FORESIGHT ICT REPORT

Foreword

The report you are about to read is one of fifteen comprising South Africa's National Research and Technology Foresight project. Twelve tackle specific aspects of the South African society and economy and three so-called "cross-cutting" aspects. Collectively they represent critical input into shaping national research and technology policy that will likely have a long-lasting and positive impact on the creation of wealth and quality of life for all South Africa's citizens.

We recognise the initiative of the Department of Arts, Culture, Science and Technology in launching the project, the leadership, drive and enthusiasm of the Foresight Project Director, Dr Philemon Mjwara, and the dedication of the team of sector coordinators and their support staff that managed a highly complex task over the past two years.

This report addresses Information and Communications Technology (ICT), a unique sector because it represents a scientific discipline and industry in its own right, as well as cutting across all other sectors. Even a cursory glance at the other outputs reveals the all-pervasive role of ICT as we enter the information age. The ICT sector is also unique in its pace of change and the rapid convergence of traditionally distinct areas of human endeavour. Indeed, it is almost impossible to construct a definition of ICT that will last longer than about six months before the boundaries shift. Nonetheless, the participants in the ICT foresight process were challenged to come up with plausible findings over a twenty-year time horizon!

Who were the participants? First, rigorous processes were used to identify a representative group of people knowledgeable in ICT in South Africa. The outcome was the following list of volunteers making up the ICT Sector Working Group, who gave many hours of their time, expertise and creativity over the eighteen months of the project. The affiliation of each is shown as it was at the start of the process.

Ms Luci Abrahams School for Public and Development Administration, Witwatersrand University
Prof Edwin Blake ..... Computer Science, University of Cape Town
Prof Peter Clayton ..... Computer Science Department, Rhodes University
Ms Lauren Fok ..... SANGONET
Ms Tina James ..... Independent Consultant
Mr Ravindra Joshi ..... Maths and Computer Science Dept., University of Zululand
Dr Mike Kahn ..... Gauteng Provincial Government
Mr Shaun Lake ..... International Trade Education

Mr Eric le Roux ..... Old Mutual
Mr Labius Lesibu ..... SATRA
Mr Charley Lewis ..... COSATU
Mr Aubrey Malabie ..... Datatec
Mr Ashiek Manie ..... Telkom
Dr Sibiletso Matabane ..... Sentech
Prof Kobus Meij ..... Institute for Information Technology, Stellenbosch University
Dr Jonathan MillerGraduate School of Business, UCT and Computer Society of South Africa (Chairperson)
Mr Niall Murphy ..... Systems Publishers
Mr Viz Naidoo ..... National Department of Education
Ms Susan Nkomo ..... SOSRDEF
Dr Sibusiso Sibisi ..... Plessey
Mr Simon White ..... Forge Ahead/BMI-T
Mr Alan Young ..... Delta Motor Corporation

Central to the Foresight process were a series of eight workshops. Senior members of government and the private sector addressed those workshops. On occasion, the working group called for comment and critique from a larger group of about eighty people—the so-called Reference Group. And when it came to the administration of the important Delphi survey of national opinion, a list of some 1 500 people was drawn up, half from the membership of the Computer Society of South Africa and the balance from several other sources. Fifteen per cent of that group committed several hours of their time to completion of the lengthy survey instrument and nearly half of them again to completion of the second round of the survey. In a very real way, therefore, the results of the ICT foresight have benefited from a wide spectrum of expert opinion. We take this opportunity to record our appreciation for the interest and commitment shown by so many people.

To help respondents complete the Delphi survey, a web version of the questionnaire was created. This unique effort was not without its technology problems! We thank the CSIR for frequently making facilities available to rework and stabilise the Website, even over the 1998 holiday period. CSIR staff (especially Karin Louw) were also provided to help with the restructuring of large quantities of “soft” data. Senior CSIR executives Adi Paterson and Chris Rust were a valuable source of expertise during the development of the key technology maps. Most importantly, another CSIR employee, Olga Crafford, single-handedly and always with good humour and dedication, administered the (sometimes fractious) working group and the myriad of details that characterised this project.

All working group members contributed significantly to the project, although, inevitably, some could not give as much as they might have liked throughout the lengthy period. Others were able and willing to go beyond expected contributions and deserve special mention. These include Niall Murphy for providing and organising,

free of charge, the ICT sector website, Sibusiso Sibisi for special advice on technology maps and the foresight process, and several group members who toiled over the successive analyses, presentations, draft chapters and other inputs culminating in the current report: Edwin Blake, Peter Clayton, Tina James, Charley Lewis, Eric le Roux and Viz Naidoo.

The ICT Sector Working Group had a coordinator of extraordinary passion, Dr Bob Day. Bob is an ICT visionary and a perfectionist. He brought those qualities to bear and we have all benefited greatly. Having worked closely with him for nearly two years on this project—in offices, in homes, in executive retreats, in cars and in airports, face to face and over the Internet—I can attest better than most to his remarkable level of commitment to get the job done. And he has succeeded.

The chapters of this report embrace international trends, local conditions, professional opinion, empirical data, and even some gazing into the crystal ball. Throughout the exercise, the working group stayed focused on this country, and its strengths and weaknesses vis-à-vis information and communications technologies. To that extent it is an unusual attempt to plot a long-term course for ICT in a developing country and especially to seek ways to reduce the gap between the haves and the have-nots. Clearly this is just one step in an unfolding process. Already we see other national projects such as the National Qualifications Framework, the Electronic Commerce Debate, and the IT Industry Strategy Project under way and promising to offer key solutions in the short term. I believe each will benefit from this study. South Africa has significant comparative advantages that we can exploit in the global arena and the intense focus on the ICT sector in this country holds great promise. We encourage you to study this report. Critique its findings, draw your own conclusions and initiate robust debate on long-term research and technology directions so that we may best use ICT to grow the economy and enhance the quality of life of all our citizens.

Jonathan Miller, *PhD*

Chair, Foresight Sector Working Group: Information and Communications Technology

October 1999

Contents

Executive Summary

Today's accelerating rate of technological change, and the social, economic and cultural changes that follow in its wake, have stretched existing institutions and the fabric of society to their limits, even in the most developed societies and the strongest organisations. Many argue that technological innovations, particularly from the Information and Communications Technology (ICT) sector, are the main drivers of these changes. Others speak of an emerging 'knowledge society' as the fundamental cause.

For countries in the developing world, like South Africa, this phenomenon can either be faced with pessimism and paralysis, or welcomed as an opportunity for long-overdue transformation and for the development of equitable participation in the global economy. The National Research and Technology Foresight (NRTF) project is intended to facilitate the latter approach, applying several long-range planning exercises to shape research and technology policy and to facilitate the growth of a flexible, adaptive culture of foresight throughout all sectors of society.

This report describes the processes used by and the outputs and recommendations of the NRTF ICT sector working group (SWG).

Chapter 1 is an overview of the general philosophy behind national foresight processes. It describes the background to South Africa's NRTF project, the main components of the methodology and the players involved, particularly the SWG, which was formed early in 1998 and continued its work until late 1999.

Chapter 2 provides summaries of extensive international and local technology scans which were undertaken in 1997-1998 as a starting point for the SWG's work. Both scans represented snapshots of the ICT sector at the time. The extent to which expectations had already become reality by the time the SWG's work was finished, emphasises the rapid rate of change in the sector.

Chapter 3 describes how the SWG set about defining its mandate and scope by using the background of the technology scans to define a mission and a set of sector foci. The identification of sector foci was followed by an initial ICT Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. Early in the process it became clear that ICT is a cross-cutter for most other areas of importance in the SA economy, and that human resource development is a cross-cutter in all areas of ICT. A strong underlying factor to emerge from the SWOT analysis was that an aggressive national ICT vision is urgently needed to counteract obstructive policies, uncoordinated efforts, a lack of funding, inadequate skills and training, and the absence of a culture that fosters the development and effective use of ICT.

Chapter 4 describes the scenario component of the NRTF project. Scenarios are rich stories that assume unpredictability, challenge conventional wisdom, clarify risks and opportunities, and encourage creativity and responsiveness. They reveal what could happen, not what will or should happen. The first four macroscenarios, depicting a wide variety of possible futures for South Africa unfolding by 2020, were developed for consideration in all sectoral studies. They were named 'Frozen Revolution,' 'Innovation Hub,' 'Global Home,' and 'Our Way is THE Way'. The ICT SWG then created ICT sector scenarios using the macroscenarios as a template, first as a table (Table 4.1), and then as four narratives. Hereafter the SWG performed a second SWOT, projecting themselves twenty years in the future in each ICT scenario and focusing on opportunities and threats that could emerge, with particular emphasis on research and technology developments.

Chapter 5 reports the design, development and conduct of a formal Delphi survey of expert ICT stakeholders throughout South Africa. A list of statements that embody miniscenarios of future technologies and processes was presented to a wide group of stakeholders with significant knowledge of and interest in the ICT sector. The statements in the survey are themselves the culmination of extensive workshopping by the SWG. The survey results include the following:

- Several statements that the respondents regard as most important for wealth creation and/or quality of life relate to education and learning, and gaining access to the global network.
- The median time to realisation for all the statements is about 10 years, with half the responses lying within a time frame of five to 15 years.
- The most popular path to realisation of the statements is the creation of joint ventures. This is consistent with the assessment that South Africa is generally behind the developed world in technology terms, but has the capability to partner and adapt technology for local needs.
- Among the more significant constraints to realising the statements are financial and human resources and social/cultural factors.

Chapter 6 considers how the complex array of empirical and conceptual data gathered in this study might be combined into a uniform framework. The structure of 'strategic technology maps' presented links the user demand for ICT at the 'key solutions' level with a logical hierarchy of technology components. Applied and base ICTs are identified and analysed to focus research attention on the development of 'strategic technology nodes' (STNs), the preferred target of national and regional research and technology policy. Because ICT is a fundamental enabler of economic and social activity in all sectors of the economy, the SWG broadened the scope of the strategic technology map by identifying and analysing the ICT-related content of the other eleven foresight sectors. It is noteworthy that in most cases the respondent

groups in the latter placed high importance on what the SWG might regard as 'current' ICT opportunities. This does not minimise their relevance, but indicates that they have yet to be fully exploited. Generally the other respondent groups placed less importance on the more 'exotic' ICT opportunities mentioned. It is in those areas that we need to raise the awareness of the user community and encourage greater insight amongst the researchers and suppliers into the significant opportunities that lie in the future.

Chapter 7 is itself a summary of the findings presented throughout the report. At a high level, it recommends a range of interventions and suggests time frames and degrees of research and technology investment. None of these recommendations is the last word, but they should be seen as a basis for more detailed discussions/investigations.

STN 'Super Clusters' Recommendations:

The ten STNs may be grouped into so-called 'super clusters.' Two super clusters are given the highest priority. Not surprisingly, major short-term national investment in **'Future Web' solutions** is expected to produce early significant returns, whereas over a longer time **knowledge and learning-intensive solutions** may well be an even greater opportunity. **Solutions essential for the sustained competitiveness of South Africa's ICT industry** need care — adequate investment may not always be forthcoming since the longer-term benefits are often not obvious to most stakeholders. In the short term, investment to establish adequate research and technology capabilities in **intelligent solutions** is likely to be the lowest of the four, but the potential for significant longer-term growth should not be underestimated.

Base Technologies Recommendations:

There are four groups of base technologies recommendations:

High Priority, High Investment: Four base technologies merit significant investment over the next twenty years to supplement existing and establish new research and technology capabilities.

Access Technologies (radio, low-cost satellite, stratospheric platforms),
Spatial Numeric Environments,
Human Language Technologies and
Security Technologies.

In particular, the results of the sector studies suggest that experts from the Safety and Security and the ICT sectors should collaborate to develop the fourth base technology.

High Priority, Medium Investment: A high-priority base technology whose research and technology needs may wane in the medium term is:

Digitisation Technologies.

Medium Priority, Medium Investment (short term): Three important base technologies do not appear to require urgent action, but may have significant longer-term potential for the South African ICT Industry:

Future Chip Technologies,
Intelligent Systems (both hardware and software) and
Biometrics.

Medium Priority, Low Investment: This group contains two base technologies, where significant capability and some capacity already appear to exist:

Server and Database Technologies,
Distributed, Cooperating Application Platforms.

Over the past 18 months, the assembled expertise of the ICT SWG has examined, debated and discussed current and future trends within the sector. We have identified several possible future scenarios for South Africa and its ICT sector, highlighting both opportunities and threats. We have canvassed the views of a wider selection of ICT expertise. And finally we have made a series of recommendations that arise from this body of work.

Getting to grips with the extraordinarily complex, rapidly changing and all-pervasive nature of ICT in our society has been a humbling experience for all contributors. It is encouraging to note, however, that there are other national studies underway, such as the IT Industry Strategy Project and the E-Commerce Debate, that in themselves must consider and inform longer-term research and technology directions. In particular, we trust that this report, and especially its recommendations, will help to focus the work of such studies. In general, we hope that the ICT community in South Africa will examine these recommendations both seriously and critically. Above all, we hope that they will form a springboard for many action plans and significant developments in the sector, which, over the next 20 years, will create wealth for and improve the quality of life of all our citizens.

Chapter 1:

The Foresight Philosophy and Process

1.1 Introduction to the Foresight Process

Foresight[1] is a family of processes intended to capture the dynamics of change by placing today's reality within the context of tomorrow's possibilities. It acknowledges a range of potential futures and seeks to add new dimensions to our thinking by providing—

- a way of thinking about the longer-term future and how it could differ from the present;
- a means of testing our current views and policies; and
- a way of overcoming the difficulties of static or retrogressive analyses.

Foresight provides a valuable mechanism for serious consideration of significant research and technology trends and their relationship to socio-economic needs. Foresight is inherently proactive and reflects the belief that the future is influenced by today's decisions and actions. By building complex pictures of alternative futures we are better able to assess how well current and proposed research and technology systems might address our future needs.

Although foresight may use several forecasting techniques (e.g. Delphi analyses, trend analyses, scanning and scoping), the outputs differ significantly. The emphasis in foresight is not on prediction but on the realisation that addressing the future necessitates the management of uncertainty. A richer and well-informed context for current decisions is developed through a dialogue involving all relevant stakeholders that emphasises the human abilities of forethought, creativity, systems thinking, analysis and judgement. The wider the range of perspectives explored, the more broadly the benefits will be felt.

Transparency is essential for foresight processes. The underlying assumptions, analytical framework and information inputs must be accessible for universal review. Such openness will also provide equal weighting for nonconformist and conventional views, thereby encouraging the identification of emerging paradigms.

In several countries,[2-7] the establishment in both the public and private sectors of a foresight culture has been a precondition for the comprehensive long-term visions of future possibilities and needs, which are so important in providing appropriate contexts for the effective integration of foresight with decision-making. Creating such a culture is complex, and requires an appropriate balance between two of the intrinsic

tensions in foresight: technology-push versus market-pull, and top-down versus bottom-up. The following four components should be present for this culture to flourish:

- there should be prior consensus on the need for foresight;
- any suspicion/cynicism of researchers, professionals and other stakeholders should be adequately addressed;
- the process should be broad, and should extend beyond established disciplines of panels dominated by elite specialists and scientists;
- institutional machinery should be put in place to translate foresight findings into specific policy initiatives and resourced action, preferably involving both the public and the private sectors.

Consultation process: Since Science and Technology (S&T) cuts across many sectors including industry, non-profit sectors and society at large, it is very important to involve all the possible participants. The Research and Technology Foresight process is as important as the product. For a foresight product to be acceptable it is imperative to maintain continuous interaction with research users and the scientific community during the process. This type of consultation increases the level of 'buy-in' and commitment from all involved.

Industry involvement: International experience shows that industry involvement and commitment are key to the success of the Foresight exercise. The role that industry plays in economic development puts more emphasis on its involvement, especially with regard to the successful implementation of the foresight outputs. It is also important to note that, although the aim of the project is to facilitate the country's global competitiveness, it is companies that compete, not government. Government's role is to create a conducive environment so that industry can compete successfully in the global arena. Technological progress and human resource development lay the foundation for continued economic growth and job creation, areas in which industry should play a crucial role.

1.1.1 South Africa's Foresight Process

Background: The National Research and Technology Foresight (NRTF) project is one of a number of initiatives launched by the Department of Arts, Culture, Science and Technology (DACST) as part of its mandate to review and reform the S&T system in South Africa. Interest in foresighting started in 1993 when the International Development Research Centre (IDRC) of Canada, at the request of the Mass Democratic Movement, conducted a Mission on S&T Policy for a Democratic South Africa. The mission report outlined the steps that needed to be taken when transforming S&T, and also assessed the status of the system. The report emphasised, as part its recommendations, that a foresight exercise should be conducted.

Shortly after the establishment of the Ministry of Arts, Culture, Science and Technology in 1994, the then Minister announced the ministry's intention to carry out a foresight exercise. The project was formally inaugurated in July 1996. In the White Paper on Science and Technology,[8] DACST committed itself to using the results of the foresight exercise as an important input into its investments in research and development within the science budget. The foresight results will also inform the management of the proposed Innovation Fund, research capacity-building programmes in the higher education sector, the SAITIS (South African Information Technology Industry Strategy) project, and other government ministries and private sector structures.

South Africa's Approach to Foresighting: Although foresight exercises have been conducted in various countries, the objectives, focal points and approaches tend to vary according to circumstances. The foresight exercise in South Africa, though informed to some extent by approaches of other countries, had to adopt its own approach to fit the South African context. Some of the unique features of the South African Foresight are addressed below:

Consultation: Perhaps one of the distinguishing features is the extent of wider community involvement in the process. The Foresight programme has been deliberately designed to involve stakeholders such as industry, government, labour and civil society. This inclusive participatory approach is an attempt to give ownership of the process to all sectors of our population.

Methodology: The methodological approach adopted in our foresight employs a combination of techniques. These include strengths, weaknesses, opportunities and threats (SWOT) analysis, scenario analysis and surveys of opinions on research and technology trends. Our methodology differs also from other countries in that, to contextualise sector work, macroscenarios for S&T in South Africa have been developed to provide a uniform frame of reference for all sectors. The section on methodology addresses all of the techniques used in the South African foresight exercise in more detail.

Foresight sectors: The process followed to select the foresight sectors is also one of the special features of our process. A series of countrywide workshops in which participants were asked to identify future priorities for the country was conducted. The sectors that were finally selected reflect the goals of the exercise and have drivers which include social development, technological development and wealth creation.

1.2 Foresight Methodology

Figure 1.1 shows a schematic representation of the foresight methodology, which is briefly described below.

Vision: The White Paper on Science and Technology envisages a future where all South Africans will —

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

In order to attain this vision three goals will have to be achieved:

- the establishment of a system of technological and social innovation;
- the development of a culture which values the advancement of knowledge as an important component of national development;
- improved support for innovation, which is fundamental to sustainable economic growth, employment creation, equity through redress and social development.

Foresight mission: To promote technological innovation and deployment by identifying opportunities for economic and social development through a national research and technology foresight project.

Macroscenarios: These are scenarios of the S&T system in South Africa in the 20-year term. They provide a futures frame of reference for the sectors.

Sector mission and foci: Each sector has developed its own mission and focus areas within the broader S&T environment. The aim of the mission and focus areas is to ensure unanimity of purpose within the working group and to ensure integration and linkages with other sectors.

Sector boundary conditions: The boundary conditions define sector foci, which were formulated on the basis of inputs from other sector stakeholders. The sector working groups finalised these foci.

International study: A study examining current technological, market, policy and strategic trends of the sector internationally.

Local study: A review of the current status of the sector in South Africa with a focus on research and technology.

Identify SWOT and STEEP factors: On the basis of the above information a SWOT analysis is performed. In addition, major social, technological, economic, ecological

and political (STEEP) factors within the sector are identified. These processes provide a picture of the current sector situation.

Sector-specific scenarios: As the benefits from the outputs of the NRTF project will only be realised in the long term (ten to 20 years) sector-specific scenarios are developed and analysed. These are informed by the macroscenarios for South Africa's S&T.

Survey and workshops: An audit of the future S&T needs of communities is conducted via workshops and surveys. Opinions of knowledgeable people in the sector on various issues are sought in a questionnaire-based survey. It focuses on perceptions of South Africa's status (current and future) as well as on appropriate strategies that may improve our competitiveness. Communication with sector stakeholders must be maintained throughout the process.

Strategic analysis and choices: Finally, future research and technology challenges and market opportunities over the next ten to 20 years are identified and recommendations developed around them.

1.3 Terms of Reference

The original terms of reference for each sector working group were as follows:

The sector working groups will investigate future socio-economic challenges facing the sector and identify the impact these will have on the sector. The sector will be analysed within the South African context while recognising its contribution to the global and regional economy. The sector working groups will then be expected to identify market opportunities as well as research and technology requirements that will assist the sector in enhancing its performance and addressing social issues. The responsibilities of the sector working groups will be to —

1. agree on proposed sector foci;
2. analyse the current status of the sector;
3. identify future research and technology challenges and market opportunities over the next ten to 20 years;
4. make recommendations on the identified cross-cutting issues/areas;
5. compile a prioritised list of research and technology topics for each sector;
6. make recommendations on implementation strategies;
7. compile the foresight sector report;
8. assist in identifying research and technology themes towards the designing of appropriate research programmes.

1.4 Workshops

A series of eight ICT Sector foresight workshops was run over a period of eighteen months to carry out the processes described in the methodology section above.

1.5 Participants in Sector Working Group

The sector working group (SWG — see Acknowledgements for list of members) is the operational arm of the project. The group is tasked to perform analyses of the sector and to identify issues, as well as suggest research and technology solutions to sector challenges.

1.5.1. Identification of expertise for the Foresight SWGs

Different methods have been applied by different countries that have embarked on similar exercises. In the United Kingdom a method known as co-nomination was used, whereas in France the exercise was primarily carried out by appointed expert panels. Co-nomination[9] is a survey-based technique that allows the major stakeholders and the broad community to participate fully in an open exercise of identifying those individuals who are to participate in SWGs. For the NRTF project, DACST suggested that a combination of methods be used. These were:

- co-nomination, adapted to our situation to identifying members of the SWGs;
- direct appointment by DACST in consultation with the Advisory Board and Project Management Team.

The co-nomination objectives were to —

- identify key individuals who would serve as members of the SWGs in the Foresight project;
- build a database of experts who would be consulted by SWGs at later stages of the project (see section 1.6).

In general, few individuals from previously disadvantaged backgrounds and from labour organisations were identified via co-nomination. To compensate, additional individuals were appointed directly into these groups, rendering them more representative of the demographic composition of the country.

A separate report[10] presents detailed findings of the South African co-nomination study, conducted during 1997-98. The major findings of the report, based on a statistical and relational analysis of 1 131 questionnaire responses across twelve socio-economic sectors, are summarised below:

- Experts in South Africa are predominantly men (86%) and most are over 40 years old (70%).
- Experts in South Africa are 'compartmentalised', with 43% being experts in only one of the socio-economic sectors, 28% having expertise in two sectors, and 12% spanning three sectors.
- Expertise in South Africa is highly concentrated in certain regions of the country, with 75% of all respondents working in two of the nine provinces, i.e. Gauteng (52%), and the Western Cape (23%).
- The expert community is eager to communicate with the world, with 67% of all respondents nominating one or two overseas experts, mainly from the USA, UK, Australia and Germany.

1.5.2. Role of the Sector Coordinators

In addition to compiling the local study and the final sector report, sector coordinators provide research and analytical support for the SWG members and coordinate all the sector activities. This is achieved by carrying out the following tasks and responsibilities, inter alia:

- Research and resourcing: for the SWG, other stakeholders, and the general public.
- Coordination: of inputs from the SWG, and general sector activities.
- Facilitation: at related workshops, seminars, presentations and other sessions.
- Inter-sectoral communication: addressing overlaps between sectors, and cross-cutting issues.

1.6 Participants in Stakeholder Group

In addition to SWG members, there are other important participants in the Foresight project. These include the 'pool'. The pool is an expert group generated through the co-nomination process which participates in the survey. The stakeholders are organisations and institutions identified during the general foresight and sector-specific consultations and serve as a reference group to the SWG. The involvement and participation of these role-players is important to the project in that they —

- are a reference group to give feedback;
- participate in the Delphi survey;
- become a source of expertise for specific issues; and
- form part of the peer review process and thus participate in the evaluation of the project.

Chapter 2:

The Summarised International and Local Scans

2.1 Introduction

This chapter provides summaries of the Local and International Scans which were used by the ICT SWG as the foundation upon which to build a common understanding of the sector as a basis for the subsequent Foresight analyses and processes. The aim, therefore, was to provide not a detailed benchmark, but rather a broad overview of the standing of South Africa's ICT sector in relation to other countries, with particular emphasis on research and technology development. The impact of the local ICT sector on wealth creation and poverty alleviation is complicated by the fact that South Africa does not perfectly fit within the 'First World/Third World' or 'developed/developing' framework. Instead, South Africa contains elements of the developed world (both technology and infrastructure), co-existing with elements of the developing world, particularly in rural and peri-urban areas. A further objective for this exercise was to gain new insights into international ICT research and technology trends. These scans were completed early in 1998 and represent snapshots of the ICT sector at that point in time. Inevitably, some aspects of these snapshots will appear dated by the time this report is published. The SAITIS report, due to be published in the last quarter of 1999, will provide an updated view of the sector.

