquisition and effective use of up-to-date S&T information and to ensure access to international electronic information resources (for example, e-mail, world-wide web, and multimedia equipment).

    The systems underpinning an effective national information system are:

    Telecommunications infrastructure

    The telecommunications infrastructure should involve

    - service provision to all sectors of the community in all geographic areas
    - digital telephone exchanges and transmission networks
    - broad and narrow-band transmission capabilities, to cater for all types of applications, from simple voice transmission to video-conferencing
    - connections abroad by means of satellites and optical fibre cables

    In South Africa 60% of exchanges are digital, as are 95% of all networks. Moreover, connections to the outside world are approaching international standards. The most inadequate performance is in the area of service provision to disadvantaged communities. This inhibits the possibility that information technology (IT) can be used to bypass obstacles in the way of development, particularly in the areas of education and health.

    Information technology infrastructure

    The IT infrastructure stores and processes the information exchanged between content providers, service providers and users and is often described as the "firmware", as opposed to the telecommunications

hardware. An available and reliable infrastructure, including national standards, will provide the platform from which competitive deployment of IT can take place. System design must minimise the skill level required of users.

An information architecture

Information architecture is that part of the infrastructure that guides the creation and utilisation of information resources. It should be designed to include the following principles:

- Freedom of access to information
- Privacy of personal information
- Respect for intellectual property rights
- Security and integrity of information.

These regulatory principles enable the smooth and civilised functioning of the information society. Disruption of principles, for example by introducing viruses or by "hacking" into confidential systems, must carry criminal penalties.

A national management structure

The management structure must co-ordinate the amendments needed to policies and regulations to ensure the inter-operability of the physical and information levels as well as the constituent physical networks, and direct or fund R&D activities aimed at supporting these. South Africa is in dire need of a management system that will facilitate a sound national information infrastructure.

2. **Libraries and Museums**

Libraries play an important role in the NSI in two ways. Technical libraries are an essential resource for research workers and technologists, and must be constantly maintained and kept up to date. The NSI must ensure that adequate funds are allocated for this purpose. Furthermore, strategies must be developed for regional sharing of such resources and for supporting specialist libraries in particular subjects, based in centres of excellence in those topics. General libraries can play an important role in adult education in general and in the public understanding of science in particular.

An important issue is the degree to which the libraries will be able to invest in modern information technology. As more information becomes available in electronic form, both the technical and general library services should develop a long-term plan to take full advantage of these developments. The existence of SABINET (the South African Bibliographical and Information Network) is a good start in this regard. Provision of such facilities in deprived rural and urban areas can be an important tool in capacity building and in increased access to resources in these areas.

There are over four hundred museums receiving public money in South Africa. The majority of these are supported by municipalities or the provinces, but some, particularly the larger ones, are funded nationally via DACST. South African museums fulfil unique research and service functions, particularly in taxonomic and even forensic sciences. Internationally museums are important participants in scientific research. In South Africa, therefore, the research role of our museums must be defined and encouraged. Museums can also play a positive role in fostering public awareness of science and technology. In this regard the Department will investigate the establishment of a science museum with a strong public awareness orientation.

3. **Statistical Services, Indicators and Data Bases**

It is the function of government to run data gathering and statistical services such as censuses and economic and climatic indicators. The involvement of government in these activities is usually predicated upon the large costs involved, the fact that the statistics should be on public domain or that privacy of personal information is relevant.

The Research and Technology Audit will result in a substantial data base which will need to be maintained and updated regularly - a responsibility that DACST will assume.

2. **Establishment, Operation and Maintenance of Technical Services (e.g. metrology, standardisation, calibration)**

By and large, measurement and calibration activities, from minerals assaying to the determination of blood sugar, are conducted outside government. Nevertheless, government must provide the legislative framework for the national measurement system. There are five basic

types of technical service which should be maintained at a national level:

Measurement standards. Measurement standards must be maintained according to international requirements in association with the International Bureau for Weights and Measures. The national measuring standards represent the highest authority in the country's measurement chain and provide the connection to the rest of the world. They have impact on trade and trade policy and are therefore strategic to government.

Calibration. The next link in the chain is the process of calibration in terms of the measures mentioned above. Calibration laboratories need to be accredited to ensure traceability in measurement and to ensure competent testing. This operates as a specialised service and therefore not at the level of government strategy.

