BUILDING A NEW SOUTH AFRICA

SCIENCE AND TECHNOLOGY POLICY

FOREWORD BY
NELSON MANDELA

From 1991 to 1995, Canada's International Development Research Centre — in partnership with the African National Congress, the Congress of South African Trade Unions, and the South African National Civic Organisation — conducted a series of missions in South Africa to assist that country in its transition to democracy. The reports of these missions — earlier ones with an analysis of their impact — are presented together for the first time as four volumes in the series entitled *Building a New South Africa*.

Volume 1. Economic Policy

Volume 2. Urban Policy

Volume 3. Science and Technology Policy

Volume 4. Environment, Reconstruction, and Development

BUILDING A NEW SOUTH AFRICA

Volume 3
Science and Technology Policy

a report from the
Mission on Science and Technology Policy for a Democratic South Africa

with a Foreword by **Nelson R. Mandela**
and an Afterword by **David Kaplan**

edited by **Marc Van Ameringen**

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FOREWORD

A nation's commitment to science and technology, or S&T, is often an indicator of its stage of economic, social, and cultural development. In South Africa, we are fortunate to have a strong S&T infrastructure, including numerous institutions and well-trained people. Unfortunately, these structures and people have been guided by a policy based on benefiting a minority and supporting the security needs of a regime whose primary objective was to maintain apartheid.

The use of S&T to bolster apartheid resulted in an international cultural and scientific boycott of South Africa. This had the effect of excluding South Africa from the international flow of S&T knowledge. A direct consequence of this has been declining investment and innovation in the area, which has had a profoundly negative impact not only on S&T research but also on the overall development of our nation.

Recognizing the importance of S&T to a democratic, nonracial South Africa before the election of the Government of National Unity, we in the alliance requested the assistance of the International Development Research Centre to help us assess the S&T system in South Africa. The resulting mission brought together not only the leading international experts with those in the democratic movement who were working in the area of S&T but also, for the first time, allowed us to interact with the heads of the S&T establishments in the country. This constructive engagement opened the door to cooperation among all sectors and resulted in a new multistakeholder body that played a critical role in guiding the discussion about South Africa's future in S&T policy.

I remember the advice given to me by one of the international members of the Mission, Dr Thomas Odhiambo, head of the African Academy of Sciences, about how important our future investments are in the area of S&T and how many African countries are only now realizing that they would have been further along the path of economic development had they recognized, following independence, the importance of investments in this area. This lesson has not escaped our new government and indeed S&T is recognized as a major pillar of the Reconstruction and Development Programme.

Nelson R. Mandela
September 1995

PREFACE

This book is the third in a four-volume series that describes policy-related processes undertaken by the International Development Research Centre (IDRC) in South Africa. It represent part of the contribution of Canada, and in particular IDRC, to the process of political transition from apartheid to democratic governance. This specific report details the IDRC-supported Mission on Science and Technology Policy for a Democratic South Africa.

Background

Over the past few years, there has been an increasing interest in science and technology (S&T) in South Africa. A reflection of this has been the emerging policy debates in this field and the establishment of some significant new institutions.

In 1993, for example, the Science and Technology Initiative was constituted. Its mandate was to provide a broad-based forum in which short- and long-term issues pertaining to science policy could be discussed. A year later, following the elections, this forum evolved into the National Science and Technology Forum for consultations on S&T issues between government and the broad S&T community. A ministry, with a national and deputy minister concerned with S&T issues, has also been established — the first time in South African history that S&T has had its own dedicated ministry. In this new context, the government is now actively engaged in formally developing a new S&T policy that will, for the first time, take into account the views of all South Africans.

There is clear recognition of the need to link S&T policy to economic policy and social needs. As the South African government's Reconstruction and Development Programme White Paper states:

> Science and technology have an important role to play in the development of all sectors of our society [and] technology policy must address the [extremely unequal distribution of resources], and must also address both the development of indigenous and exogenous science and technology, in order to meet the challenges of South Africa's people.

The current interest in S&T policy is a major break from the past. Under apartheid, S&T policy formulation was a selective process controlled by a few key officials in the government and involving limited consultation even within its own ranks. S&T policy was captive to South Africa's strategic and military interests, forwarding those of the white minority. As Jayendra Naidoo (then COSATU negotiations coordinator) remarked: "Science and technology policy was used to underpin the state's oppressive apparatus and bolster apartheid." In essence, the S&T system that emerged was fragmented, unfocused, and poorly managed.

To understand the process and function of IDRC's S&T mission in terms of the policy debate, it is first necessary to understand the political backdrop against which this initiative unfolded. A little more that a year before the commencement of this initiative, the National Party government led by F. W. de Klerk released Nelson Mandela from prison and unbanned the African National Congress (ANC) and other extraparliamentary organizations. The following year, parliament voted to scrap the *Group Areas Act* (1913), the *Land Act* (1936), and other legislative pillars of apartheid. By November 1991, 20 organizations, including the government and the democratic movement, resolved to form the Convention for a Democratic South Africa (CODESA), a forum for discussing mechanisms for transition to democracy.

The first plenary session was held in December 1991, even though the Pan African Congress had withdrawn from the process. The discussions continued though the first part of 1992, although they were characterized by dissention and ambiguity. In June 1992, negotiations were suspended by the ANC after the massacre in Biopatong Township. The ANC and 10 of its allies pulled out of CODESA — the ANC vowing to intensify mass action until its demands were met.

In September 1992, as the IDRC mission officially commenced, negotiations between Mandela and de Klerk had resumed, as had discussions at CODESA. While preparatory work for the S&T mission was under way in October, a new crisis erupted in CODESA with the withdrawal of Chief Buthelezi and Inkatha from the discussions.

The uncertainty of the direction that CODESA and the negotiations would take continued through the period when most of the Mission's work took place. At times, in fact, it was felt that the Mission process should be abandoned, given the state of negotiations and political violence.

As the main part of the Mission process was coming to a close, negotiations were getting back on track with a series of multilateral talks between the ANC, the government, and Inkatha. In April 1993, the Negotiations Council began weekly meetings to discuss the transition and the holding of South Africa's first multiparty elections, scheduled for the following year. At the same time (May 1993), the first meeting of the newly established Science and Technology Initiative was held. In July 1993, Inkatha, Kwazulu, and the Conservative Party pulled out of the negotiations.

This event coincided with the release of the Mission's report. A few days later, a draft of a postapartheid constitution was unveiled. This Interim Constitution was finalized in the months before democratic elections were held (April 1994).

Understanding this political context is fundamental to grasping the significance of the Mission. Although clearly the constitutional process was fraught with conflict, and at times appeared deadlocked, there was a willingness at the sectoral level to engage in negotiations. Indeed, one of the unique qualities of the transition to democracy was the widespread negotiations running formally and informally at all levels of society — by 1994, there were over 250 multistakeholder negotiating forums active in the country.

A precondition to the successes of these forums was the willingness of the stakeholders, particularly the government and the democratic movement, to engage in the discussion of issues of transition and the provision of a mechanism to discuss and disseminate policy positions. In this respect, perhaps the most important outcome of the S&T mission was that it did furnish the S&T community with a vehicle for such discussion.

The Mission Process

For the Mission, IDRC assembled an international team from both developed and developing nations (see Appendix A). However, unlike IDRC's earlier missions (economic and urban policy), where the members of the democratic movement and IDRC both played a role in all parts of the process, the S&T mission was modeled on the external examination style of the Organisation for Economic Co-operation and Development (OECD). In following the OECD method, the Mission members alone were responsible for the content of the report.

The Mission process comprised three stages:

1. The "buy in" of the main stakeholders and the preparation of background documents on the existing S&T system;
2. A nationwide investigation of this issue and the compilation of a report; and
3. A series of meetings between Mission members, sponsors of the review, and those who were interviewed to allow for full exploration of the observations, conclusions, and questions raised by the Mission.

During the first stage, the most critical step was obtaining the agreement of the heads of S&T institutions, most of whom where seen by the democratic movement as aligned to the National Party government. An invitation to lunch from IDRC to all these directors provided the opportunity for the ANC to approach the subject of whether these science bodies would participate in the proposed Mission process. Although there was some hesitation, the presidents and senior officials of science councils agreed to play an active role. This phase also included the preparation of the background papers that provided important information on the nature of the S&T system.

In the second stage, the Mission held workshops and interviewed key actors within the S&T community — in government, the private sector, and civil society. Most of the time allowed was spent reviewing the main S&T institutions in detail. During this process, most institutions were very open to the need for change and transformation and, in some cases, had prepared exceptional presentations. Both international and local members of the Mission team were struck by the overall openness of the actors in the S&T community and their willingness

to engage in a process of transformation and adapt to the coming postapartheid period.

Clearly, the most interesting exercise was the third and final stage of the process, or, in OECD jargon, the "confrontational" stage. As a result of the divisions between the democratic movement and government, two separate meetings were held: one with the democratic movement and civil society S&T-related institutions; the second with government, business, and more establishment-related institutions. It was believed that a joint meeting would have been unworkable, given the level of animosity and resentment.

The meeting between the democratic movement and the nongovernmental sector was useful, and a number of valid contributions were made. The second meeting was perhaps more significant. As the *Saturday Star* reported on 6 March 1993:

> They came from the four corners of South Africa — science and technology leaders representing all the major science institutions, educators, businessmen and industrialists, of all political persuasions. Their common ground was science and the conviction that their discipline underpinned all aspects of the social and economic future of the South Africa. The fact that they had gathered at all, was history in the making.

Although the historical significance of the meeting should not be overlooked, there were clearly major divisions over whether to embrace the report or challenge its main findings and also whether it was even possible to address the main issue of reforming the S&T system without first addressing its role in supporting apartheid. As Frene Ginwala said: "Unless we bring up what has happened and face its consequences, we cannot move forward."

Although this meeting unfortunately ended on an acrimonious note, there were a few key actors in the audience, including Brian Clark, former head of the Council for Scientific Research, and Frene Ginwala, who were willing to take the challenge forward and were instrumental in furthering a new agenda for S&T policy in South Africa.

The Outcome

The Mission process was significant for a number of reasons. It empowered the democratic movement by putting international resources at its disposal to undertake a comprehensive review of the

S&T systems in South Africa. Furthermore, the process gave the democratic movement the credibility it needed to engage with the leadership of key national institutions and government. It also clearly moved the terrain for charting S&T policy for South Africa from government to the democratic movement.

The report itself represented an important contribution to the S&T debate. Key principles outlined the steps that needed to be taken into account to transform the sector; at the same time, it provided a fair assessment of the status of the S&T system. Although the report was clearly important, what was more critical was the fact that the Mission provided a vehicle to address these issues. The significance of this cannot be underplayed in terms of its role in addressing the past, beginning to change mindsets, and paving the way for the future.

Today, IDRC continues to encourage this process by supporting the Science and Technology Initiative, establishing S&T policy research centres, and playing a key role in assisting the Ministry of Arts, Culture, Science and Technology in preparing Green and White Papers and reforming the overall S&T system.

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Members of the Mission on Science and Technology Policy for a Democratic South Africa with Nelson R. Mandela.

Chapter 1
INTRODUCTION

The Internal Context

The review of South African science and technology (S&T) policy presented in this report was carried out during a period when that country was in the early stages of fundamental political transition. It has committed itself to a process of transformation by abandoning its strategy of "grand apartheid," which had made it an international pariah and the object of extensive international sanctions, and which had marginalized the vast majority of its population by systematically denying it the political, social, economic, and cultural rights and freedoms that are the basis of any truly democratic state.

However, constructing a new future has not been easy. At the time this report was prepared, formal negotiations around the creation of an interim government and the drafting and implementation of a new democratic constitution were officially stalled. The climate of violence showed no signs of diminishing, and global economic recession was seriously affecting the South African economy.

To understand South Africa's institutions, it is necessary to see them as products of the apartheid system. Where else but in South Africa could one find a state that had created 15 parallel departments of education, 15 departments of health, and 14 departments of agriculture under the guise of giving different groups responsibility for their "own affairs," while systematically depriving all but one racial group of adequate resources to manage those affairs?

In a letter requesting this review, the African National Congress (ANC), through its research department, argued that:

> The institutions [of the state engaged in the research system], their policies and agendas, their employment and training practices, and even their attempts at adaptation to political change, have been shaped by years of service to a society structured on apartheid lines. Scientific research and technological development were subordinated to the ideology of "total strategy," fashioned in order to mobilise the country's resources in defence of white minority rule. Social investigation was dominated by apartheid notions and in particular with the management of "group relations." Military requirements set the agenda for technological development.

> During the mid-1980s, these institutions, recognising that the existing political and social order had only a very limited future, embarked on various programmes of restructuring. Those in control did this without consultation. Conceived within the framework of the old order, these processes excluded the major social and political actors from the determination of the programmes of change. They have, therefore, failed to confront the fundamental issues relating to the transformation of the national research system into one which will serve the needs of a democratic society.

The legacy of apartheid, as seen by members of the democratic movement, has led to the evolution of a research system whose principal characteristics are as follows:

- Orientation toward the needs of the white minority;
- Emphasis on technological development to serve the needs of state security and suppression of the majority of the population, as evidenced by the large share of resources allocated to defence and the nuclear program;
- Imposition of secrecy as an imperative value in the workings of government and the stifling of debate, even among the white population, on major issues of public policy;
- An approach to technological development — dominated for many years by domestic protectionism and external economic sanctions — that allows policy choices and resource allocations to be based on criteria related to the presumed interests of state security rather than economic efficiency or social equity; and
- Rationalization, within the scientific community, that S&T developments are, in some sense, apolitical, hence absolving this

community of any responsibility for the policies that their activities serve.

During our visits and lengthy discussions with senior officials, we saw evidence of attitudes and practices that reflect these far-reaching criticisms. There was an assumption, usually implicit, that the S&T system should continue to serve the needs of "First World" South Africa, making only token gestures to the "Third World" conditions in which the vast majority of the country's population lives.

However, we also saw people trying to understand the realities of the past and trying, to the limits of their abilities and, more importantly, to the limits of their experience, to adjust to the new way of working, as one official put it, "in a scientific institution in a large, African, developing country, not in an industrialized country with a large poor minority." Especially important, we saw evidence that many of the institutions we reviewed are struggling to find ways to meet the challenges of globalization of technological development (a process from which the international community has sought to exclude South Africa until it returns to an acceptable form of democratic behaviour) and the challenges of a global economic recession.

Our observations enabled us to evaluate and comment on the changes being implemented by many institutions as a result of the confluence of three sets of forces:

- Those created by the pressure for real political change within the country;
- Those demanding a response to the rapid globalization of the processes of technological development that no country can afford to ignore; and
- Those imposed upon the S&T system by the effects of a global economic recession that has restricted the capacities of all governments to provide resources for many activities, including those relating to S&T and, ultimately, to future prosperity.

As if these challenges were not enough, we found that individual institutions are trying to adapt in a policy vacuum at the highest levels of the current South African government. In the past, during the days of the National Party government's "total strategy," there may have been strong coordination and shared purpose among the institutions of the white-dominated state. We found no evidence of this in the current

environment. Rather, we saw a series of institutions, each trying to define a role for itself in a "new" South Africa, a concept they were only beginning to understand.

Background to the Mission

This Mission originated in discussions among researchers related to the mass democratic movement, which followed the January 1992 symposium on "The Role of Research in Transforming South Africa," cosponsored by the journal *Transformation* and Canada's International Development Research Centre (IDRC). A striking feature of the vigorous debates at that symposium was an absence of discussion of possible directions for research policy in a future South Africa. Out of this observation came discussion among the ANC, the Congress of South African Trade Unions (COSATU), the South African National Civic Organisation (SANCO), and IDRC on what steps might be taken to make research policy or, more broadly, S&T policy the subject of national debate. These exchanges led to an agreement that a useful first step would be to conduct a review of existing S&T policy in South Africa and of the institutions involved.

It is important to set out clearly the wide range of activities covered by S&T policy as this phrase is now understood; it encompasses many activities that would not be covered by the concept of research policy. Briefly, S&T policy is concerned with the generation, acquisition, and application of knowledge from all of the sciences (social as well as natural) by countries in pursuit of their own economic, social, and cultural development. It encompasses all aspects of the support of research. Equally important, it deals with educational processes that produce the participants in S&T activities. S&T policy is vitally concerned with the links that must exist between research and the institutions — public and private — that use the knowledge and technology emerging from the global S&T system. Those institutions, in turn, play a role in the national economy and in the national effort to achieve social and cultural development. S&T policy also involves the various activities of public and private bodies to design and stimulate technical change and innovation, not all of which are directly linked to research.