2.2 Process of the International Study

General terms of reference were drawn up for the International Studies of all 12 sectors of the NRTF project. Each sector coordinator identified at least three consultancies appropriately qualified to meet these requirements for their sector. The identified consultancies were invited to submit proposals for writing the International Scan. In the case of the ICT sector, the preferred organisation was the Canadian International Development Research Centre (IDRC). Their comprehensive report is summarised below.[1]

2.3 International Study Summary

2.3.1 Introduction

ICTs are digital technologies facilitating the acquisition, processing, presentation, management and communication of information. They include, for instance, the micro-electronics, photonics, computer and telecommunications industries.

The sector study looks at the impact of ICTs at a global level, and also looks at the industry. It will become apparent to the reader that ICTs touch every aspect of Foresight, that many of the issues discussed in this report are cross-cutting, and developments complementary and mutually reinforcing. The overall impression is that ICTs are changing international rules and creating new opportunities for international competitiveness. The new environment does not favour large or small, new or established enterprises— it favours innovation and flexibility and an ability to read and respond appropriately to rapidly changing circumstances.

2.3.2 The Global Context: Key issues shaping ICT strategies

The process of globalisation is the determining feature of political, social and economic discourse at the end of the twentieth century. The concept is closely linked to developments in the arena of ICTs: technological developments drive globalisation and globalisation stimulates the extension and adaptation of technologies. The Global Information Society (GIS) concerns people, knowledge and information. The Global Information Infrastructure (GII) concerns technologies that underpin the GIS. The term Global Information Society is often replaced by the term Global Knowledge Society, to emphasise the use of information for knowledge. It also implies a society empowered by knowledge, rather than controlled by technical flows of information. The main challenge for countries outside the developed world will be to shape a concept of globalisation that represents their own realities and responds to their own aspirations in a way in which previous 'global' paradigms did not, i.e. being proactive rather than reactive.

A shift of techno-economic paradigm

The Industrial Revolution produced a social compact among governments, workers and employers which, while exploiting the ordinary worker, sustained growth in capitalist economies for over a century and spawned competing ideologies to the right and left. That balance is now being challenged by a shift to new ICT-mediated modes of producing goods and services. The new paradigm is enabled by ICTs while simultaneously driving the development of new ICTs. It is information, rather than energy-intensive; it encourages customised rather than standardised production; it allows for rapid changes in product mix; it is sustained through networks rather than single firms; it supports distributed rather than centralised intelligence; it requires multiple skills and continuous learning; it replaces stable, life-time employment with labour market flexibility, it is led by government vision, regulation and information rather than control.

ICT-driven employment shifts

The impact on employment has been an issue of concern for policy makers reinforced by the pessimistic projections suggesting that ICTs will have a negative effect on overall employment. However, there are also empirical observations suggesting that some negative effects of ICTs are offset by the redistribution of human resources and are only felt in certain jobs. Globalisation also brings a further decline in the political influence and economic bargaining power of organised labour.

Political convergence

Since the disintegration of the Soviet Union at the end of the 1980s the global political scene has been dominated by the USA — and by a universal recognition of the development significance of democratisation, human rights and the centrality of market mechanisms. ICTs can reinforce these tendencies towards more open, democratic forms of governance.

The importance of regulation

The role of government within the current global political climate is increasingly seen as arbiter, facilitator or regulator rather than the direct provider of goods and services. Developing countries today face the challenge of maintaining access to international sources of investment while at the same time implementing a regulatory structure that will ensure that infrastructure development is shaped to their own policy ends.

International consensus on the importance of ICTs to development

The international frameworks will need to readjust to a global environment in which knowledge is more than ever the source of power and the information underpinning it moves without regard to borders or time. In 1995, the United Nations Commission on Science and Technology for Development (UNCSTD) concluded that, although the cost of building a National Information Infrastructure (NII) which can contribute to the creation of innovative 'knowledge societies' is high, the cost of not doing so is likely to be higher.

The context for new approaches to international governance is the GII, and the National Information Infrastructures of which it is composed. The World Trade Organisation (WTO), the International Telecommunication Union (ITU) and other related institutions provide the framework within which measures are being promoted to stimulate the development of the GII.

Challenge to the Traditional Nation-State Model

Domestic policies, whether framed by private corporations or public regulators, now have routinely to take account of the predominantly international determinant of their sphere of operations. As a result of this, the policy and regulatory framework of a country needs to itself be globally competitive in order for the country to maintain appropriate control of its own destiny.

Intellectual Property Rights

Intellectual property rights (IPRs) — how they are defined, granted and enforced — will be one of the most important factors stimulating or retarding the development of an NIS. Today's policy debate on intellectual property is cast in economic terms (especially in terms of international trade) rather than in the incentive terms (aimed at protecting the rights of individuals) that pertained at its origin. The emphasis is on investment, and on commercialisation on an international scale which itself is made possible through the application of ICTs.

New Partnerships

A major feature of ICTs is their potential for empowering segments of society which are at present marginalised. The African Information Society Initiative (AISI) has identified the main potential roles of different stakeholders. Building truly representative partnerships at the outset of technology enterprises is expected to enhance their chances for success. In addition, partnerships between government, academia, the private sector and other groups should be developed to create R&D partnerships and to stimulate innovation.

Environmental Issues

There is research to develop ICT products which carry a smaller environmental load in their manufacture, e.g. recycling and energy efficiency. ICTs are also involved in creating 'smart' systems to reduce energy consumption in other processes (such as the heating and cooling of living spaces) and in the actual measurement and monitoring of environmental indicators.

The Internet: product and driver

The Internet has changed the way people work and live and comes close to eliminating the constraints of time and distance; it opens up unparalleled access to information and contacts. The potential benefits and the risks are high.

2.3.3 Economic Trends

Adjustment to the new techno-economic paradigm

There is a general understanding that ICTs challenge current economic thinking. The importance of information ownership, and its implications for the economy in general, reflects the centrality of intellectual property rights as the main unit of value in an information economy. Every industry must change its mode of organisation, its work processes and the relationship of design to production and marketing. The main risk lies in the creation of a two-tier society of haves and have-nots.

Global Economic Trends

Employment and the Workplace

- Distance and time are no longer limiting factors in production.
- Companies can therefore choose where to site operations based on local labour skills and costs, and local taxation and incentive arrangements.
- Work is increasingly being outsourced and/or done by collaborative consortia and 'virtual business entities'.
- ICT-based systems are performing many of the tasks previously done by humans.
- ICTs have also enabled more efficient, information-centred management and contributed to the breakdown of the bureaucratic/industrial organisational model.
- A static working week is becoming less common with more people working part-time, more flexible hours and shifts to short-term flexible contracts.
- The shift towards knowledge work has accelerated the rise of the services sector, creating new work opportunities.
- Telework offers the opportunity to work from geographically isolated communities, but may bring with it problems of isolation and exploitation by absentee managers.
- Labour market flexibility may reinforce insecurity and isolation in the industrialised world and lead to less tolerance of different conditions and value systems.

Financial Sector: The distinctiveness of national financial space is being eroded, which leads to the decline of locally and regionally oriented financial institutions as the financial system becomes increasingly subject to processes of capital centralisation and capital concentration.

Trade Liberalisation: This decade has been dominated by the global trend towards trade liberalisation of telecommunications, involving the establishment of independent national regulatory authorities and the privatisation of incumbent telecommunications operators.

Investment: Foreign direct investment remains highly concentrated among the developed countries and the developing countries remain marginal.

Interest rates and the debt burden: Developing nations' debt at the end of 1990 totalled US$1,34 trillion. Since 1983 many of these countries have experienced net

negative capital outflows (i.e. they are paying back more money than is received in the form of new loans).

Barriers to market entry for developing countries: Developing countries' exports continue to face formidable barriers in the markets of developed countries: lack of skills; lack of infrastructure; lack of market information.

Opportunities and Trends

ICTs will soon be the dominant global market. Trade in ICT products and services was worth over $1 trillion in 1995. On the one hand the ICT sector is dominated by the G7 countries and a few large, international corporates, while on the other, small entrepreneurs with the right niche products are able to enjoy rapid growth with reasonably modest start-up costs. The trend amongst the major world economic players is to extend their markets into developing countries. Foreign investment in the ICT sector generally acts as a means of maintaining close ties between parent firm and subcontractor.

Telecommunications: International communi-cations are based on complementary fibre-optic and satellite channels — dominated by fewer larger players, including multi-party consortia.

Hardware Markets: The industry (dominated by the US and Japan) is not closed, but it is difficult to enter. Opportunities exist in niche markets (a company does not have to run a silicon chip foundry, for instance, to be able to design customised circuitry).

Software markets: Over half of the growing worldwide information processing market of $500 billion (1995) is related to software production. Growth areas include software packages and systems integration services. The market is dominated by firms in developed countries, but it is the 'easiest' market to enter — with over-demand, and relatively low start-up costs.

Content Development and Broadcasting: Technological convergence is resulting in overlapping roles of telecommunication providers, broadcasters, news providers, etc. The Internet brings new interactive, multimedia and virtual-reality-based modes of content production and delivery. The pace of development of the technical medium is rapid with an enormous untapped market in many niche areas.

Smart Cities: Smart organisations or cities are ones that employ ICTs in a systematic way to provide employees, citizens or governments with the best possible set of tools to extend their own capabilities. However, the impact of the 'smart' approach is as yet unknown.

The Service Industry: ICT-related services are proliferating, and traditional services are undergoing substantial ICT-enabled transformation.

ICTs and Tourism: The new socio-institutional framework (limits to growth, environmental consciousness, deregulation, etc.) is creating an excellent match with ICTs to develop a more flexible industry. But developing countries face high up-front investment costs to compete.

Human Resources: training and retraining: The acquisition of new skills and continuous learning are needed to develop a population of effective users. Younger people have shown themselves to be very adaptable to the use of new ICTs. Computer literacy is no longer a desirable quality for most workers; it is a necessary skill. The aim is to graduate students who are not only computer literate, but knowledge literate— able to integrate effectively into a knowledge-based society and workplace.

2.3.4 Strategic Plans and Foresight Studies

a) A number of countries, including Japan, Australia and the UK, have come to believe that Foresight is a worthwhile exercise because it provides a structured opportunity to look ahead and consider the future role that may be required of ICTs.
b) In many Foresight studies the process involved consultation and interaction between scientific experts, research users, policy-makers and the wider community.
c) It is recommended that Foresight processes should be transparent, allowing the underlying assumptions, analytical framework and data inputs to be subject to external scrutiny.
d) This openness allows non-conformist views to be given equal weighting with conventional ones and allows the possibility of identifying emerging paradigms.
e) The actual impact of the Foresight surveys on the ICT sector is difficult to assess.
f) Foresight is most likely to be successful as ongoing process, not a short-term project.

2.3.5 Review of Current Technologies in the ICT Sector

2.3.5.1 Technologies which provide Access to the International Network

Changes in Telecommunications Institutions

Unprecedented changes are brought about by liberalisation of the voice-carrier (telephone) network market. There is increasing usage of voice-based networks to carry data. Compression technology and related software have enabled voice-over Internet and videoconferencing applications to spawn an industry providing such services. Regulatory environments are undergoing the most substantive changes in decades. Dynamic, innovative companies are making inroads into traditional (large

and slow-moving) telecommunications companies' markets where the real market is shifting towards value-added services. The need for traditional carriers to stay in the market has led to their undertaking a number of mergers and alliances and setting up subsidiaries.

National Infrastructures

The costs and logistics of delivering universal service are onerous, but are seen as an issue of equity of access, as well as an infrastructural prerequisite for national development and economic modernisation. However, costs are being ameliorated by emerging technologies.

The Last Mile

Wireless local loops can now reduce costs and implementation times associated with rollout:

- They enable faster, more cost-effective provision of services to consumer premises.
- They provide the potential for higher bandwidth to customer premises.
- They allow mobility — mobile telephony will continue to attract greater revenues.

Cellular telephony has played a prominent role in bringing substantially improved services.

Upgrading International and National Links

The US continues to dominate the Internet internationally. There are interesting projects to vastly increase transfer rates of data and provide new services, e.g. Internet II in the US; CA*NET II in Canada; the MSC (Malaysia Super Corridor); and RACE (Research into Advanced Communications for Europe). Project Oxygen aims to extend high-capacity data links around the world using undersea fibre-optic cables.

Open Standards

The international adoption of TCP/IP (transmission control protocol/Internet Protocol) has facilitated the growth of the Internet via a common communication standard. The benefits of open systems and standards are enormous. ATM (Asynchronous Transfer Mode) is a fast, modern protocol which appears to be the favourite contender to replace existing protocols.

Tariffs

Internet users pay a fixed monthly amount for unlimited access, challenging traditional methods of tariffing. Tariffs are likely to be an increasingly important issue both between service providers, and between countries.

Fibre Optics

Fibre optic technologies which increase bandwidth and reduce costs will improve. Progress is also expected in photonics (creating devices which perform directly with light some of the processing functions which are now performed by electronics).

Satellites

Major changes to the telecommunications infrastructure will come from satellites.

Geostationary Satellites (GEOS) are following certain trends:

- DTH (Direct-to-Home) broadcasting is more cost-effective because of more powerful transmissions, increasing internationalisation and improved digitisation techniques.
- Smaller dishes and increased data needs have made VSAT popular.
- Each satellite's large 'footprint' can reduce costs with large economies of scale.

Some advantages of low earth orbiting satellites (LEOS) include:

- They have a fraction of the transmission delay problem associated with higher orbits.
- The pressure on GEO 'prime real estate' over the equator is reduced.
- Built-in redundancy in numbers protects the whole system against malfunctions.

Individuals will soon have full, mobile, global communications facilities. Organisations will set up national or international communications networks almost instantly. However, a number of international issues are raised by the advent of such systems:

- Countries need to ensure that they are informed of international spectrum allocation.
- Regulators need to make informed decisions about the systems they should license.
- Domestic networks can be bypassed, which causes a loss in revenue for national telephone companies.

Broadcasting

International broadcasters can provide content more cheaply than local TV broadcasters, and can use DTH to comprehensively cover entire countries. The economics can erode the cultural benefits of generating appropriate, local content. However, the availability of cheaper and smaller (even portable) local transmitters enables the growth of community radio for local vernaculars, cultures and concerns. The use of digital studios, with digital video cameras and mixers, allows local production at a fraction of traditional studio hardware costs.

VSAT and DTH services can aid access to communication and information in remote areas, which can be combined with other facilities to support distance education, local government, health services, SMMEs, NGOs and individual citizens. Digital broadcasting can turn existing TV sets into Web-browsing monitors, dramatically decreasing the hardware costs of Web access, while providing the high-bandwidth which satellite transmission affords.

Global Regulation and Standardisation

There is a move by regulators of developing countries to learn together, rather than to struggle in isolation. Unresolved issues include pornography, privacy and taxation of services rendered over the Internet where the provider and recipient are not in the same country.

2.3.5.2 Technologies which facilitate participation in the information society

Most of the literature refers to these trends in developed countries, with a bias towards larger (often multinational) corporations, where trade revenue is growing at the fastest rates. Hardware is benefiting from miniaturisation and improved performance, with the cost per unit of performance decreasing. More applications are being found for 'imbedding intelligence', and there are breakthroughs in mobility and portability, as well as multimedia products. Software is becoming more sophisticated, while its complexity is being masked to the user.

Human Interface

Progress has been made towards devices which use human movement and speech, and towards more intuitive interfacing using artificial intelligence to respond to users in an individualised way. The GUI (Graphical User Interface) is the standard desktop interface, and is rapidly becoming integrated with the Web-browser metaphor.

Increasing consumer resistance is leading to market opportunities for simple systems (which are also robust and cost less!). Cheaper hardware costs and multimedia functionality have increased the options for those with disabilities which

require special input or output interfaces. There is little serious development of interfaces for the significant numbers of people with little formal schooling or previous exposure to ICTs, and whose first or second language may not be English.

- Multimedia computing, until recently the domain of high-end and specialist users, is now accessible to those who can afford new PCs. The largest constraint is content production, as this requires new skills, and entails higher production costs than does mere text.
- Virtual reality has many applications where literacy is not a fundamental prerequisite.
- Intelligent Agents are designed to use artificial intelligence to assist users.

Mobility

Notebook computers have resulted from such important technological advances as flat-panel displays, long-life smart batteries, integrated circuits and non-volatile memory. Trends are towards smaller devices and devices with greater integration of functions, e.g. PDAs (Personal Digital Assistants) having increasingly sophisticated graphical interfaces to minimise the need for a keyboard. Apple Newton e-Mates (lightweight, sub-notebook-sized devices) can be powered by the energy from a spring.

Networks

The Internet Protocol (TCP/IP) is increasingly being adopted at the LAN level. Developments have facilitated the trend to distributed computing — where the geographical location of resources is becoming less relevant. Within in-house networks (especially LANs), Ethernet and Token-ring (the de facto industry standards) are being enhanced, improving the data rates 10-fold and 100-fold from present 10-Mbps limits. ATM and FDDI (Fibre Distributed Data Interface), linked by faster copper and fibre technologies, herald significantly faster networks.

The second generation of client-server models assumes that the client is serviced from a distributed computer system (with four or more tiers) rather than a single server. Software known as middleware has been developed to facilitate the complex communication between the components, to 'glue' the whole system together, and to enable business applications to run across heterogeneous systems without being concerned with the underlying architecture. The client-server model underlies Intranets.

Information Processing

Knowledge is now regarded as central to an organisation. The proliferation of accessible data has necessitated tools which can assist in its processing and conversion to appropriate knowledge. Primary functions which tools will help with are:

- Mine for data, using sophisticated searches.
- Filter useful information from data.
- Customise data gathering and filtering to suit individual users.
- Present data in ways intuitively easier for human interpretation and understanding.
- Update information in real time.

Object-oriented Databases have enhanced functionality, ranging from business items (e.g. an invoice) to multimedia (e.g. video clips). Intranets and databases are merging as unified repositories of corporate knowledge. Search engines are instrumental in making sense of the Web, and the same technologies are readily transferred to Intranets. At the higher end, there is growing use of data warehouses which analyse data from multiple sources and applications and present them in a range of intuitive ways, providing the basis for decision-support systems. Recent enhancements include graphical methods for interpreting data that is multidimensional in nature. New tools are being developed to exploit developments in artificial intelligence, pattern recognition and correlation algorithms.

Group Production Tools

Asynchronous communication using the Web Browser interface will continue to develop in sophistication, including real-time text and videoconferencing functions, remote control of workstations, full archiving of communications, document management and whiteboard spaces. Commercial videoconferencing applications use lower-cost 'videocams' via the Internet, with improved quality from developments in 'video-streaming' technology. The development of virtual worlds where each individual adopts an avatar enables greater participation and expression by communities which find existing interfaces a constraint.

Intranets

Intranets are one of the most important developments in terms of rate of growth, rate of innovation and effect on organisational structures. Systems are being devised to make archival information rapidly accessible to Intranet members, with tools available to translate between formats, and allowing real-time changes. Other tools are becoming available to visualise the Intranet and to test hyperlinks. Although business process tools are under rapid development, an important frontier which is largely undeveloped involves tools to utilise 'tacit' rather than formal knowledge.

Security, Privacy and Confidentiality

Problems, particularly on the Internet, relate to hacking, fraud, abuse, and viruses, all of which lead to theft, compromising and corruption of data. Encryption technology allows greater confidence in financial and information transactions over the Internet. However, agreement of standards and international regulation, together with the revision of security and privacy laws, poses the largest obstacle to implementation. Important developments include the establishment of protocols for SET (secure electronic transactions); cryptographic public/private keys; and digital certificates which verify the authenticity of senders. Future security will be more sophisticated, with biometric methods and widespread use of smart cards to generate changing password sequences. Privacy is becoming a greater issue as modern living leaves a digital information trail. Anonymous smart cards are a response, but electronic transactions which leave no audit trail increase the scope for undetected criminal activity.

Internet Telephony

Universities in the US and Canada are using the next-generation Internet backbone transparently for all their inter-campus telephonic communication. The president of AT&T has indicated that within five years all telephony will be over the Internet.

An Illustration from Business

Global organisations will use corporate software (e.g. SAP) to run their information-based operations, including R&D, design, management, sales and marketing, manufacturing and distribution functions. Each may be situated wherever the competitive advantage for that function can be obtained. Some functions may be outsourced or done in partnership with other companies. The company's Intranet will be the 'virtual glue' that links the functions together. It will also link component suppliers, distributors, customers and relevant financial service providers. It will be a distributed system.

An Illustration from the Service Sector — Distance Education

An investigation of institutions which are now world leaders in technology-enhanced learning showed that the introduction of technology went together with transformation:

- Planning began to focus on the needs of the learner rather than the institution.
- A mix of technologies was used, depending on the unique needs of each learner.
- A total transformation of institutions was needed, so pervasive is the effect of ICTs.
- National and international collaboration increased, creating 'virtual institutions'.
- Content needs interdisciplinary teams (educationalists, specialists, Internet experts).

- Pilot projects proved useful in testing and demonstrating technologies and systems.

2.3.5.3 Emerging Technology Markets

Developing National Technological Capacity

National technological capabilities (the complex of skills, experience and directed technical effort that enables enterprises to efficiently buy, use, adapt, improve and create technologies) depend on two fundamental concepts: innovation and technological capability.

Innovation: Although difficult to quantify there are indicators which can provide insights into innovation. R&D expenditure is a key indicator. Also of use are annual figures on patent applications, number of publications, and numbers of researchers (subdivided into the proportions doing basic or applied research).

Creating National ICT Capability: Government intervention in the market place has helped a number of countries to improve their international competitiveness in the ICT sector. Three factors are needed for ICT development: management and technical skills, access to domestic and foreign information and financing (especially with scale-intensive industries). A key overall observation is the dynamic nature of the industry — there is no 'optimal strategy' for competitive success that is independent of time and particular circumstance.

There is a tendency away from protectionism and toward highly selective assistance, to overcome some of the barriers of R&D and market uncertainty. Nations should develop conditions favourable to investors (such as cheaper labour or tax incentives), and co-develop strategies to increase transfers of knowledge and commercial linkages with local industries. Institutions which are initiated or run with various levels of government and industry involvement, play an important role in education and training, standards, metrology, technical extension, R&D, long-term credit, technology and export information.

Characteristics of Successful Businesses in the ICT Sector

Businesses which are doing well in the ICT sector are able to deal with rapid change. Finding and focusing on niche markets is extremely important for developing countries, as is the emergence of 'virtual organisations', where instead of a single institution, teams of people and resources associate around common objectives.

Technical Building Blocks: Hardware

Semiconductors: the key electronic building blocks around which the electronics industry is developed have become dramatically cheaper, smaller (per unit of processing power) and faster since they were first developed, and the predominant view is that these three trends will continue. The market is dominated by the USA, Japan, and a few countries in Asia, because the 'set-up' costs are high (US$3-5 billion) and the lifecycle of a product as brief as three to five years.

Secondary Storage Devices: are becoming smaller and cheaper and increasing in capacity. Demand is fuelled by the proliferation in size and the complexity of software. There is a growing market in the storage of mobile/portable devices.

Displays: Lighter, more power-efficient, flat-panel, solid-state technologies are replacing the cathode-ray tube screens. Newer devices include virtual-reality headsets and spectacle sets.

Technical Building Blocks: Software

Operating Systems: Microsoft will continue to dominate the desktop market and is making significant inroads into the UNIX territory of high-end and server markets, with Windows NT. Internet functionality will become basic to operating systems. Smaller systems are under development for mobile/portable devices and Thin Clients.

Applications: Software is the driver of the ICT-led economic growth being experienced across the developed world. Developing countries see opportunities for developing software industries, using three main strategies:

- Export work, where people do short-term work overseas on client premises.
- Export services.
- Export products, which generate both profits and retained learning and capacity.

It is recommended that export software markets be built on the back of domestic markets and that national training be designed to create general-purpose software developers. An interesting idea for developing countries is local training courses for the international market — encouraging 'skills tourism' to benefit from attractive local settings and weak local currencies.

Information Content

There is a considerable scope for the development of content industries, including in developing countries. Developing materials in new media is sophisticated and requires more hours of (labour intensive) design and development which extend way beyond merely digitising appropriate existing archives (a considerable task in itself). New technologies also have the potential to become relevant and appropriate to people from diverse backgrounds, and to accommodate differences in language, culture and

gender and those with disabilities, as well as to allow artistic, cultural and political expression. Local industries can capitalise on the need for relevant local information. 'Telefarms' or 'digitisation workshops' provide niche services which are outsourced from other parts of the world or from major cities within the country.

The Internet as a Commercial Marketplace (E-Commerce)

The Internet was originally used as a way of sharing information, but is increasingly being used as a means to effect transactions, mostly in business—business commerce. The on-line leaders are not the traditional commercial giants of the physical world but outsiders who succeeded because they understood the Internet and how it could be harnessed to commerce. An important source of revenue is advertising, rather than the sale of the information itself.

