

Information and Communication Technology

Research & Development and Innovation

Strategy

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EXECUTIVE SUMMARY

The purpose of the Information and Communication Technology (ICT) Research and Development (R&D) and Innovation Strategy for South Africa is to create an enabling framework for the advancement of ICT R&D and innovation, in a systematic fashion, within the context of the National R&D Strategy. It sets the agenda and framework for maximising the contribution of R&D and innovation in science and technology in South Africa; it provides a coherent, systematic approach to R&D that will contribute to improved quality of life and enhanced economic competitiveness; and it identifies a number of technology and innovation domains as critical for South Africa, each of which has unique characteristics that require specific strategies. The ICT R&D and Innovation Strategy is specifically for the ICT domain. Its vision for ICT in 2015 follows:

South Africa is an inclusive information society where ICT-based innovation flourishes. Entrepreneurs from historically disadvantaged population groups, rural communities and the knowledge-intensive industry benefit and contribute to the well-being and quality of life of our citizens. South Africa has a strong national ICT brand that captures the vibrancy of an industry and research community striving for excellence, characterised by innovative approaches to local and global challenges, and recognised for its contribution to the economic growth and well-being of our people and the region.

In line with this vision, the following outcomes are intended:

- Achieving **global leadership** in identified key scientific and technological domains
- Developing multi-disciplinary technologies, skills and methodologies to address areas of market neglect, especially to **eradicate the digital divide**
- An **indigenous ICT sector** that is developed, growing, innovative and competitive
- The smart **proliferation of ICT** within other sectors of the economy.

To implement the vision, the ICT R&D and Innovation Strategy builds on existing strengths and opportunities and addresses current weaknesses in the system in order to improve significantly the quality of life as well as creating wealth for the people of South Africa, especially the historically disadvantaged. The strategy was developed and will be implemented in the context of the new governance framework for R&D. It will support early-stage R&D in generic technologies with application across a broad range of sectors (Type 1 R&D) and more mature technology with a strong sectoral focus (Type 2 R&D).

The strategy will be implemented through a coherent, integrated and well-administered system of partnerships, financing, processes, policies and infrastructure. Underpinning the strategy are three **strategic objectives** and four **supporting objectives**:

STRATEGIC OBJECTIVES

1. **Focused world-class research** - focus and strengthen research activities at higher education institutions (HEIs) and R&D institutions to create recognised world-class research competencies in the country.
2. **Strong and robust innovation chain** which results in increased ICT patenting, improvements in digital divide indicators and a vibrant hi-tech ICT Small Medium and Micro Enterprise (SMME) industry.
3. **Advanced human resource capacity** - achieve a marked increase in the advanced ICT skills base to improve the absorptive capacity in ICT and thereby enable focused research and innovation.

SUPPORTING OBJECTIVES

1. **Effective research infrastructure** – establish powerful research infrastructure supporting focused research and local and international collaboration.
2. **Vibrant international cooperation** – create strong R&D links with countries which are the leading players in world ICT R&D to accelerate the achievement of objectives 1 to 3.
3. **ICT policy, institutional and other support** – implement effective policy and other support structures at the DST, its agencies and HEIs in support of the strategy.
4. **Resourcing the ICT R&D and innovation system** through funding that places South Africa on a trajectory where ICT GDP Expenditure on R&D (GERD) will start approaching OECD levels (0.4% of GDP) by 2015. As at 2004/2005, South Africa's Gross ICT expenditure on R&D (GERD) was 0.11% of GDP.

Achieving these objectives will support the creation of a strong South African ICT brand that reflects key focal points of the strategy: the generation of knowledge and the needs of the developing world as differentiators for South Africa. The strategy will be implemented through a number of interventions listed below, and progress will be monitored based on a number of key performance indicators (KPIs):

INTERVENTIONS

1. **Advanced human capital development programme** - dramatically improve the post-graduate enrolment and completion rate in ICT by supporting young researchers as students in employment.
2. **Critical mass research programme** - support focus and critical mass R&D in identified technology and application domains through an array of instruments that link established researchers and draw in new researchers. These include postdoctoral researchers and international experts available in the National System of Innovation (NSI). Support would go towards core grant proposals, funding, research chairs, networks and centres of excellence.
3. **International ICT R&D collaboration programme** that supports the objectives of the strategy through collaborative R&D projects, researcher mobility and science and technology networking.
4. **Large innovation initiatives and grand challenges** – address the innovation chasm by stimulating broad collaboration across disciplines and among players in various stages of the innovation pipeline through appropriate alignment with and leveraging of the Innovation Fund and other instruments.

5. **ICT R&D in industry programme** – Address current low levels of investment in ICT R&D and the low uptake by industry and other sectors of society of research results from academic and other research institutions. This will be done through awareness raising and advocacy, incentives, industry research collaboration support, for example, in the Technology and Human Resources for Industry Programme (THRIP), and people mobility. Efforts will go towards building on the ICT R&D roadmap programme and increasing collaboration at the intergovernmental and parastatal levels.
6. **ICT R&D and society programme** – contribute to the realisation of the benefits of ICT R&D for improved quality of life and in support of an inclusive information society through a multidisciplinary information society research programme, market neglect innovation and a young scientist and engineer programme.
7. **R&D infrastructure programme** - enabling simulation, experimentation, collaboration and other research processes, implemented through a number of specific infrastructures, by supporting research groups through equipment grants as required.
8. **Futures research, future technologies and strategy implementation and renewal support** - support renewal of ICT R&D and enable effective planning of ICT aspects of the NSI through ICT futures research and research in future and emerging technologies, and by providing effective support for implementation of the strategy.
9. **Funding the ICT R&D and Innovation Strategy** – support implementation of the ICT R&D strategy through increased funding levels to facilitate investment levels in line with national R&D strategy goals (R&D of 1% of GDP by 2008 and 1.5% by 2012).

The KPIs for the strategy provide a basis for measuring key aspects of the strategy implementation:

- **Human Resource Development Indicators** – will ultimately be measured through PhD graduation rate and ICT Full-Time Equivalent (FTE) researchers with PhDs. Due to the lag that can be expected in these indicators, these measures will be supplemented by short-term indicators such as the enrolment at Bachelor, Honours, Masters and PhD levels as early indications of the effects of the ICT R&D and Innovation Strategy.
- **Research Performance Indicators** – will be measured by the country's share in global ICT publications and the Relative Citation Index for ICT publications attributable to South Africa.
- **Innovation performance** – will be measured through US/EU/SA ICT patent share and business expenditure on ICT R&D and Innovation (ICT BERD).

The strategy will be implemented by existing players including universities, the Meraka Institute, science councils, business incubators, science/technology parks, industry and government. Together, these entities will work towards the objectives of the strategy. The strategy will be executed in the context of new and existing initiatives that complement the ICT R&D and Innovation Strategy such as initiatives of the Department of Communications to harness implementation of the ICT BEE Charter, various initiatives and instruments of the Department of Trade and Industry, JIPSA and planned interventions addressing mid-level skills supporting the industrialisation of the R&D and innovation outputs resulting from

the implementation of the strategy. The Department of Science and Technology (DST) is responsible for oversight and coordination of the implementation of the strategy. The DST will establish a monitoring framework, key performance indicators, measures, benchmarks, controls and models. It will also support and engage with provinces and assist them with their initiatives in line with the national plan. The DST is also in the process of establishing formal mechanisms of cooperation with key departments and agencies that will ensure coordinated implementation of the strategy.

The timeline for implementation of the strategy is illustrated in Figure 1.

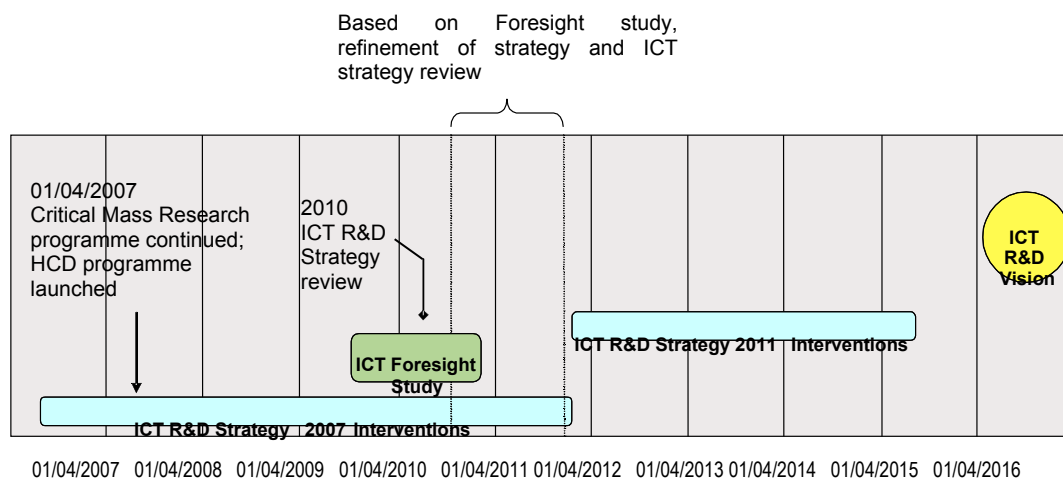


Figure 1: ICT R&D and Innovation Strategy Timeline

The strategy and the implementation thereof will be reviewed after three or four years by a panel that includes international experts. The results of this input, together with the results of the ICT foresight study, will feed into a revision of the strategy which could include new interventions or changes to the interventions initiated in the first five years. This process will be repeated after another five years. Technology and application domains that will be supported by the strategy include mobile, wireless and satellite technologies; computational science and high-performance computing; geomatics and spatial technologies; human language technology; open-source software; software engineering and software architecture; information security; human-computer interaction; ICT in education and health; ICT for disability; e-government; and ICT in manufacturing.

Implementation of the strategy is expected to yield a number of socio-economic benefits including:

- Improved quality of life for all South Africans, an inclusive democracy, good governance and social stability through the application of ICT to address basic needs. This in turn will contribute to poverty eradication and the achievement of social development goals.
- A highly competitive economy based on the comprehensive integration of ICT into all aspects of society and the economy, including smart infrastructure and effective service delivery as envisaged in the Advanced Manufacturing Technology Strategy.
- An exponential improvement in the knowledge and skills levels of South Africans brought about by effective utilisation of the benefits of ICT and the information society at all levels, from basic literacy to advanced technical qualifications.
- A vibrant, sustainable and innovative indigenous ICT industry with a strong export focus, contributing significantly to reducing the ICT balance of payment which:
 - Addresses a significant portion of South Africa's ICT needs through an indigenous component of the ICT industry;
 - Includes a thriving technology-based SMME sector;
 - Supports the emergence of South African ICT multinational corporations; and
 - Attracts investments by overseas-based multinational corporations in R&D, innovation and manufacturing facilities and resources in South Africa.

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GLOSSARY

Applied Research	Original investigation undertaken in order to acquire knowledge directed primarily towards a specific practical aim or objective (FRASCATI).
ARN	Applied Research Network
BERD	Business Expenditure on Research and Development
Basic Research	Experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation phenomena and observable facts, without any particular application or use in view (FRASCATI).
CAGR	Compounded Annual Growth Rate
CHPC	Centre for High Performance Computing
CITI	Cape Town IT Initiative
CSIR	Council for Scientific and Industrial Research
DoC	Department of Communications
DoE	Department of Education
DST	Department of Science and Technology
the dti	Department of Trade and Industry
Experimental Development	Systematic work drawing on existing knowledge gained from research and/or practical experience, which is directed at producing new materials, products or devices, at installing new processes, systems and services, or at improving substantially those already produced or installed (FRASCATI).
FTE	Full-Time Equivalent
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Expenditure on R&D
HCI	Human Computer Interface
HEI	Higher Education Institution
HERD	Higher Education Expenditure on Research and Development
HLT	Human Language Technology
HR	Human Resource
HRD	Human Resource Development
HSRC	Human Sciences Research Council
IICT	Information and Communications Technology – covers any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital or analogue form e.g. personal computers, radio, digital television and e-mail. ¹
ICT-related R&D	R&D undertaken by the “ICT-producing” sector and other sectors in ICT (FRASCATI)
ISSA	Institute for Satellite and Software Applications
KPIs	Key Performance Indicators
NACI	National Advisory Council on Innovation
NGO	Non-Governmental Organisation

¹ Tutor2u – For teachers: Online resource for business, economics, politics and related subjects. see http://www.tutor2u.net/business/ict/intro_what_is_ict.htm

NRF	National Research Foundation
NSI	National System of Innovation
Research and Experimental Development R&D)	Creative work undertaken on a systematic basis in order to increase the stock of knowledge including knowledge of man, culture and society, and the use of this stock of knowledge to develop new applications (FRASCATI).
RFID	Radio Frequency Identification (RFID)
SAITIS	South African Information Technology Industry Strategy
SMME	Small Medium and Micro Enterprise
SANReN	South African National Research Network
SNO	Second Network Operator
SPII	Support Programme for Industrial Innovation
SWOT	Strengths, Weaknesses, Opportunities, Threats
Technological Innovation	All the scientific, technological, organisational, financial and commercial steps, including investments in new knowledge, intended to or which actually lead to the implementation of technologically new or improved products and processes (FRASCATI).
THRIP	Technology for Human Resources in Industry Programme
USAL	Under Serviced Area Licensees
WSIS	World Summit on the Information Society

1 INTRODUCTION

1.1 Innovation and Technological Change – Global Drivers and Consequences

There is incontrovertible evidence that innovation and technological change are playing an increasingly important role in economic growth. Information and communication technologies (ICTs) play a key role in modern society for many reasons, one of which is that they are becoming increasingly instrumental in contributing to growth. They are the “enabling technologies”. ICTs underpin innovation and creativity in virtually all sectors and are now responsible for approximately half of the productivity growth in some economies². ICTs also play an essential role in addressing societal challenges – for instance, universal education, training, health, inclusion, security and environmental management.