Methods

It was decided that the investigation follow the process developed and tested by the Organisation for Economic Co-operation and Development (OECD) for use in the industrialized world. Invitations to participate were sent to the key institutions in South Africa's S&T system: government, universities, the private sector, and groups affiliated with the democratic movement. Almost all institutions that were invited welcomed the activity and participated actively.

The first of the three stages of an OECD-style review involves the preparation of background material on existing S&T policies. A list of the existing institutions implementing such policies is drawn up together with a preliminary commentary on how those institutions are meeting the goals and objectives of their mandates. This work was carried out between early September and late October 1992, and extensive documentation was accumulated from a variety of state institutions. A number of essays on the current functioning of the South African S&T system were written by independent researchers. (Extensive additional material was also collected during the second phase.)

The second phase of the review involves appointing a group of people, from outside the country under review, who are experienced in the areas of S&T policy, research management, and the general conduct of S&T activities. These people visit the country under review and conduct extensive interviews with those responsible for the management and direction of key institutions. This phase was carried out from 15 to 28 November. Members of the Mission are listed in Appendix A and the organizations consulted can be found in Appendix B. This report includes the observations and conclusions of the international members of the Mission, who are responsible for its contents.

The third phase involves a series of meetings between members of the Mission and the sponsors of the review and those who were interviewed, to allow for full exploration of the observations, conclusions, and questions raised by the Mission.

Objectives

As finally adopted, the specific terms of reference for the review were as follows:

- To describe:
  - ♦ The prevailing organization of the research system in South Africa, in both the natural and social sciences, and in both the public and private sectors;
  - ♦ Existing arrangements for the formulation of S&T policy within the government of South Africa;
  - ♦ Current linkages between the research system and the social, economic, and policy organizations that are expected to use the research outputs;
  - ♦ Current arrangements for training researchers;
  - ♦ Existing links between the South African research system and other such systems in both the industrialized and developing world, including questions related to access to S&T information; and
  - ♦ The current system for financing research, and the priorities pursued through that financing;
- To review and assess the current performance of the system against the goals identified for it;
- To assess broadly the extent to which the current research system meets the needs of the disadvantaged majority of the population, and to indicate where changes — in policy direction, structure, or financing — will be needed to address those needs; and
- To propose the main elements of initial S&T policy and organization to meet the needs of a postapartheid South Africa, taking into account both the domestic and international contexts within which implementation will have to take place.

The External Context

Throughout the world, countries are grappling with three broad sets of policy objectives: international competitiveness for their enterprises, social equity for all members of their societies, and sustainability of their interactions with the natural environment. Although progress may be painfully slow, there is a growing consensus, at the level of policy agendas, that these three goals are inseparable. No country can afford to emphasize only the economic goal of competitiveness and rely on "trickle down" effects to attain the other two.

In 1992, these topics were the subject of landmark documents emerging from three different fora: Economic Commission for Latin America and the Caribbean (ECLAC 1992), the OECD (1992), the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (UN 1992). As South Africa grapples with the complex task of debating, and ultimately defining, an S&T policy, it would do well to consider the ideas that have emerged from both North and South on these crucial issues. These concepts could provide the guidance necessary to begin the process of ensuring the full participation of all South Africans in the economic, political, social, and cultural life of the country in the years ahead.

The ECLAC (1992) report proposes the following policy thrust:

> Environmentally sustainable growth with equity, in a democracy, is not only desirable but possible. Indeed, just as social equity cannot be attained in the absence of strong, sustained growth, such growth likewise calls for a reasonable degree of social and political stability, and this in turn means meeting certain minimum requisites of equity. It is clear from this interdependence between growth and equity that it is *necessary to advance towards these two objectives simultaneously rather than sequentially*, and this represents an unprecedented challenge. . . .

> It is understood that equity will improve through advances in the attainment of at least one of the following three objectives. The first of these is to minimise the proportion of persons and households whose living conditions are below those which society considers acceptable, not only economically but also socially and politically. The second is to promote the development of the latent skills existing in all groups of society, progressively doing away with legally established privileges and forms of discrimination, as well as any

other forms of inequality of opportunity, including those associated with social, ethnic or geographical origin or gender. The third is to do everything possible to ensure that neither power, wealth, nor the fruits of progress are concentrated in such a manner as to restrict the freedom of present or future generations, harming the environment in which they must live and develop.

The three central elements of this integrated policy approach revolve around technical progress, productive employment, and investment in human resources. Later, we look at some directions that South Africa might take in defining suitable policy options in these areas.

The theme of policy integration is echoed strongly in OECD's work, which goes on to focus on essential new forms of integrated activity among economic actors within any economy that hopes to become and remain competitive. Recent work in the industrialized countries has highlighted the importance of "networks of innovators." Many different kinds of networks, both formal and informal, are in frequent use by the enterprises of the industrialized world. These enhance their ability to innovate, and hence their competitive performance. As expected, such arrangements are particularly prevalent in the new "high-tech" areas of biotechnology, information technologies, and new materials.

Government policies are attempting to support these cooperative ventures, recognizing the complex and multidisciplinary nature of many of the advanced projects now being undertaken. In fact, it can be argued that individual companies' recognition of the need to supplement their own in-house expertise with expertise from other fields has fostered their participation in such arrangements.

As governments of industrialized countries act to promote the competitiveness of their economies, they see the need to create or enhance a climate for innovation. Making companies and institutions of any country more innovative requires attention to a long list of policy items, which would typically include the following:

- Broad framework policies favourable to innovation — the regulatory environment; conditions favourable to young, innovative firms; policies that would make the country a more attractive location for research and development (R&D);

- A battery of human resources policies to inspire more young people to pursue technical careers and to provide much more extensive employee training; and
- At the level of the individual firm, policies to promote development, acquisition, and diffusion of technology and the most up-to-date practices (Mytelka 1992).

The other trend in industrialized countries is toward the "internationalization" of economic activity. In an attempt to articulate some boundaries for the concept, the OECD (1990) postulated that internationalization could be defined as follows:

> The wide set of processes and relationships that result when previously fairly separate national economies become increasingly interrelated and economically interdependent with one another to an unprecedentedly high degree. These processes include: the export and import of goods and services; the outward and inward flows of direct foreign investment; the flows of science and technology; transborder data flows; and international movement of skilled personnel.

This process has been given momentum by the rapid advances of communications technologies; geography is losing much of its importance in the world of electronic transactions.

One salient feature of today's more internationalized world is the growing tendency for enterprises to lose their sense of national identity as reflected in their ownership, corporate culture, and political allegiances. The pattern of technological development favoured by multinational firms has long been a subject of policy concern. Recent studies tend to suggest that multinational enterprises see the establishment of technical facilities, including R&D laboratories, as an effective means of tapping into the scientific research activities of the host countries. This leads to the view that such enterprises use, and in time strengthen, existing S&T capacities rather than play a leading role in creating them in the first place. The more complex the array of subsidiaries created by a firm, the more extensive its linkages to the global advance of S&T. Such strategies by the multinationals create a range of policy challenges for developing countries.

Bringing the two trends together has resulted in the emergence of the "globalization of competition" as a driving force behind the behaviour patterns of enterprises in the industrialized countries. Production has become more knowledge intensive, the pace of innovation has

quickened, product life cycles have shortened, and the associated manufacturing techniques have changed from one product generation to the next. Companies have been obliged to spend increasing amounts on R&D to stay at the technological forefront of their industry. To lighten the burden of these costs, companies have sought new forms of partnerships that, in previous decades, they would have shunned.

A primary concern of developed countries is to promote extensive innovation within their economies. This, in turn, calls for close cooperation among economic actors. OECD studies have shown that "the interaction with demanding and informed customers is an essential factor in both growth and industrial competitiveness" (OECD 1992, p. 19). ECLAC (1992) extends the importance of this interaction to meeting the needs of the underprivileged of society:

> The present trend towards the consolidation of democracy in the region would be further strengthened by growth with social equity, but the erosion of equity would frustrate and weaken it, giving rise to social and political instability. . . . The most appropriate course is that based on the mobilisation of the most inherently legitimate instruments of democracy: participation and consensus-building.

> For this purpose, it is necessary — among other things — to organise the beneficiary groups since they are usually not only on the sidelines of the sources of economic power but also marginalised from social and political power. Indeed, the evolution of social policies in the history of the developed countries has gone hand in hand with the democratic organisation of society. The difficulty in the present circumstances, however, is that it is not just a question of empowering those who have hitherto been excluded in order to make the program politically viable, but also of ensuring that they participate in a responsible manner, since it will obviously not be possible to fully satisfy their overdue demands in the short term.

> Clearly, no program for changing production patterns with equity can give good results without extensive consensus-building, and the overdue social demands can be kept under control only through a program which assures broad participation by the people at large in the results.

It is important to understand that the authors of these reports meant their policy considerations to cover agricultural as well as industrial activity. In the developing world, it has been repeatedly demonstrated that a first priority must be to solve the problems of all segments of the agricultural sector, from the subsistence farmer to the export-oriented commercial producer.

A global consensus of long-term significance on these same issues was attained with the signing of the Rio Charter at the conclusion of UNCED in June 1992. The charter (UN 1992) focuses on

- The problems of poverty;
- The need for equity;
- The imperatives of sustainability;
- The need to promote the participation of traditionally disadvantaged groups and to empower those groups to bring about sustainable forms of development; and
- The need for developing countries to develop their own S&T capacities to control their own development.

The charter commits all governments to work on a new agenda for the next century. We believe that the principles negotiated at Rio should be widely disseminated and discussed as South Africa seeks to redefine an S&T policy for its future (see Appendix C).

From this cursory review of some of the major policy documents germane to the development of an S&T policy for South Africa, it is evident that other parts of the world are grappling with similar issues. Although this work cannot substitute for a vigorous debate on the future directions of South African policy, at least these international documents can help inform the search for viable policy options. It is clear that the goals of the democratic movement are shared by many societies.

Chapter 2
PRINCIPAL OBSERVATIONS

Elements of a National Science and Technology System

In reviewing current S&T policy in South Africa, it was necessary to define what constitutes a national S&T system. It is our belief that a country should possess an array of institutions, in both the public and private sectors, that are capable of fulfilling the functions set out in Table 1. In some cases, only a single institution is needed; in other cases, many will be required to meet the diverse needs of various sectors of national life.

Put slightly differently, a viable national S&T policy must encompass the following:

- Policies and programs for the training of people at all levels (managers, researchers, engineers, technologists, technicians);
- Policies regarding the organization and funding of research and development systems, institutions, and networks (with networks assuming an increasing importance, worldwide);
- Policies to establish appropriate forms of governance and accountability for institutions within the S&T system;
- Policies and programs to create healthy links between the research system and the productive sector, whether public or private, while protecting the public interest;

Table 1. Components of a national S&T policy.

Policy and regulatory functions	Executing mechanisms
Mechanism(s) to formulate policies and, in some countries, plans for S&T	Financing for research and for technological development
Organizations to gather, analyze, and disseminate information, including statistical information	Mechanisms for evaluating and acquiring technologies
A capacity for forecasting and foresight, and for assessing the likely directions of technical change	Institutions to carry out research programs
Capacity to regulate complex technological activities	Mechanisms to link R&D outputs with practical uses
Mechanisms for the identification and protection of intellectual property	Facilities to educate and train S&T personnel
Policies and programs to maintain the vitality of the national S&T community	Mechanisms for providing technical services (such as metrology, standardization, calibration)
	Links to regional and international S&T activities

- Policies to stimulate technical change, both radical and incremental, within enterprises;
- Policies and programs to establish a vigorous role for the research community and the community at large, in the formulation of options for public policies;
- Policies and programs to promote unimpeded flows of scientific, technical, economic, and social information both within the national system, regionally, and internationally;
- Processes for the effective integration of a government's S&T policies with other economic and social policies of that government; and
- Structures, which are transparent in their activities, for the management of overall policy and strategy for S&T over the long term — such structures being designed to accommodate the different, appropriate roles of ministers and officials in the policy and resource-allocation processes.

Additional considerations must be brought to bear in countries with large disadvantaged communities who, traditionally, have been bypassed, and frequently further disadvantaged, by technological

change. Work in many developing countries has underlined the necessity of giving a voice to the disadvantaged in determining the appropriate goals of technological programs to be pursued for their benefit. Social scientists must also attempt to understand the dynamics of change within disadvantaged communities and be allied to all programs of technical activity seeking to promote "development" among the poor.

Overall Impressions

Our impressions of the current state of South African S&T policy and practice are based on the opinions expressed to us, on documents provided by institutions, and on background papers prepared by a number of independent researchers at the request of the ANC's Department of Research. We did not have the time, resources, or mandate to conduct in-depth evaluations of the programs of individual institutions. We visited no research facilities or projects.

We offer two things:

- First, we attempt to hold up a mirror to show South Africans a portrait of the S&T system as it was described to us.
- Second, we raise questions that, from our experience, we believe will be relevant in the formulation of an S&T policy for a new South Africa.

During the Mission, we were met with unfailing courtesy and often great interest. One official, reflecting on the frustrations currently felt within government, described discussions with the Mission as "a breath of fresh air." Most of our questions were answered with complete frankness, but occasionally replies seemed evasive. This created an impression that below the surface might lie the consequences of past decisions, which would not withstand the force of external scrutiny.

Our impression is of a highly fragmented group of institutions. They were often trying to define a role for themselves in the new South Africa, but were not sure how to go about it. These institutions exist within an overall system that officials frequently described as dysfunctional. South Africa urgently needs a wide-ranging discussion of S&T

policy options of the kind that the democratic movement proposes to launch.

We noted a series of recurrent themes in our discussions that will have to be dealt with by a future democratic government:

- Officials widely agree that there is a vacuum on the S&T issue at the ministerial level. No economic or social goals and objectives have been articulated toward which various institutions could apply their efforts. A new government will have to provide a framework for future policies, including those dealing with S&T.
- As a result of the policy vacuum, resource allocations are essentially frozen, subject only to minor variations approved by officials within a system that is nonconsultative and nontransparent, even to other high-level government officials.
- There is a pressing need to rearrange priorities, both in general and on S&T in particular. This would involve recognizing South Africa as an African country, rather than a member of the white, industrialized world. In particular, South Africa must demonstrate that it can apply its technical skills to the real developmental needs of the majority with at least as much skill and effectiveness as it applied to the perceived "security needs" of the white minority.
- If the problems of the disadvantaged are to be tackled, there must be an unprecedented rapprochement between the community groups who can help articulate the needs and wishes of the poor majority and the S&T institutions that can work toward meeting those needs.
- There is a crisis in the educational system at all levels. This crisis is at its worst when it affects the teaching of mathematics, science, and engineering. Given our mandate, we paid particular attention to problems at the tertiary level of education, but we are aware of the gravity of the situation in primary and secondary schools.
- There is an immediate need to transform the highest levels of governance of the institutions of S&T. Government-appointed boards and councils must reflect the needs of the groups whom each institution is designed to serve. These structures must also contain the skills needed to address the objectives that the institutions are designed to achieve.

- South Africa must appreciate that it is part of Africa, and that it has experiences and knowledge to share, but that it also has much to learn from other societies. It should see itself as a participant in joint ventures in S&T on the continent, not as the automatic leader.
- All organizations, both public and private, must be committed to becoming nonracist and nonsexist. For a long time, this will mean an important commitment to national affirmative-action programs.
- Deep-seated prejudices and intense resentment at past injustices will present considerable impediments to the creation of a new South Africa. The S&T community, which has been privileged to receive advanced levels of education, should be at the forefront of South African society in overcoming these obstacles and working for the common good.
- As an example to all South Africans of how political life in this country can be transformed, we call on all members of the S&T community to become active participants in the public debate on the future directions of S&T policy for this potentially prosperous home for all South Africans.