The on-line consumer can increase purchasing power through efficient access to up-to-date prices from a variety of suppliers, empowering small buyers and sellers and diminishing the intermediary role of the traditional broker (e.g. airline tickets, realty, financial stocks). In the book, music and video industry, the reduced start-up and distribution costs will create more home-based production, with direct distribution and marketing via the Internet.

Global Regulation and Standardisation

The arena combines at once collaboration and fierce competition, as players realise that common standards can benefit their entire industries, and that benefits derive from being able to assert their own standards over those of competitors.

Year 2000 Compliance

Year 2000 compliance is a significant problem, and attention to it seems to be underresourced. There is growing advocacy of a strategy to manage rather than solve the problem, by identifying critical areas which need attention and prioritisation.

2.4 Process of Local Study

General terms of reference were drawn up for the Local Studies of each of the 12 sectors of the NRTF project. Each sector coordinator was tasked with compiling the Local Study for their sector. In the case of the ICT sector, the coordinator drew from a wide range of mainly local sources, which are listed in the full report.[1] The report is summarised below.

2.5 Local Study Summary

2.5.1 Introduction

One of the features of the ICT sector is the difficulty in defining its boundaries. The ICT industry is growing in complexity because of the convergence of various related industries driven by digitisation. In addition, there is the major impact ICT is having on virtually all other socio-economic and political sectors of society. The schematic representation (Fig 2.1) attempts to clarify these components, as well as recognising that in any organisation, irrespective of its sector/industry, ICT plays a dual role:

- Within the organisation: automating, optimising and facilitating processes, etc.
- Beyond the organisation: interacting with customers, suppliers, stakeholders, etc.

2.5.2 National Trends

The complex development challenge facing South Africa includes the optimal management of three major, interrelated factors:

- The emerging global economy and related international trends.
- The impact of apartheid's legacy.
- The national socio-political commitment to its stated development path.

Population: In Africa, the current population of 758 million is expected to grow annually at an average of 2,6 % during 1995 to 2025. South Africa's current population of approximately 41,5 million is expected to increase to about 65 million by 2025. The economically active population is 14,4 million, of whom 29,3% are unemployed, and an estimated 1,3 million are engaged in the informal sector. The South African population is young, with almost 25% below the age of 10, and 47% below the age of 20.

Urbanisation: South Africa is following the global trend, with over half (55,4%) of the population living in urban areas. The squatting problem is acute in many cities.

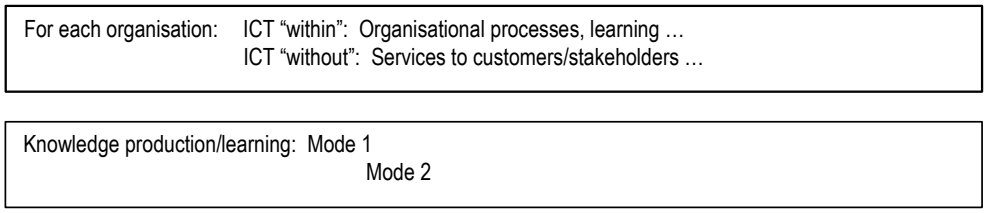
Human Development: Approximately 46%of the South African population live on or below the subsistence level. The human development index (HDI) is 0,677, South Africa ranking 86th of 159 countries.

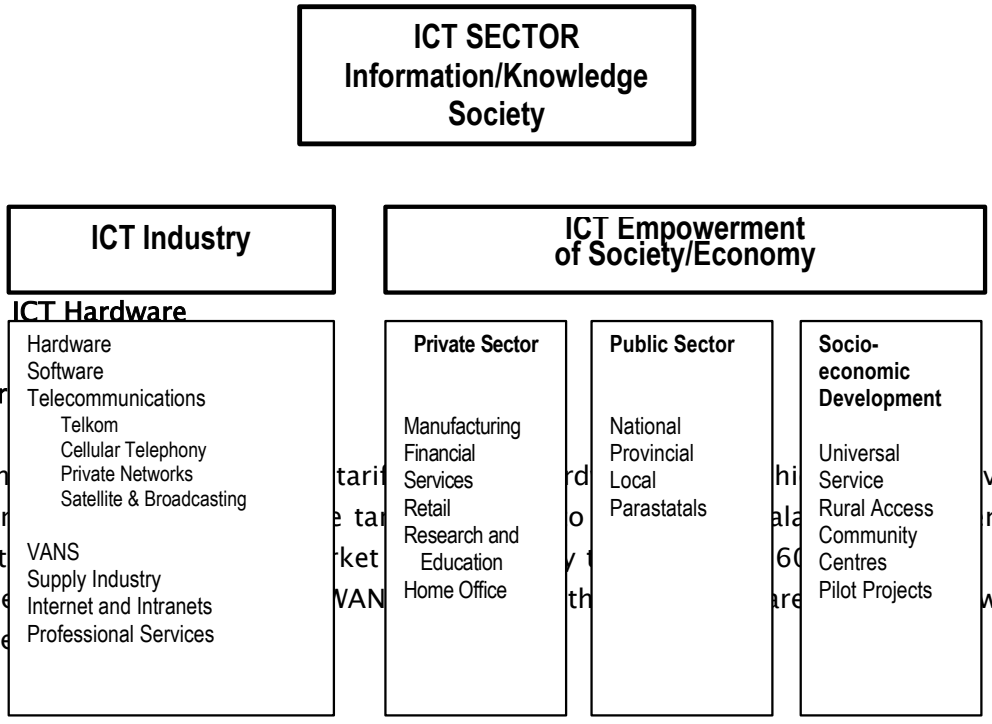
Current Status and Economic Scan of the National ICT Industry

The convergence of Internet technologies, the digital media, telecommunications, and broadcasting is stimulating a new wave of growth in the global ICT industry. In response, the local ICT industry is growing quickly, showing a market growth rate of

more than 15% in real terms in 1994/5, moderating slightly to a still impressive 9% in real terms in 1996/7.

Figure 2.1 A schematic representation of the ICT sector





2.5.3.1 ICT Hardware

Hardwar

South tarif rd hi vels have eli e tar o ala nts. The mat rket y t 60 are connecte VAN th are with develope

Hardware Production

Over 95% of hardware revenues by distributors are from imported products and components. The beginnings of trade liberalisation under the GATT agreement have seen tariffs on computer equipment come down in the early 1990s to a flat rate of 6% for both hardware and imported components. Several major brands have stimulated local PC assembly because of the flexibility that it provides for servicing the local PC market. Hardware manufacturing and assembly capabilities within South Africa have opened the opportunity to export, 30% going to Africa, but this market is very small and limits the growth of an export sector.

2.5.3.2 Telecommunications

South Africa is the telecommunications leader on the African continent, containing a third of all main lines and 85% of all cellular subscribers.

Telkom

This state-owned company has assets of approximately R16 billion, making it the 28th largest telecommunications operator in the world. Its fixed line telephony monopoly is to be phased out over a six-year period according to the White Paper on Telecommunications Policy published in March 1996. The exclusivity period is to allow Telkom to recoup the costs of providing telecommunications infrastructure to the disadvantaged areas. The South African Telecommunications Regulatory Authority (SATRA) was set up to ensure that the market is opened up. A strategic equity partnership has been awarded to the Thintana Communications partnership (of the 30% stake in Telkom, SBC has 18% and Telekom Malaysia 12%).

Infrastructure: Telkom plans to install 2,8 million new lines, including 120 000 payphones, by 2002, with 1,6 million new lines in currently underserviced areas. Ultimately, the aim is to install 4,3 million new lines in eight years financed by cashflow and debt. Telkom expects to spend R53 billion over the next five years and increase its debt by R25 billion to R32 billion to finance the rollout targets.

Upgrading programme: Integrated service digital network (ISDN) facilities have been offered by Telkom since 1995. This was driven by the prospect of videoconferencing. Both Telekom Malaysia and SBCI plan to provide extensive international submarine cable networks and satellite links for Telkom, thereby enhancing its international connectivity worldwide cost-effectively and at competitive prices, and helping to position Telkom as the primary international African hub (for telecommunications, computing media and international services).

Additional Value-added Services Offered: Telkom provides a number of value-adding customer services beyond basic telephony, including:

- Very small aperture terminal (VSAT) satellite services;
- Value-added network service (VANS) provider;
- Internet.

Quality of Service: Although Telkom performs substantially better than most African PTTs, it is far behind the quality of service available in developed countries.

Inequality of Access: Inequality of access resulted in the Vision 2000 strategy of Telkom and a number of other initiatives to improve access for previously disadvantaged communities, including the Universal Service Fund and contractual obligations for cellular providers.

Cellular Telephony (Mobile Telecommunications)

The growth of South Africa's cellular market has been of a magnitude greater than originally predicted, generating at least R10 billion worth of economic activity between 1994 and 1997. South Africa is the largest Global System for Mobile Communications (GSM) market outside of Europe, and the fourth fastest growing GSM market in the world. Two cellular licences (in the 890 to 960 MHz frequency bands) were issued to Vodacom and Mobile Telephony Networks (MTN). In 1997, these operators switched 20% of the country's telephone volume, and two million cellular subscribers are expected by the year 2000.

Other technologies, namely CDMA, fixed radio and even satellite-based cellular, are coming on stream offering basic services, possibly at lower prices. Prospective Mobile Satellite Service (MSS) operators concluded an agreement to cooperate with GSM cellular operators in Rome in 1996. Licences need not be restricted to GSM technology. Telkom is already experimenting with wireless local loop systems; AT&T remains keen to introduce its CDMA cellular technology; the low and medium earth orbit satellite based systems will be coming on stream in the next few years.

Private Networks

Transtel, Eskom and the South African National Defence Force (SANDF) present the opportunity to offer communications services (with Telkom's permission) to the general public and businesses especially in some rural areas outside Telkom's network. The restrictions on Transtel and Eskom are not valid outside South Africa. For example, Transtel offers its services to a number of African network operators in competition with Telkom, Eskom and international telcos.

Terrestrial and Satellite Broadcasting

The Independent Broadcasting Authority (IBA) regulates and licences broadcasting services and signal distribution services. Equally as important as terrestrial and satellite broadcasting infrastructure is access to receiving equipment (i.e. TVs, radios and satellite dishes), which determines whether people are excluded. Household TV ownership is almost universal except for blacks, who have penetration of only 41,9%. Although the IBA has licensed broadcasting services in the MW frequency bands, not all radios sold in SA receive both FM and MW signals.

Terrestrial: Sentech has a common carrier signal distribution license and dominates the terrestrial sector. Terrestrial broadcasting infrastructure consists of a nationwide network of microwave channels linking the radio and television broadcasting studios with the transmitters, but some rural areas receive poor or no transmission signals.

Satellite: Orbicom and Sentech are the dominant signal distributors in broadcasting, while Telkom and Transtel compete in telecommunications. There are currently three commercial satellites with footprints that cover South Africa, i.e. the INTELSAT 704, the PanAmSat PAS-4, and the PanAmSat PAS-7, launched in 1998.

- *Teledesic:* Teledesic, owned by Bill Gates and Craig McCaw, is planning to launch up to 840 satellites in the next four years to provide global, broad-band Internet access.
- *Iridium:* One of several consortiums creating Global Mobile Personal Communications by Satellite (GMPCS) systems with coverage of the entire planet.
- *Digital Audio:* It is planned that Africa will have digital audio satellite services in 1999 via the Worldspace/Afristar satellite. But receiver costs may slow penetration.

Broadcasting: In terms of the Independent Broadcasting Authority Act of 1993, the IBA is required to provide for the regulation of broadcasting. Radio and television are regulated differently.

- *Radio:* The SABC's overwhelming dominance of radio has been reduced considerably through the sale of all its regional commercial stations to new entrants. The IBA will continue to license new stations in a measured way to expand the industry.
- *Television:* The IBA adopted the British model of fewer channels with superior programming quality to satisfy the specific needs of South Africa. The SABC recently invested R50 million in the ill-fated analogue-based AstraSat satellite pay-TV project. African Growth Network (AGN) has introduced two distance education channels broadcast via the PanAmSat satellite.
- *Electronic Media Network (M-Net):* M-Net is the country's first private subscription television service. It broadcasts encrypted signals using the terrestrial frequency spectrum. M-NET has recently entered the computer on-line service market (M-WEB) based on the convergence of television, telecommunications and computer technology.

- *DSTV,* a Multichoice company, is the first satellite subscription service and covers most of the African continent.

2.5.3.3 Telecommunications Supply Industry

Intervention Policy: The intervention system of long-term contracts was abolished in the early 1990s, soon after Telkom was formed, resulting in prices of telecommunications equipment dropping by about 15% per annum. The suppliers have also introduced international product developments far more rapidly, whilst local product development has increased with faster development cycles.

Capacity: The local supply industry was estimated to have a turnover of roughly R3 billion in 1993/4, employing some 7 200 people.

- *Imports:* Growth in imports of phones, switching and carrier products is likely to remain.
- *Exports:* Although performance has been poor to date, South Africa is in a unique position to install and maintain telecommunications equipment in sub-Saharan Africa. It has also become the centre for mainly software adaptations for the SADC region, with exports of about R120-R150 million.

2.5.3.4 The Internet (and Intranets) in SA

South Africa's engagement on the Internet is growing as rapidly as anywhere else in the world with the 14th largest Internet country market. IDC estimates Web-based global electronic commerce in the region of US$200 billion by the year 2000. With the advent of the Worldwide Web, corporate use of the Internet is the most rapidly growing industry in South Africa. ISPs' resulting revenues are estimated at R700 million by the year 2000. While ISPs have a 60% share of the overall services market, other types of organisation, including creative houses, account for a further 40% of the Internet services market.

Intranets are a major new global force. 75% of South Africa's large- and medium-sized organisations are currently integrating their internal and external e-mail systems, to be followed by more sophisticated intranet and extranet applications within the next two years.

2.5.3.5 Packaged Software Industry

In 1995, the local packaged systems software market recorded sales of R1,1 billion of which 40% was operating systems, 20% network software and 40% application development tools. Packaged application software recorded similar sales. Growth in

both components was high with systems software recording an average annual dollar growth rate for 1991/5 of 13,6%, with 11,1% for application software.

- *Package Systems Software Industry:* South African package systems software is 100% imported, with about 88% of it coming from the USA. Users prefer to stick to the international industry standards such as DOS, Windows 95, OS/2 and Novell Netware.
- *Packaged Application Software Industry:* The local industry has made some inroads into the packaged application software market where market entry is easier and there is less risk for the client who goes for a lesser-known brand. The sales figure for 1995 of R110 million gives locally developed products a mere 10% share of this lucrative market. Local software developers have targeted specialised niche markets preferably where local requirements differ from international standards. Exports of software in 1996 from South Africa were estimated at 3% of the total market (or roughly R30 million).

2.5.3.6 Professional Services

Professional services firms form a key part of the ICT infrastructure in a country, stemming from the superior specialised technical skills that they have in comparison to the in-house capabilities of their clients. Thus, professional services firms play a significant role in determining a country's ICT capabilities. The South African professional services sector had an estimated turnover of roughly R2,3 billion in 1995 with ICT consulting making up 31,8%, custom application development 33,3%, implementation 20,3% and ICT education 14,6%. The sector is large, strong, offers a full range of ICT services, and has been growing at an average annual real rate of 10.9% for the period 1991/5. Most of the major international IT consulting groups are locally represented along with many local firms, some being comparable in domestic market size (e.g. Dimension Data). However, the South African professional services sector is not particularly strong in cutting-edge R&D, which is done overseas. The sector has begun to export its services to other countries in sub-Saharan Africa, but a major constraint on growth of exports is the lack of ICT adoption and sophistication throughout the region.

2.5.4 Current Status and Economic Scan of ICT Support in Various Sectors

Currently, South Africa is the 20th largest country market for ICT products and services, accounting for 0,6% of worldwide revenues. The local ICT market was worth over R19 billion in 1997. Taking note of convergence, including the telecommunications, broadcasting, and audio and video markets, this gives an impressive R28,5 billion in total for 1997. The ICT market alone is projected to grow to R30 billion in 2000, with a CAGR increase of 16%. The converged market projection for 2000 is R43 billion. The growth of the Home Office ICT market is of particular interest. Revenues in 1997 were R1,4 billion, over 5% of the total ICT market, and

significantly larger than several important sectors. PC sales account for over 50% of revenues, and are expected to grow at approximately 15% into the next millennium.

An important recent trend involves international vendors turning to South Africa as a jumping-off point for the whole African continent and even further afield. Although much smaller than South Africa in terms of ICT market size, some African country markets are growing at an even higher rate and, taken together, present an opportunity for South African-based vendors.

2.5.4.1 ICT in the Financial Services Sector

As a developing country, South Africa is probably unique in the sophistication of its ICT support for financial services. The sector was estimated in 1996 to account for 50% of the installed national ICT base, and in 1997 for 20% of annual ICT spending (R3 986 million), in part because of the disproportionate spending relative to other sectors on large mainframes. All the major financial institutions operate nationally and have extensive networks of regional offices and associated electronic networks, despite 80% of the country's economically active population remaining 'unbanked'. In this sector there are 74 PCs per 100 employees. Several of the major institutions have Web pages and some are offering on-line banking services of growing sophistication over the Net.

2.5.4.2 ICT in the Wholesale and Retail Sector

The sector contributes 16% to GDP. The major chain stores comprise about 70% of that market and exploit ICT on a par with global best practices. It accounted for 18% of ICT revenues in 1997, with growth in ICT spending (12% in 1997) expected to continue to decline until 2001. There are 24 PCs per 100 employees in the sector. As the sector matures, we can expect to see a shift towards market level logistics systems such as industry-wide distribution systems; emphasis on global markets; outsourcing of more non-core processes such as finance and accounting; and growth in home shopping.

2.5.4.3 ICT in the Manufacturing Sector

Manufacturing, currently the largest sector in the economy contributing 24% to the GDP, is not healthy. In 1997, this sector accounted for 40% of all computer users, covering a wide diversity of applications. It constitutes 20% (R3 267 million) of the total ICT market, making it the largest industry sector in 1996. One area of high growth in vendor revenues is due to the widespread adoption of client/server Enterprise Resource Planning packages, most notably SAP R/3, as well as EDI. There are only 17 PCs per 100 sector employees. A survey of several hundred SA firms confirmed serious concerns over the application of ICT in the sector. Products developed for sophisticated users in the developed world are being imported to South

Africa with little or no benefit because of the lack of concomitant appropriate skills transfer. However, if SA firms quickly grasp the global opportunities offered by electronic commerce, they should reap the benefits of dramatically reduced geographic isolation and enhanced global attractiveness.

2.5.4.4 ICT in the Public Sector

In 1994, the new government inherited systems which, at all levels, suffered from severe inefficiency and ineffectiveness, partly due to the wastefulness of apartheid, but certainly amplified by a history of inappropriate, ill-informed and uncoordinated use of ICT. While the public sector represents 15,4% of the GDP, it invested R2 885 million in ICT in 1996, i.e. 15% of total vendor revenues. The government has relied for far too long on antiquated mainframes and time-consuming, user-unfriendly, internally developed systems for such machines. In 1995, there were only seven PCs per 100 employees in the public sector. Although the government has a large infrastructure of networks, they are poorly interlinked and spread unevenly across its three tiers, between departments, and between urban and rural areas. The resultant lack of structure and great fragmentation in basic information provides minimal information for effective decision-making and dissemination to the public. Even where strides have been made to provide computer support, lack of training and a computer 'culture' limit the utility of the equipment.

Despite the magnitude of these problems, there is growing appreciation up to the highest levels of the crucial difference that ICT can make to government's transformation to a service paradigm, both in improvements to internal operations, and in the interactive dissemination of information to all sectors of the population. Given the current challenges of the emerging global digital age and the proliferation of uncoordinated government ICT initiatives, it is common cause amongst key government decision makers that South Africa urgently needs to develop a National Information Technology Strategy. It is in the 'how' that the major problems lie.

2.5.4.5 ICT in support of Socio-Economic Development

According to the DBSA, information is accepted as a fundamental factor for empowerment, productivity and competitiveness in developing countries. But most multilateral development agencies are failing to give sufficient recognition to the telecommunications sector for its contribution to economic wealth and the indirect contribution to growth in other sectors.

Important International ICT Initiatives in Southern Africa

The basic framework for cooperation in Africa, essential because of the limited resources, grew out of two major international initiatives. At a meeting in Rabat in

April 1997, both these groupings came together to consolidate donor and agency collaboration in line with the AISI (African Information Society Initiative), producing the Programme for Information and Communication Technologies in Africa (PICTA). The challenge is to identify ways of attracting private sector investment by demonstrating the market-growing potential of community access to ICTs in the remote areas which are home to most of Africa's population.

ICT in the Southern African Development Community (SADC) countries

According to the ITU, there is underinvestment in telecommunications throughout the SADC. Another area that requires continued investigation, rationalisation and upgrading is that of regional interconnectivity (trunk services between SADC countries) and gateway arrangements. South Africa could play a major role in the resolution of these problems (thereby creating a range of new markets) in collaboration with the private sector and the international community.

Community Access to and Participation in the Information Society

Accessibility is a key factor when delivering information to poor people living in rural and marginalised communities. As a result of research, development and pilot projects carried out over much of the world in the past four years, with significant contributions from South Africa, a strategic package has evolved in the form of a highly flexible model for Multi Purpose Tele-Centres (MPTCs). A MPTC can be broadly defined as a locally based centre providing a point at which people can receive and request information and other services which can be customised and prioritised to the specific needs of each community.

2.5.5 Current Status and Economic Scan of the ICT HR and Skills Base

2.5.5.1 Composition of the ICT Professional Community

In 1995 there were an estimated 25 000 ICT professionals employed in the SA economy, which is 44% higher than the number in 1989. However, 4,9 professionals per 1000 of the workforce appears insufficient for our needs considering the shortage of local professional ICT skills. Gender inequality amongst ICT professionals appears very similar to other professions (excluding nursing and teaching) yet racial inequality is slightly higher even when one factors away the impact of apartheid.

2.5.5.2 ICT Education and Training

ICT skills are acquired through formal education, and informal means either at work or at home.

ICT Education at Primary and Secondary levels

At this level, ICT education takes two forms: providing basic access and basic computer literacy skills, or providing some basic programming skills at standards 8 to 10. In 1992 some 1,6% of all students enrolled in computer science, but the figure for black students is negligible.

ICT Education at Tertiary levels

At the historically white universities the resources and curriculum are of the highest global standards. But only a few of the historically black universities offer computer science, with an inevitably inferior curriculum.

ICT Education at Private Training Colleges

Private colleges provide a wide variety of ICT training courses which address aspects of labour market demand which are not covered by the public sector institutions, and accelerate the spread of ICT use throughout the economy.

Computer Science at Teacher Training Colleges

The total number of training teachers doing computer science in 1992 was only 314. Further, the number of black and coloured computer science teachers is almost negligible.

Formal ICT Training in Industry

Performed by the professional services sector and the companies in industry, this training takes the form of short, in-house courses for the benefit of employees only. It is creating a large and growing business worth about R330 million in 1995, with an annual growth rate of 10,9%.

Computer Literacy of the Population, and other Barriers

- *Computer Literacy:* Hodge and Miller estimate the total computer literate population for South Africa at 3,2 million people (or 7,7% of the population).
- *Basic Literacy:* Illiterate people require the development of voice-text conversion technology so that they can fully interact with computers without having to read.
- *English Ability:* Most electronic information resources (locally and globally) are in English, thereby excluding 42% of South Africa's current adult population.
- *Profile of the Excluded:* The most excluded section of the population by race are blacks (50%). On the basis of gender, females are slightly more excluded. On the basis of location, rural people are the most excluded (45,5%) On the basis of employment status the unemployed are most excluded (51,5%).

2.5.6 Review of ICT-related Policies, Regulations and Strategic Plans

'Aggressiveness generates revenues, but attractiveness creates jobs'. Nations and regions, both in the emerging and the developed world, will compete on the basis of their attractiveness. An interesting alternative economic strategy has emerged in Holland, where regaining competitiveness appears to be accompanied by a balancing sensitivity to social consequences.

Policies

The Independent Broadcasting Authority Act in 1993 created the Independent Broadcasting Authority (IBA) to regulate broadcasting in the public interest. Following the 1994 elections the Reconstruction and Development Programme (RDP) gave a high priority to many ICT-related issues. Two important events followed in 1996. The White Paper on Science and Technology emphasised the role of ICT in the context of the Growth and Development Strategy (GDS), and particularly its value to the development of Science and Technology (S&T). The Telecommunications Act established a three-tier separation of roles: 1) the Ministry and Department will formulate policy and manage their shareholding in Telkom; 2) the South African Telecommunications Regulatory Authority (SATRA) and 3) the Universal Service Agency (USA) will ensure implementation of the Act, including the awarding of licences. In August 1997, a new process was launched to produce a new broadcasting law. In addition, the government has started similar processes to investigate electronic commerce.