The effective uptake and utilisation of ICT have made a demonstrable impact on economic progress and there are clear indications of ICT’s positive impact on development. Effective uptake requires investment in R&D, innovation and human capital development, both mid-level and high-level ICT skills, to create the requisite absorptive capacity in the economy, and requires that technology be created or adapted to address the specific challenges arising from our context. (Cohen and Levithal, 1990). The World Summit on the Information Society (WSIS) identified the central role that science and the sharing of research results play in the development of the information society; the need for international and regional cooperation in creating an inclusive information society; and the role of education, knowledge, information and communication in relation to human progress, endeavour and well-being (WSIS, 2003).

In many innovation processes, ICT itself plays an important role. ICT helps to speed up the innovation process and reduce cycle times, resulting in a closer link between business strategies and performance. For instance, prospective medicines can now be identified and rejected if necessary, using computer simulations rather than costly, time-consuming testing. ICT has fostered greater networking in the economy, as it has facilitated outsourcing and cooperation beyond the firm. It is also a major driver of the globalisation process. In addition, it makes faster diffusion of codified knowledge and ideas within and across borders possible. Also, ICT plays an important role in making science more efficacious and linking it more closely to business.

Another important change is the growing importance of scientific progress for innovation. Basic scientific research is the source of many of the technologies that are transforming society, including the Internet.

Everyday the public and private sectors rely more and more on ICT-based services, which in turn put high demands on capital investments and human resource development. The demands from research ends are comparatively high and cannot be considered standard

² Stimulating innovation and enterprise in Europe’s ICT sector, Viviane Reding, Member of the European Commission responsible for Information Society and Media, address to the Technology Industry Summit at CeBit, Hanover, 9 March 2005. See: www.isps.ch/site/attachdb/show.asp?id_attach=961

by any measure. This justifies special attention and a tailor-made approach. It is not realistic to expect that the needs of the R&D and higher education sector can be served, for instance, by ordinary telecommunications networks, commodity-level ISPs and stand-alone computer systems. As in many other countries, the specific ICT needs of the sector in South Africa are far above the commodity level.

There is also renewed interest in the role of human capital in the ICT sector. One reason is its (ICT) complementarity with new technology: for ICT or other technologies to be developed and used effectively, the right skills and competencies must be in place at all levels. One of the factors behind the good growth record of some countries has been the availability of a large pool of qualified personnel, while skilled labour shortages are rightly considered a constraint to the growth process.

Foreign R&D is particularly important for most countries, since the bulk of innovation and technological change in small countries is based on R&D that is carried out abroad. But domestic R&D by the private sector, research institutes, government agencies and Higher Education Institutions (HEIs) is also an important driver of multi-factor productivity (MFP) growth. It is also crucial in tapping into foreign knowledge; countries that invest in their own R&D appear to benefit most from foreign R&D³.

Growth depends on an environment that is both conducive to innovation and adaptable to future technological breakthroughs. The provision of a conducive climate for innovation requires sufficient public and private funding for basic and applied research; without it, future innovation will be jeopardised. Increasingly, innovation draws on science/engineering research, in particular in industries such as electronics, biotechnology and telecommunications. But in many countries, barriers continue to impede the flow of knowledge between science/engineering and industry. Moreover, international sources of knowledge are of particular importance for innovation, and require greater openness to trade, investment, technologies and ideas in many countries.

There is always a risk of exaggerating the potential of innovation, and the boom in ICT prior to Y2K was accompanied by hype in some quarters. However, the evidence in 2005 does suggest that governments today are faced with a new economic environment which will require a comprehensive policy approach. Clearly, innovation and growth are not the result of a single policy or institutional arrangement. The recent growth experience of OECD countries has shown that the causes of more rapid growth are several. In particular, those OECD countries that registered increased growth in GDP per capita did so by having generally drawn more people into employment, accumulating more capital, in particular ICT, and improving the average quality of their workforce. In many cases, they have also improved multi-factor productivity⁴.

1.2 Key Implications for South Africa

South Africa has not been investing in ICT R&D and innovation nearly as much as other major economies. It devotes a mere 10.5 per cent of its research expenditure to ICT,

³ Innovation in the New Economy, Dirk Pilat, Isuma, Vol. 3 N° 1, Spring 2002, ISSN 1492-0611. See: www.isuma.net/v03n01/pilat/pilat_e.shtml

⁴Ibid

compared with about 30 percent by the leading OECD countries. Clearly, the next wave of the information society will happen with or without South Africa.

ICT has been identified by President Mbeki, as well as by a number of other government strategic and policy initiatives, as a “key technological platform” that has a pervasive impact on government service delivery in domains such as education, health and social facilities, and broad aspects of industrial and economic development. Optimal utilisation of ICT for such social and economic benefits requires vigorous and focused research and innovation activity, as well as a strong skills and knowledge base.

The South African government’s National R&D Strategy sets the agenda and framework for maximising the contribution of R&D and innovation in science and technology in South Africa. It specifically identifies ICT as a key means for bringing about the improved quality of life for all citizens and boosting the economic competitiveness of its industry.

A number of international and local trends further indicate the need for a comprehensive national approach to ICT R&D and innovation:

- Technology chains are becoming increasingly complex. This makes it difficult for any single institution to establish a position of leadership in the domain. A national approach provides the critical mass to achieve such leadership.
- As global markets expand and change, ICT research is being increasingly organised on an international scale as enterprises respond to new challenges. An important trend is the relocation of R&D activities. A national approach will create a local market that is well suited to respond to these changes.
- Innovation processes are more open, and idea exchanges beyond traditional enterprise boundaries are becoming commonplace. A national system of innovation that supports these knowledge flows in general, and in ICT specifically, is necessary to capitalise on this trend.

Many strategic challenges face South Africa in the development of an effective national approach to ICT R&D and innovation. For example:

- It needs to build critical mass in ICT research in order to make South Africa a more attractive place to conduct R&D. It needs to improve the efficiency and effectiveness of its research and innovation system.
- It needs to emphasise the need to leverage South Africa’s research results.
- The joining of the world-wide community of researchers, among them a number of South Africa–Europe joint research initiatives, is regarded as essential in making many South African researchers less isolated.
- It needs to become more involved in setting the agendas internationally, for example through measures to secure information, protect intellectual property, build industrial consensus and set standards.

- What the government can do in this field is limited. It needs to secure buy-in from HEIs and industry. The growing level of interest in the concept of technology platforms is a positive sign. It needs public-private partnerships to bring South Africa closer to the forefront of ICT R&D and innovation. It is therefore essential to create the right conditions for the private sector to make substantial commitments to both short-term and long-term (strategic) research in ICTs in South Africa.

1.3 Framework for the Strategy

It is on the basis of the above discussion that the DST, together with expert domestic and international advisers, has developed this ICT R&D and Innovation Strategy.

The strategy examines the current state of ICT R&D in South Africa and proposes a number of objectives, strategies, actions and interventions to realise a vision for ICT R&D and innovation that will position South Africa optimally to take advantage of the benefits of ICT and the associated information society.

The ICT R&D and Innovation Strategy has three clear priorities:

- Develop focused and strengthened ICT research activities to achieve world-class research competencies in South Africa.
- Build a strong and robust ICT innovation environment in South Africa.
- Build advanced human capital (ICT skills base) for research and industry.

The strategy will provide direction and critical mass for R&D and innovation in **ICT technology domains**, which were identified during the foresight process. These include high-performance computing; human language technologies; information security; open source software; software engineering and software architecture; mobile, wireless and satellite technologies; future-web applications; geomatics and spatial technologies; and next generation networks and **ICT application domains** such as ICT for disability, education, health, service delivery, agriculture, manufacturing, resource-based industries and aerospace.

1.4 Context

The National R&D Strategy identifies a number of technology and innovation missions as critical focus areas for R&D in South Africa for supporting the acceleration of economic growth, the creation of wealth on a sustainable basis, and the improvement of the quality of life for all South Africans. Each of these areas has a number of unique characteristics that require specific strategies. Strategies have already been developed for biotechnology and advanced manufacturing technology. Although this strategy focuses on ICT, it will link strongly with other existing key national strategies as these other strategies are all predicated on advances in ICT.

The new governance framework for R&D identifies three types of R&D: Type 1 concerns early-stage R&D in generic technology with application across a broad range of sectors;

Type 2 involves relatively more mature technology with a strong sectoral focus; and Type 3 is concerned with routine services. This strategy is for types 1 and 2.

The overall purpose of the ICT R&D and Innovation Strategy is to create an enabling framework for the advancement of ICT R&D and innovation, in a systematic fashion, within the context of the National R&D Strategy. The following outcomes are intended:

- Achieving **global leadership** in identified key scientific and technological domains
- Developing multi-disciplinary technologies, skills and methodologies to address areas of market neglect, especially to **eradicate the digital divide**
- Creating an **indigenous ICT sector** that is developed, growing, innovative and competitive
- Enabling the smart **proliferation of ICT** within other sectors of the economy.

These outcomes can be linked to those of the National R&D Strategy as shown in Figure 2 below.

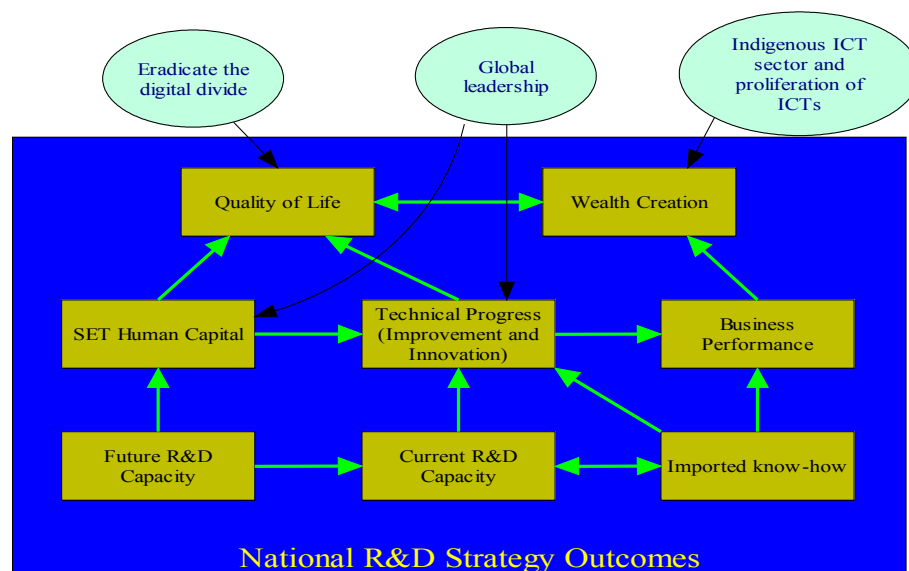


Figure 2: Outcomes of the ICT R&D and Innovation Strategy, linked to the National R&D Strategy

The relationship between the ICT R&D and Innovation Strategy and various other DST (and related) initiatives is illustrated in Figure 3.

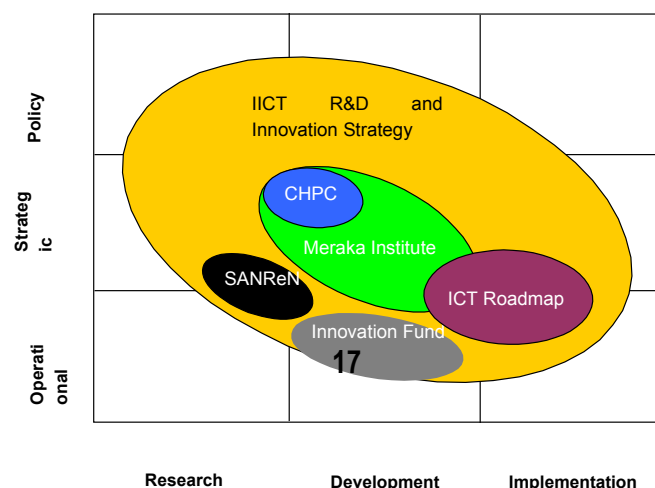


Figure 3: Relationship between the ICT R&D and Innovation Strategy and other initiatives

1.5 Relationship of ICT R&D to the Knowledge Economy and e-Government

South Africa wants to provide better government services at less cost so it can create a better place to live and do business in. Electronic government (e-government) is a forward-thinking way for South Africa to accomplish these aims.