Product and service standards. Some of these, particularly those involving products whose failure could be detrimental to health and safety, are compulsory. The majority, however, are voluntary, and their adoption is seen merely as a mark of quality. The WTO Agreement on the Technical Barriers to Trade is moving the world towards harmonisation of standards.

Quality and environmental management standards. Examples are the ISO 9000 and ISO 14000 series. These standards are closely allied to product and service standards and can enhance the competitiveness of a firm, particularly an SMME, which does not have a trade name of note. Increasingly, the application of these standards is a prerequisite for trade with European Union countries.

Accreditation. A national accreditation system has to be in place to provide for national and international recognition for calibration and testing laboratories and product and system certifiers.

To promote competitiveness in the international arena, South Africa has no choice but to remain with or adopt international systems of standards and conformity certification. To do otherwise would jeopardise the acceptability of our exports in world markets. Nevertheless, there are strong arguments in favour of abridging mechanism to address the lack of technological expertise or infrastructure, the level of which is pegged to international standards.

All government-funded organisations involved in maintaining standards and in calibration services, such as the South African Bureau of Standards, the National Calibration Service and the National Metrology Laboratory of the CSIR, will be subject to the review system for SETIs.

3. **Operation and Maintenance of a System of Awarding, Recording and Protecting Intellectual Property**

   Whatever regulatory system South Africa adopts for awarding, recording and protecting intellectual property (see section 6.1), there are certain requirements of the system administering the patents. In particular, search and retrieval capabilities should utilise modern information technology to reduce management costs and to promote compliance with international standards.

4. **Establishment, Operation and Maintenance of Major National Facilities for Research**

   Research laboratories or facilities may be established at a national rather than an institutional level for reasons of cost. Traditionally, the national facilities (NFs) cater for "big science", and draw in researchers from institutions across the country. Currently there are three NFs in South Africa:

   - the National Accelerator Centre (NAC)
   - the South African Astronomical Observatory SAAO)
   - the Hartebeesthoek Radioastronomical Observatory (HartRAO).

   The National Accelerator Centre performs three functions, namely nuclear structure research, radioisotope production and treatment of cancer patients by means of neutron and proton therapy. Its multidisciplinary character serves as a model for other similar institutions world-wide.

   The two astronomical facilities each have sound research records and are able to take advantage of the desire of northern hemisphere researchers to access quality data from the southern skies.

   All three existing NFs could benefit human resource development and the scientific community as well as the wider public's perception of them by being involved in the formal tuition programmes of local universities.

   In general, the future establishment of NFs must be motivated by national needs because such facilities consume substantial government resources. The government should also be satisfied that proposals for new NFs have the broad support of the SET community. The main criteria for the establishment or the evaluation of NFs should be:

   - Quality, quantity and diversity of scientific output in the context of clear national benefit.
   - Potential to attract international collaborators. This will be greatly enhanced if local South African conditions are seen to

offer scientific advantages to a sector of the international scientific community.
- Educational output, in terms of quality and quantity of higher degrees produced.
- Strength of interaction with universities and technikons, particularly HDIs and success achieved in encouraging a research culture.
- Partnerships with industry.

Access to the NFs will be determined according to the same principles as have been outlined for grant funding (see section 7.3), although proposals from outside the higher education sector will also be considered. Proposals will be evaluated on merit, with preference being given to larger projects which form part of broad scientific thrusts determined by the Advisory Board.

This White Paper has proposed (see section 8.2.6) that the SAFARI research reactor at the Atomic Energy Corporation site at Pelindaba be declared a National Facility. A recommendation made in submissions to the Green Paper was the establishment of a SET computing and general network infrastructure (encompassing the existing network for universities and technikons - UNINET) which would give South African researchers access to world-class computing facilities. The feasibility of establishing this network as a NF with its own budget should be investigated.

The NFs will be administered by the National Research Foundation (see section 7.3).

5. **Scientific Equipment**

Provision should be made for purchase and maintenance of costly items of research equipment not at the national facility level, for example, mass spectrometers, electron microscopes or DNA sequencers. These should be allocated by the NRF, taking into account the following principles:

- Access by all researchers in the region, particularly those from HDIs
- Optimal placement with respect to concentrations of researchers in the relevant field
- A contribution in kind from the chosen SETI.