Global Trends: Impact of ICTs on Policies and Strategies

The McKinsey Global Institute has calculated that increasing the interactive capabilities of the US economy simply by fully exploiting the opportunities of networking offered by technology would increase the GDP by one third by 2005. Over 70 million users in 1997, compared with 34 million in 1996, and 16 million in 1995, used the World Wide Web. Companies that are connecting to their customers are finding costs savings of 50% to 90% in sales, customer support, distribution and other areas.

Organisational Strategic Trends related to the Wired Marketplace

- A growing priority is to reach out and connect to customers, and the financial dividends reinforce it as a top priority — the greatest growth opportunity for the next decade.
- Capturing these opportunities will require disruptive business model changes.

- The greatest challenge is not only to spot (at an early stage) and capture the new hot growth opportunities in the wired marketplace, but also to stake out leadership.

Interactive Capabilities and National Policy

The interconnection of various infrastructure assets, such as technology, education or administration, must become a priority for public policy (nationally and regionally).

Transaction Technologies and Strategies for Competitiveness

The concept of managing transactions, especially in a decentralised environment, is becoming the cornerstone of enterprise strategies for competitiveness.

Management Strategies in the Interactive Organisation

Management is evolving in six areas that encompass the new management strategic talents required to operate in this new, interactive, competitive, global economy. New, 'intelligent' ICT applications will be required to help managers to develop and effectively use these new strategic talents and personal capabilities.

2.5.7 Research, Development and Technological Scan

In developing countries, R&D is often regarded as a luxury, with the result that these economies are dominated by innovations, products and services imported from the developed world. There is little hope for global competitiveness in this 'downward spiral' scenario. Developing nations have little choice but to adopt the often painful longer-term strategy of investing a significant proportion of their scarce resources (public and private) in appropriate, local R&D.

2.5.7.1 Research and Development in South Africa

South Africa's R&D expenditure is currently about 0,8% of GDP ($942 million in 1997), below most OECD countries (2,5% - 3%), comparable with many NICs and developing countries (Taiwan 1,1%, Mexico 0,6%), and well in advance of other African countries. South Africa's gravest concern is its shortage of scientists and engineers. The low regard for R&D within the local private sector is due, at least in part, to the historically poor linkages between tertiary education institutions, the science institutions and business.

Insecurity within the science institutions has shifted their research focus — positively to more appropriate, applied research carried out on a contract basis, but negatively to an over-emphasis on short-term projects with immediate financial returns but little strategic value.

2.5.7.2 Overall ICT R&D Levels

ICT R&D appears to be geared to business applications rather than to basic research conducted at academic institutions. Local telecommunications R&D is not basic, but concentrates on product adaptations for the domestic environment, primarily geared towards fixed line and mobile communications access.

2.5.7.3 Direction of Research and Development

Globally, the direction of R&D into ICT is determined more than ever by the commercial sectors of the developed world, and therefore by their customer needs. The result is that text is the dominant paradigm for information provision and that R&D has moved into areas such as video-on-demand, interactive television and virtual reality. Therefore, most ICT products are of little immediate use to large portions of the developing world.

The South African R&D community has been redirecting some of its efforts towards providing high-technology solutions to development problems. Technological developments such as mobile communications technology, digital multimedia and voice-text conversion make this 'leapfrogging' exercise viable. The DACST *Innovation Fund* expresses the current national R&D priorities and needs. The following key areas have been selected for support:

- Local content applications;
- Service delivery enhancement;
- Advanced software development;
- Decision support for Government.

2.5.7.4 ICT R&D for Global/Regional Competitiveness and E conomic Growth

There has been very little commercial ICT R&D within South Africa over the past 20 years, yet there have been some interesting successes, e.g.:

- Pay TV (M-Net, MultiChoice and related businesses): The exceptional (particularly by South African standards) performance of the South African Pay TV industry over the last 12 years has been characterised by technology-driven diversification, entrepreneurial development and globally oriented growth. The industry's contribution to the development of the decoder industry, subscriber management services, and signal transmission technology has had a positive impact on high value-added exports from South Africa to Europe, Africa and the Middle East. In aggregate, the industry has created approximately 5 000 jobs.
- ICT and the Technology and Human Resources for Industry Programme (THRIP).
- ICT and the FRD's Competitive Industry Programme.
- CSIR Virtual Reality Centre (VRC).

2.5.7.5 ICT R&D for Empowerment and Socio-economic Development

The recent change in policy direction offers the opportunity to blend high-technological capacity with a large underdeveloped market lacking even basic infrastructure, aimed at high-technology development solutions to reduce exclusion. Some of the related local projects include:

- Containerised Phone Shops and Fixed Cellular Payphones;
- Cheaper Telecommunications Infrastructure;
- Rural Pension Delivery;
- The Community Information Delivery System (CIDS);
- Information Kiosks.

Chapter 3:

Assessment of the ICT Sector

This chapter reports on the ICT Sector Working Group's activities to clearly define its mandate and the scope of its work for the rest of the Foresight Process. Based on the shared understanding gained from the International and Local Scans (see Chapter 2), the SWG defined their mission and finalised the sector foci. This prepared the way for the first ICT Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis.

3.1 ICT Sector Mission

The ICT SWG will develop a long-term vision and strategy aimed at using ICT to —

- empower ***all*** South Africans by providing equitable, interactive access to the knowledge society;
- promote South Africa as an Africa-oriented, global ICT player through a balanced approach to private sector growth and socio-economic development;
- provide foresight guidance that will transcend current ICTs;
- identify those key ICTs that have the potential to help create the desired future(s) and provide guidelines for their development, acquisition and implementation; and
- identify key areas for appropriate technology transfer and HR development.

3.2 ICT Sector Foci

The ICT SWG was challenged by the growing, and very broad, impact of ICT across all sectors of society. In many ways, ICT can be seen as a cross-cutter rather than a separate sector. An ICT industry can be identified, but cognisance must be taken of new components needing to be added because of technology convergence driven by digitisation. In addition, all aspects of the role ICT can and will play as an empowerment tool across all sectors of society need to be recognised (see Fig 2.1).

A consultative process to define the sector was conducted to crystallise the sector boundary conditions to enable the SWG to focus its work. Some preliminary meetings to discuss the main foci and priority functional areas of the sector were held in several main centres throughout the country. In light of the outputs of these meetings, and after analysis of the International and Local ICT Scans, the SWG selected the following foci:

F.1 Infrastructure Cost/Performance

Within five years, broad-bandwidth infrastructure is expected to be cheaply available, even to remote and disadvantaged areas. Focus is needed on —

- the 'last mile', via appropriate alternative technologies and power supplies (e.g. wireless and solar power);
- the opportunities and flexibility provided by the convergence of technologies driven by digitisation;
- developing Research and Technology (R&T) capabilities to handle emerging technologies rather than perpetuating legacy infrastructure.

F.2 ICTs and Learning, Labour, and Human Resources

As economies move from the Industrial paradigm to the Knowledge paradigm, ICT will have a growing impact on the learning and development of individuals and organisations, and on the need for flexible employment and employability. Focus is needed on—

- needs-driven, ICT-facilitated, virtual learning 'anywhere, anytime, anyway' for all ages, and across all sectors of society;
- ICT as an employment maker rather than a job taker, and its role in the 'brain drain';
- developing R&T (Research & Technology) capabilities in learning processes (individual and organisational), enhanced by ICT.

F.3 Growing the ICT Industry

With a few exceptions, South Africa's ICT Industry is fairly stagnant, often dependent on legacy technologies. Focus is needed on —

- dramatic improvements in ICT literacy, skills, training, education and R&T across all sectors of society;
- developing globally competitive software and hardware capabilities, particularly to satisfy the needs of the African Renaissance and the developing world;
- the role of ICT and related R&T in accelerating the growth of the SMME sector.

F.4 Fostering ICT Innovation

The accelerating rate of ICT innovation in the international arena requires that South Africa identify niche areas within which to compete, and develop R&D clusters and the necessary open markets to nurture 'co-opetition' type relationships with international partners. Focus is needed on —

- developing a strategy for identifying specific ICT opportunities and positioning the local industry for competitive innovation, as part of an ongoing foresighting process;
- safeguarding intellectual property rights (IPR), particularly as they apply to indigenous knowledge;
- the financial, human resource, and regulatory aspects of developing capacity for basic technology development, and for taking this all the way through to products/services;

- the use of ICT to lower barriers of entry into other R&D areas.

F.5 Public Sector and ICT

As a major, but unimaginative, user of ICT, the public sector needs to rapidly streamline its operations to make far better use of ICT, and to make wiser use of its influence as a dominant consumer of ICT products. Focus is needed on —

- a national ICT strategy, including policy for promoting local R&T, for positioning South Africa for innovation and for technical development in ICT;
- applications aimed at producing order-of-magnitude improvements in the delivery of health, housing, crime prevention, and other government services;
- the emergence of an ICT literate civil service, and an ICT-facilitated open democracy.

F.6 Access to ICT and Social Issues

The tendency of ICT to widen the gap between the already empowered haves and the marginalised have-nots is particularly evident in South Africa. Focus is needed on —

- the diffusion of technology throughout society to create a national ICT culture, to the extent that it should have an effect on the voluntary reversal of urbanisation;
- appropriate human/computer interfaces which address the cultural and language diversities of the country, and the common ICT phobias of marginalised people;
- partnerships with foreign technology developers aimed at influencing and contributing to the appropriateness of technology for South Africa, and finding a workable balance between multinational business interests and local socio-economic development.

F.7 Infostructure for the Individual and Organisation (emerging Information Society)

South Africa has moved rapidly, along with the rest of the world, towards a knowledge society in which information is the most marketable class of product and individual capabilities transcend corporate structures. Focus is needed on —

- infostructure to nurture emerging digital communities (digital libraries, virtual information, entertainment and infotainment hubs, on-line government, e-commerce and on-line marketing, and virtual reality), and promote a large ICT-empowered middle class;
- reliable and socially acceptable mechanisms (across the cultural spectrum) for data security, privacy and integrity;
- specific technologies which allow digital communities to resist non-ICT influences which work against their formation (security systems, telemedicine, teleworking, distance education);

- organisational restructuring facilitated by ICT innovations;

F.8 International (Regional/Global) ICT Issues

South Africa is a follower of global ICT trends and adopts technology largely because of aggressive marketing, as opposed to the attractiveness and appropriateness of the product. To a lesser extent, South Africa's neighbours are forced to follow South Africa's ICT decisions. Focus is needed on —

- emergence of world (including regional) collaboration on global regulations and standards, with a significant voice given to the growing developing world market (e-commerce, distance education, global network management, content creation);
- investment in international ICT ventures in order to become an influential global player;
- making South Africa attractive (tax incentives, security, a culture of ICT innovation) for digital skills migration to happen in both directions, and recognising emerging global lifestyle trends early (citizen of the world via ICT);
- a strong national ICT strategy, which has explicit linkages between political leaders (representing ownership and stakeholders) and ICT policies as they affect the emerging knowledge society, and which coordinates initiatives and responses to global ICT processes;

During this analysis, the SWG repeatedly emphasised that South Africa needs urgently to formulate an appropriate and broadly supported national ICT vision to underpin all of the above focus areas, key components of which should be —

- the development of HR across the ICT sector, which is essential to the economic survival of South Africa. The national plan should concentrate upon harnessing the potential of the youth of the country, and should aim to achieve a net inflow of brainpower in the medium term (five to ten years);
- the formulation of collaborative ventures which balance multinational and national interests;
- the identification of national needs and priorities;
- the creation of a national culture conducive to ICT innovation and to rapid adaptation to new technologies.

3.3 SWOT Analysis of Foci

Stakeholders: In preparation for the SWOT analysis, the SWG agreed that it would add value to consider the key stakeholders, including beneficiaries (direct, indirect, and potential), customers, and clients. The following groups were identified:

Key Stakeholders

S1 Government (National, Provincial, Local)

S2 Private sector (local — including SMMEs — and multinationals)
S3 Previously and currently disadvantaged people (80%+ of population)
S4 Labour
S5 NGOs + civil society
S6 Empowered individuals (including the 'connected' elite)
S7 ICT industry
S8 The international community (IFAs, the UN, ITU, WTO, etc.)

The SWG's shared understanding of the main issues under each focus area was then expanded by evaluating their impacts on each of the above stakeholder groups in terms of their social, technological, environmental, economic, political and values contexts (i.e. a STEEPV analysis). The full SWOT analysis was then performed, with the following results (they are summarised in point form in Table 3.1):

3.3.1 Strengths

A combination of national commitment and licence obligations imposed by government is driving an accelerated rollout of telecommunications infrastructure. This is complemented by a competent (though far too small) existing skills base, and the enthusiasm and desire amongst the youth of the country to acquire ICT knowledge. South Africa enjoys a culture of rapid ICT uptake. Having English as the country's common language of communication is a distinct advantage in the international ICT field.

Since 1994, the government has followed a path of consultation and accountability, culminating in a Freedom of Information Bill with ICT as the enabling technology. Several initiatives are under way to leverage public service delivery through ICTs.

The existing ICT infrastructure in the country is effective; SA is amongst the world's top twenty countries for Internet connectivity. Telkom's backbone, and the ICT capacity in financial institutions, the tertiary education sector, the CSIR, and other former statutory organisations, are very good on the whole, particularly in relation to the rest of Africa.

South Africa is the African leader for ICT vision, skills and facilities. International ICT links are continually strengthening, and many multinationals see South Africa as the springboard into Africa.

The move towards improving the ICT infrastructure and providing universal access is having a positive impact on the economy.

3.3.2 Weaknesses

Large areas of the country still have minimal ICT infrastructure, and even with the falling cost of infrastructure many people cannot afford to participate in the information society. Telkom's temporary monopoly prevents competitors from speeding up service delivery. No national strategy is in place for ICT, and there is a proliferation of uncoordinated projects.

The literacy and educational base in the country is very weak and skewed, and this has a direct effect on the production of scientists, engineers and ICT workers. The result is an extreme skills shortage in the ICT sector, exacerbated by the brain drain to foreign countries. ICT has created élite communities within the already skewed SA society.

The government suffers from many problems which manifest themselves in poor service delivery, and this also extends to public service ICT roll-out. Historical baggage in many forms (management, bureaucracy, policy) hampers the rapid establishment of information-based businesses.

The local ICT market is small and has to operate without economies of scale. South Africa has a poor record of technology transfer from multinationals to local operations, and from universities to industry.

South Africa is weak internationally in influencing global ICT policy and international standards, and is not competitive in translating international trends into 'on-the-ground' roll-out.

Inadequate incentives for international investors, lack of local skills and crime limit the finances available for ICT ventures, which result in less local development and poorer local economies of scale.

ICTs provide new opportunities for antisocial behaviour.

3.3.3 Opportunities

There is growing evidence of a possible emerging Information Society in South Africa:

- Accelerated roll-out of ICTs as a result of falling cost.
- Licence obligations of carriers.
- The availability of new technologies.
- A realisation within the developed world that major future ICT markets are in the developing countries.

The development and implementation of appropriate policies, and the local propensity to become rapid adopters of technology, will accelerate the development of an Information/Knowledge Society.

Through access to the information society, many new methods of education and training become possible.

Government policies and legislation should provide a stimulus for the development of ICTs in the country. Then Vice-President Mbeki's office set an example for this in the years 1994 to 1999. Access to ICTs will speed up public service delivery and enhance quality. The use of ICTs could transform government. Deregulation provides an opportunity for improvement through competition, and the outsourcing of public sector contracts is an opportunity for the private sector.

The reasonably strong local ICT industry and a local grasp of the problems of developing nations provide an opportunity for niche software development. The needs of smaller communities, sensitivity to multilingualism, new human-computer interfaces and translation software are examples. The Internet affords the opportunity of promoting indigenous knowledge globally. There is less investment in and reliance on older legacy systems than in developed countries.

Regional and global ICT manufacturing hubs will provide the economies of scale that are needed by exporting to African and global markets. South Africa's image as the ICT leader in Africa affords various opportunities for attracting international partnerships, influencing global ICT policy, attracting foreign investment, and promoting skills pools that transcend national boundaries.

Various opportunities exist for financing ICT development in SA: the creation of an investor-friendly environment, the falling cost of ICTs, the purchasing clout of the government requiring collateral investment from contract winners, and a well-developed banking sector. SMMEs are the future of the ICT industry and many opportunities exist for their formation. Greater work environment flexibility can be created as people adopt teleworking and virtual teams are able to work around the clock.

ICTs can help to bring down levels of crime and enhance security and safety.

3.3.4. Threats

The gap between the information haves and the unwired have-nots is exacerbated by the accelerated adoption of ICTs.

The labour force is small, and generally inappropriately skilled to benefit from the knowledge era. Retraining is essential, but difficult to implement in reality. The cost of education is escalating, whilst government is faced with severe budget constants. Current distance education methodologies are largely untested in mass markets, and there is a lack of feedback from learners.

Strengths:
S1. Accelerated roll-out of infrastructure
S2.1. Education and learning in the ICT field
S2.2. Existing skills base in place
S2.3. English — ICT's lingua franca
S3. Government will to introduce ICT-facilitated Public Sector services
S4.1. Existing ICT infrastructure
S4.2. ICT costs are relatively low
S5.1. South Africa's ICT leadership in Africa
S5.2. South Africa's international ICT links
S6. ICT is a new driver of the economy

The government is generally inefficient, and the slow rate at which policies are implemented is inappropriate for the fast-moving ICT sector. The levels of ICT literacy in the Public Sector are far too low. The effects of government downsizing and privatisation will be a worsened redundancy problem for inappropriately skilled workers.

Globalisation could easily lead to the world information society being skewed to the needs and character of the developed world. The high rate of redundancy of ICTs and globalisation expose South Africa to the threat of technology dumping by developed countries.

The declining value of our currency and a local culture of non-payment in respect of services and taxes are major threats to economic growth in a global information society.

Weaknesses:
W1.1. Inequitable qccess
W1.2. Lack of a national ICT strategy
W2.1. Low levels of literacy and education
W2.2. Inadequate ICT skills base, worsened by the brain drain
W2.3. ICT 'phobia' and élitism
W3.1. Poor government services hamper ICT roll-out
W3.2. Industrial age management is still being used in the ICT age
W4.1. Small local ICT market

W4.2. Poor technology transfer
W5. International lack of clout in ICT
W6. Poor conditions for investors
W7. ICT precipitated antisocial behaviour

New forms of social threats arise out of an untrammelled information age: invasion of privacy, increased marginalisation of sections of society, new forms of social control and new forms of crime.

3.4 Bottom line arising out of the SWOT

South Africa, with a small but strong existing skills base and infrastructure and a relatively high international profile and GDP, is well positioned to take advantage of niche opportunities to develop a software development industry and an emerging ICT-empowered middle class. However, the threatening problems of the skills flight and the existing social barriers to ICT access, particularly the low levels of literacy and education of the vast majority of the population, present serious obstacles to this objective.

An aggressive national ICT vision is urgently needed to counteract the problems of obstructive policies, uncoordinated efforts, lack of funding, inadequate skills training, and the absence of a culture which fosters the development and effective use of ICT.

Opportunities:
O1. Emerging information society
O1.1. Accelerated roll-out of telecommunications infrastructure
O1.2. Policies to foster an information society
O2. ICT enabled learning/education/training
O2.1. Distance education
O3.1. National policy to stimulate ICT development
O3.2. Public service delivery through ICT
O3.3. Transformation of government use of ICTs
O4.1. Software development to address developing world problems
O4.2. Indigenous knowledge exported via ICTs
O4.3. Less legacy infrastructure than the developed world
O5. International links solve several ICT weaknesses
O6.1. Various ways of financing ICT operations
O6.2. SMMEs, the future of the ICT industry
O6.3. Work patterns are more flexible
O7. ICTs can enhance security and safety

Threats:

T1. ICT worsens disparities in the information society
T2.1. Lack of ICT skills in the labour force
T2.2. Education funding is low
T2.3. Distance education is not a mature medium
T3.1. Government inefficiencies — too sluggish for the fast moving ICT sector
T3.2. Government policies may lead to job losses
T4. Redundant and inappropriate technologies
T5. Globalisation favours the developed world
T6. A weak economy is further threatened in a global information society
T7. New social problems arise

Chapter 4

The ICT Sector-specific Scenarios

4.1 Background

In a world of ever-accelerating change, long-term strategic planning and sound decision-making need to be based on a clear and reasoned consideration of a range of possible futures. Despite realising that the future is 'unknowable', we continue to view it through the blinkers of the present. **Scenario Thinking**[11] is a powerful tool that provides a systematic and imaginative way of preparing for a future beyond the paradigms of the present.

Scenario thinking involves the production of multiple, rich stories that extrapolate from present reality, but assume unpredictability, challenge conventional wisdom, clarify risks and opportunities and encourage creativity and responsiveness. Scenarios reveal what *could* happen, not what *will* or *should* happen. They should not be confused with the still commonly used forecasting methods, which assume predictability, conceal risks and foster inertia and reactivity through single-line, impoverished projections. To ensure their usefulness, scenarios should be —

- **relevant**: illuminating current circumstances and concerns, and linking into current mental models;
- **emergent**: challenging current paradigms, and making the invisible visible;
- **plausible**: logical and fact-based, improving systemic understanding;
- **clear**: memorable and distinct alternative hypotheses.

Besides helping nations or communities see the future with different eyes, scenarios have helped to position leading corporations of the world such as Royal Dutch Shell.[12] It is in this light that the National Research and Technology Foresight (NRTF) project decided to incorporate scenario planning as a crucial part of South Africa's strategic research and technology processes.

4.2 Foresight Macroscenarios

Four macroscenarios depicting a wide variety of possible futures for South Africa unfolding by 2020 were developed in early 1998 by a carefully selected working group. These are published in full in a separate report obtainable from DACST[13] which includes more details of the processes used. The macroscenarios are summarised below.

4.2.1. Frozen Revolution Macroscenario Summary

Behind all the sound and fury, the non-implementation of government policy intended for socio-economic upliftment leaves the masses dissatisfied and key players fragmented and individually focused.

Socio-political characteristics

- Government is not a significant player either regionally or globally;
- There are several social development plans but no delivery because of policy paralysis;
- There is no national identity;
- There is no consideration of environmental sustainability;
- Indigenous knowledge systems are unsupported.

Economic characteristics

- Reactive economic policy with markets partially open, but a non-strategic approach;
- Foreign investment limited to fluid assets;
- Initial economic growth less than 2%, and shrinks to -4%;
- Economic model remains driven by primary resources.

S&T implications

- Low emphasis on S&T, other than scattered populist projects;
- Little local innovation;
- Low impact on socio-economic development;
- S&T sourced almost exclusively elsewhere.

4.2.2. Innovation Hub Macroscenario Summary

South Africa's comparatively developed infrastructure creates opportunities for strategic regional investment. Building on the existing skills base and knowledge generates comparative advantage and a competitive edge regionally and globally.

Socio-political characteristics

- SA a dominant political player in the Southern African region, focusing on regional values and needs, but with a global view;
- Some national identity is lost, while regional identity is strengthened;
- Government directs development via innovation;
- Development of a regional social contract, with a directed plan for incremental development;
- Human development index gradually increases;
- Private services of higher quality, public services slowly improve, with universal access;
- Environmental issues are addressed for both intrinsic and economic value.

Economic characteristics

- Proactive economic policy, focused on Southern African region;
- Strong drive towards value-addition;
- Market character strategic and directed by government;
- Initially, international investment is limited, but it gradually increases;
- GDP growth slowly increases from 0% to 8%;
- Rich-poor gap remains, but the number of poor decreases.

S&T implications

- S&T policies actively promote innovation and technology management;
- Increased regional innovation, driven by regional needs;
- S&T contributes significantly to socio-economic growth;
- Appropriate technologies developed locally, while foreign technology is adapted via licences, and indigenous knowledge applied.

4.2.3. Global Home Macroscenario Summary

In line with global trends and opportunities, government embraces global liberalisation and facilitates private sector empowerment to respond to global market forces. South Africa becomes the darling of the international community.

Socio-political characteristics

- National vision determined by global alignment and international agreements;
- Government's role (globally and locally), and national identity shrink, private sector dominant;
- Private, high-quality social services only for those who can pay; but public service quality gradually decreases;
- No centralised social contract;
- Rich-poor gap increases, but number of poor decreases;
- Environment only addressed through compliance with international standards.

Economic characteristics

- Economic policy facilitatory;
- Open market — full liberalisation;
- High international investment;
- Economic agenda determined by international agreements;
- Growth in GDP initially 6%, but slowly shrinks.

S&T implications

- S&T used for SA to be globally competitive;
- SA innovation focused on global market niches — some pockets of local excellence;
- S&T allows exploitation of niches;
- Global access by licence and technology developed to exploit niches;

- Global knowledge system dominates with decreased consideration of indigenous knowledge system.

4.2.4. Our Way is THE Way Macroscenario Summary

South Africa believes in its ability to challenge the conventional route to globalisation by rallying developing countries' support for the development of a significant South-South economic bloc. This catalyses isolation by the developed world. During isolation, South Africa focuses on long-term core competencies and emerges with a robust 'knowledge society' as the 1st world's economy crashes after 2015.