Using e-government, citizens and companies can do business with government more easily and get what they need to make informed decisions. The public and the business community can find government information and services on the Internet without having to fully understand the structure and functions of government. This will help all interested parties see the government as a positive force in their lives.

E-government requires a good or excellent ICT infrastructure along with a wide range of human skills. Best-practice findings from Europe and elsewhere show that enabling e-Government requires a considerable amount of research and planning, and attention to interoperability and security⁵.

Therefore, an important two-way interaction exists between various aspects of ICT R&D and e-government.

1.6 Policy and Regulatory Environment

R&D and innovation cannot happen in a vacuum. They are informed by the broader context, of which the policy and regulatory environment is particularly critical. All the policies, legislation and regulations that impact on the ICT sector, and that could therefore have a potential impact on local ICT R&D and innovation, have been reviewed as part of the strategy development. In formulating the strategy, careful consideration was also given to the different and complementary roles that different actors play in undertaking and

⁵ "Value Creation in e-Government projects - An explanatory analysis conducted for the Danish presidency of the e-Government workgroup of the Directors General", IDA e-Government Newsletter - March 2003 See: http://europa.eu.int/idabc/jsp/docs/dsp_showPrinterDocument.jsp?docID=987&lg=en

realising the benefits of ICT R&D and innovation. These actors include universities, science councils, industry, government and civil society.

Parallel to the development of this strategy, government has recently established a significant intervention in the ICT landscape in the form of the Meraka Institute, also known as the African Advanced Institute for ICT - AAICT. The Meraka Institute's goals are closely aligned with this strategy and it will be a key vehicle for its implementation.

Another government initiative relevant to the strategy is the SEDA Technologies programme of the dti, which seeks to develop innovative technology-based platforms that result in the creation of sustainable, globally competitive SMMEs that contribute towards the accelerated growth of our economy. The ICT-focused SoftstartBTI Incubator⁶ and the Eastern Cape Information Technology Initiative (ECITI) in particular complement the R&D and innovation activities of the Meraka Institute and others, and provide a vehicle for aspects of the strategy's implementation.

Other actors in R&D and innovation in ICT include the Innovation Fund, science and technology parks, such as the Innovation Hub and the Cape Town IT Initiative (CITI), as well as local and international industry. The implementation of the strategy will work towards aligning the efforts of these actors in order to reach the expressed vision of vibrant ICT R&D and innovation activity leading to socio-economic development.

1.7 Approach

The National ICT R&D and Innovation Strategy provides an **enabling framework**, based on a compelling future vision of a vibrant and relevant ICT "ecosystem" that will have a profound impact on South Africa. It will establish an environment where ICT R&D and innovation are able to flourish. This environment will:

- be enabling and influencing rather than controlling;
- have appropriate interventions where necessary;
- be derived from a vision and guided by specific objectives, rather than extrapolated from the past;
- provide direction to R&D and innovation activities;
- support R&D and innovation through the provision of appropriate resources;
- build on existing and future initiatives across the spectrum in a synergistic fashion;
- be crafted and executed in a partnership philosophy; and
- creates the space for global leadership and be firmly rooted in South Africa's own context with all its opportunities and challenges.

⁶ Incubators and Science and Technology Incubators

1.8 Document Structure

Figure 4 shows the structure of this document.

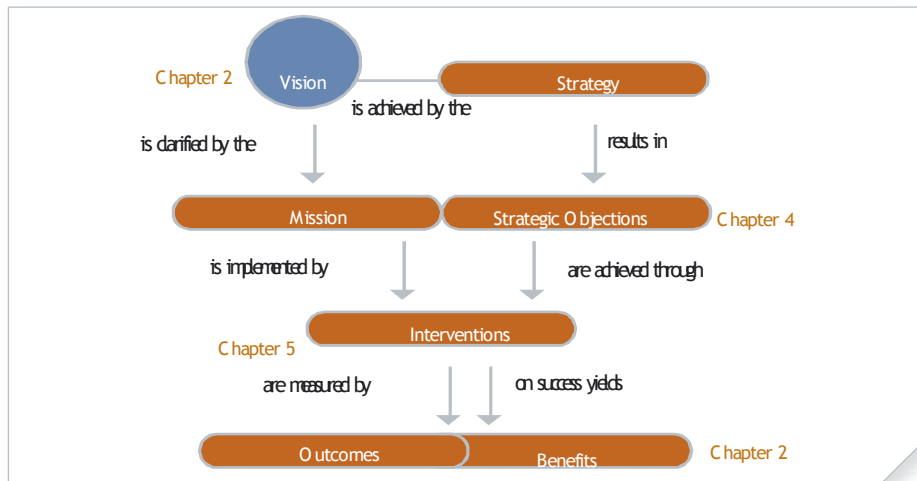


Figure 4: Document structure

- Chapter 2 describes the vision of the ICT R&D and Innovation Strategy for South Africa in 2015.
- Chapter 3 reviews the current state of ICT R&D and innovation activity in the country and concludes with a strength, weaknesses, opportunities, threats (SWOT) analysis.
- Chapter 4 provides a synthesis of a number of strategic objectives based on the vision and current reality.
- Chapter 5 proposes a number of strategic interventions to achieve the objectives in Chapter 4 and the vision outlined in Chapter 2, as well as implementation mechanisms for the strategy and for evaluating performance against the vision and objectives.

2 VISION FOR ICT R&D AND INNOVATION – 2015

The National ICT R&D and Innovation Strategy is based on a future perspective or vision, which has been conceived to show the outcomes that will have been achieved with the successful implementation of the strategy. From this vision, specific opportunities, challenges and barriers to success are deduced and appropriate objectives and interventions are defined. The setting of specific objectives allows for broad participation in pursuing the vision.

2.1 Vision for an ICT Landscape for South Africa

The vision of the ICT R&D and Innovation Strategy is that by 2015:

South Africa is an inclusive information society where ICT-based innovation flourishes. Entrepreneurs from historically disadvantaged population groups, rural communities and the knowledge-intensive industry benefit and contribute to the well-being and quality of life of our citizens. South Africa has a strong national ICT brand that captures the vibrancy of an industry and research community striving for excellence, characterised by innovative approaches to local and global challenges, and recognised for its contribution to the economic growth and well-being of our people and the region.

The vision for an ICT future for the country within the next 10 years encompasses a South African ICT landscape that has made a material socio-economic impact.

2.2 Mission and Strategic Approach

The mission of this strategy is to contribute to significant improvement in the quality of life and the creation of wealth for the people of South Africa, especially the historically disadvantaged, by creating a coherent, integrated and well administered ICT R&D and innovation system of partnerships, financing, processes, policies and infrastructure.

The mission will be implemented by initiating a number of strategic interventions, which are guided by strategic objectives with concrete outcomes that can be used to measure progress towards achieving the vision of this strategy.

2.3 Impact of Achieving this Vision

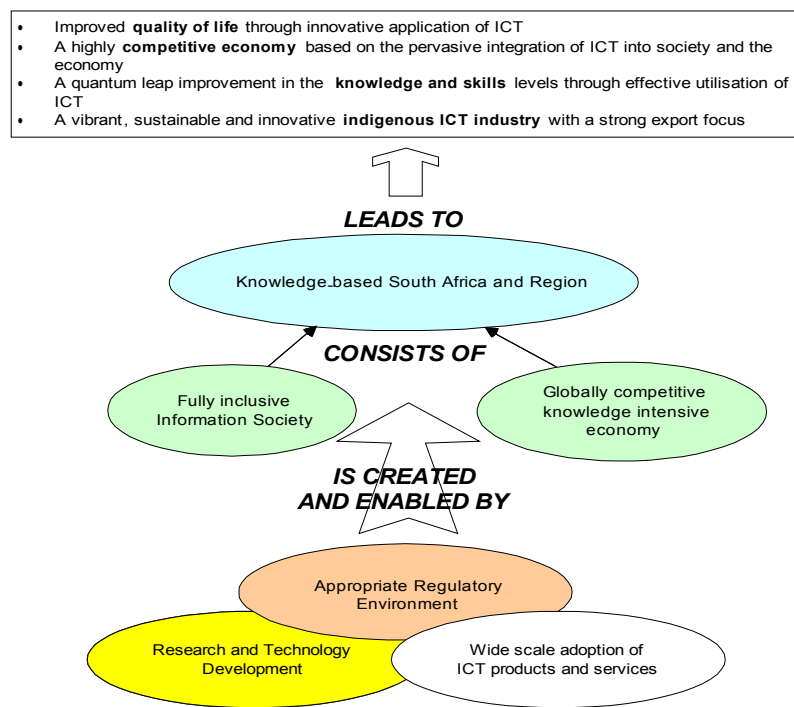


Figure 5: Impact on society and the economy resulting from actions at lower levels with intermediate consequences during the process

Some of the benefits associated with achievement of the vision (See Figure 5 above):

- Improved quality of life of all South Africans, an inclusive democracy, good governance and social stability through the application of ICT to address basic needs. This in turn will contribute to poverty eradication and the achievement of social development goals.
- A highly competitive economy based on the comprehensive integration of ICT into all aspects of society and the economy, including smart infrastructure and effective service delivery as envisaged in the Advanced Manufacturing Technology Strategy.
- An exponential improvement in the knowledge and skills levels of South Africans brought about by effective utilisation of the benefits of ICT and the information society at all levels, from basic literacy to advanced technical qualifications.
- A vibrant, sustainable and innovative indigenous ICT industry with a strong export focus, contributing significantly to reducing the ICT balance of payment which:
 - addresses a significant portion of South Africa's ICT needs through an indigenous component of the ICT industry;
 - includes a thriving technology-based SMME sector;
 - supports the emergence of South African ICT multinational corporations;
 - attracts investments by overseas-based multinational corporations in R&D, innovation and manufacturing facilities and resources in South Africa.

The vision, mission and anticipated benefits are summarised in Figure 6 below.

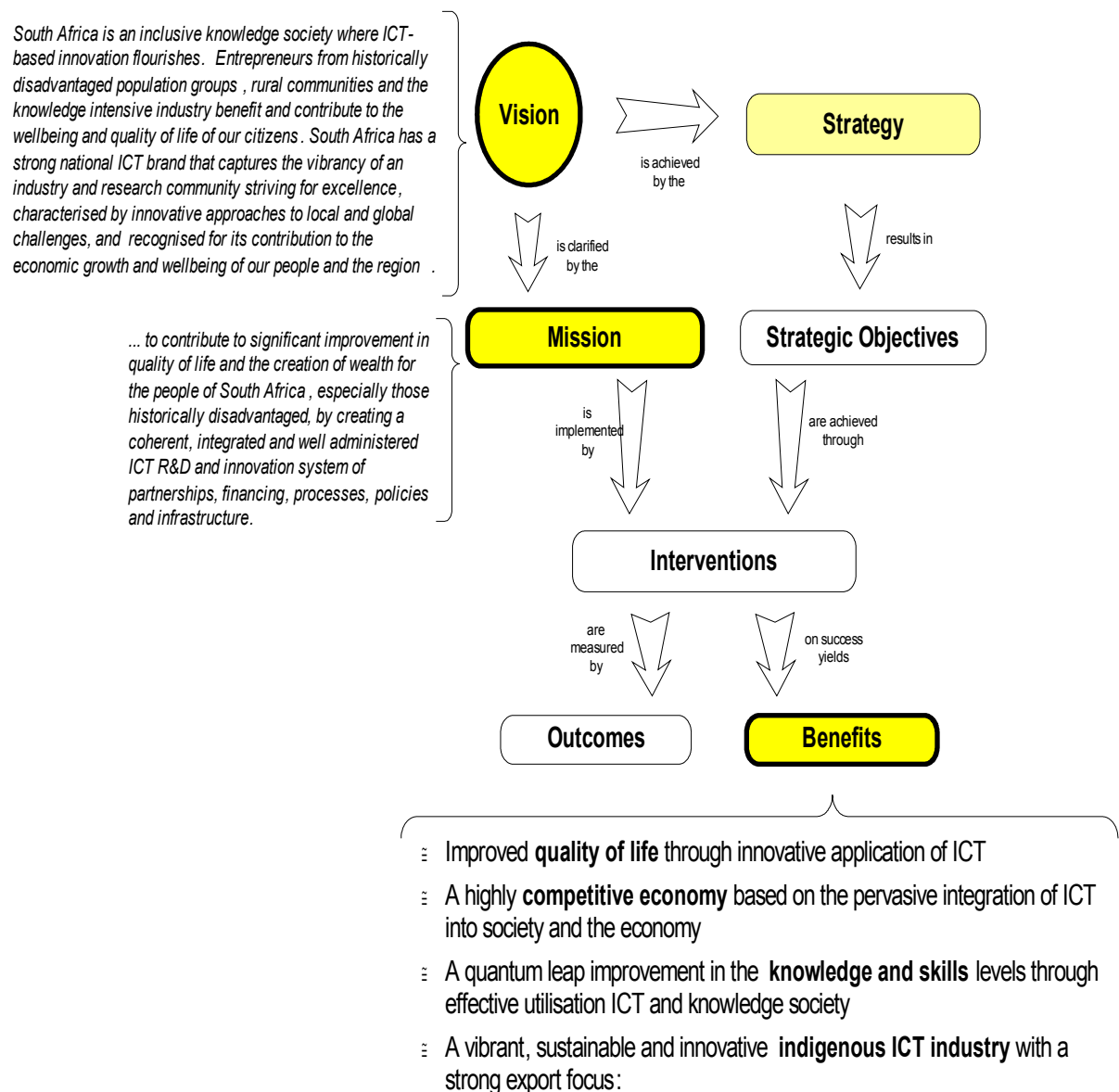


Figure 6: The vision and mission in the context of the ICT R&D and Innovation Strategy

3 CURRENT STATUS AND CHALLENGES IN ICT R&D

3.1 Introduction

Concrete objectives and the associated interventions required to reach the vision of the ICT R&D and Innovation Strategy can be formulated only once the current situation has been rigorously assessed. Figure 7 outlines the key requirements to achieve the vision of the strategy:

- A healthy pipeline of human resources with advanced capabilities;
- World-class, focused R&D activity with active local and international collaboration leading to internationally recognised leadership in a number of key areas relevant to the South African context;
- A strong South African ICT brand, particularly focusing on innovative ICT solutions which address the needs of the developing world;
- A shift in the orientation of the domestic ICT economy to give greater emphasis to development, production and export;
- A market-driven approach that addresses needs through innovative products, services and solutions as well as a mechanism that addresses areas where market forces have failed;
- Effective mechanisms for technology transfer, from knowledge generation through to productive implementation (including export); and
- State-of-the-art research infrastructure (including organisational, regulatory, policy and other support infrastructure) and ready access to new technology, including sufficient and affordable bandwidth, by researchers.