"The Republic of Science"

In the early 1960s in Europe, when discussions of the concept of a national science policy were in their infancy, Polyani (1962) described the ethos of those engaged in fundamental research. He proclaimed that science should be viewed as political and that scientific activity should be governed by researchers' intellectual interests and the stringent norms of excellence that the scientific community alone could set for itself. As time passed and the debate on science and, later, technology policy became broader, it became evident that the "republic of science" could and should only exist for a small minority of scientists and engineers. Most researchers are engaged in activities whose goals are economic or social, rather than strictly scientific, and they must compete with other societal needs for funding. However, the members of the Mission believe that the 30-year-old idea of a "republic of science,"

in its simplest form, can still guide the operation of South Africa's long-term S&T policy.

During the Mission, several people prefaced discussions with the remark that science policy is a technical rather than political subject. We cannot agree. Decisions, for example, that lead to heavy investments in research on proton-beam therapy for cancer treatment, in a country with little or no research in the field of public health, represent intensely political choices, affecting the allocation of significant amounts of public funds.

We also believe that the expressed needs to "pursue excellence" and "maintain international standards" were, in part, a justification for the low levels of resources allocated to redress the effects of apartheid on black members of the research community. Excellence and justice are not incompatible concepts.

Commentary on Individual Institutions

Scientific Advisory Council

The Scientific Advisory Council (SAC) was established as the single most important source of independent advice on science policy and programs to the South African government. Its terms of reference are broad (Department of National Education 1988a) and, in theory, it has the ear of the government. Legislation requires it to advise the minister of national education on the following:

- Objectives of the national strategy in the field of science;
- General areas of priority for R&D (taking into account socioeconomic objectives);
- Provision of S&T workers;
- Promotion of the coordination of R&D;
- Promotion of the use of research results;
- Operation of the science system;
- Adjustments to the staff administrative norms and funding of the science councils under a dispensation of framework autonomy; and

- Interaction with neighbouring countries and the international scientific community.

In practice, the SAC is the target of extensive criticism from both within and outside government.

The SAC is constrained by the cloak of confidentiality that shrouds its activities. No independent assessment can be made of the extent, quality, relevance, or impact of its advice in the absence of a public record of its activities.

It also lacks an independent secretariat. The Department of National Education is an inappropriate source of secretariat assistance as much of the SAC's work should involve critical analysis of that department and its management of the science vote. The kinds of difficulties that arise when a secretariat serves two masters are illustrated in the recent decline in budgetary purchasing power of the statutory councils. The Department of National Education, as an executive arm of government, must accept the budgetary constraints that have reduced the purchasing power of statutory councils by 25 percent since 1987, the baseline year. An independent analysis by the SAC might have raised questions about the long-term effects of such a decline. However, the SAC does not appear to have conducted such an analysis — as its chairman claimed in meetings with the Mission — that, to date, all of its advice has been accepted by government. In recent years, such advice appears to have been limited to issues that did not raise questions about the overall direction of government financing of R&D.

A third handicap is the vagueness of the SAC's responsibility for advising on matters of technology policy following the demise of the responsible council. The SAC's membership, heavily weighted in favour of pure science interests, appears to believe that technology policy should not be within the SAC's mandate.

Our overall impression of the SAC is that it expends its energy on matters of detail within the existing system, rather than taking a broad view and tackling the many problems that confront South Africa in the area of S&T. The SAC, as currently constituted and constrained, does not seem to be a useful mechanism for advising on S&T policy. A new government, committed to participation by all South Africans in debates on public policy, would do well to set up structures appropriate to this kind of political culture — structures that would provide appropriate advice.

Other countries have established different models, all aimed at ensuring that ministers have the best range of analysis available when difficult choices have to be made. Many governments use more than one approach. Among the popular models are the following:

- A specific ministry to deal with S&T policy, either as a ministry in its own right (such as in Germany) or attached to another ministry. The practice of attaching a ministerial responsibility for science to a ministry of education is common, but this underplays the critical importance of technology policy. In many countries, the ministry of industry has either been given the mandate to deal with only technology or, in some cases, to deal with S&T. It is important that the minister responsible for S&T policy be a member of the cabinet-level structure dealing with economic policy, to bring about the necessary integration of economic and technology policy.
- An advisory council, which may act as a confidential adviser (like the current SAC) or as a mechanism for promoting wide public debate on issues of S&T policy (like the Zambian Council for Scientific Research and the now-defunct Science Council of Canada). The functioning of such bodies is closely related to the quality of the secretariat services they command.
- Use of leading national science and engineering institutions or societies as a source of opinion in response to specific requests from government (for example, the US National Academy of Science has undertaken much work on public policy).
- Encouraging academic groups to work and publish in the field of S&T policy (for example, the role played by the Science Policy Research Unit at the University of Sussex, United Kingdom).

One model that has fallen into disuse, for good reason, is the monolithic ministry or academy, which controls all research.

"Framework autonomy" and the statutory councils

In April 1988, the adoption of a system of "framework autonomy" as the basis for managing the statutory councils was a significant step (Department of National Education 1988b). It terminated a system of excessive micromanagement of the affairs of what were designed to be

Table 2. Total income (millions of rand) of statutory councils, 1987–1992.[a]

Organization[b]	1987	1988	1989	1990	1991	1992
CSIR	306.7	377.8	391.1	425.3	444.1	—
HSRC	62.2	70.1	83.2	95.5	101.7	—
Mintek	—	—	63.5	72.2	—	—
MRC	—	—	41.9	46.8	—	—
SABS	—	—	—	91.0	107.1	—
FRD	—	—	—	—	n.c.	114.5

Source: Annual reports and data supplied to the mission by CSIR and HSRC.

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

[b] CSIR, Council for Scientific and Industrial Research; HSRC, Human Sciences Research Council; Mintek, Council for Mineral Technology; MRC, Medical Research Council; SABS, South African Bureau of Standards; FRD, Foundation for Research Development. No data were available for the Agricultural Research Council, which was established in April 1992.

research institutions. The institutions were able to restructure themselves in ways in which they believed would best serve the needs of their clients. Today, this system applies to seven institutions:

- Council for Scientific and Industrial Research (CSIR);
- Human Sciences Research Council (HSRC);
- Council for Mineral Technology (Mintek);
- Foundation for Research Development (FRD; established September 1990);
- South African Bureau of Standards (SABS);
- Medical Research Council (MRC); and
- Agricultural Research Council (ARC; established April 1992).

Table 2 provides some perspective on their relative size and operations.

The main features of the system of framework autonomy are as follows:

- Clear delegation of authority and accountability to the boards and management of each council;
- A system of baseline funding for individual councils (Department of National Education 1988b, section 2); and
- A requirement that much future funding be generated by contract from outside the council.

A major weakness of the new system of funding has been bureaucratic adherence to a distribution of funds based on the 1987/88 budgets of the councils that existed then. The problem is compounded by the division of the baseline funds for most of the councils into two parts: one for the council's in-house functions and one for its "agency" responsibilities in support of research in the universities. (In the case of FRD, the division is between funding of a series of expensive national facilities and the agency function, which is its principal raison d'être.)

According to senior officials in councils receiving these dual-purpose parliamentary grants that cannot be reallocated from one "pot" to the other, the current system appears to be managed solely by officials within the Department of National Education. We found no evidence that the existing Inter-ministerial Committee of Ministers responsible for the councils was in any way active in the process of resource allocation. In only one case did we hear of a minister who was actively interested in the affairs of the council for which he bore parliamentary responsibility.

The members of the Mission believe that a future government must

- Designate S&T resource-allocation decisions that should be taken by ministers, and establish appropriate structures to ensure that ministers are able to make such decisions with full awareness of their impacts on the various parts of the national research system. Such a system should be informed by competent, external advice generated in a transparent process, which should allow for significant input from all groups affected by the resource allocation process. Based on the evidence presented to us, we do not believe that this is the current situation.
- Ensure that other resource-allocation processes are established within councils in ways that are transparent and permit the boards to exercise the authority delegated to them.
- In light of the major responsibilities allocated to the council boards, ensure that those boards are constituted in a way that makes them fully representative of the constituencies they were established to serve. This is far from the case in a number of existing boards.

Table 3. Proportion (percent) of statutory council funds derived from parliamentary grants, 1986–1990.

Organization[a]	1986	1987	1988	1989	1990
CSIR	66.2	67.0	62.7	57.1	56.7
HSRC	93.8	93.5	84.1	77.1	77.2
Mintek	88.0	83.0	80.8	80.0	77.1
MRC	95.0	94.3	93.6	90.8	88.5
SABS	37.0	39.8	40.4	38.2	35.1

Source: Pouris (1992).

[a] CSIR, Council for Scientific and Industrial Research; HSRC, Human Sciences Research Council; Mintek, Council for Mineral Technology; MRC, Medical Research Council; SABS, South African Bureau of Standards.

Table 4. Proportion (percent) of statutory council revenues from external sources, 1986–1991.

Organization[a]	1986	1987	1988	1989	1990	1991
CSIR	31.1	34.7	39.8	42.0	42.9	43.8
HSRC	5.1	14.5	2.7	21.5	22.7	27.1
Mintek	—	—	—	16.1	18.1	—
MRC	—	—	—	7.4	7.7	—
SABS	—	—	—	56.9	56.7	—

[a] CSIR, Council for Scientific and Industrial Research; HSRC, Human Sciences Research Council; MINTEK, Council for Mineral Technology; MRC, Medical Research Council; SABS, South African Bureau of Standards.

The proportion of income from parliamentary grants of the five oldest councils is declining (Table 3). Discrepancies may arise because some councils have included interest income (surprisingly large in some cases) with their parliamentary grant, while others did not.

From data provided to the Mission, we calculated the share of annual expenditures of five of the councils covered by external revenues — from contract research, sale of services, and sale of publications (Table 4). In principle, generation of income from external sources by research institutions is good management practice, provided that the "customers" have effective purchasing power. A major shortcoming of the exisiting system lies in the fact that only large industries, and some government departments, have budgets that allow them to commission research. As a result, at least one council is already obtaining a significant share of its income from offshore contracts. The government has entirely failed to address the lack of

capacity of the disadvantaged groups to marshal resources to commission contract research. There is a similar lack of capacity in small and medium-sized enterprises (SMEs) to satisfy their technological needs. Devising new ways of converting the needs of South Africa's disadvantaged into an effective (economic) demand for their satisfaction will be an urgent priority of a future government.

Council for Scientific and Industrial Research

CSIR represents a significant South African investment in scientific research. It has modern facilities and a tradition of technical competence. Since the introduction of framework autonomy, it has conducted what has probably been the most thorough re-evaluation undertaken by any government-created research organization in the country of its own performance, goals, and strategy.

In earlier phases of its history, CSIR saw itself as similar to many government laboratories in the industrialized world: science driven, emphasizing the freedom of individual researchers over specific corporate goals or strategy, a "university without the inconvenience of students," as one official put it. However, the democratic movement perceived CSIR as a part of the state's military–industrial complex, designated as a "national key point," and accorded special security status.

Since the beginning of this decade, CSIR has been restructuring along the most up-to-date lines to equip itself to play a leading role in making postapartheid South Africa capable of becoming internationally competitive in a highly technological global marketplace. It has commissioned reviews of S&T policies in a variety of countries (CSIR 1991a) and conducted a far-reaching management review (CSIR 1991b), which has led it to articulate a sophisticated concept of its own mission and of organizational initiatives designed to achieve that goal.

Our comments on the strengths and weaknesses we perceived in the work of CSIR are linked to the needs of the three groups of clients CSIR is seeking to serve: large firms, SMEs, and communities.

Large firms — The restructuring of CSIR was aimed at allowing it to serve the needs of large-scale industries facing decreasing tariff protection, the end of international sanctions, and substantially increased international competition. From the description of the strategy adopted, it seems that CSIR has made the correct internal changes to allow it to enter into strategic alliances with large enterprises. CSIR is

now technology and market driven and customer oriented. Like large, similar government-created laboratories in the industrialized world, it is also geared toward cooperation with technologically sophisticated partners.

CSIR appears to have been most successful at articulating the different but complementary roles of its board and senior management. (We rarely heard the boards of other councils described as sources of strategic advice and counsel.)

We did not discuss CSIR's possible involvement in initiatives that might flow from the National Economic Forum, where COSATU, business, and government are now discussing specific technological initiatives that could be the basis of positive restructuring in some sectors of South African industry.

Small and medium-sized enterprises — The impact of CSIR'srestructuring on its capacity to respond to the needs of SMEs is much less clear, and the treatment of this issue in background papers is too cursory to be of much assistance.

The South African government seems to have studiously avoided experimentation with policy instruments to improve the technological performance of SMEs. No matter how "noninterventionist" they proclaim themselves, governments in all industrialized countries, either individually or collectively in the case of Europe, have a wide range of programs to meet the needs of both the new high-technology companies springing up with great rapidity in OECD countries and the multitude of other traditional SMEs on whom many countries rely for the bulk of job creation.

Given the apparent lack of government interest, it is not surprising that CSIR does not appear to be developing industrial extension services or financial support programs for in-house R&D on SMEs. Neither is it stimulating innovation or technology-transfer mechanisms and programs geared to the needs of SMEs, as found in many other parts of the world. In some countries, in which support for both large and small enterprises is housed in a single institution, the competition for resources becomes intense.

Community development — The post-1990 CSIR is least well-equipped to deal with the problems of disadvantaged communities. It has no experience in conducting research whose specific goals have emerged from long processes of consultation and discussion with

disadvantaged people. Nor does it have a long tradition of using social science research as a route to the interpretation of the complex dynamics of societies that are dramatically different from those of its researchers. There is a long, sad history, throughout the developing world, of well-intentioned technological interventions that failed through lack of understanding of how the beneficiary populations would react to technological change.

The recent move to involve social scientists in CSIR is worthwhile. However, the council should consider reaching out to some of the long-established social science groups already working with communities. It is possible that partnerships could be forged to link the competencies of the various groups. The process will not be easy, but it could lead to much better assistance to communities in the long run.

CSIR has already made overtures to institutions such as the World Bank, offering its expertise in addressing the problems of other African countries. It would do well to discuss lessons of the past with major donor agencies. A knowledge of "what has worked" in other developing countries might yield some clues about how to maximize the council's contribution to tackling the backlog of needs to be fulfilled among South Africa's own poor majority.

As CSIR continues to refine its corporate strategy, it should particularly examine its capacity to provide effective support to both SMEs and disadvantaged communities. In doing so, it need have no fear of compromising its standards of S&T quality; some of the "simplest" technologies in the eyes of the user can be the fruits of highly sophisticated research.

Human Sciences Research Council

HSRC ranks among the most controversial research institutions in South Africa today. Many foreign governments view it as irretrievably compromised by its contribution to much of the analysis behind the policy of "grand apartheid." Despite efforts to reform (the Mission was provided extensive briefing on the "new" HSRC), it is still regarded with suspicion, even within parts of government. Some government bodies were noticeably uncomfortable when asked if their own needs for greater input from the social sciences could be met through collaboration with HSRC.

It is difficult to gauge the extent to which the work of HSRC has, in fact, been influential in setting government policy. In areas where it claims to have had an effect, a comparison with the contemporary situation leaves much open to question. For example, claims that the 1981 de Lange Report on Education "paved the way for the transformation of education in this country" seem at odds with the crisis in education for much of South Africa's population.

We expected to find much larger HSRC-managed programs aimed at training black social scientists and developing the institutions within which they work. Certainly, the foreign donor community active in South Africa in recent years sees this as a high priority. However, the share of HSRC resources devoted to this essential area does not appear to be commensurate with the magnitude of the task.

Of all the statutory councils, HSRC seems to be the one that will enter a new South Africa with the greatest need to demonstrate its appropriateness as a developer of future policy options. The following comments of the external members of the Mission refer to international practice in support of social science research in democratic societies, which might be more useful than specific suggestions about HSRC per se.

- Social science research has a significant role to play, both in formulating options for public policy and providing informed critiques of such policies; the outputs of both activities must be in the public domain, to inform political debate.
- Although some of the research needed by government can appropriately be purchased via contract, much of the activity must be pursued in the public interest; this point was clearly made some years ago in the United Kingdom by Lord Rothschild (1989) when he argued that:

  The need for independence from government departments is particularly important because so much social science research is the stuff of political debate. All such research might prove subversive of government policies because it attempts to submit such policies to empirical trial, with the risk that the judgement may be adverse. It would be too much to expect Ministers to show enthusiasm for research designed to show that their policies were misconceived. But it seems obvious that in many cases the public interest will be served by such research being undertaken.