Socio-political characteristics

- South Africa is globally aligned but on her own terms;
- The emerging South-South alliance motivates developed countries to isolate South Africa;
- Strong national identity;
- Focused national social development plan;
- Selective focus on some national environmental issues;
- Emphasis on a indigenous knowledge based culture with traditional systems and values.

Economic characteristic

- Proactive economic policy, with markets partially open following strategic plan;
- Very limited international investment, and active disinvestment by developed countries;
- Initial growth in GDP approximately 2%, shrinks to negative 3%, then grows slowly to 5%.

S&T Implications

- S&T aimed at self-sufficiency;
- Growth in local ('useable') innovation;
- SA-specific technology basis contributes to socio-economic development;
- Access to global S&T capacity and information by every possible means.

4.3 ICT Sector Scenarios

The method used to create the ICT sector scenarios from the above macroscenarios was to prioritise the most important issues identified in the SWOT process (see Chapter 3), show which of these were highly variable (i.e. highly sensitive to potential changes in all aspects of the national environment), and then characterise them in the context of each macroscenario. The following were identified by the SWG as the 12 most important variable factors expected to differ significantly across the four macroscenarios:

4.3.1 ICT Scenario Variables

a) Attractiveness for international and national investment;
b) Challenge of employment creation;
c) Education/Intellectual base (Science, Technology, Engineering, Maths (STEAM) capacity; direct skills development);
d) Work and play anytime/anywhere — the reality of telework;
e) Interactive, electronic government service delivery;
f) Increased access through rapidity of roll-out of infrastructure and on-line services;
g) New approaches to all types of learning facilitated by ICT;
h) Culture of alliances and partnerships;
i) Presence in Africa;
j) ICT for development (starting with the original RDP applications);
k) ICT industry skills strategy;
l) Virtual learning.

4.3.2 ICT Scenario Assumptions

In this process, five important ***assumptions*** (i.e. factors of high importance, but with low sensitivity and therefore unlikely to vary significantly across the four macroscenarios) were also established:

a) Empowerment of young 'wireables';
b) Globalisation;
c) Professional clustering/interaction (government, industry, academic);
d) Wireless: near-term demand satisfaction; medium-term global alignment; long-term pervasiveness (cheap bandwidth);
e) Everwidening gap between information 'haves' and 'have-nots'.

The SWG then considered what would happen to each of the above variables in the context of each macroscenario. The results of this process are summarised in Table 4.1.

Table 4.1: ICT Sector Scenario Matrix

Variables	Frozen Revolution	Innovation Hub	Global Home	Our way is THE way
Attractiveness for International and National Investment	Investment flows to other countries	After slow start, money flows in, SA gateway to SADC	SA dependent on international agenda, compliance with world order	Investment dries up, isolation and punishment, risk
Challenge of Employment Creation	Job losses with elite pockets, informal activities grow	More and better jobs, but slow at first	Jobs for the "haves": some "dribble down" growth at first	Limited job growth (lack of investment), but employment spreads
Education/intellectual (STEAM) base capacity	No sense of urgency, little coordinated funding	High level of investment in formal professional (S&T/engineering) capacity building, "specialist" intellectual capacity	Some intellectual investment in islands of capacity, driven by first world needs	Government incentives for local needs oriented capacity, holistic intellectual capacity
Work and play anytime, anywhere – reality of telework	Those connected are "tele-couch potatoes". Consumers not producers, much junk	High degree of tele-working, mainly centred on large organisations	High teleliving uptake for the economically active (big gap to rest of society)	Tele-employment mushrooms after 2015 when latest ICT becomes available
Interactive, electronic government service delivery	Uncoordinated delivery, conflicting services, variable quality	Regional advantage through local knowledge. Services mainly "top-down"	High dependence on foreign information and innovation – low-level government services	Innovative, participative ("bottom-up") services, hindered by poor ICT at first
Increased access – rapidity of roll out	Some increase in access, mainly for elite	Reduced social disparities in ICT usage (down to < 50%?)	Better access, but increased disparities	Increased access (approaching universal) with decrease in quality
New approaches to learning via ICT	No sense of urgency and no funding	High level of innovative formal STEAM education	Pockets of innovative education – private institutions	New styles of STEAM learning focusing on whole population needs
Culture of alliances and partnerships	Cooperation not seen as a priority	Strong focus on organisational partnerships (local and regional)	Few local partnerships – multinationals drive	Focus on internal (national) and South-South cooperation
Presence in Africa	Stagnation leads to reduced impact	SA leadership in regional ICT expansion	National and African ICT needs ignored	SA well positioned to exploit regional and developing world ICT markets
ICT for development (RDP applications)	Fragmented and under-funded with few successes	Significant growth leading to export opportunities	A few foreign applications, customised for peri-urban areas	Many "bottom-up" applications satisfy range of community needs
ICT industry skills strategy	Low-level, amateur training, strategy uncoordinated. Well qualified "drain" away	Widespread specialist oriented skills profile, eventually equalling the world's best	Niche oriented high-tech education – no strategy – information industry colonisation	Strong, coordinated, vertically deep, holistic, training strategy. Risk of parochial approach
Virtual learning	Poorly funded, outdated and ineffective	Given high priority, pervasive with strong local content	What is available from overseas as accessible to the "haves"	Locally dominated content for ALL, but restricted by poor ICT at first.

4.4 Sector Scenario Narratives

The SWG used the information in Table 4.1 first to produce summaries for each scenario, and finally to create four narratives or vignettes. The vignettes are valuable

because they add context and body to each scenario, making it easier for the reader to become substantially immersed in that particular possible future.

4.4.1 Frozen Revolution summary

a) The local ICT Industry remains peripheral, far behind global growth; professional, engineering and technical capabilities stagnate with no ICT skills strategy.
b) Some innovative 'startups' but they soon relocate; investment in the sector dwindles.
c) Uncoordinated government ICT initiatives, no NIS strategy, little 'public-private' collaboration.
d) Shrinking elite have full connectivity benefits, but as consumers, not producers.
e) ICT tends to take, not make jobs — becomes a focus of growing civil unrest.
f) Few disadvantaged gain access, and SA not a player in the global 'ICT for development market'.
g) The 'African Information Society' initiative fails.

'Frozen Revolution' Vignette

George Sithole winced as the headlights of his 10-year-old 4x4 raked across his farm's sagging electro-gate, highlighted the rusting nano-irrigation tank, and came to rest on the crooked nameplate, 'Amathole'. His trip into Pretoria hadn't been worth the petrol (something of a luxury in 2020!). The bank manager 'wasn't available for the foreseeable future,' most of the spares and hardware he needed were out of stock, and there was as little interest in his surplus crops from the locals as there seemed to be, permanently, on the global electronic market.

As George entered the farmhouse, he instinctively checked the log of the security system and switched the perimeter to 'night-mode'. Next, he activated his Videowall, and was shocked to see 23 sessions open at one time, all displaying the faces of harried farmers. Not surprisingly, last month's global stock market crash had only worsened the difficult times that most farmers had been experiencing in recent years. Things were coming to a head...

George flicked the Videowall out of privacy mode and the speakers crackled into life:

'... so we're holding a reps meeting of almost all the farmers from Southern Africa.' Themba, the regional chairperson, was saying, 'We've managed to get one of the founders of Dolphin International, Jack Deventer, to talk to us. The only reason he has found time to talk to such an out-of-the-way, unproductive region is because he used to be Kobus van Deventer, a South African who left 15 years ago for greener pastures. Literally!'

By 2016, Dolphin had established itself as the global leader in nanotechnology for yield improvements, offering a wide range of automated farming tools, and had become a major international broker for farm produce. Like George, most owners of large South African farms had signed up with Dolphin over the past 15 years

because Dolphin provided state-of-the-art technology which promised dramatic improvements in competitiveness as well as access to global markets.

'There are 13 of us crammed into one room here!' said an angry voice from Cathcart as its image flickered wildly and filled with static. 'The AgroNet loop in the Eastern Cape is down and no Dolphin technicians are available to fix it. The local technician had a go, and this was the best he could give us...'

'Our nanotech is off-line completely, so my farm has ground to a halt!' exclaimed a Natal rep. Nodding heads filled the Videowall as most farmers seemed to be experiencing maintenance and other problems with their entirely automated farms.

'Jack! You appreciate how stuck we are unless Dolphin re-establishes technical support centres in each Province, staffed with qualified Dolphin technicians?' asked Themba, trying to bring some order to the proceedings.

'Dolphin has simply given up.' Jack replied, 'Very few foreign technicians, including the inexperienced, are prepared to spend even six months in South Africa. And as soon as locals are trained up to a reasonable level of expertise, they move on to better economies - Dolphin skills are sought after globally.' Jack's responses were very smooth. He was probably using an autoprompter, a technology not available on George's ageing Videowall. Even if George could afford Dolphin's latest videocomms technology, it would be in breach of South Africa's 2018 telecommunications regulations.

'Do Dolphin appreciate that since the bottom has dropped out of the Rand, we need to be paid in US Dollars or Euros?' Themba was doing his best to prioritise the farmers' wide range of concerns.

'I understand, but Dolphin is ***not*** *a charity and must off-load its Rand reserves.' said Jack, 'No one has confidence in the currency of a country which has sustained a negative GDP for six years, especially when the Reserve Bank seems powerless even to slow the local plummet triggered by the recent global crash.'*

'OK, then', Themba's voice was sounding pretty strained, 'How about a guarantee of global sales for 25% of all Southern African autofarms' produce? This is only fair seeing that most other countries already have guarantees of more than 50%.'

Jack sighed and shrugged. 'Sorry, guys, but let's be realistic. Dolphin won't provide any guarantees while South African farmers continue to grow the 'wrong' products, following their government's policy recommendations, which change almost every 18 months. Despite the fact that Dolphin's produce recommendations are based on global market, climatic and environmental information, most farmers seem to be blinded by the 'quick buck' of government subsidies. You remember that Dolphin tried to negotiate with the government some years ago, but...'

Suddenly, the Videowall went dead, and a distorted, videoless, female voice announced:

'People don't require maintenance. If you still used labour instead of selling your souls to technology and Dolphin International to automate your mortgaged farms, you wouldn't be having all these problems right now! You farmers have become an elite. Most people don't even have PCs, let alone your fancy Videowalls and other

technology. You have lost touch with your roots and with the rest of the country. It's time we took the land back to feed our own people and provide some jobs, instead of growing for the global....'

'Damn 'have-not' hackers!' mumbled Themba as the Videowall connection was restored.

'She does have a point, though,' thought George.

4.4.2 Innovation Hub summary

a) Public/private collaboration on ICT skills strategy— professional, engineering and technical capabilities grow. After a slow start, ICT industry grows dramatically.
b) Investment follows growth of ICT industry, some dramatic local 'start-up' successes.
c) Clear, long-term, regionally focused NIS strategy, government remains focused despite 'neglected' needs — appears autocratic.
d) Connectivity spreads, with significant growth in innovative ICT-related production.
e) Full job creation impact of ICT only emerges after ten years, then socio-political paradigms change.
f) Many (50%?) remain outside the new, large S&T/ICT élite, **but** SA corners a significant share in the global 'ICT for development market'.
g) The 'SADC Information Society' thrives under SA leadership, but the rest of Africa struggles.

'Innovation Hub' Vignette

Walter Harsensson was already more than halfway through his World Bank report on the global strikes in response to last month's 25% stock market crash. His young research team had assembled much of the background data within a remarkably short seven working days. In that time, he had been able to interview all the important first-world experts via virtual-conferences from his home tele-office in Stockholm.

He had decided to complete the report in Southern Africa for several reasons. Firstly, of all the world's major emerging economies, South Africa's had been least affected by the global crash. Secondly, the strike in South Africa had been a sideshow compared with the wave of civil unrest sweeping much of the developing and developed world. Thirdly, he could work from his brother's home in the tranquil Tsitsikamma Mountains, which had the identical facilities to his home tele-office. Fourthly, there were several Southern African experts who could not easily be consulted 'electronically,' so he needed a convenient base from which to set up in-person interviews. Finally, he loved coming to his brother's adopted home - the climate, the wildlife, the magnificent scenery and especially the dynamism and diversity of the people.

'Walter! You left an urgent message for me to call you as soon as I got in.'

Walter's head snapped up as he heard Susan's laughing voice. He quickly unfolded his port-o-screen.

'Good to see you, Susan. By the way, you're an elephant,' said Walter.
'What?!'
'Relax, your image is superimposed on my live Kruger Park feed, so the third elephant on the left has your head. Grey suits you.'
'Oh... right. Anyway, what did you have me call you for?'
'I need you to have a look at the material I've got so far for the report on the South African angle on the global strike.' Said Walter, 'Room, show the interview tapes, please.'
More windows invaded the Kruger Park. Walter checked to see that they were all there and asked the room processor to send copies to Susan.
'I've got five icons here Walter, what next?'
'Let's start with the government's position. Room, play the minister's interview.'
The wildlife faded into an on-line video debate with the usual cross-section of opinions. The room processor started the videobite with the government minister's views.
'The strikers are an ungrateful and irresponsible minority. Look at what we have achieved! If government hadn't stuck to its policies, but had spread its resources too thinly, wouldn't we be on our knees now, like so many other countries?'
The union leader quickly chipped in. 'Things are NOT all sorted out here. In three provinces the crime rate remains amongst the worst in the world. Unemployment is above 50%, and it is very difficult to mobilise these people, scattered as they are geographically and ideologically, and lacking quality connectivity. They are intimidated by the government.'
The community elder took up the argument. 'Africa is a patient continent. So many things have been improving over the past 15 years throughout Southern Africa. However, there are still too many who fall outside of the miracle. Perhaps government has been too slow to address their needs.'
Susan had to raise her voice to be heard above the debaters. 'Great. I really like the contrasts. Have you finished your summing up yet?'
'No,' replied Walter, as he used a hand gesture to stop the videobite so that he could talk simultaneously to Susan, 'but it'll probably be along the lines of 'Twenty years ago, only ten per cent of South Africa's population were 'haves'. It is a remarkable achievement to push that figure to over fifty per cent in such a short time. But they appear to need another miracle not only to deal with the forty per cent who have been largely left out, but also to speed up its spread to the rest of Africa.''
The room processor's voice interrupted as a new face was superimposed on the Kruger feed : 'Excuse me, Mr Harsensson, a Professor Ndinga is here to see you. Is she the person you are expecting?'
'That's her. Please send her up, Room,' said Walter. 'I'm afraid I've got to go, Susan. I'll copy that conclusion to you later. Room, I need the files on the proposed Ndinga Social Technology Centre.'
The images of Susan and the Kruger Park were replaced by a virtual reality model of an impressive eight storey building....

4.4.3 Global Home summary

a) The ICT skills strategies respond to global (first-world) needs — the 'local' ICT industry thrives only in islands where the multinationals show interest.
b) Little local ICT innovation; investment centres on multinationals.
c) No coordinated NIS strategy; dependence on first-world ICT developments.
d) The connected élite gain great benefits (global teleworking), but gap grows.
e) ICT has little impact on job growth, but causes 'indirect' brain drain.
f) The global 'ICT for development market' passes Africa by.
g) The 'African Information Society' is established, but only for the small élite of 'haves'.

'Global Home' Vignette

It was a month since Sipho had disappeared. To Solly, Sipho was his best friend, mentor, and the big brother he had never had. He remembered how strangely Sipho had been behaving those last few days. Sipho kept mumbling about 'stock exchanges' and saying that things had to change, but refused to tell Solly any more. Sipho's sister, Matsie, was desperate, and had asked Solly to go through Sipho's electronic files for any clues. Solly agreed, even though there was a code amongst the 'HUC kids' that you didn't touch each other's files. It had taken Solly a week to hack through Sipho's security system. It was brilliant, and if Sipho hadn't helped Solly set up his own system in a similar way, he doubted that he could have broken it. Solly thought that the most promising place to look for clues would be in Sipho's voice-mail archives, but it took another three days to work out how to decrypt them.

Today, at last, Solly had succeeded. But he wasn't smiling. Solly sat paralysed, mouth open and tears in his eyes. He was staring at the auto-transcript of a voice-mail that Sipho had sent to some 'global leaders' in Washington and the United Nations, dated 2020-08-10. The day before he had disappeared. It read:

'I'm Sipho Molefe from Southern Africa. I must tell you about a man called Herman Uljievic. I thought I owed him so much! In fact, he has turned me, and many like me, into cyber criminals.

'Ten years ago, when I was eight, I was living with my mother and younger sister in a shack in Alexandra. School was a joke. Ma couldn't afford to buy the compulsory books, and the teachers were pretty bad. The one good maths teacher we had soon got snapped up by one of the expensive private schools. So the only education I have came from two sources — the street, and the Herman Uljievic Centre.

'I was lucky. They set up an HUC only half a kilometre from our shack. The HUC caused quite a stir amongst the local kids. Most of us had seen computers, either at school, where they wouldn't allow us to touch them until we were 15, or at one of the two old MultiPurposeTeleCentres, set up by the government before I was born. At the MPTCs the computers were very out of date, mostly Pentium 4s which

couldn't even run Windows 2007, let alone Linux 5. But at least we kids were allowed to get our hands on the computers — until they finally closed the MPTCs down in 2011 because of a lack of government support.

'By then I had long since moved over to the HUC. It was great. They had 20 of the latest computers and a wide range of software. And if you passed their aptitude test, you could spend hours on the machines every day. The test was no problem for me, which was a surprise considering how uneducated I was. I soon discovered that there were about 30 kids like me using the HUC who had passed the test. We didn't have any formal teachers, just older kids who helped us when we got stuck. But most of the time we taught ourselves by playing around. By the time I was 13 I was a whizz at all the strategic games around, and could programme in environments such as Virtual C++, Winux-2011, Java-6, and EON-4.

'That was 2015, the year Ma died, and I met Herman for the first time. He realised that my sister depended on me now, so he started paying me for programming work. I though he was the greatest guy on the planet - he paid for the HUC, he had given me computer skills, and now he was paying me more money than my teachers were getting. At that stage, I gave up school and worked for Herman at the HUC full time.

'Soon, I was helping out in other HUCs —Herman had set up 20 in South Africa, and more in other African countries, all 'to help the poor, and at his own expense'. I had started to do some exciting programming on security systems. I seemed to be particularly good at this, and I ended up with a small group of black teenagers with similar backgrounds to me, who were encouraged to hack into any network system we could find. We were told that this was to identify weaknesses so that they could then be fixed.

'Of course we had heard the rumours that 'Bra Herman' was involving us in some shady activities. Some said he was an international 'tsotsi', but we thought of him more as Africa's Robin Hood. He certainly seemed to be doing more for the poor than the government, who had abandoned us to fend for ourselves years ago. And why should we worry about laws which seemed only to protect the rich, 'connected' communities in Midrand and Cape Town, who worked mostly from their fortified homes when they weren't flying overseas.

'Herman treated us like real people, paid us good money, and we in turn could help our families and friends in the poor communities. We know Herman isn't a saint. He has a bad temper, and demands loyalty. In fact, it would be very difficult for any of us to get formal jobs in the 'connected' communities because we don't have any formal qualifications. Only a fool would cross Herman. So why am I doing just that?

'I did some hacking into a couple of Herman's systems the other day. I found that whenever we cracked a security system, Herman's organisation would use our knowledge to siphon millions of dollars from electronic transfers. These transfers are primarily between the advanced systems of multinationals and the outdated machines used by smaller, local businesses here and in other developing countries.

Each time the security systems are repaired, we 'HUC kids' would enthusiastically figure out how to crack them again!

'But that's not the worst of it. Herman is a prominent member of a global network of fellow, shady 'philanthropists' dotted around the developing world and using groups of kids like us to expose and exploit other weaknesses in the global electronic networks. Apparently, his network has almost perfected 'electronic insider trading', and seems to be able to manipulate the world's stock exchanges without being detected.

'I don't know how they did it, but Herman's logs show a flurry of electronic activity just before last month's stock market crash. It's the developing world that is suffering most because of that crash. Herman and his cronies aren't robbing the rich to feed the poor, they are robbing the poor to feed themselves.

'Please. You are the only people who can stop them!'

Sipho's voice-mail transcript had shocked Solly. But what had paralysed him was the message box that had appeared shortly after he had decrypted it. It simply said:

'Hi, Solly. Herman here. My car is waiting for you outside....'

4.4.4 Our Way is THE Way summary

a) Robust ICT skills strategy, linked to a strong innovation/knowledge production strategy. Old ICT Industry fades, slowly replaced by local-knowledge industry.
b) Many innovative ICT 'start-ups', but most relocate during investment boycott.
c) Clear NIS strategy, but secondary to government's focus on 'indigenous knowledge' projects; locally customised ICT plays crucial supportive roll; core strengths (and jobs!) develop (eventually).
d) 'Universal Access' is achieved, but quality is poor for >10 years, so ICT-assisted production suffers.
e) Focus is on knowledge production and new modes of learning for ALL, supported by ICT. By 2015, SA emerges as global leader in 'ICT for development'..
f) SA's 'knowledge society' has a wide impact after 2015, as the global (first-world) economy hits severe problems.

'Our Way is THE Way' vignette

Nebo Mamela was enjoying the view from her patio over the lush African Lowveld. One of the many benefits of tele-working from a rural area was that you couldn't see the burnt-out shells of skyscrapers that, even in 2020, still marred the derelict CBDs of Johannesburg, Durban and Cape Town.

Nebo watched the plain roll away from her, the glowing images hovering in front of her face. She was enjoying some leisurely global shopping. She glided through the three-dimensional virtual shops broadcast to her from anywhere via her new HoloSpecs, which allow the wearer to see both real and virtual worlds simultaneously. She was currently in virtual Surinam, having clothing fitted for her

son. She had had body scans done of all her family to create accurate digital clones with which she could try out clothes, see jewellery worn, create virtual snapshots, and much more...

'Mr. Seyrus, the CEO of Pharmaria would like to confirm a holomeeting with you in 10 minutes, what is your reply?' inquired her earpiece.

'Confirm it.' she said ' What does he want this time?' she mused to herself. Seyrus was the CEO of a large, northern hemisphere pharmaceutical multinational. In the light of last month's 25% 'correction plunge' on the global stock markets, she doubted that anyone would try to buy her out again. Especially now, when her company's stocks were still rising, in contrast with their long-established first-world markets (and related buying power) which were shrinking dramatically.

Before she made her way into her HoloStudio, she called up the electro-bio that Pharmaria had asked her for recently. As the HoloSpecs displayed the ageing video material, the voice-over filled her earpiece:

'Twenty years ago Nebo Mamela worked for Pharmaria as a student. She even played an unwitting part in the then rampant biopiracy — the unilateral patenting of developing world indigenous flora by some first-world multinationals. Her realisation of this was a major reason for her return to South Africa to create her own research and development intensive business. This coincided with the start of the 'Isolation', when the first world's political and economic powers started to marginalise South Africa. Ironically, the Isolation had been kind to her field in that it all but stopped the plundering of South African flora, allowing her to formulate strategies to safeguard indigenous knowledge and its symbiosis with her own research.

'However, the Isolation caused severe hardships for most South Africans. This led to several years of serious civil unrest from which the main CBDs in particular continue to bear the scars. Given the changed nature of work in South Africa, and the related redundancy of centralised infrastructure, it seems unlikely that these CBDs will ever fully recover.

'A major hardship during those years was the isolation from first-world developments, particularly the Global Information Infrastructure, where South Africa's refusal to accept first-world terms had led to the first retaliations. At least universal access had been achieved before isolation, followed by ten years of low bandwidth, inadequate content, and insufficient electronic-commerce. Following the Global Crash of 2015, however, South Africa had the advantage of little legacy technology, and many empowered, self-motivated individuals, whose demand quickly drove the development of a state-of-the-art regional information society, providing widespread, high-quality global connectivity.

'Nebo was one of those individuals who quickly embraced the newly-available information society, and used it to enhance her learning organisation. By 2018 Nebo found herself at the helm of a blossoming multinational biopharmaceutical (her term) with a distributed structure and staffed by self-motivated co-owners who understood, cared about, and enjoyed their work. Her company emerged from

South Africa's isolation and built a broad network of partnerships among third-world countries with rich indigenous herbal knowledge.

'Following the Isolation, as South Africa re-entered the global market, many first-world pharmaceutical companies tried to buy Nebo out, but she fought them tooth and nail. Successfully! To this day, she continues to fight several of them to end their practices encouraging biopiracy which.....'
Nebo cut the feed as she reached her HoloStudio, which contained a smiling Mr Seyrus.
'Good morning, Dr Mamela, or should I call you Boss?' he said, catching her off guard.
'Why 'boss'?' she asked.
'Because we want you to be our CEO. We need to learn how to do things your way....'

4.5 SWOT from the Scenario Process

A second SWOT was performed by the SWG, which immersing itself into each ICT scenario as the context for new, future-based considerations. The exercise focused on opportunities and threats that could emerge over the next 20 years in each scenario, with particular emphasis on research and technology developments.