The current ICT R&D status was examined through a baseline study and by benchmarking South Africa's ICT R&D performance and activities against those of other countries. Workshops with experts in ICT, undertaken as part of the formulation of the ICT R&D and Innovation Strategy, identified a number of clear trends.

This chapter highlights baseline information on South African ICT R&D and innovation in the context of the requirements outlined above.

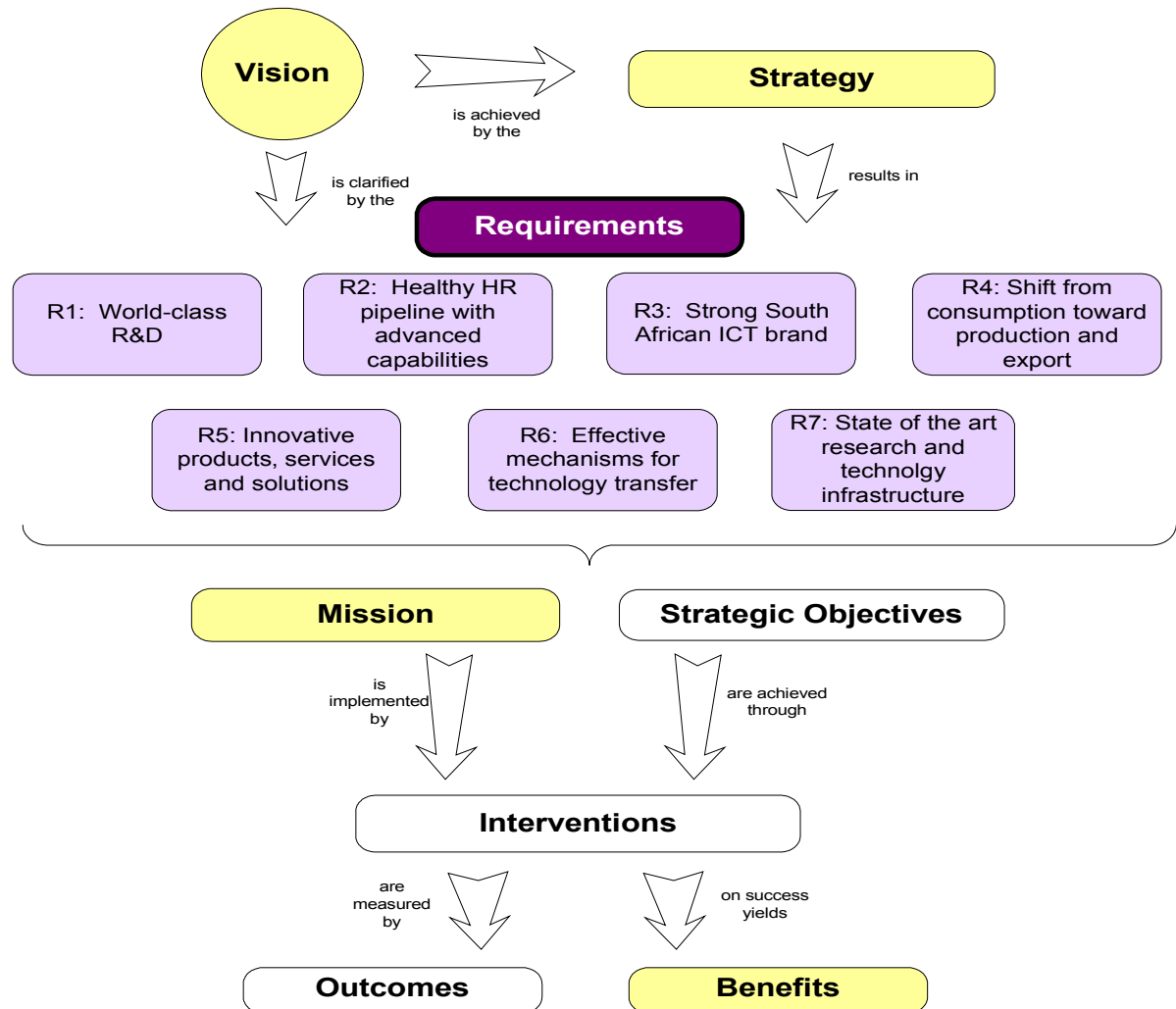


Figure 7: Key requirements for achieving the vision

3.2 Human Resource Development

The quality of South Africa's **ICT R&D human resource profile** is indicated by the percentage of the total population with tertiary qualifications in ICT, ratios of advanced degrees versus first degrees, and the percentage of full-time-equivalent researchers compared to international examples.

As illustrated in Table 1, the vast majority (89%) of ICT qualifications obtained in 2003 in South Africa were Bachelors or Honours degrees, and less than 11 percent were advanced degrees (Masters and PhDs).

Table 1: ICT qualifications granted by South African universities in 2003⁷

Category	Number	%
Bachelors	2 483	70.1
Honours	677	19.1
Masters	346	9.8
PhDs	36	1.0
Total	3 541	100
PhD : Graduates ratio		1.4%
PhD : Masters ratio		10.3%

The ICT PhD graduation rates and PhDs as a percentage of the population do not compare favourably for South Africa. In terms of numbers of researchers, South Africa is in the same league as Turkey, Romania and Argentina (OECD, 2004c). In proportion to its population, South Africa is performing significantly worse than Malaysia, Singapore and most OECD countries.

South Africa has some catching up to do in relation to countries like Canada and Ireland, which have policies in place for increasing the graduation rates in science and engineering at Masters and PhD levels⁸.

There has been considerable progress in achieving demographic representation of graduates in ICT overall. For example, African student numbers increased from only 57 (3% of the total) in 1991 to 1 651 (43% of the total) in 1999. But an ongoing challenge is to achieve more even representation, also in relation to gender, at advanced levels and in engineering, which is a key ingredient for technology transfer.

In this respect HEIs will continue their primary role in postgraduate teaching and will play a leading role in human capital development. This strategy will put in place measures that will support them in these activities.

Whereas advanced skills in ICT are critical to ICT R&D and innovation, it is also recognised that these need to be complemented with mid-level skills that will support industrialisation and operation of the ICT innovations that result from the implementation of the strategy. There also needs to be a healthy pipeline of school-leavers and graduates who are equipped to pursue postgraduate studies in ICT fields.

3.3 Focused Research and Research Collaboration

⁷ Adapted and summarised from ED (2003) according to 100% Cat.06, 100% Cat.0807 and 35% Cat.0808 Adapted and summarised from HSRC (2003). Original Source: Department of Education (DoE) SAPSE database (1991 to 1999).

⁸ Canada seeks to double graduation rates in science and engineering at Masters and PhD levels and has set targets for increasing the admission of Masters and PhD students at Canadian universities by 5% per year (OECD, 2004a). Ireland aims to increase ICT PhD rates to 300 PhDs per year from the 124 ICT PhDs in 2000 (IAE, 2004).

The extent of focused research activity is assessed in terms of ICT publication rates and the quality of scientific publications in ICT and rated researchers, including clustering of rated researchers.

ICT publications rates and quality – Pouris (2003) found that South Africa’s already low scientific publication rate is being eclipsed by emerging countries in Asia, South America and Europe.

Comparison with a number of countries in relation to general scientific publications indicates that the rate of ISI-listed publications per million of the population is an order of magnitude lower for South Africa (87 per annum) than for the UK (940 per annum) or Australia (1 110 per annum). South Africa’s international standing in scientific research publications declined steadily from 1987 to 2000. Moreover, in relation to ICT, the situation is even bleaker, with publication rates in the field less than the South African average of 0.5 percent.

The Relative Citation Index (RCI) is a measure of research quality and importance. There are indications that South Africa is declining in both importance and share of the ISI database in fields relevant to ICT such as Computer Science and Mathematics.⁹

Rated researchers – A healthy ICT R&D system is largely dependent on the intellectual and technological leadership of senior researchers. Sufficient numbers of rated researchers and clusters of rated researchers at specific institutions are required to drive focused research strategies at these institutions. As Table 2 shows, the number and percentage of ICT-rated researchers in South Africa is low.

Table 2: National Research Foundation (NRF) rated researchers in ICT¹⁰

	A	B	C	P	Y	L	Total	Total (A, B, C)
General	55	396	866	16	186	58	1577	1317
ICT	2	19	40	1	8	1	71	61
Ratio – ICT: General	3.6%	4.8%	4.6%	6.3%	4.3%	1.7%	4.5%	4.63%
A - Leading international researcher, B - Internationally recognised researcher, C - Established researcher, P – Young researcher with exceptional potential (NRF Presidential Awardee), Y - Young researcher with potential, L – Late entrant into research ¹¹								

In summary, the total number of senior researchers (A, B and C rated) in 2006 was 61, and the ratio of ICT-rated researchers versus general was 5 percent. The institutional distribution of NRF-rated researchers in ICT in 2006 indicates some clustering of rated researchers at HEIs, which could potentially form the basis for focused research groups at these institutions.

⁹ Figure A1 in Appendix B shows the change in Relative Citation Index versus Publication Rate of South African publications in the ISI National Science Indicators Database in a number of fields between the early and late 1990s.

¹⁰ The number of ICT personnel was inferred from the research specialities indicated in the NRF database (figures downloaded in October 2006) - a certain degree of interpretation had to be applied [NRF F&F2]

¹¹ For a full explanation of NRF rating see: www.nrf.ac.za/evaluation/Content/Faqs/faqs.htm#categories

3.4 Innovation Environment

The state of the innovation environment is discussed below in terms of perception of innovation and entrepreneurship attractiveness, ICT patenting rates and the state of the digital divide. Figures are derived from international comparisons.

Perception of innovation environment – South Africa was scored equal lowest¹² out of 46 locations in a 2000 *Wired* magazine survey of perceptions of different countries' attractiveness for innovation. Locations in each country were rated from 1 to 4 in four areas: 1) ability to train skilled workers or develop new technologies, 2) presence of established companies and multinational corporations, 3) the population's entrepreneurial drive to start new ventures, and 4) the availability of venture capital to help ensure that the ideas make it to market (UNDP, 2001, p 45).

ICT patenting rates - ICT patenting is an indicator of the nature and extent of innovation in ICT. South Africa is responsible for only about 0.06 percent of the world's annual patents¹³. It is essential that the ICT strategy actively promotes South Africa's collaboration with the leading countries, namely the United States, European Union and Japan, which are collectively responsible for over 90 percent of the world's annual patents.

ICT-related patent applications at the European Patent Office (EPO) by OECD countries have grown much more rapidly than overall patent applications. Around 33 percent of all OECD patent applications are ICT-related (OECD, 2003).

In terms of ICT patent presence at the EPO, South Africa is fairly closely matched with Russia, New Zealand, Hungary, India and Hong Kong. China's patenting activity in ICT has rapidly escalated from around South Africa's level in 1998 to treble that of South Africa in 2000.

Digital divide indicators – The provision of ICT infrastructure is fundamental to development. Unfortunately, many people in Africa do not have access to basic tools like telephones, computers and the Internet. Although addressing the digital divide is not solely a technological issue, digital divide indicators measure the extent to which innovation in ICT is addressing areas of market neglect or failure.