We suggest that, in formulating new S&T policy for South Africa, thought is given to the pros and cons of having a body whose exclusive role would be to provide grants for independent social science research — whether carried out in the universities or in not-for-profit institutes, which usually work in areas highly relevant to the needs of the disadvantaged majority. Such a body would in no way impede the commissioning of specific social science research projects by government departments, by periodic commissions of enquiry, or by private groups, who seek to base their policies and programs on a better understanding of South Africa's social dynamics. If such a body were to emerge, its governing board would have to be truly representative of all parts of the South African population, as well as encompassing a broad range of expertise in research across the gamut of the social sciences.

We also believe that careful consideration — not based solely on past HSRC activities — should be given to the question of whether there is an appropriate role, within government, for a body to conduct extensive in-house, social science research. Alternatives could include the conversion of at least parts of HSRC to independent "not-for-profit" status. The new, potentially highly competitive budgeting system that HSRC is about to introduce will give its staff a foretaste of what it might be like to work in an independent research centre without an annually guaranteed funding base.

Foundation for Research Development

FRD has emerged as the principal source of agency funds in support of research and the training of researchers in the tertiary education system. A spin-off from CSIR, it became independent in September 1990. In principle, it deals with both universities and technikons. In practice, virtually all its resources for human resource development are allocated to the universities.

According to FRD, its mission is "the cost-effective and balanced provision of human resources and expertise in science and technology to meet the requirements of the nation." (Apparently an earlier version focused on supporting research, but the more recent emphasis is on human resource development.)

To implement its goals, FRD has undertaken to

- Maintain and foster research excellence;

- Set priorities according to future human resource requirements;
- Develop and assist in maintaining the necessary infrastructure for education, research, and training;
- Assist selectively in improving and rationalizing education and training at the primary, secondary, tertiary, and occupational levels;
- Assist in enabling disadvantaged communities to contribute fully to the pool of human resources;
- Promote, develop, and coordinate multidisciplinary and multi-institutional cooperation;
- Establish, reinforce, and exploit international scientific contact and collaboration; and
- Evaluate participants, programs, and their outputs.

FRD has a major responsibility beyond that implied in the above statements; it is the organization responsible, at least on paper, for the management of three major national research facilities: the National Accelerator Centre, the South African Astronomical Observatory, and the Hartebeesthoek Radio Astronomy Observatory. Funds for the operation of these facilities are separate from those provided for the other FRD responsibilities, and their amount is determined outside FRD, on the advice of the Department of National Education (Table 5). According to FRD officials, FRD acts only as a "post box" and exercises no substantive role in the management of the national centres.

In many countries, experience has shown that it is better not to combine agency functions with any form of responsibility for the management of national facilities. In times of budgetary restraint, an institution will inevitably be drawn to protect its own employees. Although FRD does not have budgetary discretion over the allocation of funds to national facilities, in the long run, some alternative administrative system might be found for maintaining national programs. Later, in dealing more generally with the financing of fundamental research, we return to the question of budgets for these facilities.

The members of the Mission discussed, at some length, the adjudication processes used to allocate funds under the core and the bursaries programs. We found them effective when the sole criterion was technical merit. The policy problem facing the new South Africa will be to determine the proportion of its S&T budget to be allocated on

Table 5. FRD's 1992/93 budget (millions of rand).[a]

Agency functions		National laboratory management	
Program	Budget	Facility or program	Budget
Core programs	30.2	NAC	39.1
Bursaries	13.7	SAAO	6.5
Special programs	18.8	HRAO	3.3
Research equipment	2.0	International liaison	4.9
Scientific services	2.7		
Management and administration	7.9		
Subtotal	75.3	Subtotal	53.8

Note: These figures include not only parliamentary grants but also funds brought forward from previous years, contributions from partners in joint programs, sales of isotopes, and user fees from Uninet. The individual parliamentary grants (in millions of rand) are as follows: FRD, 57.06; NAC, 28.8; SAAO, 4.9; HRAO, 2.4; international liaison, 2.3 (NAC, National Accelerator Centre; SAAO, South African Astronomical Observatory; HRAO, Hartebeesthoek Radio Astronomy Observatory).

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

this basis rather than toward specific problem areas or toward bringing about a more rational organization of tertiary-level activities, both in teaching and in research. We believe that a significant share of national resources will have to be directed to the rationalization of the tertiary system. Only then can institutions be set up to meet the higher education needs of all South Africans and to conduct research on the problems of all parts of society, including, in particular, the disadvantaged.

FRD seems to have created a variety of useful channels (such as the university development program, other special programs to enhance activities in specific fields, and even a program on teaching science in schools) through which to direct resources once South Africa has decided what steps to take regarding these burning issues. However, it is clearly not FRD's mandate to define a future strategy for tertiary education or for research on the problems of the disadvantaged. Until a democratically elected government takes office, FRD would be well advised to see that any additional resources it obtains are channeled into its special program stream of activities rather than to its core program.

Medical Research Council

Although MRC receives the smallest grant of all the statutory councils, it is the main channel for public-sector support of health research. Through its internal decision-making procedures, MRC has the final say in the establishment of independent research units, institutes, and centres that rely on its funding.

The research conducted by MRC staff, or university research funded by MRC, has traditionally focused on biomedical research. Areas of research depended on the interests of individual researchers, who, in turn, were judged on their records as researchers rather than on the basis of any assessment of the health needs of the population. This discordance between research interests and public health needs is nowhere more evident than in the expenditure (via FRD) of almost 40 million rand on the accelerator.[1] This was justified on the basis of its use in the search for proton therapy treatment of a rare condition of esophageal cancer. Research like this is clearly geared to South Africa's perceived "First World" needs.

South Africa currently boasts at least 14 departments of health, with mandates to look after the health needs of different segments of the population. The lack of a coherent national health policy and coordination of delivery of health services has surely contributed to the lack of a coherent health research policy. The many faults in the system have been carefully documented (Henry J. Kaiser Family Foundation 1991).

Since 1991, MRC has attempted to shift the emphasis of its in-house research toward addressing wider needs. To this end, the 50 percent of its budget traditionally used by its own institutes has been reallocated to a series of national research programs in tuberculosis, nutritional interventions, AIDS, urbanization and health, malaria, and trauma. For the first time, research teams consisting of public health specialists, social scientists, and other related researchers are participating, with their biomedical colleagues, in programs aimed at addressing public health needs. In the words of the chairman of MRC's board (see MRC 1991, p. 3):

> This national program structure makes provision for a portfolio of projects within a program from the most basic to the most applied.

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[1] In July 1993, about 3.4 South African rand = 1 United States dollar. By October 1995, 1 US dollar was equivalent to 3.7 South African rand.

Where the project is carried out depends on where the facilities, expertise and human resources are situated. In practice, the more basic projects will usually be carried out at the academic institutions while the more community-oriented projects, which are epidemiological in nature, will mainly be handled by MRC's own structures. The key to this system is that research will be carried out wherever it will be most effectively handled.

The research is to be followed through to implementation. MRC is to be encouraged in this new approach, and should set up evaluation systems to help keep the overall program on target. A major area to be monitored carefully will be the extent to which this change of direction is carried through to the level of the practicing researcher. Even with this reorientation, major gaps remain, especially in the area of health policy and health systems research. These gaps must be filled if ways are to be found to redress the imbalances in access and availability of basic health care.

Lack of trained workers in public health, epidemiology, health policy, and systems research will hamper for some time to come MRC's program of research in areas identified for "essential national research" (Commission on Health Research for Development 1990).

Continuing allocation of a significant share of MRC's budget to university-based units and centres for the conduct of basic research must be questioned at a time when so much research is needed on how to tackle the basic health needs of "Third World" South Africa. What, for example, is the justification for continued expenditures on research on biomembranes, the cell biology of atherosclerosis, inherited skeletal disorders, transplantation, or ecogenetics? MRC should engage each of the groups it currently supports in a serious review of the public health contributions to be expected of their programs.

An articulate statement of some of the challenges in community health research was made by two South African academics — W.M. Pick and G.N. Padayachee in the *CHASA Journal* — who saw them as "stemming from the very nature of community health — how to empower communities so that the content of research is determined by the participation of communities." We cannot judge the extent to which MRC's new national programs will meet this challenge.

MRC has traditionally had research links with institutions in developed countries. Now, however, it must develop and strengthen ties with African and other Third World research institutions to

address the current health needs of the majority. For example, work on AIDS could certainly be informed by access to results of research carried out at the universities of Nairobi and Makerere.

Major efforts will be needed to strengthen the training of specialists in public health. There are already two initiatives, each involving more than one university, seeking to establish two schools of public health. However, there is no recognized forum in the South African health system where the question of the appropriate pattern of development of public health training facilities can be broached — yet another vacuum at the policy level.

Specific attention must be given to the universities traditionally attended by black students. Their capacity to train competent health practitioners and researchers should not be undermined by a system that automatically situates new capacities in the already strong institutions. Only sustained efforts directed toward these institutions will bring hope of redressing the gross inequities of race and gender to be found within South Africa's health systems.

Council for Mineral Technology

Given the important position of the minerals industry in the economy of South Africa, it is not surprising to find a 60-year-old institution playing an important role in mineral technology development. In some important ways, Mintek has a privileged position among the statutory councils. It has a clearly identified and technically sophisticated clientele: the major mining houses. Given this important advantage, it appears that Mintek has paid serious attention to technology development and transfer and has made significant contributions to the mineral industry over a long period of time (see Mintek 1987). Its close interaction with minerals companies, during the process of technology development, has undoubtedly played an important role in the final transfer of new technologies into use.

The arrival of framework autonomy appears to be having a paradoxical effect on Mintek. South African mineral producers, who are accustomed to receiving Mintek services free of charge, are now reluctant to pay contract fees. The companies argue that their large annual tax contributions are sufficient payment to government. As a consequence, "international" contracts have risen from 1 percent of total contract income in 1987 to almost 50 percent in 1991 (Table 6).

Table 6. Mintek income from R&D contracts (millions of rand).[a]

Year	Value of R&D contracts	Contract income as share of total (percent)
1986	4.4	12.0
1987	6.4	13.9
1988	8.0	14.6
1989	10.4	16.4
1990	13.1	18.1

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

The global recession may have affected the mineral industry's attitude toward financing work in Mintek. However, these companies should be aware that their international competitors are showing increasing interest in joining consortia to finance precompetitive research. Such behaviour was unheard of in the past. It will be in the interests of South Africa's mineral industry to map out a joint long-term research program with Mintek and to be prepared to finance an increased share of its activities. If the industry fails to do this, Mintek's capacity may well be increasingly used by the industry's offshore competitors, or Mintek might be forced to reduce its scale of operations if future governments cannot maintain the current level of expenditure in the face of intense competition for resources in future budgets.

The members of the Mission agree that there is a floor level of government funding that ought to be maintained to allow Mintek to stay ahead of the industry and its needs. The proportion of government funds in a future Mintek budget should certainly not fall below 25 or 30 percent of total, but there is much room for the industry to expand its financing.

Mintek has an "agency role" and spends about 2 percent of its budget (almost 1.6 million rand) on financing research in the universities. However, unlike the other statutory councils, Mintek views this funding as an integral part of its own program. There is extensive interaction between university-based researchers and Mintek staff in the definition of projects to be supported by these funds. Given Mintek's mandate, this is good management of a scarce resource, and it contributes to the impression that there is a national program of mineral technology development.

In the past, Mintek worked closely with selected universities to develop their capacity in fields of emerging importance to the minerals industry. Such support has gone beyond the simple transfer of funds and has included the secondment of Mintek staff to specific universities for several years to assist in setting up new programs. (It might be instructive to examine this model in terms of extending it to strengthen the research and teaching functions in selected university or technikon departments as part of a national effort to upgrade the tertiary education system.)

South African Bureau of Standards

Although most S&T policy is directed toward R&D or technological innovation, a broader range of scientific activities must take place for an economy to be internationally competitive. One area of crucial importance to industry is the establishment of standards and the certification of products and processes. SABS is the only statutory council that is not a research organization. However, it is a sophisticated technological institution whose performance is important to all South African industries and, ultimately, to the South African consumer. As set out in its profile of activities (SABS 1991a, p. 5):

> SABS concerns itself mainly with the development of standards for products and services, and is responsible for the Administration of the Mark Scheme and the Listing Scheme to regulate the application of such standards by industry. It also offers a consignment inspection scheme; administers compulsory standards; and provides testing and related services.

Although maintaining technical standards is important in a domestic context, it is crucial in international trade. SABS participation in the International Organization for Standardization (ISO) has allowed it to offer important services to South African companies seeking to trade in international markets (see SABS 1991b). International practice has moved toward ensuring that quality assurance is a concern throughout firms, rather than the responsibility of a quality-control unit. The Mission was impressed to discover that SABS has been helping South African firms meet international standards for firms practicing "total quality control" for over a decade. Although, during the era of sanctions, the main demand for quality control may have come from the military, all South African exporters will increasingly find that

Table 7. Annual expenditures and sources of income of SABS (millions of rand), 1990 and 1991.[a]

	1991	1990
Operating income	60.7	50.1
Interest grant	11.4	7.4
Parliamentary grant	35.0	31.9
Total income	107.1	89.4
Expenditures	84.3	70.8
Net income (after adjustment)	18.4	11.8

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

quality assurance is an important element in international competition. The drive to bring more companies up to international standard should be supported by any government. South Africa, via SABS, is also participating in international discussions around a scheme to certify companies' environmental performance in much the same way as quality is graded.

The financial structure of SABS is markedly different from that of the other statutory councils. Its annual income exceeds its expenditures (Table 7). The SABS has a building fund, into which a small share of the parliamentary grant is placed, a "general fund," and a "general reserve"; these accounts contain capital holdings of close to 125 million rand.

Unlike other councils whose staffs have decreased, SABS has grown. This is due, in part, to the increasing number of requests for testing services from companies who are unwilling to establish their own facilities in time of recession. An important justification for the continuation of government funding of SABS activity lies in its role in the determination of national standards. Complete private funding of SABS would create at least the impression, that such standards would be drafted with the financial interests of the main funders in mind.

Atomic Energy Commission

The Atomic Energy Commission (AEC) appears to have few friends. Among the members of the mass democratic movement, it is seen as part of the state's military–industrial complex; in many parts of government, it is viewed as a huge drain on resources.

The Mission was able to piece together the following information, which may be germane to a future government wrestling with decisions about resource allocations:

- The AEC's current budget is apparently about 700 million rand, which is about 70 percent of the annual budget administered by the Department of Mineral and Energy Affairs.
- Given South Africa's abundant coal reserves, and southern Africa's huge untapped hydroelectric potential, no further expansion of nuclear generating capacity is likely to be necessary for many years to come.
- Since 1986, the AEC's staff has been cut by more than 50 percent, to its current level of about 3 400 people.
- The AEC currently spends "about 80 million rand" annually on technology development (its own research budget). Of this, about 3 percent is used to commission research from the universities.
- Nonresearch funds allocated to the AEC, which appear to amount to about 600 million rand per year, must presumably be used to support its production of nuclear fuel and other products.
- The AEC estimates that it will sell about 70 million rand worth of nuclear fuel annually to the Electricity Supply Commission (Eskom) over the next 5 years, and that its sales of non-fuel products will rise from under 50 million rand in 1992 to over 150 million rand by 1997. These figures should raise questions about the long-term economic justification for government support of the nuclear program in its current form.
- According to government observers, much of the AEC's work is in response to external sanctions and government-defined "security needs," which entirely ignore the commercial viability of processes being developed. As sanctions are removed and a new government redefines South Africa's needs and priorities, a re-examination of the country's commitment to a nuclear program will be imperative. Given the existence of one successfully operating nuclear plant, South Africa will have long-term nuclear obligations to fulfil, but that does not mean that all elements of the Commission's program should be subsidized in perpetuity. Hard choices will have to be made, and they will inevitably have implications for the

size and focus of any continuing South African nuclear research activity.

- Given the size of the investment made to date, we have no doubt that AEC has built considerable and broad competence in a variety of high-technology areas. Attention should be paid to the possibility of redeploying this valuable capacity in support of non-nuclear industrial activities, as has been done in some industrialized countries.

Commentary on Some Key Sectors

The tertiary education sector

The tertiary education sector of any country plays a vital role, both in the advancement of knowledge through research and in training people for productive roles in society. In turn, the tertiary system is dependent, in large measure, on the flow of young people from the secondary education system. During the Mission, we became aware of a range of general problems, as well as problems affecting S&T in particular. Many stem from the enduring legacy of apartheid.