CONCLUSION

There is a broad perception in South Africa, which was confirmed by the Green Paper and by many of the submissions to the Green Paper, that we have in place an ailing national system of innovation. It is fragmented and is neither co-ordinated within

itself nor with national goals; innovation capacity is not being built but is being eroded; national investment in R&D is not increasing relative to GDP, but falling. This decline is taking place at a time when we can ill afford it. We have embarked upon huge programmes of redressing the imbalances and inequities of the past, but are less able to meet the challenges with new and innovative solutions. We have committed ourselves to regional development but lack the resources to honour our commitments. We have opened our markets to international competition, but we are becoming less competitive.

Whilst it must be the concern of the whole nation to breathe new life and vitality into the NSI, there are several areas where government must play its part, either exclusively or with its partners and at several levels. This is the focus of the policies contained in the White Paper. The policies have not been proposed in isolation of other developments in government. Wherever possible, the White Paper has attempted to align the proposed policies and actions with the stated policies of other government departments. It has taken cognisance of the National Strategic Vision, the recently published Macroeconomic Strategy of the Government, other White Papers and the submissions to the Green Paper itself in order to prepare a policy agenda for government which will take the country into the 21st century. Many of these policies are specifically attempting not only to sweep aside the deficiencies of the past, but also to set new standards and goals by which scientists of all types, engineers, technologists and innovators can achieve new heights of national and international respectability.

Within the NSI, the White Paper has proposed policies :

- to create clear channels for capacity building, human resource development and inequity redress
- to create channels to promote innovative solutions to some major problems of the country relating to S&T
- to establish mechanisms to re-allocate government spending according to new priorities, particularly the problems of the disadvantaged
- to set in motion processes that will challenge government research institutions to derive more support from competitive sources of funding
- to introduce a longer-term perspective in thinking, planning and budgeting which will be facilitated by the introduction of the Medium-Term Expenditure Framework
- to introduce institutional changes and new management approaches.

Government's prerogatives include the establishment of laws and regulations, the allocation of public resources according to its priorities, and the initiation and implementation of programmes of activity relating to these functions. The White Paper has defined a policy agenda which covers all three areas.

It is our firm conviction that, by addressing the agenda set in this White Paper, we can turn a fragmented and inefficient NSI into a system that will increase the output of products, processes and organisations which are truly and remarkably innovative, and thereby help to build the new South Africa which we are all seeking.

List of Abbreviations

ABET	Adult basic education and training
AEC	Atomic Energy Corporation
CSIR	Council for Scientific and Industrial Research
DACST	Department of Art, Culture, Science and Technology
DBI	Department-based institutes
DG	Director General
DTI	Department of Trade and Industry
FA	Framework autonomy
FRD	Foundation for Research Development
GDP	Gross Domestic Product
GDS	Growth and development strategy
GEIS	General Export Incentive Scheme
HDI	Historically disadvantaged institution
HES	Higher education sector
HRD	Human resource development
IDC	Industrial Development Corporation
IPR	Intellectual property rights
ISO	International Standards Organisation
IT	Information technology
LBSC	Local Business Service Centre
MA	Maximum averages
MCST	Ministers Committee for Science and Technology
MTC	Manufacturing Technology Centre
NACI	National Advisory Council on Innovation
NF	National facility
NGO	Non-government organisation
NQF	National Qualifications Framework
NRF	National Research Foundation
NSI	National system of innovation
NSTF	National Science and Technology Forum
NSV	National Strategic Vision
NTB	National Training Board
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
SADC	Southern African Development Community
SANDF	South African National Defence Force

SAQA	South African Qualifications Authority
SC	Science council
SET	Science, engineering and technology
SETI	Science, engineering and technology institutions
SHE	Safety, Health and the Environment
SMME	Small, medium and micro enterprises
SOC	State-owned corporations
SPII	Support Programme for Industrial Innovation
S&T	Science and technology
SYSTEM	Students and Youth into Science, Technology, Engineering and Mathematics
THRIP	Technological Human Resources for Industry Programme
WTO	World Trade Organisation

Footnotes

1. The National System of Innovation is defined and discussed more rehensively in Chapter 3.
2. This is the annual meeting of Foreign and Finance Ministers of OECD Countries.
3. Henceforth referred to as The Green Paper.