Table 3: Key ICT parameters for South Africa (APC Website, 2005)

TV sets per 1 000 people	152	Number of mobile networks ¹⁴	3	Personal computers per 1 000 people	68.5
Radios per 1 000	338	Mobile phones	20	Internet users	3 068

¹² El Ghazala, Tunisia received the same score. Campinas, Brazil scored double Gauteng's score, Bangalore three times and Silicon Valley, Boston, Stockholm-Kista and Israel were four times as high.

¹³ In 2005, only 6 of the 46 patents filed in the United States by South African inventors were in ICT. This number can be compared with that of Australia which had 767 patents of which more than 40% were ICT-related.

¹⁴ Operated by Vodacom, MTN and Cell C.

people		(millions) (2004)		(thousands)	
Telephone mainlines (millions) (2002)	4.84	Mobile phones per 1 000 people	450	Internet users per 1 000 people	69¹⁵
Telephone mainlines per 1 000 people	112	Third-generation (3G) networks ¹⁶	2	Broadband (ADSL) users (thousands) (June 2005)	67
		3G customers (thousands) (June 2005)	26.3	Broadband (ADSL) users per 1 000 people	1.5

The characteristic elements of the digital revolution (e.g. digital broadband access) are significant innovations, bringing with them inherent opportunities and threats. The Digital Access Index and Networked Readiness Index (NRI)¹⁷ are composite indices used internationally to assess performance in this regard.

In 2004, South Africa had a Networked Readiness Index score of 0.33 and a world rank of 34 (out of 104 countries). This compares favourably with 70 countries that rank lower, including India at a score of 0.23 and a rank of 39. However, South Africa's rank is significantly below international benchmarks for countries within a similar economic category. See Canada (score 1.27, rank 10), Australia (score 1.23, rank 11) and Malaysia (score 0.69, rank 27).

The indicators behind the critical NRI components are:

Indicator	Approx. value for SA
Internet users/1 000 inhabitants.....	69
Broadband Internet subscribers/1 000 inhabitants.....	1.5
Personal computers/1 000 inhabitants.....	68.5
Government online services.....	not known

A snapshot of South Africa's ICT statistics/trends includes the following further observations:

- Tele-density¹⁸ (50 percent) is low by world standards.
- Declining fixed-line tele-density (this means that the population is increasing but fixed lines are static).
- A very high proportion of mobile subscribers (20 million) versus fixed-line subscribers (5 million).
- 71 percent cellular coverage (high for a large developing country).
- Growth has slowed down in the mobile sector, as indicated by the decreasing compounded annual growth rate (CAGR).

¹⁵ This is somewhat higher than the 4% average for Africa, but lower than Réunion and the Seychelles (over 20%), Mauritius (15%) and Morocco (12%). This compares with over 50% penetration in developed countries.

¹⁶ 3G services were introduced in December 2004 by Vodacom which was subsequently followed by MTN.

¹⁷ Digital Access Index (by the ITU); Networked Readiness Index (NRI) (by the World Economic Forum, World Bank, INSEAD).

¹⁸Tele-density is defined here as the number of telephones per 1 000 of the population.

- ADSL broadband was not introduced until 2002 and the take-up (177 500 in June 2006) - is still significantly behind that of other countries despite recent growth¹⁹. Broadband as defined in South Africa is also not comparable to >2 Gbps in many other countries.
- Relatively high costs of Internet access despite reductions in ADSL rates in mid-2005.
- SMMEs are slowly moving away from dial-up connections to high-speed options, such as ADSL and various wireless alternatives. The number of SMME companies using ADSL increased from 2 percent to 25 percent between 2003 and 2005²⁰.

Recent evolutions in telecommunications regulation aimed at stimulating competition may have a positive influence on the indicators discussed here.

3.5 R&D Infrastructure

Advanced national and trans-national R&D and innovation systems are characterised by sophisticated support structures. These include institutional infrastructure and appropriate policies, strategies, systems of indicators and futures research that guide and support R&D and innovation activities.

Existing support structures in South Africa include:

- National System of Innovation (NSI) - comprising organisations performing R&D in the pursuit of a common set of social and economic goals. The NSI has a combined expenditure of about R10 billion, with public research institutions performing about 45 percent of the total R&D.
- The Meraka Institute, CSIR and other science councils, which can play an important bridging role between universities and industry: between institutions that undertake leading edge, frontier-type research in new knowledge areas, and those driven by the imperative to innovate or translate new knowledge into new products and services.
- The Innovation Fund - is an instrument of the Department of Science and Technology whose mandate is to promote technological innovation. It implements this mandate through investments in end-stage R&D in any technology field, where a clearly defined new technological product or service can result from such R&D. Furthermore, support is provided for patenting and early technology commercialisation activities.

A further infrastructural element of ICT research and innovation relates to appropriate regulation. In South Africa, recent developments in telecommunications regulation,

¹⁹ Leading countries have broadband penetration of more than 70% of households, with South Korea achieving 92.7%. South Africa's ADSL penetration is estimated to be 62nd out of the 68 countries for which statistics are available. - Point-Topic, World Broadband Statistics: Q3 2006

²⁰ MWeb business survey: www.itweb.co.za/sections/internet/2005/0507181039.asp

including the Convergence Act, 2005,²¹ (introduced into the National Assembly in February 2005), indicate progress in this regard.

The Internet - Although all science councils and universities in South Africa are connected to the Internet, infrastructure developments have not kept pace with international developments, and Africa is now the only continent with no Internet II activity. There are no significant ICT test beds to support research and innovation in areas such as next generation wireless networks and Internet architecture; nor are there grid networks or infrastructural centres of competence.

For the universities and major research institutions, the South African National Research and Education Network (SANReN) is of key importance and appropriate experts from South Africa need to engage with international counterparts, for example, AARNET Pty Ltd (Australia) and CANARIE (Canada) to work through the model and the important management and cost recovery aspects.

Science and technology parks and incubators – These are an accepted aspect of R&D infrastructure, supporting a robust innovation chain and the development of technology clusters of distinct geographical locations where technology-based firms, entrepreneurs and researchers can locate themselves close to community assets, like universities and research institutions that can help them in their endeavours. In South Africa, a number of science and technology parks have been established in large metropolitan areas such as the Innovation Hub in Tshwane and CITI in Cape Town. ICT incubators include Softstart, BTI, Maxum Business Incubator and the UUNET Bandwidth Barn. These support a relatively high percentage of ICT-based businesses²² and can contribute to critical mass in ICT innovation.

International examples of research infrastructures - ICT infrastructure relevant to R&D occurs in several areas, including networks, test bed facilities, high-performance computing facilities and information infrastructure (scientific and technical data sets, education materials and research reports, etc) (Anderson, 2003). There is some information²³ on a selection of different kinds of ICT research infrastructures, either country-specific or inter-country collaborative. Investment in these research infrastructures ranges from €10 million to €250 million. The following examples give an indication of the scope and scale of the effort and the specialisation for which some countries are aiming:

- **Ireland:** Cosmogrid is a virtual organisation that encompasses all the major universities and institutions involved in grid technology and high-performance computing in Ireland. They are connected through GridIreland which is also a virtual organisation. All the institutions share their computing facilities and expertise at a national level. The major facilities and services offered are computing facilities, databases and grid technology expertise.

²¹ An Act to promote convergence in the broadcasting, broadcasting signal distribution and telecommunications sectors and to provide the legal framework for convergence of these sectors; to make new provision for the regulation of communications and network services; to provide for the granting of new licences and for new social obligations; to provide for the control of the radio frequency spectrum; to provide for the continued existence of the Universal Service Agency; and to provide for matters incidental thereto.

²² 13 of the Innovation Hub's 26 tenants (June 2005) could be classed as involved in ICT or ICT R&D.

²³ Table 9 (Appendix B).

- **Finland:** Agora organises research where the social sciences intersect with technology. Areas include psychology, education, the humanities, sport and health sciences, and economics. The objective is to develop the future information society from a human point of view. Major facilities and services offered comprise a number of interdisciplinary thematic working environments, which include the Game Laboratory, Learning Laboratory, Industrial IT Group and the Psycho-centre network for social and human research in the information society.

3.6 Resourcing and Incentives

Resourcing of ICT R&D and innovation is examined below and comparison with other countries is made. ICT R&D expenditure in South Africa was 0.11 percent of GDP and 12.8% of the total expenditure on R&D in 2004/2005. Figure 8 shows the R&D expenditure in different research fields for 2001/2, 2002/3 and 2004/5. There has been a consistent increase in ICT expenditure during this period. The increase in R&D Expenditure in ICT is, however, proportional to the increase in total expenditure on R&D and does not represent growth relative to other sectors.²⁴

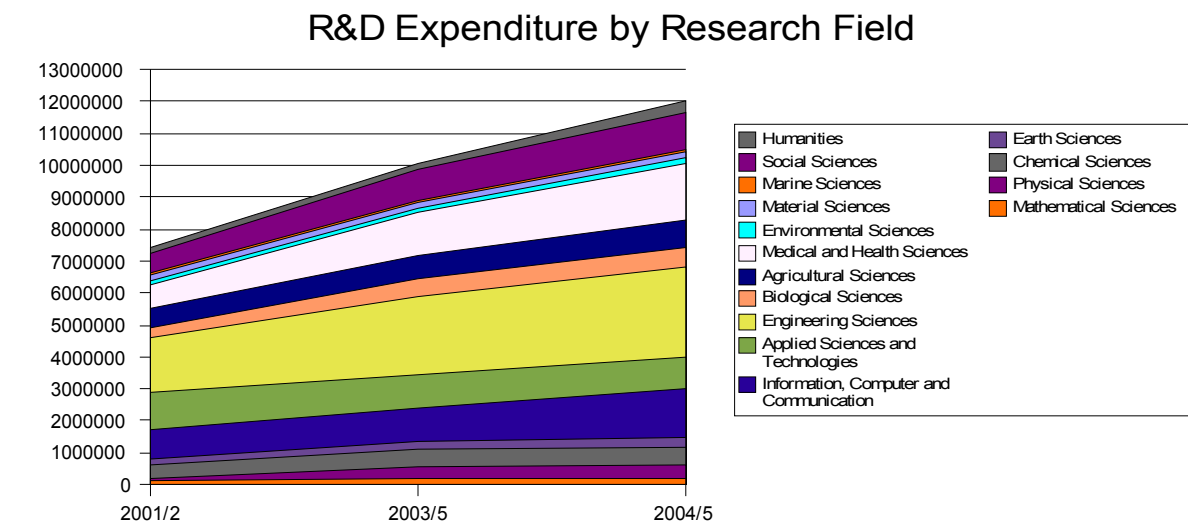


Figure 8: Expenditure on R&D by major research fields in South Africa, 2001/2 to 2004/5²⁵

In OECD countries, the ICT sector invests heavily in R&D and is highly innovative. In 2000, ICT manufacturing industries accounted for more than 25 per cent of total manufacturing business R&D expenditure in most OECD countries – double the South African figure – and more than 50 per cent in Finland, Korea and Ireland.

The degree of a country's specialisation in ICT is inferred from the ratio of R&D expenditure to GDP. Finland, Korea and Sweden are relatively more specialised than large OECD countries in both ICT manufacturing and services. Business expenditure on ICT R&D in Finland, South Korea and Australia was 1.5 percent, 1 percent and 0.2 percent of GDP

²⁴ As witnessed by the 2001/2 and 2004/5 figures at 12.1% and 12.8% of total R&D expenditure.

²⁵ Source: HSRC, 2005

respectively in 2000, compared to South Africa's business expenditure on ICT R&D of only 0.07 percent of GDP in 2001.

Although the data on South Africa's R&D expenditure by ICT Industry Grouping and Research Field²⁶ at first glance seem fairly healthy, indicating 18 percent of Industry R&D investment in ICT, this figure is low in comparison with the USA's 40 percent and represents less than 0.1 percent of GDP. The South African Information Technology Industry Strategy (SAITIS) report adds the following:

- *"The majority of respondents (70%) in the sample did not undertake expenditure on IT research and development."*
- *"73% of IT user organisations indicated that they did not undertake expenditure on IT research and development during 1998. Half of the IT vendors did not undertake expenditure on IT research and development, and 29% spent less than R100 000."* (SAITIS, 2000, p 138).

The Johannesburg Stock Exchange ranks among the 10 largest in the world, indicating scope for financing ICT R&D and Innovation if the right conditions could be created.

Comparison between Australia and South Africa

Overall ICT expenditure as a percentage of GDP is similar for South Africa (9%) and Australia (11%). However, the relative spending on R&D in South Africa (0.74% of GDP) is less than half that of Australia (1.6% of GDP), an amount already considered low in the OECD rankings. The ICT component is even less favourable, with South Africa spending 10.5 percent of R&D on ICT compared with Australia's 20 percent: in each case the ICT R&D expenditure is dominated by business by over 2:1.