The universities see themselves as divided into two groups: 11 "historically white universities" (HWUs) and 10 "historically black universities" (HBUs). The HWUs tend to have mostly white faculty members and only a small, but in some cases growing, minority of students who are black. These institutions tend to have all the faculties one would expect in a modern university, and they attract the lions' share of research funding allocated on the basis of excellence. The black universities tend to have faculty members of all races and a student body that is largely black. Typically, these universities do not have all the faculties of a modern university; for example, only one has a faculty of engineering. Their success rate in competition for research support is low. (The Mission saw no data on the levels of staff qualification typical in the two sets of universities). We also became aware of a deep sense of rivalry between and among these institutions and their staffs; any rationalization of activities will have to overcome these rifts.

Similarly, of the 15 technikons, 7 could be categorized as "historically white" (currently, more than 75 percent of their student population is white) (Sonn 1992, p. 9) and 8 in which the student body is predominantly black. All technikons suffer from disadvantages in

funding; the state formula for financing technikons is even less adequate than that used to calculate grants to universities. The existing formula is related to student numbers and is believed to provide insufficient recognition of the differential costs involved in providing education in different fields. In particular, many believe that it does not adequately reflect the cost structure of education in the sciences and engineering. Technikons are striving for better recognition of the role they play in tertiary education. This campaign involves a demand to have the right to grant degrees. The technikons are also seeking increased recognition of their role in research.

Three main avenues are currently used to finance research in the tertiary education sector:

- An element of formula financing, administered by the Department of National Education, is related to the publication of some books and papers in "approved journals." There is some support for this approach from the research-intensive universities, but also criticism of various ways in which it can be manipulated. There is general agreement that it is to the benefit of the institutions that some share of research financing be passed through the them rather than being channelled directly to specific research groups.
- Direct support of researchers or research groups is provided by government via the "agency function" of various statutory councils. To differing degrees in the different councils, these funds are allocated by "open competition" among scholars (selections are based on merit) and to "special programs" that may be designed to increase activity either in designated fields of research or by designated institutions. A key policy issue is how the relative allocation of funds between these two channels is determined.
- Contract research is financed by government councils or departments, private enterprises, and foreign donors. The foreign channel is important in terms of making funding available for research on the problems of disadvantaged communities.

We believe that all of these diverse channels of funding research in the tertiary education sector should continue. We found it difficult to obtain a single, authoritative view of the volume of funds flowing through each of these channels. Although we have some data on agency funds administered by individual statutory councils (see

Table 8. Funding (millions of rand) of R&D in tertiary-level institutions by source for the 1989/90 fiscal year.[a]

	Government	Tertiary sector	Business sector	Not for profit and foreign	Total
University					
Natural sciences	51.1	240.4	43.7	1.0	336.2
Human sciences	5.5	160.9	8.0	1.6	176.0
All R&D	56.6	401.3	51.7	2.6	512.2
Technikons	0.2	5.0	0	0	5.2

Source: Department of National Education 1991, pp. 54–56.

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

Table 5, p. 30), we have seen no estimates for funding provided to tertiary educational institutions via the Department of National Education's formula for research support. Nor have we seen a comprehensive accounting of the amount of R&D support provided by government departments. The most comprehensive information is available from the Department of National Education's biennial survey (Table 8). (We are aware that there is no good source of data on support from foreign donors, which has been increasing in recent years.)

To understand the magnitude of the discrepancies in R&D funding between the HBUs and the HWUs, we reviewed data published by the Department of National Education (1991). The HBUs that they cover are the universities of Durban-Westville, the Western Cape, Vista, Zululand, the North, and Medunsa; no data are provided for the universities of Fort Hare, Venda, Transkei, or Bophuthatswana. The HWUs covered are the universities of Pretoria, Cape Town, Witwatersrand, Natal, Stellenbosch, Orange Free State, Potchefstroom, Rhodes, Port Elizabeth, and Randse Afrikaanse. Data for the University of South Africa have been omitted, given that institution's special character as a distance education facility working primarily via correspondence courses. The data are for a period before the introduction of FRD's University Development Program. The extent of the disparities are huge (Table 9), and we have seen no indication that the gaps are being narrowed to any significant degree.

The members of the Mission were dismayed to discover that the executive of the Committee of University Principals had never discussed research policy as it affects their institutions. This body appears

Table 9. Research support (millions of rand) by university group and source of funding.[a]

University group[b]	Government	Tertiary sector	Business sector	Not for profit and foreign	Total
Natural sciences					
HBUs	0.5	21.9	1.2	0	23.6
HWUs	50.5	212.6	42.5	1.0	306.6
Human sciences					
HBUs	0.5	14.3	0.2	0	15.0
HWUs	4.7	110.7	7.8	1.6	124.8

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

[b] HWUs, historically white universities; HBUs, historically black universities.

to devote its energies to the discussion of administrative matters. Although these matters are important, in other countries they would be the responsibility of less senior university officials. In sharp contrast, the Committee of Technikon Principals, who face a range of problems at least as difficult as those confronting the universities, appeared to be tackling a set of issues that go to the heart of their institutions' mission and ethos. They also appeared to be making some progress in developing a common front among institutions that have been racially divided.

There are significant distortions in the pattern of enrolment in tertiary education in South Africa. The number of students per 1 000 population of the corresponding racial groups in the universities are as follows: white, 31; Indian, 20; coloured, 6; and black, 4. In technikons: white, 10; Indian, 6; coloured, 2; and black, 0.5 (see Sonn 1992). Not only are there interracial distortions, but there is also an unusual imbalance between the numbers obtaining university education and those in the technikon stream. In most countries, technikon students would far outnumber those in the universities. We are not implying that the numbers of university students are too high, but rather that the numbers of technikon students seem to be far too low.

There is broad agreement on the magnitude of the problem of education for black students at the secondary school level. According to FRD, for every 10 000 black children entering primary school, only 113 will pass the matriculation examinations. Of these, only 27 will receive a "matric exemption," only 1 in mathematics and science.

Table 10. Number of students in different levels of the education system by race.

Group	Grade 1	University	Technikon
Black	799 984	91 462	9 654
White	81 044	156 737	47 662
Asian	21 335	19 179	5 558
Coloured	109 358	18 968	5 444

Given that about 800 000 pupils enter Grade 1 each year, the education system produces about 80 black students annually who have the formal qualifications to enter university mathematics, science, or engineering programs. Overall enrolment figures at different levels of the education system was supplied by FRD (Table 10).

A new government may decide to make upgrading primary and secondary schooling a priority. However, redressing the large problems regarding education of the black population will be a lengthy process, involving upgrading teachers' qualifications, improving physical facilities, and so forth. While this necessary process is being pursued, the system will still produce large numbers of poorly trained students who will need significant help to improve their basic knowledge and skills to allow them to proceed to higher levels of education and training. This will give rise, for a considerable period, to a heavy demand for remedial courses. Although existing efforts, such as those of the College of Science at the University of Witwatersrand, are good pilot schemes, ways and means will have to be found to make such courses more widely available. This will of course put pressure on education budgets forcing educators to be innovative in their use of physical facilities.

In addition to the overall problem of inadequate schooling for black South Africans, there is an important trend away from tertiary education in science and engineering. The share of South Africa's university student population involved in science and engineering is already low, in comparison to many rapidly growing developing countries. Data presented to the Mission indicated that the share of graduates in science and engineering, as a proportion of all graduates, declined over the last 5 years in every South African university.

There is substantial controversy over the restructuring of the tertiary education system in South Africa. Some people believe that any

rationalization will inevitably mean that HBUs will be relegated to a second-class role as "teaching colleges," where little or no research is carried out. Equally, others fear that massive affirmative action to upgrade HBUs will imperil the funding of institutions that have already established themselves in positions of research strength.

Examples of interinstitutional cooperation are few. The main examples cited revolved around the creation of two schools of public health — one based on joint efforts by the University of the Western Cape and the University of Cape Town, the other involving the universities of Witwatersrand, Pretoria, Medunsa, and the North. In the developing world, many examples exist of activities aimed at strengthening individual departments, faculties, or entire institutions by "twinning" them with institutions of tertiary education in the North. Such programs usually involve the exchange of staff and students, joint curriculum development, and joint research. Such an approach could be attempted within South Africa, with well-established faculties or departments playing a significant role in strengthening their weaker partners.

The future direction of tertiary education policy is of such crucial importance to S&T policy that we will return to this matter in the concluding sections of our report.

Industrial sector

From interviews with representatives of the Department of Trade and Industry, CSIR, SABS, the South African Chamber of Business (SACOB), Mintek, Eskom, and AEC regarding technology policy to support industry, we formed the following impressions:

- The South African manufacturing industry is characterized mainly by large companies, many of which are subsidiaries of foreign corporations. Most carry out little R&D within South Africa.
- Relatively few SMEs display a capacity to innovate.
- Government recognizes the need for South African enterprises to be competitive on world markets and wishes to stimulate innovation, but has failed to translate this position into a comprehensive national technology policy.
- To date, government has provided baseline funding to CSIR, SABS, and Mintek; and has helped to finance a scheme to promote

innovation in the electronics industry and is considering the expansion of this to other industrial branches. However, the sums spent on the electronic industries scheme are significantly smaller that the value of contracts placed by private corporations with the statutory councils. South Africa is the only country (that we are aware of) in which there is a net flow of direct financing of R&D from the private to the public sector.

Most industrialized countries have developed a variety of tax incentives to stimulate R&D and technological innovation. However, the South African government treats R&D expenditures as an ordinary business expense for tax purposes. In some cases, existing South African tax policy acts as a disincentive to industrial development. For example, an existing 35 percent tax on gold has made it difficult for a jewelry industry, which is potentially labour intensive, to expand.

SACOB is taking the issue of a future technology policy in support of industry very seriously. It believes that one of the principal challenges facing a future government will be to remove the many distortions that have been created by past isolationist, protectionist policies, and the "security interests" of a state faced with extensive international economic sanctions. SACOB favours discussing industrial policy and strategy within the National Economic Forum. It also believes that discussion of technology policy should, separately, address the issues of manufacturing, quality of life, services, and infrastructure. As representatives of industry, SACOB's members believe that the current government, especially the Department of Trade and Industry, has been much too cautious in experimenting with a range of policy instruments that many other governments have found helpful in creating an environment that favours innovation by enterprises.

In our discussions, there was surprisingly little reference to the technological needs of small and medium-sized industries or to the need to stimulate rural industry. In other countries, governments have played a significant role in these areas. We believe that it would be useful for the National Economic Forum, and for SACOB, among other bodies, to study these experiences and assess their relevance for South Africa (for useful summary of such experience, see Bhalla 1991).

International competitiveness depends on a firm's ability to innovate, sometimes making radical changes to existing technology. More commonly, it will involve groups of engineers and workers making

many small incremental changes and the firm must be able to manage these changes. Government research organizations, such as CSIR, will have little impact on industry unless they have the internal capacity to innovate. More attention must be given to training creative engineers who can introduce technical change, as well as managers of technical change.

The rest of the world is devoting increasing attention to worker training as an essential strategy to harness technological change. South African firms, too, must address the need to continually upgrade the skills of their workforce. Studies in OECD countries have suggested that, although employers show strong support for literacy programs, they rarely match their rhetoric with significant action (Hirsch 1991; OECD 1991). We do not know if South African employers, as a group, treat this issue more seriously.

Other issues that must be resolved include the following:

- The extent to which SMEs might provide opportunities for employment;
- How the South African manufacturing industry can be reintegrated into the global economy and encouraged to participate in collaborative research and strategic alliances;
- The extent to which government support for innovation should be redirected to the needs of the disadvantaged majority (such a redirection could imply a cutback of government support for innovation to make South African industry more competitive on world markets, placing an increasing onus on firms to invest in their own competitiveness); and
- The extent to which South Africa's armaments industry, and its expertise in military technology, can be converted for civilian objectives. (This is a complex issue which is of concern to many countries, including the former Soviet Union, the United States, China, and several European countries. In both the United Kingdom and Sweden, a process is under way to convert former military microbiological establishments to civilian scientific institutions.)

In trying to formulate policies for the support of technological development in SMEs, one must take into account the significantly different attitudes of different classes of enterprise to R&D and to technological innovation (Table 11).

Table 11. Typical attitudes toward R&D of various classes of companies in both industrialized and developing countries.

Class of company	Attitudes
Large enterprises	
Multinational companies	• Dependent on extensive inputs from R&D in a wide range of fields to retain competitiveness. • In addition to having in-house R&D capacity, increasingly involved in R&D consortia involving other enterprises; have wide range of relationships with developed country universities.
National companies	• Highly developed internal systems for technology transfer among affiliates. • Generally have good links between R&D function and production.
SMEs	
New technology-based companies	• Usually underinvest in R&D; in protected markets they show no inclination to innovate. • May have some contact with government R&D facilities, mainly for troubleshooting rather than long-term development; prefer to purchase or import technology rather than to engage in its development. • Technology importation done as discrete contractual arrangement, not as part of a continuing relationship. • May have poor or no links between R&D and production. • R&D essential to their existence. Many were created by former university researchers. • Likely to have good contacts with universities as they are in fast-moving fields. In fact, the greater their in-house R&D capacity, the more sophisticated their strategy for dealing with university researchers. • Many sell technology rather than manufactured goods. • R&D is the heart of the company, which lives or dies by its ability to commercialize new technology.
Traditional SMEs	• Usually unable to identify their own technical deficiencies or needs; have zero contact with R&D. • Rarely have any contact with their national S&T community unless the local R&D institutions have made special efforts to get in touch. • Usually use outmoded technology; resistant to change. • Have limited access to capital for upgrading their technology. • Need access to proven technology.

Research in agriculture

Currently, agriculture and agricultural research in South Africa can be characterized as follows:

- " White" commercial agriculture, with significant but unquantified long-term financial support from the state (primarily via long-term credit at low interest rates), has made South Africa self-sufficient in food production. However, prolonged drought in the region is having extensive effects. Past inappropriate policies that supported crop production on unsuitable land are creating problems for the Department of Agriculture.
- On 1 April 1992, the Agricultural Research Council (ARC) was organized as a statutory body. It was made up of the former research groups within the "white" Department of Agriculture. For the first time, governmental agricultural research was given a legal mandate to consider the problems of black farmers.
- The lack of official knowledge of the demographic features of the rural population in South Africa is appalling. The most recent census used aerial surveying as a technique for estimating rural populations. This method is universally believed to be unreliable. The rural population is thought to consist of two groups: a large group of "displaced urban dwellers," whose size and composition are unknown, forced by apartheid to live on marginal rural land, subsisting primarily on money earned by urban males; and a possibly much smaller traditional, rural peasant population, also unquantified.
- Little information is available on the flow of people into urban areas in search of employment, or of the possibly increasing flow of males back to the rural areas as a consequence of escalating levels of black unemployment in urban areas.
- The question of land ownership and use lies at the heart of some of the most difficult issues that will face an interim government and, later, a democratic government operating under a new constitution. (ARC has expertise and information relating to the agricultural potential of lands within South Africa, which should become part of a national geographic database.) Until the question of land title is resolved, the process of planning for rural

development, including agricultural development, will remain hopelessly complicated.

- Despite the existence of at least 14 separate departments of agriculture, a number of Agricultural Development Corporations in the various homelands, and the Development Bank of South Africa, there seems to be no overall understanding of the potential role of peasant, subsistence, or even smallholder agriculture as a source of livelihood for at least some of South Africa's disadvantaged population. The problems of such small farmers, and the difficulties they are struggling to surmount, are at least partially documented in a recent World Bank (1992) study.
- ARC, which represents about half of the agricultural research capacity in South Africa (the remainder lying principally in the universities and the private sector), appears to have no experience with the "farming systems approach" developed by the international agricultural research centres of the Consultative Group on International Agricultural Research, together with a variety of regional, national, and bilateral donor agencies active in the developing world. This approach is considered an essential element in any attempt to assist subsistence farmers.
- There is external criticism of ARC from other government bodies on the grounds that it consumes a disproportionately large share of government science expenditures. One estimate suggests that 35 percent of government R&D expenditures are allocated to agriculture, forestry, and fishing, which contribute only 7 percent of the (formal-sector) gross domestic product (Pouris 1992). However, even this source did not contain budget figures for ARC (Table 12).
- ARC must have access to social science capacity, including agricultural economics, if it is to successfully develop a program of research to assist smallholder agriculture. A group of economists whose mandate is limited to considering the problems of commercial agriculture is not the answer.