4.5.1 Frozen Revolution Scenario Opportunities and Threats

In this scenario there is little coordinated organisational progress, and multiple reactive strategies tend to reinforce the industrial paradigm.

Opportunities arise, but mostly for individuals and small groups who are able to respond swiftly and take advantage of the chaotic environment. Growth occurs by default in an inertia-bound society, unable to implement, let alone police, rules and regulations that are constantly revised and usually fragmented and contradictory. Grey areas (national and international) become fair game for exploitation. Since these grey areas continue to occur frequently in the application of ICTs within the global economy, South Africa would be a haven for such activities.

Obviously, this could also be seen as a threat. Further threats include the decline of our major institutions, competitiveness, and world-class skills base, and the growth of crime and civil unrest as unemployment escalates. ICT is 'thrown at' organisational problems as the way to the future, but becomes a major threat since, if it is not in response to organisational learning, it simply embeds the old, outdated processes.

4.5.2 Innovation Hub Scenario Opportunities and Threats

This scenario is dominated by a strong government with a research and technology oriented 'top down' approach. The dominant paradigm remains industrial, although knowledge work flourishes in pockets.

Opportunities exist for large and small ICT organisations to grow domestically and internationally, supported by strong government incentives and a rapidly growing skills base. The African subregion provides much of the expansion market, and large inter-state projects are undertaken across SADC countries. ICT is both a commodity in its own right and a driver for the growth of other industries.

The emergence of South Africa as a significant ICT player and a dominant force in Southern Africa works against the interests of both global players and immediate neighbours, leading to a variety of mainly covert commercial and political sanctions. The top-down structure which dominates ICT innovation acts as a further threat to South Africa, and results in opportunities for big players but not for small entrepreneurs, a widening of the gap between information haves and have-nots, and a government with too much local influence, within which corruption and the misuse of power are able to thrive.

4.5.3 Global Home Scenario Opportunities and Threats

In this scenario, large multinationals dominate, with few opportunities for the individual. The private sector approach is predominantly 'top down,' operating in a local industrial paradigm secondary to the élitist first-world-knowledge economy.

Opportunities are good for a subset of local private organisations to form strong partnerships with international operators, and to access international investment capital, but little ICT innovation happens locally. The cost of ICT products and services drops in international terms, but this is offset by an ever-weakening local currency. Excellent ICT services are available privately for those who can afford them. Small numbers of local ICT developers are able to exploit niche opportunities through international partnerships, and local entrepreneurs in the services industry who align themselves with international product lines do well.

A consequence of this scenario is that the country declines slowly into a backwater for ICT innovation dominated by imported off-the-shelf ICT solutions, and in which any projects requiring innovation are contracted out to foreign ICT providers. The weak national government is unable to set strategies for ICT that private industry will follow, and South Africa has little influence on the development of international standards and trends. There is a steady decline in the quality of public services. All forms of indigenous technology are marginalised. The ICT skills base disintegrates as

quickly as it is developed, and an ever-widening gap between rich and poor exacerbates the crime and corruption problems.

4.5.4 Our Way is THE Way Scenario Opportunities and Threats

In this scenario a strong government is forced by isolation and scarce resources to adopt the knowledge paradigm and to facilitate a predominantly 'bottom-up' approach. Empowered individuals proliferate in a culture of slow but sustainable development. ICT development is stunted, but opportunities mushroom after 2015.

Opportunities for collaboration with, and export to, other developing countries with similar needs and problems emerge, and investments in ICT development pay off in the long term. Isolation forces a national drive to identify unique indigenous competences and knowledge, resulting in innovative local 'high-tech' developments throughout the country. Particularly valuable in the longer term is the subsidised roll-out of technology amongst sectors of the population which would otherwise be seen as commercially unviable.

A major threat is the long period for investments in ICT development to yield profits; many efforts do not survive the wait. Isolation from current international ICT players leads to diminished international marketing possibilities, a lowering of manufacturing standards, and ideological bias in the choice of projects undertaken, all of which reinforce the position of isolation. Venture capital becomes increasingly scarce, and retrenchments in the private sector are common.

4.6. Conclusion

The Foresight macroscenarios provide a valuable template upon which a rich variety of possible futures may be developed, and the variations of their respective trajectories may be evaluated and compared. On the basis of these macroscenarios the ICT sector scenarios were developed and embellished, both as a tool to enrich the ICT Foresight process itself, and as a potential sounding board for a range of other processes. The statements developed for the Delphi Survey (Chapter 5), the issues and priorities highlighted in the Strategic Technology Map (Chapter 6), and the final recommendations (Chapter 7) have been both significantly influenced by and also repeatedly tested against each of the ICT sector scenarios.

Chapter 5

The Survey Analysis

5.1 Background

The aim of the Foresight exercise, through each Sector Working Group (SWG), is to assess emerging market opportunities and technological trends over the next twenty years to inform decisions on the balance and direction of research and technology development. If the SWG is to be of a manageable size, it is not possible to have comprehensive coverage of all the necessary expertise, particularly for a sector as broad and crosscutting as ICT. To gain the necessary commitment and consensus needed for the foresight process, it was crucial to consult with a wide range of ICT stakeholders. A substantial amount of consultation was done through the working group members, associated individuals and the reference group. However, a much more structured dialogue with a cross-section of stakeholders was required to test preliminary strategies emerging from the sector workshops. This becomes even more pertinent to South Africa, whose science and technology system to date has operated in a fragmented way. The method chosen to achieve this objective is the questionnaire-based ***Delphi survey***,[14] a process in two iterations aimed at broader consultation with the stakeholders in the sector. Delphi surveys were included in other international studies (e.g. in Japan, Germany, Hungary and the UK),[15] either as the main tool, or in support of other foresighting tools.

5.2 ICT Survey Methodology

Through the methodology of the Delphi survey, several iterations of a questionnaire are used to obtain responses, ratings and comments from an identified pool of expertise on a range of statements setting out potential trends in the sector concerned. In the further round(s), providing individual respondents with feedback from the entire response pool enriches responses.

The most important components of the survey questionnaires (rounds 1 and 2) are the ***statements*** and ***questions***. Each statement is basically a miniscenario about which the survey respondents were asked to give feedback, both in the form of answers to a series of questions and by way of optional comments. The SWGs spent significant time generating these statements. The questions included in both questionnaires were devised by the Foresight Coordinators Team using several other national Delphi surveys to provide guidelines, and are common to the questionnaires of all 12 sectors.

Identification of Survey Statement Topics

Generating the survey statements involves a lengthy and complex process. The first stage is to identify a wide range of proto-strategies of significance to the ICT sector over the next twenty years. To generate these proto-strategies, the SWG started with the combined outputs from the two SWOT analyses reported in Chapters 3 and 4. The process involved "pairing analyses" by taking each —

- opportunity, and devising an appropriate strategy (or strategies) to implement it;
- threat, and devising an appropriate strategy (or strategies) either to minimise it, or to change it into an opportunity;
- strength, and identifying strategies that might enlarge it or prolong its duration;
- weakness, and devising strategies to remove it, and in some cases change it into a strength.

During the process, the SWG considered a series of issues for each of these proto-strategies:

- New market opportunities arising from the SWOTs;
- new products, processes and/or services to meet the needs of some of the market opportunities; and
- technologies, breakthroughs, scientific advances or innovations needed to underpin products, processes, services and products.

The resultant list of strategies was then prioritised, with approximately 60 of the most important being selected, ensuring that all eight focus areas were represented. In light of the limited number of statements required for the survey, balance was sought with the need to represent the complexity and breadth of the ICT sector. A particular problem is the exceptionally rapid turnover of technology in this sector (an average cycle of less than two years), which could have resulted in an emphasis on short-term issues that would be inappropriate in a 20-year foresight study. The SWG therefore employed further iterations focusing on the identification of longer-term technologies, breakthroughs, scientific advances or innovations needed to underpin a broad range of emerging societal needs.

Formulation of Delphi statements

The final stage of the process was to convert the prioritised proto-strategies into the statements to be included in the questionnaires. The formulation of appropriate statements proved to be lengthy and complex, as certain of the focus areas and issues were less obviously amenable to the questionnaire format. This was the case particularly for issues that were less technology-specific or more broadly social in character as well as those in respect of which we wished to test for potentially unsatisfactory outcomes.

The formal definition of a Delphi statement used by the SWG was as follows:

A concise, unambiguous expression of the event, achievement or phenomenon upon which stakeholder opinions are sought.

The aim is to incorporate any key conditions but exclude separate issues that warrant one or more additional statements. It is important for the working group to communicate the state of development of the idea they had in mind, especially involving technologies, research and innovations. Hence, the following guidance was used to select *lead words* for each statement:

If the technology/innovation does not yet exist, then use:
- *Elucidation*: to scientifically and theoretically identify principles or phenomena, or
- *Development*: to attain a specific technological goal or complete a prototype.

If the technology/innovation already exists, then use:
- *Practical use*: to indicate the first practical use of an innovative product or service, or
- *Widespread use*: to indicate significant market penetration resulting in common use of a product or service.

For final validation, the statements produced in the above process were then tested by the SWG and members of the reference group against the survey questions and against the technology, market, socio-economic development, culture and innovation criteria. The resultant first-round statements are shown in Appendix 1.

5.3 Survey Process and Results

5.3.1 First Round

Altogether 1 500 survey questionnaires were mailed. The recipients comprised a random sample of approximately 750 members of the Computer Society of South Africa and 750 from lists of people that emerged during the co-nomination process that started the Foresight study. It can be assumed therefore that the recipients are a group knowledgeable in the ICT arena. The printed questionnaire was placed on a web page and, under password control, respondents could also complete the questionnaire on-line.

By the closing date, 223 responses had been received and Appendix 1 shows all the results in histogram form. The results of the first round were used to rework the survey instrument for the second round. Careful inspection of the responses to individual questions and written commentary led to the discarding of fifteen

statements before the second-round questionnaire was issued. Essentially, items were dropped where it was felt that a second set of responses would not add further insight. There was one new statement to specifically address the impact of ICT on jobs in the manufacturing sector. Six statements were reworded for clarity.

5.3.2 Second Round

The revised 46-item questionnaire was issued to all 223 respondents from the first round together with a summary of the text responses to each statement (if any). In some cases statements had proved to be ambiguous or overly general. In those cases the working group added commentary to help clarify the intent. Each recipient received the full set of results from the first round together with their own ratings. The intention was to inform the recipients about the group responses and invite them to compare those results with their own first-round responses. Respondents were free to adjust their responses in any way they saw fit. In particular they could add text commentary to explain their own assessments.

Eighty people responded to the second round of the survey. Appendix 2 presents those results.

With regard to the respondents' self-assessments of their answers, the difference between the two rounds is very noticeable. In the first round, 20%-30% of the responses for each statement fell into the "low confidence" category. In the second round the number fell to well below 10%. Possible reasons for this are that people lacking in confidence in their knowledge of the ICT arena (as expressed in the survey) chose not to submit a second-round opinion, or that people gained confidence in their insights as a result of their participation in the survey, or both.

As is typical of Delphi surveys, the range of responses to particular items narrows from one round to the next, which can be interpreted as a move towards consensus. This is particularly noticeable for the "Likely time frame for realisation," where in virtually every case the range of responses narrows. Also noticeable is that there is hardly any shift in the "Median estimate of time to realisation".

The following commentary applies to the results shown in detail in Appendix 2.

Importance to South Africa

Respondents assessed each statement as having high, medium or low importance for both wealth creation and quality of life. The values ascribed to high, medium and low were +1, 0, -1 respectively, and were used to calculate normalised numerical indices of the importance of wealth creation and quality of life separately, as well as an overall importance index which combined the two. Table 5.1 shows the values for the

composite index as well as the wealth creation and quality of life indices separately for all 46 statements.

Of interest are the "top twenty" based on all three of the above criteria. Note that 13 of the top 20 for the composite index are also in the top 20 for the separate wealth creation and quality of life indices. They are —

17 SA's computer literate population grows to 60%.
46 ICT-enabled activity leads to net job gains for the whole economy.
22 SA is a leading producer of ICT innovations for developing countries.
26 ICT-enabled, world-class learning methods.
27 ICT-based security devices significantly reduce crime.
42 Knowledge work comprises >50% of economic activity.
18 More than 95% of schools use the global network and multimedia for learning.
44 Growth in ICT sector reverses ICT brain drain.
06 60% have home access to global infrastructure.
14 90% of SMMEs use the global network for >20% of their business transactions.
23 Locally developed human-computer interfaces enable access for 75% of population.
20 Interactive tele-learning widely used.
38 90% of connectivity is over existing electricity infrastructure.

So it is the above aspects of ICT that the respondent group believes offer the greatest prospects of wealth creation and improvement to quality of life for the citizens of the country. Noticeable are the number of items that relate to education and learning (both formal and informal) and access to the global network.

Also of importance are those items that respondents feel are of least importance. The seven items lowest on the composite index (from bottom up) and also in the bottom 10 or 11 on the separate scales are —

04 Uniform international legislation on copyright, patent and intellectual property.
10 Development of on-body connectivity for continual medical monitoring etc.
01 90% of all new microprocessors are photonic.
09 Miniaturisation of technological applications.
08 Virtual environments become the new meeting place and communication paradigm.
30 Use of stratospheric telecomms platforms over urban areas.
28 Local capabilities focusing on on-body/in-body ICT innovations.

It is noticeable that several of the lowest rated items have a high technological component.

Table 5.1 Ranking of importance of second-round survey statements according to three indices

Item	Composite Index	Item	Wealth Creation	Item	Quality of Life
17	82.14	22	86.21	17	80.36
46	78.57	17	83.93	26	76.79
22	78.45	46	82.14	27	75.93
26	71.43	31	74.51	18	75.44
27	62.04	44	73.58	46	75.00
42	60.78	43	70.37	22	70.69
18	60.53	42	68.63	06	66.67
44	59.43	26	66.07	20	66.67
06	56.35	12	65.00	23	62.26
43	53.70	14	54.55	39	60.38
14	51.82	27	48.15	13	60.00
31	46.08	06	46.03	07	54.10
12	45.00	18	45.61	37	53.85
23	41.51	03	35.59	42	52.94

South Africa's comparative standing

This set of scales offers little information in the ICT arena. For virtually every statement, over 95% of the respondents believe South Africa is equal to or ahead of other Southern African countries. In most cases more than 80% believe we are equal to or ahead of other developing countries. (Given that there is a wide range of economic circumstances in all developing countries, however, the responses here are hard to interpret.) For all but five statements, more than 80% of respondents believe we are behind developed countries. The five where more than 20% believe we are equal to or ahead of developed countries are —

2 Use of personal mobile communications systems.
3 Global acceptance of open standards for ICT.
7 Use of home surveillance systems.
25 Development of technologies serving Africa-centric niche markets.
27 Use of ICT-based safety and security devices.

Time frame for realisation

The results show the 25%, 50% and 75% quartiles, so half of the responses lie between the "walls" of the house and the "peak" represents the median. As mentioned above, it is clear that there has been little shift in the median from round one to round two, but the spread has narrowed distinctly. This is in line with typical Delphi surveys and strengthens the validity of the median values as seen by the respondent group. The median value for all statements shown at the end of the chart is approximately ten years, well within the twenty-year horizon of the study.

Aspects that the respondents believe will be realised well within a ten-year time horizon include —

2 Personal mobile communications.
3 Global acceptance of open standards for software.
5 Global electronic promotion of indigenous products.
7 Practical use of ICT-based home surveillance systems.
12 Widespread use of broadband communications in business.
27 Widespread use of ICT-based security and safety devices.
41 Vehicle transponders in all new vehicles.
45 Ongoing adoption of ICT innovations in the manufacturing sector.

By contrast, the goals respondents believe will only be realised well beyond ten years include —

6 Widespread access to the global infrastructure from homes.
10 "On-body" connectivity for monitoring and communication.*
11 Automated public transport devices.*
17 High levels of computer literacy.
23 Locally developed Human-Computer Interfaces provide easy access.*
24 Speech translating telephones.*
28 Local development of on-body/in-body ICT innovations.*
31 SA captures 20% of the global market for specialised software.*
33 Interactive access for all to 90% of government services and information.
39 Major role for tele-health consultations.
42 Knowledge work contributes more than half of all economic activity.

Indeed, a significant number of respondents be-lieve that several of these (shown by asterisks above) and other possibilities will never occur. The latter include —

22 SA being a leading producer of ICT innovations for the developing world.
32 Half of the world's software being freeware.
37 90% of the rural and peri-urban populations within 2 km of interactive, multimedia access.
38 Almost all connectivity being supplied over the electricity network.
44 Growth of the ICT sector reverses the ICT skills drain.
46 ICT-enabled economic activity provides a net gain of jobs in the national economy.

Acquisition of technology or capacity

For each item, respondents indicated how they thought SA might acquire such technology or capacity. For most items there was a dominant view, i.e. with more than 50% of the responses applied to just one of the alternatives:

Develop in South Africa

5 Promotion of indigenous products.
17 Computer literacy of the population.
22 ICT innovations for the developing world.
23 Locally developed human-computer interfaces.
25 Development of technologies serving Africa-centric markets.
31 SA carrying out niche-market software developments.
42 Dominance of knowledge work in the local economy.
43 Rapid growth in the local professional ICT community.

All the above are unsurprising, given their content.

Import complete

1 90% of new microprocessors are photonic.
9 Miniaturised, wearable personal assistants.
10 Development of "on-body" connectivity.

Presumably, the respondents felt that the production of such items could require substantial capital investment, would be usable as is in South Africa and would benefit from economies of scale if produced in the developed world.

Customise existing technology

13 Telecommuting for 25% of the workforce.
14 SMME use of the global network.

Here the issue is local use of already existing technologies, so customisation to suit local conditions may be all that is needed to achieve widespread use.

Engage in joint ventures

Since respondents suggest that so many aspects be undertaken as joint ventures (2, 11, 12, 15, 16, 18, 21, 26, 27, 28, 29, 30, 34, 36, 38, 39, 40 and 41), the reader is referred to the content of these items in the survey questionnaire. Why is this solution so widely favoured? Because it is consistent with the widespread belief, recorded elsewhere in the questionnaire, that South Africa is behind the developed countries in virtually all aspects of ICT. At the same time the responses suggest a perceived need

for local adaptation rather than automatic adoption of new technologies as is, and a confidence that South Africa has or could develop the managerial and professional capacity to partner with overseas firms in developing products for local consumption.

Constraints on the realisation of possibilities

In the first-round questionnaire, "finance" was included as a constraint and, as can be seen in Appendix 1, it was generally seen as the barrier to realisation. Finance was excluded as a possible constraint in the second round, so it is instructive to see what constraints are perceived in its absence. Using the value of 50% of mentions per item, *human resources* and *social/cultural issues* emerge as the most significant, followed by *technology* and *policy*. *R&D issues* and *market constraints* are of relatively much lesser concern. Following are those occasions where more than 75% of the respondents highlighted a particular constraint:

Technology Constraint:
24 Development of automatic speech translation telephones.

Market Constraint:
32 Freeware making up more than half of all available software.

R&D Constraint:
1 Dominance of photonic microprocessors.

Policy Constraint:
4 Uniform international legislation on software matters.
29 Telephony over the Internet.
35 Government use of collaborative software tools.

Human Resources Constraint:
17 Growth of computer literacy in the population.
22 Leading producer of ICT innovations.
31 Capturing 20% of global market for specialised software.
43 Trebling of ICT professional cadre.

Social/Cultural Constraint:
13 A telecommuting workforce.
14 SMME use of the global infrastructure.
15 ICT-led organisational transformation.
17 Growth in the computer literate population.
39 Remote interactive primary health consultation.

5.4 Conclusions

This chapter reports the design, development and delivery of a formal Delphi survey of ICT experts in the country. The statements in the survey are themselves the culmination of extensive workshopping by the ICT working group. The response rate of about 15% for the first round is quite acceptable for a "cold canvass," especially since the survey demanded a good deal of time from senior members of the ICT stakeholder group. About 40% of those polled for the second round responded, also a respectable result, particularly given that almost all the second-round respondents regarded themselves as knowledgeable in the field.

The chapter highlights those items the respondents regard as most important for either wealth creation or quality of life or both. Several relate to education and learning and gaining access to the global network. Those least important in their eyes are also noted and reflect the more "high-tech" ICT possibilities for the future.

In almost all cases in respect of ICT developments, the respondents consider South Africa to be equal to or ahead of other Southern African countries and also developing countries in general. At the same time, most consider this country as being behind the developed world.

The median time to realisation for all the statements in the survey questionnaire is about ten years, with half the responses lying within a time frame of five to 15 years. Of the several items respondents believe will be achieved well within ten years, only a few lie in the top twenty on the importance scales:

- ICT-based security devices reducing crime.
- Most SA companies making extensive use of broadband communications.
- Use of personal mobile communications devices.
- All new vehicles having transponders.

Other important items are only expected well beyond ten years:

- 60% with home access to the global network.
- A 60% computer literacy rate for the population.
- Knowledge work comprising >50% of economic activity.
- Locally developed computer interfaces enabling access for 75% of the population.

The most popular path to realisation of the items in the questionnaire is the creation of joint ventures. This is consistent with the assessment that South Africa is generally behind the developed world, but has the capability to partner and adapt technology for local needs. Local development is, however, the preferred route for four of the top twenty:

- Population computer literacy.
- Becoming a leading producer of ICT innovations for developing countries.
- Developing appropriate human-computer interfaces.
- Knowledge work comprising >50% of economic activity.

Among the more significant constraints on realising the items in the survey are human resources and social/cultural factors. In particular, both human resource and social/cultural factors are seen as the major constraint on raising the level of computer literacy of the population. Human resources are seen as the major inhibitor of local development of human-computer interfaces. Social/cultural factors stand in the way of SMMEs as they try to exploit the global network for business transactions.

The next chapter moves on to consider how all the empirical and conceptual data gathered in this study can be combined into a uniform framework. The notion of "strategic technology maps" is presented and applied to the ICT sector. While ICT is a sector in itself, it is of course a fundamental enabler of economic and social activity in all sectors of the economy. The next chapter therefore broadens the scope of the ICT investigation by identifying and analysing the ICT-related content of all the other sectors in the Foresight study.

Chapter 6:

Devising and Applying a Strategic Technology Map for ICT

6.1 Introduction

Building on the preceding analyses, it is now necessary to integrate the various strands linking ICT tools and applications and try to sketch promising directions for ICT research and technology development. In this chapter, outputs from the other 11 Foresight sector surveys are combined with the material from the ICT sector survey to give insights into a wide range of strategic cross-sectoral issues and opportunities. In order to give structure to this large quantity of data, the concept of Strategic Technology Maps is introduced. A Strategic Technology Map for the development of the ICT sector over the next twenty years is produced, and is subsequently used (see Chapter 7) to consider research and technology implementation issues.

In the next section the notion of a strategic technology map is discussed and its component parts are defined:

- Key solutions,
- strategic technology nodes,
- applied technologies,
- base technologies, and
- the enabling environment.

The principles are applied to the ICT sector on the basis of the working group's analysis of the data gathered within the ICT sector and also through analysis of the demand-driven needs for ICT emerging from the 11 other sectors. In the process, ten Strategic Technology Nodes are defined.

As might be expected, ICT features to a greater or lesser extent in all the Delphi surveys in the Foresight project. Indeed, in some sectors, like Safety and Security, Youth, and Finance, many of the most important possibilities for the future have a strong ICT component. Those results are used to identify priority needs for ICT and associate them with one or more of the ten Strategic Technology Nodes. The insights gained from that analysis are used in the final chapter to draw firm conclusions and make recommendations for further action.

6.2 Strategic Technology Maps

Strategic Technology Maps are simply high-level technology trees which are being used ever more frequently to give structure to the highly complex and multi-factorial world of research and technology development, management and policy.[16,17] There

are several variations on this theme, but the six-layer strategic technology map used in this exercise is represented schematically in Figure 6.1 and defined below.

Focus areas

These are obtained from the needs determination process and address the dominant strategic issues facing the South African ICT sector over the next twenty years. These issues were identified in Chapters 3 and 4 and represent desirable directions for the ICT sector itself or ICT-supported endeavours in the other sectors of the economy. A focus area might manifest as a government priority (e.g. specific support for an industry segment), or as a formal industry initiative (like an ICT cluster development), or simply as a natural phenomenon that emerges as a result of a snowball effect (perhaps a post hoc realisation that many independent rural efforts to market local crafts have resulted in a new industry).

Key solutions

These are integrated sets of ICT-related solutions addressing specific needs or focus areas that will have a high impact on industry and society. Predominantly, they will be identified within sectors other than ICT itself, such as tourism, manufacturing, etc., although of course the ICT sector will have needs of its own to grow the industry (e.g. supply chain management). Given the high level of the use of the technology map in this exercise, there is little value in distinguishing between the focus areas and the key solutions.