Over the past two decades, Australian governments have established and enhanced a systemic approach to funding R&D and promoting innovation through a range of schemes including tax incentives, grant schemes for both business and research institutions, and financial incentives for industry and the research community to interact. Over the past two to three years, national priorities have been established to further focus research expenditure; also, the emphasis on the role of ICT has changed to one of enhancing productivity throughout the entire economy. Australia has also supported the development of the Internet Economy by putting in place a regulatory and policy environment conducive to the development of e-Business.

3.7 ICT R&D Indicators

In its final Growth Project report (OECD, 2001), the OECD concluded that there was an uneven divergence of growth in several OECD economies and attributed this to ICT (particularly investment in ICT), increased use and quality of labour and multi-factor productivity growth arising, in part, from increased business innovation. All these elements would be part of a knowledge-based economy and society.

The implementation in South Africa of the FRASCATI survey to determine the national spend on R&D resources and infrastructure (R&S Survey) and the Oslo Innovation survey [OECD] is starting to provide quality information on the current state of R&D and innovation in general and provide some information on ICT specifically.

²⁶ See Table 10 in Appendix B

Implementation of the ICT R&D and Innovation Strategy will require supplementary measures that can be used to assess implementation progress²⁷.

3.8 Strength, Weaknesses, Opportunities and Threats

Arising from the above review, the SWOT summary is shown in Table 4. Note that this is not intended as a complete list of all strengths, weaknesses, opportunities and threats.

Table 4: Strength, Weaknesses, Opportunities and Threats for SA ICT R&D

STRENGTH	<ul style="list-style-type: none"> ▪ The CSIR, other science councils and the Meraka Institute, which can play an important bridging role between universities and industry ▪ The National System of Innovation (comprising organisations performing R&D in the pursuit of a common set of social and economic goals) ▪ Existing Science and Technology parks and incubators ▪ Considerable progress in achieving demographic representation of graduates in ICT overall ▪ Mobile phone network coverage is good in South Africa, as is the take-up of cellular phones ▪ Exemplar ICT companies with significant foreign revenue ▪ The implementation of the FRASCATI survey to determine the national spend on R&D resources and infrastructure and the Oslo Innovation survey to provide information on the current state of R&D and Innovation ▪ The Johannesburg Stock Exchange ranks among the 10 largest in the world, indicating scope for financing ICT R&D and innovation.
WEAKNESSES	<ul style="list-style-type: none"> ▪ The low number of people with ICT qualifications and the number of ICT researchers exacerbated by insufficient mid-level skills ▪ The rate and quality of South African ICT publications are low and have not kept pace with those of other countries, both developed and developing. Fields pertinent to ICT have a publication rate less than the South African average. ▪ South Africa scores very low in terms of how it is perceived as an attractive innovation destination. ▪ Lack of breakthrough innovations in ICTs. ▪ The tele-density for fixed phones is low by world standards, but this is not surprising given the poverty levels. ▪ South Africa has fallen well behind in Internet and broadband penetration. ▪ Network infrastructure for science councils and universities has not kept pace with international developments. ▪ There are no significant ICT test beds to support research and innovation in areas such as next generation wireless networks or Internet architecture; nor are there grid networks or infrastructural centres of competence. ▪ South Africa's Gross Domestic Expenditure on R&D is significantly below international benchmarks for countries within a similar economic category.
OPPORTUNITIES	<ul style="list-style-type: none"> ▪ Scope through policies to increase graduation rates in science and engineering at Masters and PhD levels. ▪ Scope to achieve more equitable demographic representation at advanced degree levels. ▪ Scope to increase collaboration with the leading R&D countries,

²⁷ Measuring a Knowledge-based Economy and Society - An Australian Framework, Chapter 5: Possible Indicators. See: <http://www.abs.gov.au/Ausstats/abs>

	<p>namely the USA, EU and Japan. This should be assisted by South Africa's trade relationships with these countries, for example the European - South African Science and Technology Advancement Programme.</p> <ul style="list-style-type: none"> ▪ Scope to promote Open Access scholarly communication as an overt intervention regarding knowledge diffusion (needs policy intervention). ▪ Scope to work through the remedies for South Africa falling behind in Internet and broadband penetration. ▪ South Africa has to compete on an R&D front against Europe and elsewhere where significant investment is taking place in ICT infrastructure relevant to R&D. ▪ The SANReN network is crucial for the universities and major research institutions. ▪ South Africa is under-provided with science/technology parks and needs to address this deficiency, possibly following the Innovation Hub precedence. ▪ With technology being seen by the major international aid funding bodies as a key component of economic self-sufficiency, South Africa can focus on innovative ICT solutions addressing the needs of the developing world. For example, South Africa is probably the best-placed country to service the rest of Africa.
THREATS	<ul style="list-style-type: none"> ▪ Stiff competition from numerous countries which are not only better placed than South Africa with regard to ICT R&D, but are highly committed at both government and private sector levels. ▪ World economic and/or political problems, which are forcing a re-think of all priorities.

3.9 Summary of Current State of ICT R&D in South Africa

The overall position of ICT in general and ICT R&D in particular would seem to put South Africa in the second quartile of the world's 100 largest countries, which means that it generally lies well behind OECD countries but is still significantly ahead of numerous other developing countries. There is evidence, however, that South Africa's position started to slip during the 1990s in relation to some key indicators of global rankings for ICT R&D.

Other key points:

- ICT R&D expenditure in South Africa was less than 0.1 percent of GDP in 2003/04. There has been an increase from the previous year for two key categories, namely government and science councils, and business. But the drop indicated for the higher education sector is cause for concern.
- Strategies are required to develop a healthier pipeline of human resources with advanced capabilities in ICT. This should include engineering skills, which are crucial to technology transfer.
- There are conspicuous gaps in the area of the Internet. It is necessary to find the reasons for South Africa having fallen so far behind in Internet/broadband penetration, e-commerce, and so on, and to find ways of closing the gap.

- Measures are needed to encourage R&D and innovation in the private sector through appropriate incentives.
- There is scope for increasing collaboration with countries that are leading R&D countries, which should be assisted by South Africa's trade relationships with these countries. An example of a collaborative initiative is the South African Science and Technology Advancement Programme.
- With technology being seen by the major international aid funding bodies as a key component of economic self-sufficiency, South Africa can focus on innovative ICT solutions that address the needs of the developing world.

Following on from the current snapshot of ICT in South Africa given in this chapter, the following chapter describes a set of strategic objectives for attaining the ICT vision and mission, as presented in Chapter 2.

4 ICT R&D AND INNOVATION STRATEGY OBJECTIVES

The ICT R&D and Innovation Strategy is based on a vision for ICT as discussed in Chapter 2. Three strategic objectives have been determined as key to realising the vision of the strategy. A further four supporting objectives will be pursued based on this vision and taking into account the current reality discussed in Chapter 3. These strategic and supporting objectives will guide the implementation of specific interventions and will serve as measurable milestones in pursuing the vision. The objectives are framed in terms of the requirements for attaining the vision of the ICT R&D and Innovation Strategy as outlined previously.

There are three key strategic objectives, which in turn are enabled by a set of four supporting objectives (See Figure 9).

The **strategic objectives** of the ICT R&D and Innovation Strategy are:

- **Strategic Objective 1:** Develop **focused world-class research** - focus and strengthen research activities at HEIs and R&D institutions to create identified world-class research competencies in the country.
- **Strategic Objective 2:** Build a **strong and robust innovation chain** – establish a strong and robust innovation chain that results in increased ICT patenting, improvements in digital divide indicators and a vibrant hi-tech ICT SMME industry.
- **Strategic Objective 3:** Build **advanced human resource capacity** - achieve a pronounced increase in the advanced ICT skills base to improve the absorptive capacity in ICT and thereby enable focused world-class research and a strong and robust innovation chain.

These strategic objectives and the vision of the strategy will be supported by the following **supporting objectives**:

- **Supporting Objective 1:** Establish and maintain **an effective research infrastructure** – establish a powerful research infrastructure that supports focused research and local and international collaboration.
- **Supporting Objective 2:** Foster **vibrant international cooperation** – create strong R&D links with those countries that are the leading players in world ICT R&D, including South-South collaboration, to accelerate the achievement of objectives 1 to 3.
- **Supporting Objective 3:** Provide **ICT policy, institutional and other support** – implement effective policy and other support structures at the DST, its agencies and HEIs in support of the strategy.
- **Supporting Objective 4:** Adequately **resource the ICT R&D and innovation system** through funding that places South Africa on a course on which ICT GERD will start approaching OECD levels by 2015.

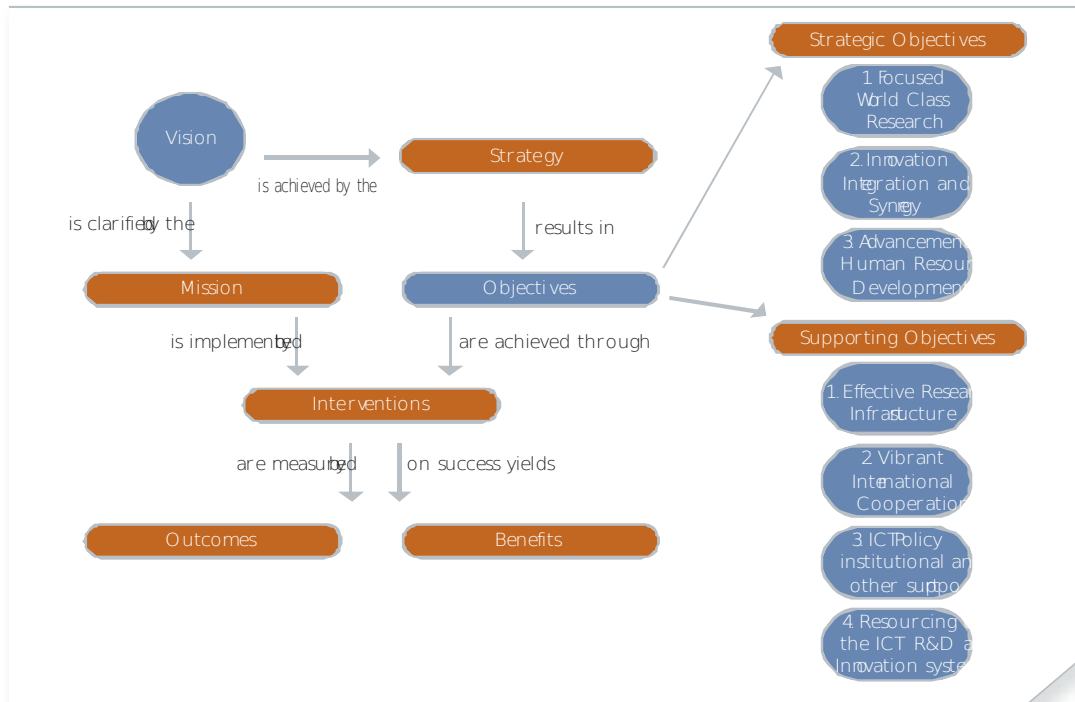


Figure 9: Strategic and supporting objectives of the ICT R&D and Innovation Strategy

The objectives of the strategy are discussed below, along with approaches to achieving them.

4.1 Strategic Objectives

The key strategic objectives are discussed in the following three sub-sections:

4.1.1 Strategic Objective 1: Focused World-Class Research

To achieve global prominence in ICT R&D and innovation, the strategy will position South Africa to overcome the challenges of the current reality, which is ICT R&D that is unfocused, largely fragmented and late-stage. Focused world-class research is essential and will achieve the following:

- Increase the intensity of effective public and private R&D by coordinating the R&D agenda set by the many actors in this effort.
- Balance and focus the portfolio of R&D initiatives required to address both market needs and market neglect in domains that are clearly identified.

- Drive multi-disciplinary and cross-cutting R&D; develop world-class competence by developing excellent people and communication networks supported by the resourcing of sufficient scale and scope for the identified domains.

The ICT R&D and Innovation Strategy objective for **focused research** is to focus, group and strengthen research activities at HEIs and R&D institutions to create identified world-class research competencies in the country. Achievement of the objective will be evident through improvements in research output as measured by publication rates and the citation index, and by the rating of ICT researchers. This will be accompanied by close collaboration between the public sector, the private sector and academic institutions.

Strategies and actions that support the objective include:

- Identifying and supporting key technology domains that can be used in multiple application domains where global differentiation can be achieved.
- Identifying and supporting key application domains that combine multiple technology domains and contribute to improved quality of life or enhanced economic competitiveness.
- Establishing focused research units (national research centres) at relevant institutions. This includes centres and other initiatives in partnership with industry and with industry involvement in advisory structures of other units.
- Creating networks of researchers, industry and other role-players collaborating in joint research plans, both local and international.
- Supporting directed R&D projects that address identified socio-economic needs, including areas of market neglect.
- “Seeding the future” by ensuring support for areas outside the identified focus areas to ensure renewal of the portfolio of focused research domains.
- Conducting regular fore sighting and road mapping updates continuously to calibrate and update the focus domains that are being supported.