Environmental affairs

At the beginning of this report we singled out three concerns that dominate international thinking on S&T policy: competitiveness, equity, and sustainability. In meetings with the Department of Environmental

Table 12. Sources of R&D expenditures in agriculture, 1989/90.

Source	R&D spending on agriculture, forestry, and fisheries		Total R&D spending
	Amount (thousands of rand)[a]	% of total R&D spending	
Government	146 803	25.4	578 008
Tertiary education	67 197	13.0	517 565
Business	50 695	7.7	656 951
Not for profit and foreign	11 823	53.9	21 923
Total	276 518	15.6	1 774 447

Source: Department of National Education (1991, Table 2.9).

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

Affairs, we discussed the ideas and practice of sustainable forms of development. This department, currently, has four components:

- The Chief Directorate of Marine Fisheries is involved in the management of renewable marine resources. The titles of the research projects supported by this directorate in 1992/93 suggest an appropriate emphasis on understanding the population dynamics of commercially important fish species. This allows the directorate to set appropriate annual harvest levels. According to data provided, expenditures on this research, which is carried out principally by departmental staff, will amount to 17 million rand. We did not enquire about the detailed functioning of this research section.
- The Weather Bureau finances some research, including a controversial weather-modification project, Cloudquest. The budget for 1992/93 is 4.2 million rand.
- The Antarctic Program is managed in conjunction with the universities; its budget is about 4 million rand.
- The Chief Directorate for Environmental Conservation receives 15 percent of the overall departmental budget; its research budget for 1991 and 1992 fiscal years is displayed in Table 13.

Like many other fields of jurisdiction in South Africa, environmental matters are fragmented:

- Air pollution is the responsibility of the Department of Health;

Table 13. Department of Environment Affairs research support for environmental conservation (millions of rand).[a]

	Fiscal year	
	1991	1992
Nature conservation	2.007 (23%)	1.897 (21%)
Pollution control	1.002 (12%)	0.870 (10%)
Resource utilization	0.494 (6%)	1.171 (13%)
Rivers and wetlands	1.327 (15%)	1.693 (19%)
Coastal management	1.539 (18%)	1.064 (12%)
Information services	1.572 (18%)	1.234 (14%)
Legislation	0.525 (6%)	0.949 (10%)
Cultural resources	0.225 (3%)	0.177 (2%)
Education	0.000 (0%)	0.065 (1%)
Total	8.691	9.120

[a] In July 1993, about 3.4 South African rand = 1 United States dollar.

- Water pollution is the responsibility of the Department of Water Affairs (which may also have jurisdiction over solid waste disposal inasmuch as groundwater quality is an issue);
- Soil erosion is the responsibility of the Department of Agriculture; and
- Control over nuclear operations is the responsibility of the Council for Nuclear Safety.

We were also told by officials that, since 1986, "executive functions concerning the environment have slowly been devolved to lower levels of government . . . [but] the problem is that lower levels of government don't have the capacity or expertise to deal with many of the issues that relate to the environment." The current government (at least in matters of environmental regulation) was described as preferring to "govern by persuasion and by self-regulation." Officials say that the Department of Environmental Affairs "is weak in the area of the human living environment but strong on endangered species and wildlife conservation." These relative strengths and weaknesses are reflected in the current pattern of research funding.

The department has held consultations on a draft white paper called *Policy on a National Environmental Management System for South Africa*. The draft clearly reflects the struggle to come to terms with the

interrelated nature of environmental sustainability and development (often inappropriately considered to be simply equivalent to economic growth). For example, the first principle (p. 6):

> Every inhabitant of the Republic of South Africa has the reasonable right to aspire to live, work and relax in a safe, productive, healthy and aesthetically and culturally acceptable environment *in as far as this is compatible with economic growth*. [Emphasis added]

Similarly, it states (p. 5):

> *In so far as it is reasonably applicable in the South African context* the government endorses the 27 Principles of the Rio Declaration as adopted at the United Nations Conference on the Environment and Development. [Emphasis added]

Both these statements imply a prior judgement that all activities that contribute to economic growth will automatically take precedence over environmental concerns. This is an unsophisticated, and potentially harmful policy stance in the long term. In this light, we were concerned to learn that the Chief Directorate for Environmental Conservation has no economists on staff. A major challenge to sustainable development is devising acceptable means to assess the economic importance of environmental decisions, something not attempted currently in South Africa.

To contribute to informed public debate on the future directions of environmental policy, this report includes the 27 principles of the Rio Declaration (see Appendix C). We believe that a new government should reconsider South Africa's commitment to the concept of "sustainable development" for all of its population. It should then make more appropriate institutional arrangements than are at present contemplated.

Chapter 3
KEY ISSUES

Accountability

One of the many concerns raised frequently by members of the democratic movement was whether a future government would have the necessary means to ensure that the institutions of the state's S&T system are fully accountable to government for their policies and programs.

In the short term, the government has the key power to appoint ministers of departments and members of boards of governors for statutory bodies. Because much of South African scientific activity occurs in various statutory councils and parastatal agencies, the methods of appointing board members and ensuring that appointees fully understand their powers and responsibilities will be important.

It is an anomaly, in world terms, that appointments to statutory boards are not staggered. In South Africa, all terms of membership expire simultaneously. This anomaly will provide an interim government with the opportunity to reshape boards without having to request the resignation of existing board members.

We believe board membership for any institution should, in aggregate, reflect the needs of the groups in society that the institution is designed to serve, and the competencies that the institution will need to achieve its objectives. For example, the current CSIR board is well suited to interpreting the needs of large-scale industry in South Africa, but has no representation for two other significant groups whom CSIR has a mandate to serve: SMEs and disadvantaged communities.

Once members are appointed, they must be well briefed on the powers appropriately exercised by boards, as distinct from those that should be the prerogative of management. The international donor community could help the democratic movement by offering training courses or study visits designed to show potential board appointees how effective boards operate.

In contemporary management circles, a board's most important function is described as hiring and firing senior management. This power, formally delegated to the boards of the statutory councils, must be seen to be exercised in the interests of all South Africans. Future searches for council presidents must be diligent in the examination of candidates, both female and male, from all racial groups; where an international search is decided upon, the time provided for that search must be adequate to make the search an effective one.

In modern organizations, the chief executive officer has a set of agreed-upon annual and long-term goals that have been negotiated with the relevant board. Success in fulfilling them is a trigger for rewards, failure to attain them to the board's satisfaction is an accepted reason for dismissal.

Affirmative-Action Programs

The democratic movement believes that it is crucial for South Africa to be transformed into a nonracist, nonsexist society. The members of the Mission asked each of the institutions it visited — those involved in education and training and others — about their affirmative-action programs.

Many explained the poor representation of black people in South African research institutions as a result of lack of supply — a result of apartheid. They often argued that the support of excellence is incompatible with action to remedy past injustices. We do not accept this argument. A future South Africa is not looking only for a somewhat bigger sprinkling of black or female faces in an otherwise unchanged institutional landscape; it will wish to see its institutions, including those in the research system, become fully reflective of the diversity of the country's population. The debate should shift from whether this is feasible, toward consideration of a timeframe for making acceptable progress in light of the magnitude of the problem and the availability of resources of all kinds.

We heard frequent references to private-sector competition for qualified black candidates for professional positions and to the high salaries that such candidates command. However, this evidence was anecdotal, as we are not aware of any survey carried out on the supply and demand for qualified black citizens.

The picture that emerges of existing affirmative-action programs is of highly fragmented efforts. There is clearly no effective leadership emanating from the current government or its civil service.

- The universities are divided. Some are implementing useful programs to permit disadvantaged students to prepare for a university education. Others have reacted negatively to a feared future loss of resources in favour of remedial action to strengthen HBUs.
- FRD has begun a promising initiative — its University Development Program. This is approaching, head on, some of the weaknesses of HBUs; but, despite its early growth rate, it is still small in relation to the magnitude of the problem (its planned 5.5 million rand budget for 1993 will be about one eighth of the budget of NAC, which is also administered by FRD). No other statutory council with an agency function for the support of academic science has developed a comparable initiative.
- The other statutory councils each have affirmative-action programs with respect to their hiring practices. Some, such as CSIR and Mintek, have small programs designed to upgrade the skills of black schoolchildren to the point where they can proceed to a university or a technikon. One encouraging initiative by Mintek's senior management is an attempt to persuade the companies with whom Mintek cooperates to replicate its initiative. If the target of 500 companies joining the scheme in the next year is met, this will rank as one of the largest initiatives of which we are aware. However, even this pales in view of the magnitude of the problem of upgrading the skills, particularly in mathematics, science, and language, of the vast majority of black students.
- The professional scientific, engineering, and technological societies, via their coordinating bodies, are actively forging a coalition to tackle the twin problems of affirmative action and a significant improvement in the overall level of teaching and training in mathematics, science, and engineering. One business plan

provided to the Mission listed 40 separate programs aimed at enhancing the teaching of science and mathematics, some sponsored by industrial enterprises, some by educational institutions, some by foundations. However, there was no indication of the scale of individual programs, nor any evidence of a mechanism for their coordination.
 • The picture we received of actions in the private sector is similarly haphazard and fragmented.

We can only conclude that, currently, no programs or policies to encourage affirmative action are commensurate with the magnitude of the problem. Although most citizens are realistic enough to know that the pattern of employment will not change overnight in a democratic South Africa, they have every right to expect that the problem will be treated as a high national priority. Our comments on higher education, elsewhere in this report, are pertinent to this issue.

Research for Disadvantaged Groups

Most of the institutions we visited told of their plans to reorient programs to "meet the needs of the community." Nonetheless, we were left with the clear impression that the individual groups really had little concept of the processes involved in trying to bring about positive technical change in the lives of poor, disadvantaged populations. Both South Africa's imposed isolation and an abiding predisposition of many South African researchers to look only to the industrialized world for inspiration has resulted in little, if any, exposure to the ways in which technological development is being supported in various parts of the Third World.

Three important features of research relating to disadvantaged groups have emerged:

- Effective means of consultation must be developed with those groups whose lives the researchers wish to help improve. This is not a simple process, given the substantial cultural differences that almost invariably exist between the members of the disadvantaged community and the highly trained researchers.
- Strong emphasis must be placed on understanding the social aspects of a community before planning any technological

intervention. Successful research on poverty requires substantial time to develop truly interdisciplinary approaches; this would facilitate an accurate assessment of needs and the translation of those needs into technological research objectives.

- The "needs" of the disadvantaged must be converted into "demands" on the research system through a variety of funding mechanisms.

South Africa has a strong capacity for technological development, in the statutory councils and in the universities. However, this capacity is not linked either to a social science capacity of any meaningful size or to a consultative tradition that would allow communities to have a real say in the directions of research. On the other hand, a number of small, social science groups are allied to the democratic movement, with good contacts and credentials in disadvantaged communities. These groups have neither links to, nor influence over, the groups engaged in technological development. Companies operating in sophisticated markets have long since learned the value of market research as a factor in determining strategy; organizations getting into "community research" should take that lesson to heart.

Research and the Democratic Movement

An increasing number of research groups and research centres are supporting the different elements of the democratic movement. They share a few common features:

- They are almost all in the social sciences (education, economics, urban planning) with a few in the field of health.
- They are highly committed to research that is relevant to the definition of policy alternatives for a new South Africa.
- They often have good contacts with grassroots organizations (similar to a long-standing tradition in Latin America where many nongovernmental organizations (NGOs) and not-for-profit research institutes are closely allied with grassroots organizations of the disadvantaged).
- They depend on funding from external donor agencies that support the democratic movement as it seeks to bring about

fundamental change in the political life of the country. However, once a democratic government is installed, external donors will probably revert to their normal modes of operation, dealing directly with government. It will be important for the long-term flourishing of civil society that a new government recognize the need for many of these groups to survive.

Even where there is some form of coordination, as for example under the National Education Policy Initiative, their reliance on individual initiatives in defining research topics may leave some important issues untouched. In other fields, rather than coordination, there are vigorous disputes. During interim government rule, the democratic movement should pressure this body into maximizing its contribution and help to define viable policy alternatives.

Just as a democratic South Africa will have much experience, based on the work of groups related to the democratic movement, to share with other African countries on linking policy research to policymaking, other African countries contain networks of researchers empowered to participate actively in policy-relevant research. A good example is the Nairobi-based African Economics Research Consortium, a not-for-profit entity that enjoys close relations with government policymakers and is financed by a carefully constructed consortium. A democratic South Africa should seek to participate in such useful, regional activities.

Military Research

We collected no data, and only scattered comments, on the state of military research in South Africa. It is widely assumed within the democratic movement that, until recently, military research was well funded and technologically sophisticated. A military trade fair, held while we were in South Africa, was attempting to convince international buyers that this was the case. We heard of significant reductions in both funding and staffing of military R&D in recent financial years. However, the relevant data are not in the public domain. Among other things, it would have been useful to know where displaced military personnel were finally relocated. Given their training, they could help in upgrading the technological performance of civilian industry.

Of considerable concern to the democratic movement and to the international community are persistent fears that South Africa was intent on developing a nuclear weapons capability. It is a subject of some concern that a noted international journal (*Nuclear Fuel*, October 1992) published an estimate that South Africa has already produced about 400 kilograms of highly enriched uranium, an amount sufficient for about 20 nuclear devices. The recent signing by South Africa of the Nuclear Non-Proliferation Treaty, and the concomitant acceptance of inspections by the International Atomic Energy Authority, is a welcome step toward dispelling fears regarding the direction of military policy.

It is clear that a new, democratic government will wish to conduct a prompt and thorough review of current military and space research, to ensure that they are consistent with the needs of the new South Africa.

Chapter 4
SUGGESTIONS AND RECOMMENDATIONS

Priorities for Strategic Research

Because no country can afford to be the world leader in all branches of science, choices have to be made. In recent years, both countries and organizations have developed sophisticated techniques to help them determine research priorities. These techniques usually involve some combination of knowledge about the most promising research areas in scientific disciplines, together with an identification of societal needs.

These "research foresight techniques" have been used to identify national priorities for long-term (15 years) strategic research. They have helped identify areas of basic scientific research that are most likely to benefit society within the specified timeframe. Other studies have helped determine the most promising areas in which to concentrate resources, within specific sectors or scientific disciplines. Martin and Irvine (1989) have summarized the research foresight approaches followed in a number of industrialized countries and corporations; these approaches could be adapted to South African conditions.

The Japanese government and firms have had considerable success in "breeding" new technologies by identifying priorities. Indeed, the process itself has proved to be most significant. The Japanese government has articulated a process of involving many scientists, industrialists, and policymakers from government, industry, and academia in a variety of delphi-type exercises. Such a process of participation helps unite all parts of the scientific and technological communities to achieve objectives within agreed upon priority areas.

South Africa might embark on a similar participatory exercise, involving not only the scientific community, but all parts of society in an exercise that joins an identification of scientific opportunities with an identification of societal needs. A truly national exercise to identify priorities for strategic research could be a powerful tool in forging a democratic South Africa.

Fundamental Research

Most countries have a science policy that includes support of fundamental or basic research. Although there is debate on the definition of fundamental research, it is usually taken to mean the research undertaken to satisfy curiosity about nature. It is sometimes called "blue sky" research and is not related to direct economic objectives. Any research that is unlikely to be exploitable within, say, 20 years is frequently referred to as fundamental.

Governments of the industrialized countries, and a small number of developing countries such as India, support fundamental research for a number of reasons. First, it is a creative activity and, just as governments support creativity in the arts, so do they support creativity in science. Second, supporting fundamental research in universities makes it possible to train the next generation of researchers. By participating in this type of research, students develop skills that make them more versatile researchers than if they had learned these skills by doing more applied work. Third, because fundamental research has no immediate commercial value, the results are published and become internationally available. Scientists doing fundamental research in one country are thus connected with scientists in other countries. This makes it easy to tap into the world storehouse of scientific knowledge. However, without a local capability, it would be difficult for any country to gain access to this knowledge.