Strategic Technology Nodes (STNs)

In essence, the STN forms the central focus of a technology map. An STN can be defined as —

> *an innovative process, methodology or base product that facilitates the development of a family of products or solutions to fulfil a set of market needs.*

The advantage of STNs is that they focus the Research and Technology effort on important developments that will have a significant impact on technology and the industry. STNs also call for proper project strategic planning (short and long term) and a coordinated effort in order to achieve maximum results. Well-developed STNs prove useful over extended periods of time for the ongoing development of key solutions and/or products that, in turn, can be used to address urgent needs. STNs can only be developed if they are supported by a range of appropriate applied and base technologies.

Different STNs may depend on each other, and may be combined to provide even broader-ranging key solutions. STNs are particularly significant to Foresight in that it is expected that much ICT-related research, technology and innovative development will take place in this area. For example, the Innovation Fund might target STNs for funding, and STNs might guide recommendations from the National Advisory Council on Innovation.

To help with the understanding of this important concept, an example of the value of STNs is given from outside the ICT sector:

> *In 1970 Black and Decker had hundreds of products in the market using more than 30 different motors, sixty different motor housings, and dozens of different operating controls. Each product also had a unique armature. The B&D management realised that, in order to remain competitive, it would have to decrease its cost of goods by a third. They then embarked on a $20-million development programme to design product families based on an STN. The STN consisted of a standard motor that could serve all their power-tool needs, standard motor housings and controls and a standardised adhesive bonded armature. Subsequently, each product family was re-engineered (drills, jigsaws, sanders, etc.). The results were dramatic: a 50% reduction in product costs, a market share increase from 20% to dominance, and a reduction in the number of competitors to three from more than 20.*

Applied technologies

Applied technologies (or capabilities as defined by Patterson and Kfir[17]) are formed through the utilisation of a number of base technologies and the addition of innovative applications in order to form a certain capability or competency in an organisation or industry. They usually do solve an immediate problem, but have not been broadened to address a wide range of related problems cost-effectively over a longer time span as STNs have. They manifest specific functionality, although that functionality may not be fully useful until it is combined with one or more other applied technologies (for e.g., smart-card technology relies on database technology to render it operational).

Base technologies

Base technologies are close to existing research and technology specialities, but cannot be used directly to solve significant problems. They represent the fundamental building blocks needed by Applied Technologies and dictate what solutions are or are not possible (e.g. gigabit data transmission technologies and photonic microprocessors). They usually involve a significant investment of time, human resources and money to be established, and therefore are particularly significant to Foresight exercises.

Enabling Environment

This comprises the environment that enables the development of Base and Applied Technologies, and STNs, which in turn lead to Key Solutions. In addition to technology and equipment that is easily accessible ('off the shelf'), it encompasses technical, human, regulatory, legal, political, institutional and socio-economic aspects and extends from national to global arenas.

6.3 Strategic Technology Nodes for the ICT Sector

The SWG created the ICT Sector Strategic Technology Map by positioning all the ICT sector survey statements at one (or more) of the six levels within the above structure. This process highlighted the ten STNs described in this section. The focus areas and key solutions were combined with those identified in the other 11 sector surveys (see section 6.4), whilst the applied technologies, base technologies and enabling environments are listed in Table 6.1 below.

As described above, the STNs are at the heart of the ICT sector technology map. They form the most useful point of focus on which to base the high-level recommendations of the Foresight process and are briefly described below:

Future Web

The Internet, and particularly the web, epitomises the dynamic growth of the global ICT sector. It is driven by digitisation, the convergence of a range of technologies (e.g. broadcasting, telecommunications, networking, and computing) and results in the convergence of a range of markets. It is not possible to predict accurately how this complex, dynamic phenomenon will continue to evolve over the next three years, let alone 20 years. However, we can say with some certainty that it will continue to grow, that base technologies will continue to converge, and that more applied technologies will continue to emerge. In order for service evolution to proceed separately (though not independently) from infrastructure evolution, there will be an increasing need to separate service provisioning from network infrastructure provisioning. Simultaneously, established markets will continue to converge and many new, often transitory markets will emerge locally, nationally and globally, whilst the way successful individuals and organisations work will change significantly. It is very likely that future web will have a growing impact on the other nine ICT strategic technology nodes, particularly over the medium term.

All-pervasive though future web is likely to be, the SWG thought it important to ensure that potential developments in the other nine STNs received sufficient attention by considering future web in somewhat artificial isolation.

The SWG believes that future web needs to be considered under two main headers:

- Serving specialists and developed world organisations and businesses; and
- Serving developing individuals and communities.

Emphasis is given to e-commerce, e-business, tele-working, tele-learning, tele-health, tele-governance and tele-policing.

E-Tagging (Humans, Animals, Plants, Things)

This involves all aspects of electronic security, tracking and auditing. Emphasis is given to surveillance, authentication, identification, certification, verification, and non-repudiation. In particular, the global network and related virtual market place will require virtual policing and defence agents working in the interests of the users balanced with the need for 'fair practice'.

Advanced User Interface Platforms (Human and Animal)

These are platforms to facilitate the production of seamless, fully interactive, non-intimidating, highly functional computer interfaces that are appropriate for the particular processes in question.

The emphasis is on interactive natural language environments, interactive virtual and/or immersion environments, and visual simulation with real-time monitoring and feedback. A particular issue is the integration of interfaces for a particular single system that support a wide range of hardware capabilities, with communication links ranging from low-bandwidth to high-bandwidth (>155 Mbit) and interfaces spanning the range from hand-held devices to fully immersible systems.

Intelligent Systems

This refers to the simulation and embedding of intelligence in machines and systems. Emphasis is given to automation, robotics, artificial intelligence, automated surveillance, and particularly sensors. It is anticipated that in the medium term, sensors will broaden to employ optical, chemical and biological technologies.

Bio-ICT (Humans, Animals, Plants)

The use of ICT to enhance the abilities (physical and mental) of humans, animals, and plants. Emphasis is given to on- and in-body ICT devices; prostheses (physical and neural, with both silicon and photonic interfaces); and sensory enhancement (visual, audio, tactile, taste and smell, and including extra-sensory ranges).

Smart Materials, Appliances and Environments

Materials able to respond to their environment, usually combined with intelligent systems and even Bio-ICT, to create smart appliances and environments. Particularly relevant here are Piezo-Materials, which are useful not only for measuring movement and stress in materials, but also for manipulating the analogue world, thereby creating materials that will actively sense and respond to a range of stimuli.

Knowledge Management

This has to do with the capturing, classification and dissemination of knowledge, whether it is explicit data or so-called tacit knowledge in the minds of people. The advance in emphasis compared with similar concepts such as Management Information Systems and Decision Support Systems is a focus on the specific capture of information and insights from people, and especially groups of people, enabling us to recognise patterns in information and make decisions. Emphasis is on the ICT-based facilitation of in-situ knowledge production and decision making by groups (real and virtual).

ICT-Supported New Learning Methods (focus on the individual)

These refer to the use of ICT to enhance and implement new learning methods and environments fed by the accelerating growth in understanding of the workings of the human brain and intellect. There is particular emphasis on appropriate interactive multimedia and virtual learning environments.

Content Development (includes 'unstructured data' issues)

The impact of ICT in South Africa will depend on the extent to which appropriate local content is developed to handle the complex, dynamic and interactive systems which are used in the real world. Such local content includes niche requirements in local culture, education and human resource development, as well as natural resource exploitation, commerce and industry. It is vitally important that local content development be protected through the appropriate use of intellectual property rights (IPR). Emphasis is on advances in pattern recognition, diagnostics, automatic indexing, modelling and simulation.

Advanced Software Development Platforms

These are tools and methods building on the latest developments in software science and technology to create ever more advanced, efficient and effective software development environments and include users with a broader range of sophistication. Simple visual and declarative programming systems are needed for non-programmers, where users say 'what' has to be done but not 'how'. Professional programmers

require advanced software engineering tools. Support is particularly needed to help with the coding of 'million-line' programs by geographically spread-out cooperative teams.

Table 6.1 contains 'clusters' of technologies and environments situated in the bottom three layers of the full ICT Strategic Technology Map. The lists within the three categories are not intended to be comprehensive for the ICT industry and all its applications. What they reveal is the emphasis provided by the SWG in these ICT research and technology areas.

Table 6.1	The lower three layers of the ICT Strategic Technology Map
Applied Technologies	Future web applications: Development tools (joint applications); authoring tools for web applications (commercial and community); expert navigation systems for Universal access; telephony via IP; info kiosks. Interactive multimedia applications and simulations: Edutainment technologies; e.g. gaming, videostreaming; multimedia enabled devices (desktop; mobile; on/in body); learning and research applications; technology simulation centres; simulation techniques (business, animation); visualisation development environments. Human-computer interfaces: Technologies include voice; visualisation; interactivity, disabled; language and text independent, e.g. pictograms (for financial services); automatic speech translation environments (phones, interfaces). Monitoring (including remote) applications: On/in body applications. Methods and technologies for moderation and facilitation: Technologies to foster community "democracy," indigenous (formal and informal) knowledge systems; methods and technologies to assess "delivery" by governments, IFAs; interactive visualisation (facilitation environments). Knowledge systems: Groupware (collaboration s/w); Integrated Formal Knowledge Systems; methods to capture organisational "history" (storytelling for learning); technologies and protocols which enable/ensure "Quality of Service"; interactive visualisation (facilitation environments).
Base Technologies	Future Chip Technologies: Bio-chips; molecular circuitry; photonic microprocessors; miniaturisation (nanotechnology). Access Technologies: Radio (terrestrial and non-terrestrial); satellite-based technologies; stratospheric communications platforms; mega-bandwidth technologies (e.g. Internet 2); affordable connectivity for ICT-enabled community centres; connectivity via electricity supply infrastructure. Server and Database Technologies: New generation databases; server technology for businesses and ISPs. Distributed, Co-operating Application Platforms: Middleware and APIs; network s/w technology; navigation, search technology; compression protocols and technologies. Digitisation technologies: Imaging technologies. Intelligent Systems (hardware): CAD/CAM techniques; intelligent manufacturing processors; robotics; intelligent transponders; embedded systems. Intelligent Systems (software): Artificial intelligence; data mining; pattern recognition; expert systems; neural networks; diagnostics. Spatial-Numeric Environments: Virtual reality (including distributed); immersion environment technologies; "Future GIS"; modelling; animation/simulation; visualisation tools; holography. Security Technologies: Automated fingerprint identification; remote, automated surveillance and detection capabilities; body recognition (remote); identification and authentication capabilities; certification and verification capabilities; smart cards; encryption. Biometrics: Sensor h/w & s/w (visual, audio, tactile, smell, including enhancement, and extra-sensory ranges); "smart" materials in sensors; portable DNA analysis; intelligent prostheses (physical and neural); organo-silicon and organo-photonic interfaces. Human Language Technologies: Voice recognition; natural language synthesis (audio patterns recognition, phonetics…)
Enabling Environment	Access to existing hardware products ("off the shelf"). Access to existing software packages ("off the shelf"): NB: Includes Freeware and Shareware. Globally Accepted Open Standards and Protocols: Open Source. Flexibly Regulated Local Telecommunications Market. Uniform International Copyright and Patent Legislation. Evolving National, Regional, and Continental Information Society Strategies. Sustainable Economic Models for Future Web. ICT Expertise: Human Capacity and Development Anticipating Substantial Growth. Knowledge Consultancies and Expertise (Cultural Interface, Boundary Spanners).

6.4 Priority Needs from ICT-related Foresight Studies

The most important ICT-related items that the various sector working groups have identified are shown in Table 6.2. Key solutions have been identified by inspection of the 'top twenty' statements in the respective Delphi surveys (see Chapter 5, section 5.3.2). ICT is all-pervasive nowadays and manifests itself in a range of ways in all aspects of economic and social life. It should be noted that only the items that make

explicit, or at least fairly obvious, reference to ICT, and that go beyond simple conventional application of computers, are shown in the table. Then an attempt is made to associate the ICT needs with one or more of the Strategic Technology Nodes (STNs). These are shown with X's in the table. The percentages at the top of Table 6.2 show the frequency of occurrence of the different STNs in the table.

There are many more ICT-related key solutions in statements below the top twenty from the 11 other sector Delphi surveys (see Appendix 1). Although in many cases these items rank quite low in perceived importance, they are nevertheless important to note, particularly where similar ideas appear in more than one sector. For instance, a 'virtual reality' (VR) application may rate relatively low in importance in a particular sector, but if several sectors all identify VR as a promising direction, then that direction merits close attention.

Table 6.2 Priority ICT-related statements across all Foresight sectors
(The numbers prefixed with a # are the priorities calculated by the HSRC. The numbers in parentheses are the statement numbers in the original Delphi survey questionnaires.)

	Future Web	E-tagging	User Interface	Intelligent Sys-tems	Bio-ICT	Smart Environments	Knowledge Management	New Learning	Content Development	Advanced S/w
TOTAL (12 sectors)	**64**	**30**	**24**	**22**	**12**	**5**	**44**	**16**	**20**	**9**
Percentage	**26%**	**12%**	**10%**	**9%**	**5%**	**2%**	**18%**	**6%**	**8%**	**4%**
Agriculture										
# 1 (15) New ways to link researchers, extension officers, farmers	X		X							
# 3 (68) Market Information Systems	X						X		X	
# 16 (23) Drip irrigation and not overhead irrigation (possible high tech micro-irrigation methods)	X			X	X					
Biodiversity										
# 10 (11) Modeling disturbances to ecosystem functions.					X		X		X	
Environment										
# 7 (41) Accurate weather forecasting systems	X			X			X		X	
# 17 (35) decision support tools for sustainable land-use planning							X		X	

	Future Web	E-tagging	User Interface	Intelligent Sys-tems	Bio-ICT	Smart Environments	Knowledge Management	New Learning	Content Development	Advanced S/w
TOTAL (12 sectors)	**64**	**30**	**24**	**22**	**12**	**5**	**44**	**16**	**20**	**9**
Percentage	**26%**	**12%**	**10%**	**9%**	**5%**	**2%**	**18%**	**6%**	**8%**	**4%**
Finance										
# 1 (29) Innovative methods to provide financial services to the unbanked	X	X	X				X		X	
# 8 (35) Electronic business simulation techniques for e-commerce training							X	X	X	
# 9 (3) Information kiosks in PostBanks to inform rural South Africans	X		X							
# 10 (1) Financial services delivery technologies	X	X								
# 11 (13) Technologically sophisticated holistic risk management systems							X		X	X

	Future Web	E-tagging	User Interface	Intelligent Sys-tems	Bio-ICT	Smart Environments	Knowledge Management	New Learning	Content Development	Advanced S/w
TOTAL (12 sectors)	**64**	**30**	**24**	**22**	**12**	**5**	**44**	**16**	**20**	**9**
Percentage	**26%**	**12%**	**10%**	**9%**	**5%**	**2%**	**18%**	**6%**	**8%**	**4%**
Mining										
# 5 (7) Mechanisation, robotics, etc. for productivity, safety and health			X	X		X				
# 7 (2) Distance Learning	X	X	X				X	X		
# 8 (24) Robotics for safe coal mining				X						
# 9 (29) Seismic prediction and hazard assessment				X					X	
# 10 (1) Centralised database of mineral resources & markets	X						X			
# 12 (17) Ore bodies database for small-scale miners	X						X			
# 16 (16) drilling-free 3D exploration technology			X	X					X	
Energy										
# 6 (55) Communications systems reduce the need to travel	X	X	X				X			
# 11 (50) Integration of current knowledge and technology into mainstream building design				X		X	X			
Safety and Security (All the top twenty statements have ICT components.)										
Integrity analysis for identification of corruption		X		X						X

	Future Web	E-tagging	User Interface	Intelligent Sys-tems	Bio-ICT	Smart Environments	Knowledge Management	New Learning	Content Development	Advanced S/w
TOTAL (12 sectors)	**64**	**30**	**24**	**22**	**12**	**5**	**44**	**16**	**20**	**9**
Percentage	**26%**	**12%**	**10%**	**9%**	**5%**	**2%**	**18%**	**6%**	**8%**	**4%**
ICT (By definition all the top twenty are ICT-related)										
# 1 (17) SA's computer literate population grows to 60%								X		
# 2 (46) ICT creates net job gains in economy										
# 3 (22) Innovative ICT for development	X		X				X	X		X
# 4 (26) ICT-enabled world-class learning methods	X		X					X		X
# 5 (27) ICT-based security devices	X	X		X	X					
# 6 (42) Knowledge work > 50% of economic activity	X						X	X		
# 7 (18) > 95% schools use global MM network for learning	X							X		
# 8 (44) Growth of ICT sector reverses skills drain										
# 9 (6) 60% have home access to global infrastructure	X		X							
# 10 (43) Professional ICT community trebles in size										
# 11 (14) 90% 0f SMMEs use global network for > 20% of their transactions	X									
# 12 (31) SA captures 20% of global niche market for s/w production							X			X
# 13 (12) 85% of SA companies make extensive use of broadband communications	X									
# 14 (23) Locally developed HCIs provide easy access for 75% of population	X		X							
# 15 (20) Interactive telelearning widely used	X							X		
# 16 (38) 90% of connectivity is via electricity network						X				

The following sections summarise noteworthy features in the two tables:

Agriculture

Table 6.2 shows three ICT items in the top twenty. The top item highlights the potential value of better linkages between researchers, extension officers and farmers. Communications trends, such as 'Future Web' will clearly be relevant here. The value of accessible market information systems for all agricultural sectors emerges, as does the move to 'drip' as opposed to 'overhead' irrigation. The latter item points to the potential value of remotely controlled 'intelligent' irrigation methods.

Most of the ICT-related agriculture items in the two tables entail information management and computer modelling techniques that are already available in the marketplace. One or two items such as 'intelligent robots for harvesting and sorting' suggest more futuristic opportunities.

Biodiversity

There is only one clearly ICT-related item in this top twenty — 'modelling the effects of disturbances and management practices on ecosystem functions.' Among the balance of statements the biodiversity group identified several other ICT opportunities, including micro-biosensors for research and conservation.

Energy

Two items in the top twenty have clear ICT elements: the use of modern communications technologies to reduce the need to travel (i.e., leading to tele-working models) and integration of current knowledge technology into energy-efficient 'smart buildings.' Among the relatively less important areas were items such as the use of electronic commerce, the creation of nationwide energy information databases, and traffic management systems.

Environment

There are few clearly ICT-related statements from this sector. Two in the top twenty are 'accurate weather forecasting systems' and 'decision support tools for sustainable

land-use planning.' Others include conservation databases and pollution monitoring from space. Again it is noted that the kind of ICT support that emerges is currently available.

Finance

At least twelve of the most important possibilities targeted by the finance working group are strongly dependent on ICT, which is hardly surprising given the degree of penetration in the sector. They range from opportunities to bring financial services to the 'unbanked' through the use of information kiosks to the use of satellites to deliver financial services throughout Africa. The group discusses the replacement of a large proportion of physical cash with electronic cash and the use of 'neural networks' of financial information and knowledge. Overall the finance working group paints a picture of radical change in the conduct of financial services, delivering new services to all and conventional services into all areas of the country. Underpinning this vision is ICT and in particular the 'FutureWeb' Strategic Technology Node.

Health

The only two ICT statements that appear in the top twenty (18th and 20th respectively) are the use of ICT for an SADC-wide disease control and monitoring centre, and a national health management information system. There are, however, several other statements in the health sector survey that point to very sophisticated opportunities for more effective health services. They include telemedicine, bio-micro-imaging, body-sensor technologies and intelligent artificial limbs and prostheses.

ICT

Of course all the Delphi statements in the ICT sector relate closely to the socio-economic role of ICT in the economy. It is significant, however, that the top priority items are in a sense 'outward-looking,' noting the importance of ICT in other sectors of the economy. For instance, several important items stress the value of ICT in learning: growth in computer literacy, world-class learning methods, the use of the global network for learning in schools, etc. Others are directly relevant to the conduct of business in the country: SMME use of the global network, the impact of tele-commuting on the workforce, etc. Still other statements refer to areas such as natural resource management, multi-purpose community centres, safety and security and so on.

Particularly noteworthy are several statements emerging from the ICT sector that relate to ICT and the public sector. The latter was not identified as a sector for special

analysis in the overall Foresight study, but is clearly of great importance to the economy.

Manufacturing

The manufacturing group singled out several trends that demand ICT support: mass customisation of products, the use of flexible teams, communication systems that bring SMMEs together with major industrial partners, and concurrent engineering methods.

Mining

By contrast with manufacturing, the mining group focused on potentially valuable new directions that emphasised productivity, health and safety. In the top twenty these included mechanisation and robotics for mining in difficult and dangerous areas, and seismic prediction and hazard assessment. They also identified the potential for large-scale databases of mineral resources and markets and provision of information to help small-scale miners.

Also mentioned in Appendix 1 are computer modelling applications, multilingual translation services and on-body warning, communication and navigation devices and tagging technologies for precious metals and stones.

Safety and Security

Every item in the 'top twenty' and many others are strongly reliant on information management, systems integration, and high-tech devices to combat crime and increase safety. Top priorities include visual, sound and sensory surveillance, electronic protection of cash in transit, intelligent intruder devices, electronic vehicle identification and firearms containing identification to automatically restrict use to the owner. There are also several examples of national databases and systems to integrate activities throughout the justice chain, advanced fingerprinting systems, and electronic tagging of articles for surveillance.

Tourism

This sector also identifies many areas for rich contributions from ICT. The global nature of tourism is recognised in the top twenty through things such as Future Web, access to international operators and travellers, satellite-based communications, and the use of Geographic Information Systems. According to the rankings, the most potentially beneficial item is the use of large wall-hung HDTV screens for the promotion of tourism.

Youth

This sector produced a plethora of ICT-related statements. Among the top twenty are the use of FutureWeb to sell indigenous products and bring training in conservation to rural communities, free services and data bases to young entrepreneurs, and distance education, multimedia training devices and computer games and simulations for inculcating economic principle.

6.5. Summary

This chapter introduces some order into a complex array of ICT-related phenomena. It presents a so-called 'technology map' that links the user demand for ICT in Focus Areas and Key Solution Areas with a logical hierarchy of technology components. It demonstrates how Base Technologies combine to yield Applied Technologies. Applied and Base Technologies can be used in combination to focus research attention on so-called Strategic Technology Nodes (STNs). Arguably, national and regional research and technology policy should target the development of STNs.

The chapter also brings together the results of the various empirical exercises conducted by the SWG itself and through the Delphi survey to show suggested technology components. To complete the Technology Map, it then presents, in summary, ICT-related results from the other eleven Foresight sectors.

It is noteworthy that in most cases the 11 sector survey respondent groups have placed high importance on what the SWG might regard as 'current' ICT opportunities: databases and knowledge management techniques, games, simulation and modelling, electronic commerce, tele-medicine, tele-learning and tele-commuting. This is not to minimise the relevance of those opportunities. Clearly, none have yet been exploited to the full and it is important to bring them to the attention of the wider public. Equally, as the technologies improve (gigabit bandwidth) and become cheaper (WTO agreements, Moore's Law, etc.) so will pilot projects become mainstream applications.

Generally of less importance in the eyes of the other 11 sector survey respondent groups are the more 'exotic' ICT opportunities mentioned: robot miners, satellite monitoring of habitats, e-tagging of precious stones, multilingual translation machines, bio-sensors, virtual-reality applications and surveillance technologies. It is in these areas that stronger partnerships between ICT research and technology specialists, suppliers of ICT, and users need to be forged to raise the awareness of the user community and allow the researchers and suppliers greater insight into the real opportunities that lie in the future.

Chapter 7:

Conclusions and Recommendations

7.1 Introduction

In the previous chapter, constructing a Strategic Technology Map identified promising directions for ICT research and technology development over the next 20 years. In this final chapter the strategic technology map is used to consider implementation issues, leading to recommendations both at the strategic level (STNs), and at the Base Technology level. First, however, we briefly discuss the Enabling Environment (i.e. the lowest level of the technology map), giving the broader national and global context that inevitably influences technology and research opportunities for ICT.

7.2 The Enabling Environment

As described in the previous chapter, there are several elements in the overall environment that bear directly on ICT opportunities, but in themselves are not necessarily areas for ICT research and technology development. Policy makers, planners, business leaders and researchers need to establish positions on some or all of the following factors to maximise chances of success in new research and technology ventures.

- Access to existing hardware, software and telecommunications products ('off the shelf'): The ongoing availability and non-exclusive costing of world-class products

(including freeware and shareware) to use, adapt or incorporate in the course of new developments.

- Globally accepted open standards and protocols: The pace and extent of evolution towards this preferred future. Includes open-sourcedevelopments, i.e. the extent to which the source code of available software is provided for modification and adaptation (e.g., Linux, Netscape).

- Flexibly regulated local telecommunications market: Of particular relevance to South Africa are how the transition from Telkom's fixed-line monopoly will occur, and what policies are put in place subsequently to manage the converging digital environment.

- Uniform international copyright, patent, and IP legislation: This is an especially active arena, with both developed and developing countries formulating national positions and negotiating formally and informally to further their own national interests. International bodies such as the WIPO (World Intellectual Property Organisation) are actively facilitating a coordinated, united approach. The extent and nature of agreements reached over the next few years will impact fundamentally on the future of research and technology, as well as product development.