4.1.2 Strategic Objective 2: Strong and Robust Innovation Chain

A key challenge is to create an environment in which ICT-based innovation flourishes, originating from different levels of society. A strong and sustainable ICT R&D environment is not possible if R&D is confined to universities and science councils. This necessitates the development of a robust innovation chain. The innovation chain must support the migration of ideas, theories and other outputs from fundamental and basic research to application to market needs and to problem solving in areas of market failure.

For market needs to be successfully addressed, industry needs to participate actively in helping universities and training institutions to do more and to deliver more relevant R&D outputs. Strong industry linkages have the potential to bring about a significant increase in training and research activities. Interventions such as the National ICT Roadmap process are critical for facilitating a seamless flow of knowledge, intellectual property and people between academia and industry.

Quality of life issues are not always naturally addressed by market forces and specific interventions are required to ensure that R&D and innovation in ICT benefit communities in general.

The ICT R&D and Innovation Strategy objective for realising the benefits of ICT through **technological innovation** is to support the creation of new technology platforms, products and services and to establish a robust innovation chain, all of which will result in increased ICT patenting, improvements in digital divide indicators and a vibrant hi-tech ICT SMME industry with new players and new markets. The objective includes undertaking large, directed R&D projects that tackle specific societal or industrial challenges in a strategic and critical mass fashion. The innovation pipeline will facilitate local and international collaboration and effective technology transfer.

A robust innovation chain supporting the migration of early-stage R&D through research and innovation stages that lead to the exploitation of research results will be created. Strategies and actions that support the objective include:

- Setting national grand challenges to stimulate integrative R&D and inspire researchers and research groups;
- Identifying and supporting large-scale collaborative innovation projects that build on local research and involve HEIs, research institutions, industry and relevant government structures;
- Implementing processes and structures for regularly updating and reviewing the national ICT Roadmap;
- Expanding national initiatives promoting co-investment from industry in ICT R&D projects (especially via funding of collaborative research activities and tax incentives);
- Developing or refining indicators and processes to assess the state of ICT R&D and innovation accurately;
- Support for institutions at various points in the innovation chain and implementing mechanisms for the flow of ideas, technologies and people;
- Marketing of R&D outputs and outcomes and market development;
- Setting up an implementation framework for industry to use the outputs of R&D and innovation; and
- Creating mechanisms that actively facilitate cooperation between industry, research institutions and HEIs (e.g. business incubators, technology clusters and science/technology parks).

4.1.3 Strategic Objective 3: Advanced Human Resource Capacity

Research findings worldwide indicate the need for knowledge production to generate new ideas, products and technologies in support of a modern economy. This is predicated upon the creation of an adequate pool of highly qualified ICT professionals, supported by requisite mid-level skills, forming a fundamental building block in a national ICT R&D and

Innovation Strategy. Current challenges in relation to human resource capacity are highlighted in Chapter 3. To support the ambitious ICT R&D goals, Human Resource Development (HRD) interventions must expand the number and increase the demographic diversity of the academic and industrial labour force as well as increase the number of students involved in postgraduate research. This must be supported by measures that encourage the pursuit of basic and advanced qualifications, retention of researchers and innovators in the R&D and innovation system and leveraging international collaboration. HEIs will continue to play a primary role in postgraduate teaching and this will be supported by the strategy.

The ICT R&D and Innovation Strategy objective for **advanced human resource capacity** is to achieve a pronounced increase in the advanced ICT skills base. This should bring South Africa closer to OECD levels of PhDs and Full-time Equivalent (FTE) researchers as a percentage of the population. Strong engineering skills to support technology development and transfer are also required. The objective is to enable local innovation that will support socio-economic development by developing young graduates, leveraging and enhancing existing skills and implementing transformation in terms of gender and race. This will support the ambitious ICT R&D goals with a healthy human resource profile that includes sufficient leadership capacity.

In addition to the advanced level skills that are required for world-class R&D and Innovation in ICT, the need for mid-level skills to industrialise the innovations resulting from the strategy is recognised. Addressing these needs is beyond the scope of this strategy, but the DST and its agencies will work with other players to do this.

Strategies and actions that support the objective include:

- Implementing a supportive environment and funding mechanisms which allow young people to work under the leadership of experienced ICT professionals while pursuing postgraduate qualifications.
- Creating advanced ICT skills development programmes aligned to the ICT R&D and Innovation Strategy, including advanced academic qualifications and skills as well as entrepreneurial orientation.
- Establishing mechanisms for re-training people mid-career and allowing senior scientists and engineers to pursue postgraduate studies, thereby enriching the pool of diverse skills available to the ICT sector and building the necessary leadership capacity.
- Establishing programmes that facilitate higher levels of cooperation between industry and academia, including a healthy flow of ICT professionals between these sectors.
- Implementing affirmative programmes and initiatives to promote a more representative population of skilled ICT people in terms of gender and race.
- Supporting career paths in research institutions and HEIs to create the leadership and supervisory capacity necessary for high-quality, high-level student throughput and advancement to internationally recognised expertise (the establishment of

research chairs, appropriate remuneration and creating greater awareness of career paths in research and innovation²⁸ are needed for this).

- Exchange mechanisms that will allow young researchers to be exposed to the global research environment and senior overseas scientists to provide intellectual and technical leadership to young researchers.

4.2 Supporting Objectives

In order to achieve the above **strategic objectives**, there are four key **supporting objectives** that will enable the strategic objectives and vision of the strategy to be realised. The associated but more specific interventions are outlined in Section 5.2.

4.2.1 Supporting Objective 1: R&D and Innovation Infrastructure

Sufficient and appropriate infrastructure is required for world-class collaborative research, application development and the development of human resources. Effective R&D collaboration is only possible if a sound enabling infrastructure exists to support the interaction between individuals and institutions.

A 2003 landmark report commissioned by the US National Science Foundation states:

*'The research community needs more broadly trained personnel with blended expertise in disciplinary science or engineering, mathematical and computational modelling, numerical methods, visualization, and the socio-technical understanding about working in new grid or collaborative organizations. Grid and collaborative environments built on cyber infrastructure can enable people to work routinely with colleagues at distant institutions, even ones that are not traditionally considered research universities, and with junior scientists and students as genuine peers, despite differences in age, experience, race, or physical ability. These new environments can contribute to science and engineering education by providing interesting resources, exciting experiences, and expert mentoring of students, faculty, and teachers anywhere there is access to the Web. The new tools, resources, human capacity building, and organizational structures emerging from these activities will also eventually have even broader beneficial impact on the future of education at all levels and likely on all types of educational institutions.'*²⁹

The ICT R&D and Innovation Strategy objective for **R&D and Innovation Infrastructure** is to implement effective research infrastructure supporting the research and innovation environment and international collaboration aspects of the strategy³⁰. This includes establishing a powerful SANReN that supports large-scale, nationally cross-cutting ITC R&D and innovation. SANReN should establish strong linkages to other NRENs across the

²⁸ See for example: Address by Derek Hanekom, Deputy Minister of Science and Technology, at the launch of the African Advanced Institute for ICT (AIICT), 17 May 2005 at the CSIR.

²⁹ Revolutionizing Science and Engineering Through Cyber Infrastructure, January 2003. Report of the National Science Foundation Blue Ribbon Advisory Panel on Cyber Infrastructure, <http://www.nsf.gov/od/oci/reports/toc.jsp>, Page ES3

³⁰ This needs to tie in with the National Research Infrastructure Strategy.

world (such as the European Géant network, CANARIE (Canada) and AREN/AARNET (Australia) to facilitate international collaborative R&D in general and ICT specifically.

Many other ICT fields require equipment and other infrastructure. Examples include high-performance computing infrastructure, wireless communication test beds, and facilities supporting application-orientated research such as a technology-enhanced learning laboratory or a tele-health laboratory.

Strategies and actions that support the objective include:

- Proactively identifying research infrastructure needs and long-term planning;
- Undertaking large projects to develop suitable research infrastructure; and
- Implementing mechanisms to share research infrastructure effectively.

4.2.2 Supporting Objective 2: International Cooperation

International cooperation can fast-track the improvements in the ICT R&D system envisaged by the strategy. South-South collaboration can contribute to addressing needs that are specific to the developing world or that build on strengths in the South to support regional integration. The objective is to create strong R&D links with those countries that are the leading players in world ICT R&D and that support regional integration through mechanisms that go beyond project-level approaches and individual researcher relationships:

- Support meaningful cooperation in R&D and innovation with counterpart international scientists and engineers.
- Enable interaction between local actors in the innovation chain (industry, incubators, science/technology parks, HEIs and R&D institutions) and international counterparts.
- Connect entrepreneurs with markets, sources of venture capital and role-players in key international locations.
- Support regular and well-targeted overseas study tours by appropriate policy makers, research managers and senior researchers to investigate at first hand significant ICT research infrastructure/services, to tap into current experience, to keep abreast of government policy, and to attend conferences for networking. Also, to bring international experts to South Africa, thereby promoting broader exposure to international leaders and thinkers.

Strategies and actions that support the objective include:

- Supporting science and technology networking through international conferences and participation in international forums;
- Implementing mechanisms that promote long-term institution-to-institution partnerships including initiatives beyond individual projects with multiple partners in different countries;

- Implementing mechanisms, such as the European-South African Science and Technology Advancement Programme, that allow local and overseas researchers to work together on research tasks;
- Creating opportunities for technical skills and knowledge exchange, sharing of problem solving and planning approaches and the joint pursuit of challenging research goals;
- Supporting visiting overseas scientists to work with South African research groups to inject new knowledge and accelerate the development of research groups;
- Seconding of South Africans to overseas research groups to develop new research competencies and to advance local skills;
- Leveraging competitive and donor/foundation funding for international collaboration to create the necessary financial resources and links between researchers; and
- Supporting global and regional research partnerships specifically focused on objectives of the strategy with the support of governments and donor agencies, and leveraging these to create longer-term international networks that work and contribute to HRD, technology transfer, creation of markets and research collaboration.

4.2.3 Supporting Objective 3: ICT Policy Initiatives, Institutional and other Support Structures

In order for the strategy to be realised, its research, innovation environment and human capital objectives need to ensure that institutional and other support structures at the DST, its agencies and HEIs implement effective intelligence, strategic R&D management, guidance and direction-setting instruments, review mechanisms, as well as an enabling policy and regulatory environment.

Institutional infrastructure and other support structures that are required include:

- Technology road mapping and other futures research
- Internet Protocol (IP) and commercialisation support
- An enabling policy and regulation regime

Strategies and actions that support the objective include:

- Establishing a governance and support structure for the ICT R&D and Innovation Strategy
- Engaging in policy and regulatory issues to ensure support of the vision and objectives of the strategy
- Ensuring supportive regulation in other government departments, such as the Department of Home Affairs, and universities for measures that support the inward mobility of foreign scientists, engineers and other staff required for effective research and innovation

- Encouraging HEIs to incorporate strategic IP management as a core subject for undergraduate, postgraduate and research students of courses that typically lead to ICT-related careers
- Providing guidance to companies and public research institutions on how to develop appropriate IP management policies, procedures and employment and technology agreements³¹
- Implementing a policy whereby publicly funded ICT R&D institutions will be required to prepare and report annually on their IP management and commercialisation policies, procedures, agreements and outcomes
- Industry and government working with public research institutions to identify ways to facilitate better access to IP generated in those institutions
- Implementing a comprehensive set of ICT R&D indicators, taking into account that the most appropriate indicators will change over time for some characteristics.

4.2.4 Supporting Objective 4: Resourcing of the ICT R&D and Innovation Strategy

In order to create a sustainable ICT R&D and Innovation Strategy framework, the means and mechanisms to resource the strategy need to be addressed, including public funding and private sector involvement. Critical to addressing these resource issues are the appropriate coordination and streamlining of new and current resources to meet the objectives of the ICT R&D and Innovation Strategy.

An appropriate funding framework must:

- support the institutions that focus on R&D;
- provide incentives for large companies in the ICT industry to fund and participate in R&D; and
- enable ICT SMMEs to obtain funding efficiently to perform and absorb R&D.

This framework must also support commercialisation and developmental application of the fruits of the R&D effort. Existing funding mechanisms for ICT R&D must be aligned with this framework.

The objective for **resourcing of the ICT R&D and Innovation Strategy** is to provide funding that supports the research, innovation and human capital objectives of the strategy. It also places South Africa on a course on which ICT GERD will start approaching OECD levels by 2015. Effective resourcing is aimed at:

- Ensuring higher levels (critical mass) of national activity in ICT R&D and innovation.
- Ensuring that remaining gaps in the innovation chain are addressed.

Strategies/actions that support the objective include:

³¹ Sponsor: Australian Government, Australian Research Council. See: www.arc.gov.au/grant_programs/national_ip.htm

- The establishment of national funding for ICT R&D and Innovation (as a line item budget for the DST) to support the research, innovation and human capital development objectives of the strategy;
- A review of existing funding schemes and mechanisms supporting ICT R&D, and refocusing funding to align with the strategy and themes and issues that it identifies;
- A review of international funding sources and funding schemes, and the establishment of focused efforts to access these sources where appropriate (for example, the EU Framework Programmes and the Japan International Cooperation Agency (JICA));
- The creation of research and innovation institutional capacity as effective instruments for investing increased funding levels;
- Organisational control, matching distribution of funds with expected results according to approaches and processes similar to R&D funding in single organisations which have a significant interest in the outcome and progress of their R&D; and
- Implementing strategies to secure donor agencies and foundation funding and creating incentives that will attract multinational corporations (MNCs) to South Africa.