There are no objective guidelines to suggest how much a country should spend on fundamental science. In the end, it is largely a political decision based on how much the country can afford. It is sometimes suggested that a country should spend as much on this type of science as it does in supporting the arts. In many countries, the amount averages about 10 percent of total government R&D budget. Only the new government in South Africa can decide how much of the state-funded research budget should be set aside for fundamental

research and how those funds should be allocated. Because this type of research, by definition, has no immediate commercial value, it should be left to the scientific community to organize and dispense the resources allocated, without any justification in terms of economic relevance.

An issue raised by many interviewees in connection with fundamental research was related to the financing of NAC, currently administered by FRD. This laboratory received a parliamentary grant of 28.8 million rand in 1992/93 — an amount almost equal to that budgeted for FRD's core program, which supports university research in the natural sciences and engineering. (The budget of 39.9 million rand cited earlier includes 10.4 million rand accumulated in earlier years to complete the construction phase of the facility and an estimated 0.7 million rand in revenue from the sale of isotopes.)

NAC is an expensive facility designed for nuclear physics research, medical research related to neutron and proton beam therapy for certain classes of cancers, and the production of radioisotopes for medical use. No one we met, outside those directly involved in the NAC program, supported or justified the continued use of scarce R&D funds for this project. We agree with this view. Nuclear physics is an expensive area of pure science, which many industrialized countries have difficulty supporting. No country with the huge education problems faced by South Africa should perpetuate this misallocation of scarce resources.

The medical justifications presented as the primary reason for continued funding of the NAC do not withstand scrutiny from any reasonable public-health perspective, given the costs involved. South Africa faces enormous challenges in attempting to improve the health status of its poor majority. A future government that reallocated NAC's budget to other, more socially relevant research would risk criticism from only a small minority of South Africans.

International Collaboration in Science and Technology

South Africa contributes less than 1 percent to world S&T. It must be able to draw on, and benefit from, the other 99 percent. This can be accomplished in several ways, and the government can play a greater or lesser role in fostering the process. Also, by participating in

international collaborative activities, South African scientists can influence the research agenda in other components of world science.

Governments encourage their scientists and technologists to collaborate internationally for a variety of reasons, which may be scientific, technological, economic, or political. In addition to involvement in government-sponsored collaborative schemes, many scientists are also involved in collaborations with colleagues in other countries in many informal ways.

Industrial enterprises have also found it necessary to be involved with foreign enterprises, government laboratories, and universities in a wide range of collaborative schemes. Some of these are encouraged and subsidized by governments and international organizations. International collaboration in S&T has grown in volume and importance over the last decade, and most industrialized countries have developed policies and mechanisms to encourage it.

During this period, South Africa has been largely isolated from these developments. In our view, it must be a priority of the new government to encourage South African scientists and technologists to participate fully in new collaborative ventures with foreign institutions. In the past, collaboration was principally with First World institutions. In the future, South Africa must be linked to some of the innovative Third World networks, such as the international agricultural institutes that are a part of the Consultative Group on International Agricultural Research. Equally, it will be important to see South Africans elected to membership in the African Academy of Sciences and young South African scholars participate in some of the Academy's programs, such as those on capacity building in forestry research or in soil and water management. Of particular importance would be South African participation in the Academy's program on research priorities for the education of girls and women in Africa.

Science and Technology Policy Research

To make wise decisions about how to use S&T most effectively to meet society's needs, the government will need access to the relevant knowledge. Because each country is unique, each must have its own S&T policy research capability. In South Africa, we found expertise in this area within the program on evaluation and policy of FRD and the new technology policy group recently established within CSIR. We

identified no formal S&T policy research group at any South African university, although we met individual academics with a strong interest in the subject operating from departments at the University of Witwatersrand, the University of Cape Town, and the University of the Western Cape.

In our view, South African institutions must strengthen their capacity in this area. They must be able to tap into the international knowledge base, develop local knowledge, and make the relevant knowledge available to decision-makers throughout South Africa. There should be a network of research groups able to provide a contract research service and some academic groups who can train both S&T policy analysts and policy researchers. These groups might also be encouraged to develop an assessment capability that could be drawn upon for technology assessment and research foresight expertise.

Technology Missions

Some countries have found it useful to define a social objective that requires a major technological input, then mobilize all necessary resources to achieve that objective within a specified timeframe. This process is called a technology mission. The process whereby the United States put a man on the moon by the end of the 1970s, for example, was a technology mission.

The Government of India has defined a number of missions that benefit disadvantaged, largely rural communities in that country. These include the provision of clean water, access to telephones, and the attainment of literacy targets, each within a specified time. To achieve these objectives, appropriate technologies have to be identified and developed and financial and human resources mobilized. These resources may require private-sector involvement as well as public-sector financing. They require the combined efforts of many people, including voluntary agencies, in a major national endeavour (United Nations Advisory Committee on Science and Technology for Development 1990).

The new South Africa will have a need for similar technology missions. These could relate to housing or electrification, water, sanitation, education, etc. It would be valuable for the new government to identify a few social objectives for which technology missions might be designed.

Promoting Debate on Policy Options

This report is only a first contribution to a public debate on future directions for S&T policy for South Africa under a fully democratic government. We agree with our sponsors in the democratic movement that such an exercise is important. We believe that the National Economic Forum is a promising new locus for discussions on the future directions of South Africa's formal economic sector. We hope participants will consider adding to their agenda some detailed discussion of technology policy in general, and of some technological initiatives that might become vehicles for revitalizing important sectors of South African industry. South Africa has a great need to focus on developing employment-intensive technological strategies. The needs of the informal sector must also be explored.

For a truly national discussion of S&T policy to ensue, initiatives must come from many quarters. We expect that the ANC, COSATU, and SANCO will see to it that their members have the opportunity to express their views. We also invite the various scientific and professional societies of all disciplines to initiate discussions on S&T policy among their members. We hope this review will provide a starting point for debate. However, the challenge will be to define a process that allows South Africans from all backgrounds to discuss the issues embodied in S&T policy — from the democratic movement, from the social, natural, and health sciences, from employers groups, government, and unions. If the ANC, COSATU, and SANCO are able to follow through successfully in their intention to promote such a wide-ranging debate, they will have made a significant contribution to promoting a participatory form of democracy in the country.

An Important Issue to Address in the Short Term

The democratic movement supports a deliberately participatory form of government and is committed to the promotion of wide public discussion of future policy options. Given this orientation, which we fully support, one particularly pressing issue needs careful consideration, assessment, and debate: the future structure of the tertiary education system and the definition of its roles in teaching, research, and

community service. We have sketched some of the dimensions of the problem: disparities in performance; lack of clarity in the roles to be played by different kinds of institutions; and the need to deal with poorly prepared students.

A signal contribution of the democratic movement would be initiation of a process of wide consultation around the development of policy options in this field for a future government. We are aware that there has been a proposal to establish a National Education Negotiating Forum, whose terms of reference and agenda, once agreed upon, will cover a much wider domain than that of tertiary education alone.

A central question is how such wide consultation might be mobilized, and the democratic movement must develop a clear proposal. One option, which would parallel a process frequently used in other democratic societies, would be the appointment of a nonpartisan independent commission of enquiry into the tertiary education system. Such a commission would need to have the following:

- A set of commissioners who, by dint of their origins and accomplishments, would command wide respect throughout South Africa;
- Clear terms of reference and an acceptable timeframe within which to report;
- The power to hold public hearings, to invite submissions, and to conduct studies and research if necessary;
- The requirement to make public their findings, any testimony that they gather, and the results of any research that they commission (a well-conducted commission could set new standards for transparency in its operations);
- A competent, professional secretariat; and
- An adequate budget (such a commission would be of considerable interest to the donor community and a consortium of external donors could almost certainly be assembled; however, an encouraging sign would be the appearance of a South African group willing to contribute funds while imposing no conditions beyond the normal demands of for financial probity).

Clearly, this is only one option; we have not had time to explore, for example, the pros and cons of the creation of a national forum on tertiary education as an alternative. Whatever structural option might finally be chosen, its legitimacy will depend on the openness of its proceedings, the transparency of its processes, and the perceived quality and representativeness of the group of people charged with carrying out the task.

AFTERWORD
by David Kaplan[1]

What effect did the Mission have on the trajectory of debate and discussion around S&T policy in South Africa? It is widely recognized that the IDRC-sponsored Mission had a significant impact. Indeed, it is regarded as an enduring historical landmark. However, to fully appreciate its significance, the work of the Mission, like all historical landmarks, must be situated within the South African context of the time — both the S&T environment and the broader political context.

The Context of the Mission

The idea of a mission on S&T first surfaced in discussions at a symposium — "The Role of Research in Transforming South Africa" — cosponsored by IDRC and the journal *Transformation* in January 1992. However, at this stage, S&T was already an area of concern for the democratic movement — notably the ANC and COSATU — and an area of contestation with the government of the day.

Some 2 years earlier, following the unbanning of the ANC in February 1990, a small number of ANC members concerned with S&T

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issues organized as the ANC Interim Science and Technology Group and had a number of discussions with the prominent players in the existing S&T system. In October 1990, this group produced *A Draft Position Paper on Science and Technology Policy*, which provided a critique of the existing system and some concrete proposals for reform.

In May 1991, following discussions between Alec Erwin, then National Education Secretary of the National Union of Metalworkers, and Stuart Saunders, Vice Chancellor of the University of Cape Town, a Technology and Reconstruction Colloquium was held at the University of Cape Town. This colloquium, jointly sponsored by COSATU and the university was attended by over 100 participants, drawn from the principal constituencies concerned with S&T: government, extraparliamentary organizations, academia, the research institutes, business, and the trade unions. There were wide-ranging discussions around the question of what S&T policies were appropriate for the new dispensation facing South Africa (UCT 1991).

In March 1992, a follow-up meeting chaired by Dr Saunders and attended by a smaller group of 19 people drawn from the same constituencies discussed the institutional processes by which the formulation of effective policies in S&T could best be advanced. This follow-up meeting was addressed by Geoffrey Oldham — later one of the members of the Mission — and was attended by Tito Mboweni (now Minister of Labour) and Bernie Fanaroff (now Deputy Director General in the Reconstruction and Development Programme).

The outcome of this work was the development of a position on S&T by the democratic movement. The essence of that position was that the priorities governing S&T had to be redefined. In particular, S&T should serve the needs of all of South Africa's people and the democratic movement would seek the support of all sectors of the population and S&T stakeholders to this end. In this light, for example, the ANC Interim Science and Technology Group called for the creation of a broadly based national council for S&T. The council would be composed of representatives from industry, the trade unions, agriculture, the technikons and universities, funding bodies like FRD, and the Academy of Science.

But the democratic movement's position on S&T and its engagement with and understanding of the existing S&T system was still rather limited and superficial. The Mission provided the opportunity for a qualitative change.

Immediately before the arrival of the members of the Mission, there was a series of discussions and deliberations between those concerned with S&T in the democratic movement and, more importantly, a series of preparatory interviews and discussions among a number of people concerned with S&T in the democratic movement and key S&T performers. These interviews and discussions were to inform the S&T performers of the advent of the Mission, to help secure their cooperation and engagement with the process and also to begin preparation of the more detailed analyses of each of the key institutions.

Following this, a number of background studies of each of the key S&T performers was commissioned as the first stage of the Mission. These studies of all major components of the S&T system, excluding higher education, were completed in October 1992 (ANC 1992). They both deepened the criticism of the existing S&T system and suggested new policy directions for the democratic movement.

The existing S&T system was also being seen as increasingly dysfunctional. In August 1991, a "Symposium on Science Policy and Research Management" was organized by HSRC. The opening lines of the preface of the publication that resulted from that symposium (HSRC 1992) make clear reference to the process of change.

South Africa is now in the throes of moving from a new situation to the creation of a quite different future. In the process of dynamic change, policy issues are accorded overriding significance. The redressing of past inequalities and structural problems as well as meeting the needs of the developed sector are receiving high priority.

In the same publication, J.G. Garbers (1992), then Director-General, Department of National Education, admits to problems with the existing S&T system, albeit in moderated tones: "There is good reason to contend that the interaction between the science and research efforts and the public sector in South Africa is not optimal."

However, although many within the existing S&T system recognized at least some of its limitations, this concern was rarely made public. Indeed, one of the features of the Mission was that it was able to provide an initial public forum for dissenting voices from within the S&T system. This was later given further expression with the establishment of the Science and Technology Initiative (STI). After the Mission, the S&T system was increasingly and openly fractured. It was the more far-seeing dissenting voices from within the system who were

most prepared to embrace the Mission's report and who were to play a leading role in the work of STI.

The political context in which the preparatory work (ANC 1992, p. 2) for the Mission was undertaken in October 1992 was described as follows:

> Although the negotiations process broke down some months ago and is still to be resumed, it appears that the transition will be phased and relatively protracted. In particular (it) is envisaged that the installation of a democratically elected government may be preceded by two phases of interim government.

In the first phase, it was envisaged that the National Party government would give way to a multiparty interim governing council. This council would have direct control over those state functions linked directly to the exercise of state power and the holding of free elections. This phase would see essentially a continuation of existing policies. The second phase was envisaged as a Government of National Unity. This phase would allow more room to manoeuvre with regard to introducing policy changes. However (ANC 1992, p. 3),

> Even during a second interim phase, presided over by a government of national unity based on the outcome of elections to the constituent assembly . . . it is not anticipated that major policy initiatives would be taken in advance of the installation of a democratic system of government.

Thus, the political context appeared to indicate that only a limited restructuring of the S&T system would be possible, at least for the foreseeable future. More radical restructuring would have to await the demise of the Government of National Unity. What appeared to be of more concern at the time than the development of radically new policies for S&T was the perceived processes of unilateral restructuring on the part of government designed to shore up minority power. At the insistence of the democratic movement representatives, therefore, the prohibiting of unilateral restructuring of the S&T system was the first item of the agenda at the first plenary of STI, and it was to be the focus of much of the activity of STI, particularly in its early stages and before the advent of the Government of National Unity.

The Immediate Impact of the Mission

Public debate

The Mission received a great deal of publicity. The press and other media made great play of its criticism of South Africa's S&T system. A headline in the *Star* (15 February 1993) following a press statement from the democratic movement before the release of the Mission's report was typical: "SA's scientific research a mess — international team." After the report was made public, the *Sunday Times* (25 April 1993) reported: "South Africa's research and technology programmes have been slammed by a mission of international experts."

However, the press, particularly the business press, also provided considerable detail from the report, and all of the principal concerns raised by the Mission were reflected in the press. There was considerable opportunity for the major local "protagonists" to provide perspectives on the Mission's work. In this regard, the *Saturday Star* (13 February 1993) published a lengthy interview with Roger Jardine and, in the same issue, an editorial that echoed and reinforced the criticisms voiced by the Mission. It called for "a permanent, politically neutral body, independent of government, to implement a coherent policy that caters for government needs, the demands of research and the requirements of the community."

The following week, the same newspaper carried a lengthy reply from Chris Garbers, chairman of the Science Advisory Council, (*Saturday Star*, 20 February 1993).

Issues and the proceedings of the 5 March 1993 meeting between members of the Mission and representatives of South Africa's existing S&T system, headlined as "historic" by the *Star*, were also covered extensively. The *Star* was unambiguous in its reporting of the ascendancy gained by the democratic movement in initiating the Mission (6 March 1993): "The ball, as far as S&T policy is concerned, is solidly in the hands of the democratic movement, and judging from yesterday's meeting, they have every intention of keeping it there."

Press coverage stressed the strength of the Mission's criticisms of the S&T system, but also provided informed detail on the issues. This was the first time that debate about S&T "went public." Furthermore, the existing S&T system and the National Party government were further discredited in their widely perceived inability to provide coherent

national policy while, in contrast, the democratic movement was portrayed as deeply concerned about the issue and far in advance of its opponents.

The formation of the Science and Technology Initiative

Following meetings of the Mission members with representatives of the democratic movement and of South Africa's existing S&T system on 4 and 5 March 1993, further discussions took place within the democratic movement regarding the appropriate road forward. It was widely and strongly believed within the movement that action was needed to maintain the initiative it had gained. With expectations raised, a bold move would have to be made and seen by all concerned as a genuine attempt to begin to address the problems and issues identified by the Mission.

The demoncratic movement organized a further meeting to consider processes and developments relating to S&T. The letter of invitation stated that its purpose was

- To follow up the IDRC-sponsored review of the South African research system by initiating an inclusive consultatitive process to take the matter forward; and
- To discuss the process for jointly addressing how issues relating to the country's science system and policy could be initiated during transition and beyond, into a democratic South Africa.