- Evolving national, regional, and continental information society strategies: Many countries (including South Africa), some regional groupings (such as SADC) and even continents (e.g. the African Information Society Initiative (AISI)) are developing strategies to best exploit ICT for both economic growth and socio-economic development. Without strategic coordination, facilitated by government but involving all stakeholders, it is likely that the ICT sector will not realise its potential. The present Foresight study, the parallel South African Information Technology Industry Strategy (SAITIS) project, and the Electronic Commerce Green/White Paper process are good examples of organised attempts by South Africa to achieve these ends. The research andtechnology community is clearly influenced by and should itself influence the ongoing development of such strategies.

- Sustainable economic models for FutureWeb: The interrelationships between international telecommunications operators, regulators, national governments, local Internet service providers, the business community (from large multinationals to SMMEs), and underdeveloped communities are extraordinarily complex. Economic models that will shape and ensure the long-term sustainability of this essentially global phenomenon are still evolving and should be used in the further development of research and technology policies and strategies on an ongoing basis.

- ICT expertise: It is common cause that there is a worldwide and growing shortage of skilled ICT professionals. At the same time, the nature of work, desirable skills and job specifications in the sector are changing continuously. Of particular relevance to developing countries is the level of general and computer literacy, measures to ensure the net creation of employment, and the overall upskilling of job content. How, and how successfully, national public and private sectors collaborate to meet these challenges will determine the extent to which ICT will stimulate growth in all sectors of the economy, as well as facilitate socio-economic development.

- Knowledge consultancies and expertise: At the interface between demand for and supply of innovative ICT solutions lie people who understand technological capabilities and the needs of particular societies. These are the people who understand the broader social and economic context of communities and countries and appreciate the cultural interface. They are particularly important to the successful use of ICT in socio-economic development. The availabilityand development of such so-called 'boundary spanners' will directly affect the direction and success of ICT innovations.

In short, it is important for scientists, ICT specialists, and ICT professionals to recognise the potential influence of the enabling environment described above. The positive and negative aspects of the status quo need to be factored into current research and technology initiatives, and the ICT sector should identify and advocate appropriate changes in many areas to maximise the future benefits of the sector. The cross-cutting nature of the ICT sector demands much greater emphasis on interdisciplinary research and development work, bringing the ICT specialists together with technologists, politicians, lawyers, educationists, sociologists, civil servants, business people, workers, farmers, and citizens. In addition, it is essential to bear in mind the need for an Equitable Information Society, relevant to the lives of ordinary people in the townships and rural villages. Readers are encouraged to keep these issues in mind as they evaluate the recommendations in the following section.

7.3 Recommendations resulting from the Strategic Technology Nodes (STNs)

As described in Chapter 6, STNs make ideal platforms to focus strategic processes, in this case at the national level. The SWG has identified all ten STNs as platforms representing major opportunities that merit significant further investigation in their own right, even though several were not prominent in the combined survey results of the 12 Foresight sectors.

STNs can, and often do, depend on each other to varying degrees related to the particular key solutions in question. From this viewpoint the following four 'super clusters' of STNs emerge:

7.3.1 Solutions that are significantly related to near-term developments of 'FutureWeb'

- 'FutureWeb',
- E-tagging (humans, animals, plants, things), and
- Advanced user interface platforms (human and animal).

As the responses to all 12 sector surveys suggest, this super cluster is likely to dominate the near-term research and technology strategies of any national ICT industry, whether in the developed or the developing world. In South Africa, although the growth rate of Internet hosts has levelled off in the past two years, there has been substantial growth in both private and public sector interest in this area, which should be encouraged. Initiatives to coordinate this activity in the national interest are already under way (e.g. the E-commerce green/white paper process, the SAITIS project). The danger is that, given the rapid rate of developments in this area, driven particularly by the USA, South Africa's scarce resources will be primarily invested in short-term 'catch up' strategies. Instead, it is recommended that significant investments should begin now to establish capabilities in the medium term that would position South Africa's ICT industry as a global player in 'Future Web'. This includes significant opportunities with regard to the needs and environment of developing communities both locally and globally. Such opportunities are most obvious in the E-tagging and Advanced User Interface Platforms STNs.

Recommendation: *Significant investment should be made immediately to coordinate existing and establish new capabilities in the short to medium term that would position South Africa's ICT industry as a global player in 'Future Web,' particularly in relation to the developing world's needs.*

7.3.2 Intelligent solutions that replace people, enhance people, or enhance their environments

- Intelligent Systems,
- Bio-ICT (humans, animals, plants), and
- Smart materials, appliances and environments.

Although aspects of this super cluster are of immediate importance, particularly to the manufacturing sector, the benefits of investment are likely to be reaped in the medium and longer terms. This probably explains the low priority given to this area by the respondents to the 12 sector surveys. The negative impacts of ICT-enabled automation (people replacement) upon an economy already faced with high levels of structural unemployment should not be underestimated, and strategies that encourage the net creation of ICT-enabled quality jobs merit the immediate attention of both the public and the private sectors. At this stage, it is difficult to estimate the levels and/or

timing of growth of this cluster, but this uncertainty should not be used as an excuse to ignore its mainly longer-term potential. South Africa should use the time available to establish adequate and coordinated research and technology capabilities both to monitor and understand developments, as well as to grow private sector capacity quickly as and when required.

Recommendation: *South Africa should, in the short term, establish adequate and coordinated research and technology capabilities both to monitor and to understand developments in the Intelligent Solutions super cluster, with a view to identifying likely longer-term market opportunities.*

7.3.3 Knowledge and learning-intensive solutions

- Knowledge Management, and
- ICT Supported New Learning Methods (focus on the individual).

This super cluster featured fairly often in the 12 sector surveys, but it is likely that respondents see only the tip of the iceberg. Throughout the Foresight process, the SWG has repeatedly identified the primary importance of various aspects of this cluster that relate closely to the emerging knowledge economy. Market forces are already driving significant private sector investment in short-term aspects of knowledge management. The danger is that this will be seen to be adequate, and that it will mask the need for much more substantial, coordinated, long-term investment from both the public and the private sector in order to take advantage of possibly the greatest opportunity for South Africa's ICT industry.

Recommendation: *To take full advantage of potentially the greatest opportunity (locally and globally) for South Africa's ICT industry, it is recommended that the highest priority be given to substantial, coordinated, long-term investment from both the public and the private sector in the broader aspects of this super cluster.*

7.3.4 Solutions essential for the sustained competitiveness of South Africa's ICT industry

- Content Development (includes 'unstructured data' issues), and
- Advanced Software Development Platforms.

Most of the solutions provided by this super cluster satisfy needs from within the ICT industry itself, and hence are hidden from most stakeholders. This may well explain the comparatively low presence of thisarea in the 12 sector surveys. Nevertheless, it should be recognised by both the public and the private sector that these capabilities are fundamental for a healthy ICT industry, and, therefore, that adequate investment must be sustained throughout the 20-year period and beyond.

Recommendation: *Adequate investment in these capabilities, which are essential for a healthy ICT industry, must be sustained throughout the 20-year period through public/private sector collaboration.*

7.4 Recommendations related to the Base Technologies

The four super clusters described above have provided a convenient structure for formulating the highest level recommendations stemming from the work of the SWG. However, more detailed recommendations can be identified by examining the layers of the technology map below the STNs (see Table 6.1). It is clear that the applied technologies match the STNs too closely to warrant separate attention. However, an analysis of the base technologies appears to add significant value.

7.4.1 Future Chip Technologies:

This cluster includes all developments in silicon, photonic, bio- and molecular micro-circuitry, and is strongly related to developments in miniaturisation and nano-technology.

These are fundamental technologies, and therefore impact on all the ICT STNs. However, they have the greatest impact on the following STNs:

Advanced User Interface Platforms,
Intelligent Systems,
Bio-ICT,
E-tagging, and
Smart Environments.

Since mature photonic, bio- and molecular micro-circuitry components are several years away, developments depending on these (particularly in Bio-ICT and Smart Environments) are likely to be in the longer term.

There is little point in South African organisations attempting to break into the silicon chip market at this late stage. However, there is time for capability and capacity to be established in photonic, bio- and molecular micro-circuitry. Appropriate feasibility studies should be carried out in the near future, particularly if the Bio-ICT and/or the Smart Environments STNs are seen to be attractive.

Recommendation: *Feasibility studies should be carried out in the short term into the establishment of capability and capacity in photonic, bio- and molecular micro-circuitry, particularly in relation to the attractiveness of the Bio-ICT and/or the Smart Environments STNs.*

7.4.2 Access Technologies:

This cluster includes all aspects of broad bandwidth connectivity, but with emphasis on affordable connectivity, particularly for ICT-enabled community centres, via radio (both terrestrial and non-terrestrial), low-cost satellites, and stratospheric communications platforms.

These technologies impact most on the following STNs:

Future Web,
E-tagging,
Advanced User Interface Platform,
Knowledge Management, and
ICT-supported New Learning Methods.

All technologies are relatively mature, so developments can be rapid.

Since these five STNs are given high priority, this suggests that South Africa should, in the short term, focus on developing significant, coordinated capability and capacity in one or more of the three connectivity areas (radio, low-cost satellite, stratospheric platforms). Since South Africa's needs in this area are mirrored throughout Africa and much of the rest of the developing world, it is likely that by developing this capability in the short term, South Africa could establish itself in an important and expanding global market over the next few years.

Recommendation: *South Africa should give high priority immediately to the development of significant, coordinated capability and capacity in one or more of the three connectivity technologies (radio, low-cost satellite and stratospheric platforms).*

7.4.3 Server and Database Technologies:

The emphasis in this cluster is on new generation databases and server technology for businesses. It involves high-speed storage and access; high speed distributed database architectures; and high-speed application in concentrated network nodes. These technologies impact immediately and directly on the Knowledge Management STN, and in the medium term on the Future Web and ICT Supported New Learning Methods STNs.

These technologies are mature, and South Africa is unlikely to be successful in attempting to establish significant shares of their current global markets. However, the above three STNs are important and likely to increase in importance in the longer

term. Hence it may be wise, at least in the medium term, to establish a sufficient cadre of world-class capability and expertise in these areas to facilitate technology transfer, customisation, and the identification and establishment of appropriate joint ventures.

Recommendation: *South Africa should establish, at least in the medium term, world-class expertise in database and server technologies to facilitate technology transfer, customisation, and the identification and establishment of appropriate joint ventures.*

7.4.4 Distributed, Cooperating Application Platforms:

This cluster supports the development of ever more sophisticated services on top of the existing layers of telecommunications services. The emphasis is on Middleware and APIs (i.e. open-platform technologies allowing flexible creation of services independent of the underlying network infrastructure), network software technology, navigation and search technologies and compression protocols and technologies.

These technologies impact most on the following STNs:

Future Web,
E-tagging,
Advanced User Interface Platforms,
Knowledge Management, and
ICT-supported New Learning Methods.

All the base technologies involved are developing rapidly, and they are likely to remain essential, at least in the medium term, for the ongoing healthy growth of a national ICT industry. There is anecdotal evidence of individuals and groups in South Africa (in the academic, defence and private sectors) with high levels of expertise in several of these technologies. But in general, these capabilities appear to be addressing short- to medium-term organisational rather than national needs. It is suggested, therefore, that the market-driven processes should be supplemented bya national strategy to encourage collaboration, coordination and the enhancement of research and technology capabilities in these areas.

Recommendation: *In the short term, a national strategy should be developed to encourage collaboration, coordination and the enhancement of research and technology capabilities in distributed, cooperating application platforms.*

7.4.5 Digitisation Technologies:

This cluster underpins the convergence of ICTs and their related markets, and is instrumental to the dynamic growth of the global information economy. In this sense,

it impacts on all the STNs. However, the emphasis here is the extent to which appropriate local content can be digitised to handle the complex, dynamic and interactive systems which are used in the real world. In particular, niche requirements in local culture, education and human resource development are highlighted.

The STNs most impacted, therefore, are:

FutureWeb (developing individuals and communities),
Advanced User Interface Platform,
Bio-ICT,
Knowledge Management,
ICT-supported New Learning Methods, and
Content Development.

Although most technologies in this cluster are mature, barriers to entry in emerging areas (e.g. local culture content, education, etc.) are likely to be comparatively low. This suggests that, in the short term, South Africa should coordinate existing and develop new local capabilities and expertise in these areas, not only to facilitate technology transfer and customisation, but also to address unsatisfied needs that are likely to emerge in Southern Africa and/or the rest of the developing world.

Recommendation: *South Africa should immediately coordinate existing capabilities and develop new local expertise in digitisation technologies, particularly to address unsatisfied needs that are likely to emerge in Southern Africa and the rest of the developing world.*

7.4.6 Intelligent Systems (both hardware and software):

In the hardware aspects of this cluster the emphasis is on CAD/CAM techniques, intelligent manufacturing processors, robotics, intelligent transponders, and embedded systems. The software components that the SWG highlighted include artificial intelligence, data mining, pattern recognition, expert systems, neural networks, and diagnostics.

These technologies impact most on the following STNs:

Intelligent Systems,
Bio-ICT,
Smart Materials, Appliances and Environments, and
Knowledge Management.

Given their primary role in improving industrial processes, these technologies are dominated by the developed world and the NICs. South Africa has some pockets of

excellence, but is unlikely to be successful in attempting to establish significant growth in mature global markets. However, three of these STNs (Bio-ICT, Smart Materials and Knowledge Management) are anticipated to grow in importance to South Africa in the longer term. This suggests that, for the short term, the existing capabilities and expertise should be coordinated to facilitate technology transfer, customisation and the identification and establishment of appropriate joint ventures to strengthen both the national ICT and manufacturing industries. To satisfy potential longer-term growth in the Bio-ICT and/or the Smart Environments STNs, studies should becarried out in the near future to identify which aspects of these technologies may warrant further local development.

Recommendations: *a. In the short term, existing capabilities and expertise should be coordinated to strengthen both the ICT and manufacturing industries.*
b. For the long term, studies should be carried out in the near future to identify which aspects of these technologies may warrant further local development, particularly in relation to the attractiveness of the Bio-ICT and/or the Smart Environments STNs.

7.4.7 Spatial Numeric Environments:

This cluster of technologies combines interactive visualisation techniques with sophisticated mathematical tools, emphasising virtual reality (including distributed environments), immersion technologies, modelling, animation/simulation, holography and 'Future GIS.'

The STNs most directly impacted are:
Future Web,
Advanced User Interface Platforms,
Knowledge Management,
ICT-supported New Learning Methods, and
Content Development.

Although the developed world is driving dramatic developments in all these technologies, South Africa has established pockets of world-class capabilities in many of them. However, these appear to be uncoordinated and located primarily in academic, defence and parastatal research and development environments. Given the high importance of the five STNs in the short, medium and long terms, this cluster merits significant, coordinated public/private sector investment. In the short term, the existing pockets of excellence could be coordinated and encouraged tocollaborate with the private sector in strengthening and broadening these competencies, thereby enabling the national ICT industry to address a wider range of local and global market needs.

In the longer term, South Africa could build on its advantages in these capabilities compared with the rest of Africa and much of the developing world. South Africa shares most of the development needs that could be addressed by this cluster (see Chapter 6) but that are unlikely to be targeted by developed-world market forces. By addressing these unsatisfied needs, South Africa could establish itself as a major player in an emerging, but potentially very large global market.

Recommendation: *These technologies merit significant investment:*
a. In the short term, existing pockets of excellence should be coordinated to address a wider range of local and global markets in collaboration with the private sector.
b. In the longer term, South Africa should build on its advantages in these capabilities to focus on the potentially very large developing world market.

7.4.8 Security Technologies:

The emphasis in this cluster is on remote, automated surveillance and detection capabilities (including body recognition), identification and authentication capabilities (including automated fingerprint identification), certification and verification capabilities, smart cards and encryption.

The STNs impacted are:

Future Web,
E-tagging,
Intelligent Systems, and
Knowledge Management.

It is generally recognised that South Africa's heavy investment in defence-related research and technology development during the apartheid years has resulted in several world-class capabilities within this cluster. Again, the established capabilities have yet to be coordinated, particularly for the benefit of a national ICT industry, and it is possible that there are further capabilities of significant potential that have yet to be identified. The fact that all of the top 20 survey statements produced by the Safety and Security Foresight SWG involve ICT (see Chapter 6) confirms ICT's primary importance in the eyes of their broad group of expert stakeholders. Given the urgent need for innovative solutions to South Africa's many crime-related problems, it makes sense that experts from the Safety and Security and the ICT sectors should collaborate on these issues in the immediate future, perhaps using the two sector foresight reports as a starting point. In addition to the national imperative, it is likely that many of the resulting innovative solutions might find significant global markets, and lead to the establishment of a vibrant local industry.

Recommendation: *Given the urgent need for innovative solutions to South Africa's many crime-related problems, a high priority should be given to the collaboration of experts from the Safety and Security and the ICT sectors on addressing these issues in the immediate future.*

7.4.9 Biometrics:

The technologies emphasised in this broad-ranging cluster are intelligent prostheses (physical and neural); organo-silicon and organo-photonic interfaces; sensor hardware and software (visual, audio, tactile, smell, plus enhancement, extra-sensory ranges, and 'smart' materials); and portable DNA analysis.

The STNs most impacted by the cluster are:

E-tagging,
Advanced User Interface Platforms,
Bio-ICT,
Smart Materials, Appliances and Environments, and
ICT-supported New Learning Methods.

Most of the technologies in this cluster are only likely to mature in the medium to longer term, with the developed world driving most developments. However, South Africa has the established research and technology infrastructure, located primarily in academic, defence and parastatal organisations, to develop sufficient expertise for technology transfer and customisation. The country also has world-class research and technology capabilities in certain focused areas within this cluster. There is also time to establish such capabilities, and the related capacity in the private sector. Therefore, in order to identify which focus areas may warrant a local research and technology development capability, studies should be carried out in the near future, particularly to satisfy potential longer-term growth in the Bio-ICT and/or the Smart Environments STNs.

Recommendation: *To identify which focus areas may warrant a South African research and technology development capability, studies should be carried out in the near future, particularly to help assess the longer-term attractiveness of the Bio-ICT and/or the Smart Environments STNs.*

7.4.10 Human Language Technologies:

This cluster emphasises developments in voice recognition, translation, natural language synthesis (including audio patterns recognition and phonetics), and voice-based user interfaces (initially 'command and control').

The cluster impacts on the following STNs:

FutureWeb,
Advanced User Interface Platforms,
Bio-ICT,
Knowledge Management, and
ICT-supported New Learning Methods.

These five STNs combine to give high priority to this cluster over the short, medium and long terms, justifying a significant level of research and technology investment. Furthermore, South Africa's levels of illiteracy and its multiplicity of languages necessitate immediate attention to this area if our information society is to be genuinely equitable. Although small pockets of academic expertise in this cluster exist locally, they cannot begin to address the needs represented by the STNs. In the short term, existing expertise should be identified, coordinated, strengthened and encouraged through a national strategy, to collaborate with the private sector in addressing the immediate needs (e.g. voice-based user interfaces). In the longer term, as the technology cluster matures, it is unlikely that the developed world will address ongoing African language needs. By developing this capacity now, therefore, South Africa could establish leadership in a long-term African market that may extend further into the developing world.

Recommendation: *High priority should be given to a significant level of research and technology investment in these technologies in the context of a national strategy to coordinate and strengthen existing public and private sector expertise, targeting not only the urgent local development needs, but also a potentially significant global market.*

7.5 Summary

Since this chapter is itself a summary of the findings of the significant body of work developed throughout the ICT Sector Foresight process, to summarise it further must inevitably result in many important issues falling by the wayside. The intention is to give a high-level idea of the range of interventions that are recommended, over what time frame, and with what degree of research and technology investment. The reader is reminded that all STNs and base technologies identified in Chapter 6 are deemed important enough by the SWG for further actions, and that reading this summary (and even this chapter) in isolation is likely to lead to serious misinterpretations of the SWG's intentions. Finally, none of these recommendations is 'cast in concrete'. Instead, they should be seen as a launch pad for more detailed discussions/investigations within the context of each reader's interests.

7.5.1 STN 'Super Clusters' Recommendations:

Two super clusters are given the highest priority. Not surprisingly, major short-term national investment in 'FutureWeb' Solutions is expected to produce early significant returns, whereas knowledge and learning-intensive solutions may well be an even greater opportunity, but over a longer time period. Solutions essential for the sustained competitiveness of South Africa's ICT industry need care — adequate investment may not always be forthcoming since the benefits are often not immediately obvious. In the short term, investment to establish adequate research and technology capabilities in intelligent solutions is likely to be the lowest of the four, but the potential for significant longer-term growth should not be underestimated.

7.5.2 Base Technologies Recommendations:

The base technologies recommendations can be summarised in four groups.

High Priority, High Investment:

Three base technologies:
Access Technologies (radio, low-cost satellite, stratospheric platforms),
Spatial Numeric Environments, and
Human Language Technologies,
are thought to merit significant investment over the next 20 years to supplement existing and establish new research and technology capabilities. Not only do they satisfy crucial, immediate national needs, but they also have significant potential for satisfying global markets, particularly, but not exclusively, in the developing world.

A fourth base technology:
Security Technologies,
merits significant and immediate investment for similar reasons. However, it should be treated differently, i.e. by collaboration of experts from the Safety and Security and the ICT sectors.

High Priority, Medium Investment:

A further high priority base technology is:
Digitisation Technologies,
but less investment is likely to be required to coordinate existing capabilities and develop new local expertise. The need may also wane in the medium term.

Medium Priority, Medium Investment (short term):

Three important base technologies:
Future Chip Technologies,
Intelligent Systems (both hardware and software), and
Biometrics,

do not require such urgent action, but they are thought to have significant longer-term potential for the South African ICT industry. It is recommended that studies be carried out in the near future to identify which focus areas may warrant a national research and technology development capability. It should be recognised that all three appear to impact upon the longer-term attractiveness of the Bio-ICT and/or the Smart Environments STNs.

Medium Priority, Low Investment:

Two base technologies fall into this group:

Server and Database Technologies, and

Distributed, Cooperating Application Platforms.

Again, although they are important, the need is not immediate. Investment in both cases is expected to be comparatively low, since significant capability and some capacity appear already to exist. The recommendations centre on national strategies to coordinate and enhance these capabilities, bringing general benefit to the ICT industry.

References:

1. Foresight in Science and Technology; Ben Martin, Technology Analysis and Strategic Management, Vol. 7, No. 2, 1995.
2. The Place of Foresight Studies in Dutch Science and Technology Policy, Pim den Hertog and Ruud Smits, TNO Centre for Technology and Policy Studies (STB-TNO), Apeldoorn, the Netherlands, 1993.
3. Technology at the beginning of the 21st century, Hariolf Grupp, Technology Analysis and Strategic Management, Vol. 6, No. 4, 1994.
4. Developing long-term strategies for science and technology in Australia. Findings of the study: matching science and technology to future needs 2010, ASTEC (Australian Science Technology and Engineering Council), 1996.
5. Innovation in Korea, Park et al., Science and Public Policy, Vol. 23, No. 2, 1996.
6. Science shaping the future? - Technology Foresight and its Impacts; Parliamentary Office of Science and Technology; London, UK; 1997.
7. Technology development and transfer: experiences from Malaysia, Jegathesan et al., Int. J. Technology Management, Vol. 13, No. 2, 196-214, 1997.
8. White Paper on Science & Technology: Preparing for the 21st Century; Department of Arts, Culture, Science and Technology; Government Printers; Pretoria, SA; 1996.
9. Co-nomination in foresight; Luke Georghiou, Denis Loveridge & Maria Nedeva, Report by PREST/SQW to the Office of Science & Technology; Manchester, UK; 1994
10. Expertise and Networks in Knowledge Production and Utilisation - a report on the findings of the SA NRTF Exercise. Maria Nedeva, PREST, Victoria University of Manchester, UK, May 1999.
11. Scenario Thinking Readings; Centre for Innovative Leadership (CIL); CIL; Rivonia, Johannesburg; 1995.
12. Scenarios for energy: sustainable world vs. global mercantilism, Adam Kahane, Long Range Planning, Vol. 25, No. 4, 38-46, 1992.
13. The National Research and Technology Foresight Project 2020 Macroscenarios; Department of Arts, Culture, Science and Technology; Pretoria, SA; 1998.
14. Group Techniques for Program Planning: Guide to Nominal Group and Delphi Process; Delbecq, A.L., Van de Ven, A.H. and Gustafson, D.H.; Scott, Forestman, Glennville, Illinois; 1975.
15. The UK Delphi Survey, Loveridge, Georghiou and Nedeva, Chapters 1,2 and 3; 1995
16. The product family and the dynamics of core capability. Meyer, M.H. and Utterback, J.M.; Sloan Management Review; Spring, 1993.
17. Assessing the utilisation and the effectiveness of investments in science and technology using a thrust portfolio approach. Paterson A.W. and Kfir, R.; Proceedings of the 7th International Forum on Technology Management; Kyoto, Japan, November 1997.