A wide range of organizations were invited to this meeting, which took place on 3 May 1993. In addition to members of the democratic movement, representatives from all of the science councils, universities, technikons, and government departments attended. Their decisions were recorded as follows:

The meeting agreed that the institutions and organisations represented provided a sufficiently broad basis for initiating a joint process which could deal with the issues identified during the meeting as needing to be handled through inclusive discussion, and agreed unanimously to:

1. Establish an Initiative on research, science and technology. Its purpose would be to discuss both issues of immediate concern, relating to transition and those with longer term implications, and to concern itself with both policy and system.

- The convening of a meeting of the Initiative within the next two months.
- In the spirit of inclusivity and to broaden participation in the Initiative, to invite to the next meeting other interested organisations and groups, in particular the Department of Trade and Industry and parastatal enterprises.
- The establishment of a Joint Working Group to facilitate the Initiative.

The Working Group, neatly balanced with representatives from the existing S&T system and the democratic movement, was co-chaired by Jayendra Naidoo (COSATU) and Brian Clark (CSIR); the other members were Chris Garbers (SAC), Rolf Stumpf (HSRC), Friedel Sellschop (Committee of University Principles), Roger Jardine (ANC), Cromet Molepo (SANCO), and Bernie Fanaroff (COSATU).

The Working Group decided that the process initiated at the 3 May meeting would be termed the Science and Technology Initiative (STI); those present at that meeting would be termed "the plenary" and the Working Group would be accountable to the plenary.

STI was to be the most important outcome of the Mission's work. Apart from promoting debate on S&T within the various concerned organizations, the Mission (see p. 66 "Promoting debate on policy options") believed that

> The challenge will be to define a process that allows South Africans from all backgrounds to discuss the issues embodied in S&T policy — from the democratic movement, from the social, natural, and health sciences, from employers groups, government, and unions. If the ANC, COSATU, and SANCO are able to follow through successfully in their intention to promote such a wide-ranging debate, they will have made a significant contribution to promoting a participatory form of democracy in the country.

STI fulfilled the function of institutionalizing a transparent and wide-ranging discussion among all the participants regarding the route forward for S&T.

The Working Group identified six priority issues, which were later ratified by the plenary. These issues were to form the framework for the work of STI:

- Information on the existing S&T system;

- Transparency and influence of the existing decision-making and advice-formulating processes;
- A future S&T system and its decision-making processes;
- Enabling research establishments to respond to major issues;
- Human resources development; and
- Governance.

STI held five plenary meetings, the last on 26 May 1994. At that stage, STI was dissolved. However, the Minister of Arts, Culture, Science and Technology has "formally requested the STI to be reconstituted as a National Science and Technology Forum (NSTF) for the purposes of consultation on science and technology issues between the ministry and the broad S&T community" (*Weekly Mail and Guardian*, 20–26 January 1995). The organization of NSTF is now under way.

Thus, STI, which resulted directly from the Mission's report and process, became the focus for debate and discussion on S&T policy reform. STI provided a structured focus for the interaction of those concerned with S&T across political boundaries. Moreover, it provided a focus for interaction among the various institutions concerned with S&T — precisely what the Mission had found to be missing within the existing system. Through the workings of STI, a far more holistic and integrated vision emerged of the possible role of S&T. In particular, there was considerable discussion of the priorities that should guide the activities of the S&T system and a notable drawing together of the various "parties" in this respect. STI drew into these discussions scientists and researchers and their respective organizations, who previously had no input into national policy. At the same time, the debates became far more public, far more transparent, and incorporated new participants from organizations of civil society — the civics and the trade unions, in particular.

However, the measure of agreement over the broad goals and objectives for the S&T system, which STI was able to secure, should not obscure the likelihood of fierce debate and division that will inevitably occur when the government implements new policies designed to realize these objectives. The area is still very much a "contested terrain" and the division and fragmentation of the S&T system that the Mission emphasized so strongly is likely to reassert itself when real policy choices are made. Nevertheless, STI has also

contributed to advancing the debate around concrete policies, principally by commissioning four reports in relation to priority areas:

- *The South African Science and Technology System: Structure and Policy* by C.F. Garbers, chair of SAC (on information about the existing S&T system).
- *Proposals for a Future National Science and Technology Management System in South Africa* by Gideon de Wet and David Kaplan (on a future S&T system and its decision-making processes).
- *The Employment Composition and Affirmative Action Programmes of the Science Councils in South Africa* by Enver Motala (on human resources development).
- *Science Councils: Towards the Democratisation of Governance* by Saleem Badat and Walter Prozesky (on governance).

These reports provide points of departure for initiating policy changes in the field of S&T. They have been welcomed by the Minister, who stated: "The work done by the STI on a future science and technology system for South Africa, will form the basis of the work for the Department for the next six months" (B.S. Ngubane, debate on the Ministry's budget, 1 September 1994); and by the Deputy Minister, Winnie Mandela (at the STI 5th plenary meeting, 26 May 1994), who drew attention to the links as between the Mission, the STI, and the commissioned reports:

> This initiative (the S&TI), which followed the historic IDRC funded mission report "Towards a Science and Technology Policy," is an initiative which you can be proud of. The commissioned reports . . . undoubtedly will be very important in contributing to the path that we choose to meet the challenges that we face.

Although the Ministry has yet to effect major policy changes, the recent appointment of key personnel, especially Roger Jardine, a member of the STI Working Group, as Director General, will speed up the process. It appears likely that these reports will for important input into the processes of restructuring policy and management of S&T.

S&T policy research

The Mission urged that local capacity in the S&T policy research arena should be considerably strengthened. Local initiatives were already

under way (with much encouragement, particularly from Geoffrey Oldham). However, the Mission's explicit recommendation helped galvanize local efforts in this direction. At least one S&T policy research centre based at the University of Cape Town is likely to take shape in 1995, and the Mission will have done much to facilitate its establishment.

The Long-Term Impact of the Mission

The Mission's report provided some context for the development of S&T policy by outlining, albeit briefly, the experiences of other countries. It stressed the need to ensure equality as well as economic growth and the importance of environmental considerations and self-sustaining growth. Like the OECD missions, which examined the state of S&T in particular countries, the IDRC-sponsored Mission sought not to provide solutions, but rather to bring new perspectives to the debate on future direction for S&T in South Africa.

To some degree, the Mission succeeded in this task. However, there were also some failings in this regard. The Mission's report was highly uneven in its treatment of key S&T issues and performers and in its explication of international experience. This limited its longer term impact on the South Africa S&T policy debate.

On at least one issue, the Mission's report attempted to provide a specific solution to a concrete problem. In relation to the National Accelerator Centre, the report recommended that state support should be withdrawn (see p. 63, "Fundamental research"):

> No one we met, outside those directly involved in the NAC program, supported or justified the continued use of scarce R&D funds for this project. We agree with this view. Nuclear physics is an expensive area of pure science, which many industrialized countries have difficulty supporting. No country with the huge education problems faced by South Africa should perpetuate this misallocation of scarce resources.

Many in the scientific and tertiary education community took umbrage at this solution. This was not only because they disagreed with it, but also because this solution was seen to be based on flimsy evidence. Furthermore, it seemed to fly in the face of the major thrust of the Mission — to advocate a dialogue of all of the players regarding restructuring of the S&T system.

In contrast, the Mission frequently provided vague and rather superficial analysis of some key S&T issues and S&T performers. In some cases, the complexity of the problem was so evident that the Mission chose to "duck the issue" and simply called for much deeper discussion. This is most obvious with regard to the crisis in tertiary education; the Mission proposed "the appointment of a nonpartisan independent commission of enquiry into the tertiary education system" (see p. 67, "An important issue to address in the short term"). The recommendation in this case was opposite, and such a commission has now been appointed although it is hardly traceable to the influence of the Mission. The Mission provided no perspective on how S&T issues should be taken account of in the debate on the future of tertiary education. Its work has, therefore, had little significance in this area.

A more serious limitation lay in the Mission's analysis of the key S&T performers. The problem was not so much that the Mission's assessments were wrong — its judgements were frequently accurate. Rather, the problem related to the often superficial nature of the Mission's treatment and analysis. Most of the science councils, for example, had prepared voluminous submissions on every aspect of their activities; these seemed hardly to have been taken into account in the very circumscribed assessments presented in the report. Although the Mission was unambiguous in stressing the need for restructuring of the science councils, its assessments of the councils provided only a limited basis from which such restructuring could be planned.

An exception in this area is the Mission's remarks on HSRC. Although it appeared to make little use of the documentation provided by HSRC, it made some important suggestions, including: "Alternatives could include the conversion of at least parts of HSRC to independent 'not-for-profit' status" (see p. 28, "Human Sciences Research Council"). HSRC has recently produced a discussion document to elicit feedback on how it might optimize its contribution to South African society. The document contains a number of proposals, one of which is similar to the suggestion made by the Mission. The proposals are said to be formulated within the context of the IDRC Mission and the STI investigations into aspects of the South African S&T system (HSRC 1994, p. 8).

Finally, the Mission failed to reflect on many critical aspects of the international debate and experience with S&T policy. For example, it

provided little perspective on how the management of a national S&T system could be organized or on the governance structures of S&T performers. The work undertaken by STI with regard to these questions made no direct reference to the work of the Mission. The conversion of military and atomic energy R&D to civilian uses and — perhaps the most critical issue facing S&T in South Africa — how to ensure that S&T performers respond to the needs and requirements of those with limited market power were also given only limited attention by the Mission. One major omission was consideration the policies that the Department of Trade and Industry was adopting in relation to technology advance. All these issues have moved, or are now moving, into the forefront of the policy debate, and this debate is proceeding without reference to the Mission's work.

Conclusion

The Mission was most effective in providing a focus for developing the dialogue between the existing S&T system and the democratic movement. The timing of the Mission was propitious. Discussion was already underway, but the Mission deepened it. It shifted the debate from critique and formulation of rather vague alternatives to a search for common goals and implementable policies. The Mission was particularly effective in promoting a debate about how the S&T system might be transformed — its most effective and frequently employed metaphor was that of holding up a mirror that reflected the different views that had been expressed before the Mission, and the near universal opinion of the principal players within the S&T system that the system had no clear or consistent goals or direction.

The work of the Mission had a direct impact on the formation of STI — indeed, this was to prove its most important legacy. As in other spheres of South African public life, S&T became an area in which an inclusivist forum, STI, was established and later recognized by government. This has contributed toward making policy formulation more open, participatory, and transparent.

The Mission contributed to the longer term debate on S&T, although here its impact has been far more limited. In part, this situation was inevitable because the Mission was never intended to be a policy blueprint. However, it could have had more impact in the longer term if it had reflected more on international experience in a number

of pertinent policy areas, if it had been less superficial in its treatment of S&T performers and some key policy issues, and if it had been more consistent in its overall approach.

Nevertheless, these limitations should not detract from the overall assessment of the project as undeniably positive. The Mission is, quite correctly, now seen across the political spectrum and by all of the major players in S&T as a major turning point in the effort to restructure the South African S&T system to benefit all our peoples.

Appendix A
MEMBERS OF THE MISSION

External Members

James Mullin (Mission Leader) — *Former Chairman, OECD Committee on Science and Technology Policy, Paris, France*

Deanna Ashley — *Principal Medical Officer, Secondary and Tertiary Care, Ministry of Health, Kingston, Jamaica*

Lydia Makhubu — *Vice-Chancellor, University of Swaziland, Kwaluseni, Swaziland*

Thomas Odhiambo — *Director, International Centre of Insect Physiology and Ecology, and President, African Academy of Sciences, Nairobi, Kenya*

Geoffrey Oldham — *Science and Technology Advisor to the President, International Development Research Centre, Ottawa, Canada, and Former Director, Science Policy Research Unit, University of Sussex, Sussex, United Kingdom*

South African Members

Ivy Matsepe-Casaburri — *Executive Director, Education Trust for South Africa, Johannesburg, South Africa*

Jairam Reddy — *Vice-Chancellor, University of Durban, Westville, Durban, South Africa*

Jakes Gerwel — *Vice-Chancellor, University of the Western Cape, Cape Town, South Africa*

Frene Ginwala — *Director, Department of Research, African National Congress, Johannesburg, South Africa*

David Kaplan — *Development Policy Research Unit, University of Cape Town, Cape Town, South Africa*

Stanley Sangweni — *School of Rural Community Development, University of Natal, Durban, South Africa*

Appendix B
ORGANIZATIONS CONSULTED DURING THE MISSION

In addition to representatives of the organizations listed here, a number of interested individuals from universities and the private sector participated in meetings organized by the Mission.

Agricultural Research Council

Association of Science and Technology Societies

Atomic Energy Commission

Centre for Development of Information and Telecommunications Policy

Centre for Health and Social Services

Chemical Workers Industrial Union

Committee of University Principals

Community Agency for Social Enquiry

Congress of South African Trade Unions

Cooperative for Research and Education

Council for Mineral Technology

Council for Scientific and Industrial Research

Department of Education, ANC

Department of National Education

Department of Economic Planning, ANC

Department of the Environment

Development Bank of South Africa

Economic Trends Group

Education Development Trust

Education Policy Development Unit

Education Policy Unit, University of the Western Cape

Education Policy Unit, Univeristy of Natal

Education Policy Unit, University of Witwatersrand

Energy for Development Research Unit

Environmental Development Agency

Electricity Supply Commission

Foundation for Research Development

Group for Environmental Monitoring

Health Systems Research Trust

Human Sciences Research Council

Industrial Strategy Project

Institute for Urban Primary Health Care

Macro-Economic Research Group

Medical Research Council

Military Research Group

Natal Gender Research Network

National Education Policy Investigation

National Land Committee

National Union of Metal Workers of South Africa

New Public Administration Initiative

Progressive Primary Health Care Network

Research Department, ANC

Royal Society of South Africa

Rural Advice Centre

Science Advisory Committee

Science and Technology Group, ANC

South African Bureau of Standards

South African Chamber of Business

South African Health and Social Services Organisation

South African National Civic Organisation

Union of Democratic University Staff Associations

Urban Sector Network

Appendix C
THE 27 PRINCIPLES OF THE RIO DECLARATION

1. Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.
2. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.
3. The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.
4. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.
5. All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.
6. The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.
7. States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place

on the global environment and of the technologies and financial resources they command.

- To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.
- States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.
- Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.
- States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.
- States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing trans-boundary or global environmental problems should, as far as possible, be based on an international consensus.
- States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.
- States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause

severe environmental degradation or are found to be harmful to human health.

- In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
- National authorities should endeavour to promote the internalisation of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.
- Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.
- States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.
- States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse trans-boundary environmental effect and shall consult with those States at an early stage and in good faith.
- Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.
- The creativity, ideals and courage of the youth of the world should be mobilised to forge a global partnership in order to achieve sustainable development and ensure a better future for all.
- Indigenous people and their communities, and other local communities, have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognise and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.
- The environment and natural resources of people under oppression, domination and occupation shall be protected.
- Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the

environment in times of armed conflict and cooperate in its further development, as necessary.

- Peace, development and environmental protection are interdependent and indivisible.
- States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.
- States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

Appendix D
ACRONYMS AND ABBREVIATIONS

AEC Atomic Energy Commission

ANC African National Congress

ARC Agricultural Research Council

CODESA Convention for a Democratic South Africa

COSATU Congress of South African Trade Unions

CSIR Council for Scientific and Industrial Research

ECLAC Economic Commission for Latin America and the Caribbean

Eskom Electricity Supply Commission

FRD Foundation for Research Development

HBU historically black university

HRAO Hartebeesthoek Radio Astronomy Observatory

HSRC Human Sciences Research Council

HWU historically white university

IDRC International Development Research Centre

ISO International Organization for Standardization

Mintek Council for Mineral Technology

MRC Medical Research Council

NAC National Accelerator Centre

NGO nongovernmental organization

NSTF National Science and Technology Forum

OECD Organisation for Economic Co-operation and Development

R&D research and development

S&T	science and technology
SAAO	South African Astronomical Observatory
SABS	South African Bureau of Standards
SAC	Scientific Advisory Council
SACOB	South African Chamber of Business
SANCO	South African National Civic Organisation
SME	small and medium-sized enterprise
STI	Science and Technology Initiative
UNCED	United Nations Conference on Environment and Development

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