4.3 Summary

It is intended that the vision of the ICT R&D and Innovation Strategy will be achieved through effective implementation within the framework provided by the objectives, enabling strategies and implementation actions outlined in this chapter.

Referring to the SWOT analysis in Section 3.8, it is important to recognise that resource constraints and changing economic and global market conditions may affect some of the strategies and actions for implementation.

The next chapter discusses the specific range of targeted and determined interventions that will implement the strategy.

It should be noted that it is intended that the strategy and its implementation will be reviewed after three or four years. The review results, together with the results of the ICT-foresight study, will feed into a revision of the strategy (see Section 5.1).

5 ICT R&D and Innovation Strategy Implementation

5.1 Implementation Overview

The vision of the ICT R&D and Innovation Strategy will be achieved through:

- Implementing a set of nine interventions that support the strategic and supporting objectives
- Setting national goals captured in key performance indicators (KPIs) and cascaded to appropriate levels to enable the implementation of the strategy to be effectively measured
- Assigning responsibility for key aspects of the strategy implementation to specific role-players.

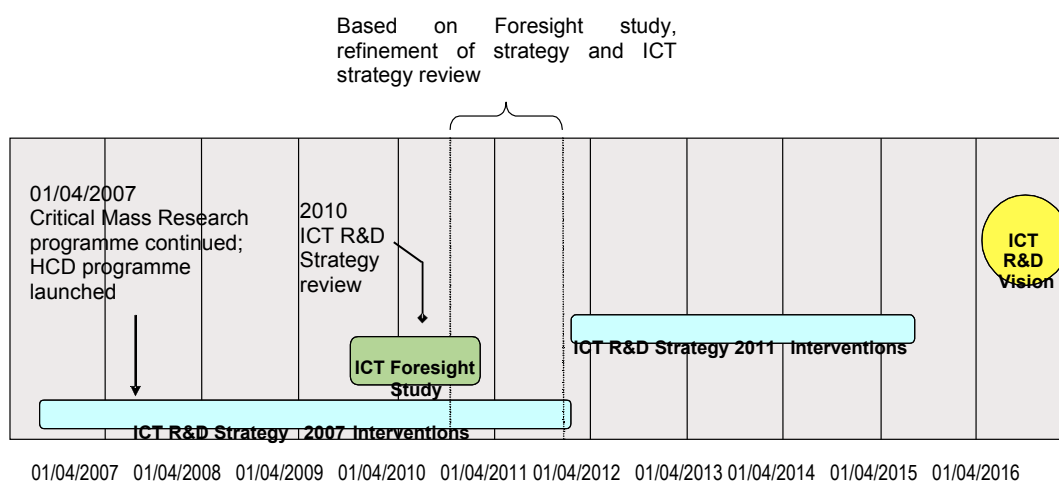


Figure 10: ICT R&D and Innovation Strategy timeline

The timeline for the implementation of the strategy is illustrated in Figure 10. The strategy and its implementation will be reviewed after three or four years by a panel that will include international experts. An ICT foresight study will be undertaken in 2009, which together with the results of the review, will feed into a revision of the strategy. This could include new interventions or changes to the interventions initiated in the first three or four years. This process would be repeated after another three or four years.

5.2 ICT R&D and Innovation Strategy Interventions

The vision of the ICT R&D and Innovation Strategy will be achieved through effective implementation within the framework provided by the objectives outlined in the previous chapter. This chapter discusses the specific interventions that will implement the strategy.

A set of nine interventions has been proposed and is summarised in Figure 11.

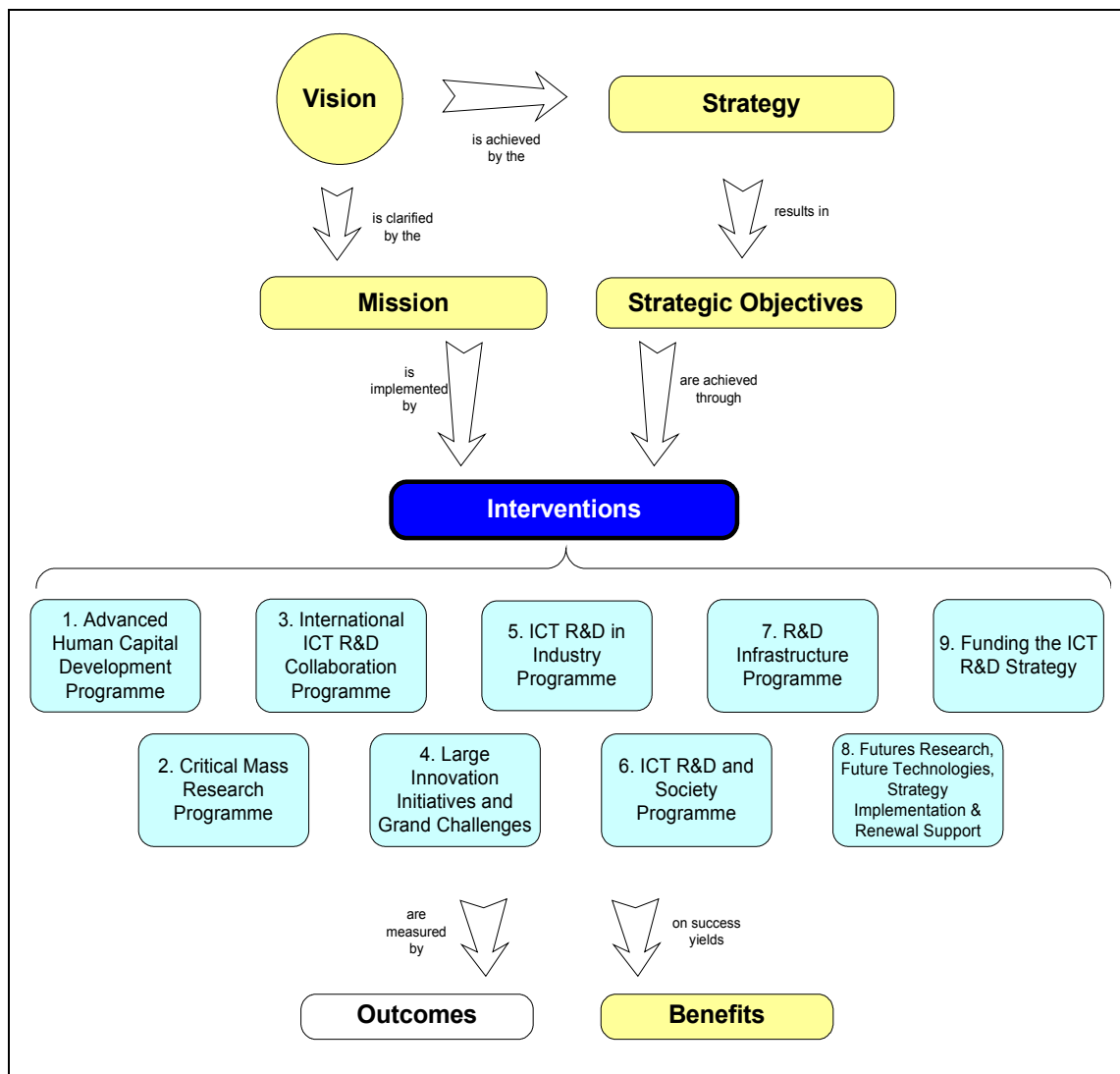


Figure 11: Summary of interventions of the ICT R&D and Innovation Strategy

5.2.1 Intervention 1: Advanced Human Capital Development Programme

The Advanced Human Capital Development Programme aims to change the current low enrolment rate of postgraduate students in ICT dramatically. The goal is to increase the number of PhDs graduating annually from around 20 (in 2004) to 300 by 2015, and increase the number of ICT Masters degree candidates graduating annually to almost 500. This is in order to bring South Africa closer to OECD levels in terms of PhDs per thousand of the population. This is not only a requirement of focused world-class research, but is

also essential to implementing a robust innovation chain and for effective international collaboration. It will also supply South African Industry with highly qualified people, thereby helping to improve industry's ability to absorb new technology and engage in local R&D. It will implement specific measures needed to encourage women researchers to pursue research careers and higher degrees.

The Advanced Human Capital Development Programme will build synergies with the DST's Human Capital programmes and with the Human Capacity Development Programme of the National Research Foundation.

The Advanced Human Capital Development Programme draws on similar models that are being used in Germany, Canada and India. It will support PhD and Master students to do research under the guidance of experienced researchers at the Meraka Institute and HEIs. Young researchers will work as students in employment, gaining professional experience while pursuing their postgraduate studies. They will benefit from working in research groups pursuing the goals of a long-term research plan. This high throughput employment model will be a key mechanism for technology transfer to industry. It is expected that many graduates will eventually start their own hi-tech SMMEs based on their research and the excellent contacts that they should have by then established domestically and overseas.

Figure 12 shows the number of PhD and Master degree students which should be supported in order to reach the ambitious target of 300 ICT PhD graduates annually by 2015. The model assumes that the enabling environment created by the strategy will allow a high percentage of PhDs to be completed in three years and most Master degrees in two years. It is also assumed that the current enrolment will be supplemented by the additional opportunities created by the ICT R&D and Innovation Strategy.

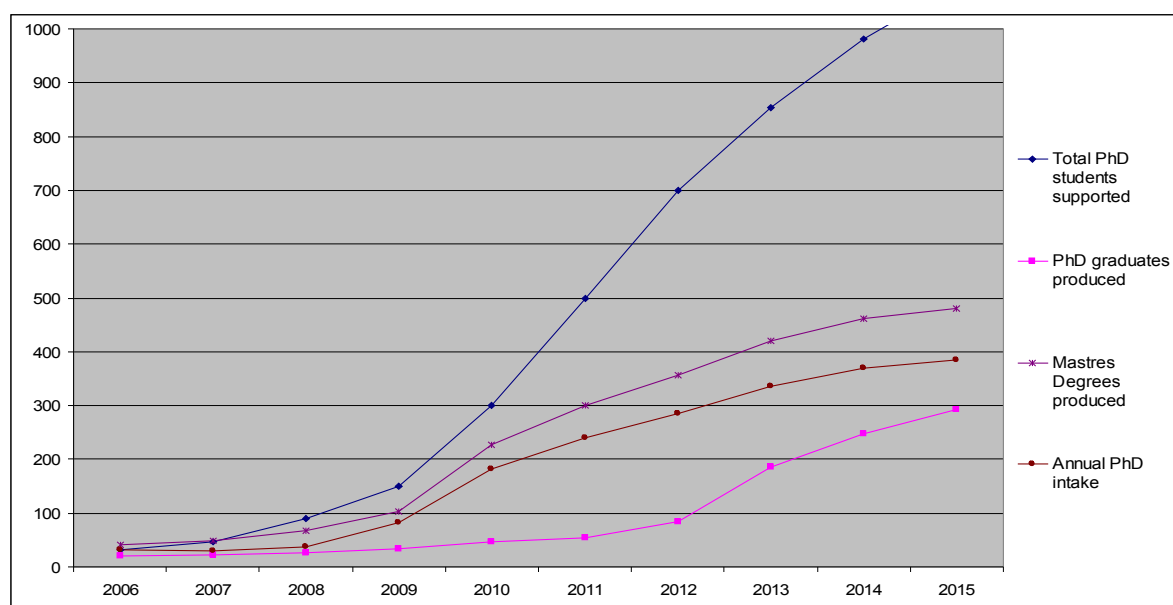


Figure 12: PhD and Master intake and projected graduation rates

The Advanced Human Capital Development intervention of the ICT R&D and Innovation Strategy will therefore support postgraduate studies through bursaries and internships as indicated in . The programme depends on the technological and intellectual leadership that will be provided by academics and researchers supported through the Critical Mass Research Programme. The programme will specifically support women researchers and black researchers in order to address current imbalances and to leverage the entire talent pool.

Table 5: Advanced Human Capital Development Programme (Years 1 to 4)

	2007	2008	2009	2010
PhD Studentships	15	25	50	75
PhD Bursaries	5	15	25	40
Masters Student-ships	25	33	48	60
Masters Bursaries	10	35	50	95

An important mechanism that will be leveraged for implementation of the strategy in support of all three the strategic objectives, but in particular for human capital development, is the presence of Multinationals. The DST's MESIP programme provides seed funding and other support to enable investments by Multinationals to invest in local R&D centres which has already resulted in R&D cooperation with SAP, Intel, Cisco and Nokia.

5.2.2 Intervention 2: Critical Mass Research Programme

The Critical Mass Research Programme will contribute to realising the vision and objectives of the ICT R&D and Innovation Strategy by bringing focus and critical mass to R&D in carefully selected technology and application domains. The set of activities that will be supported will catalyse world-class ICT R&D. In each case, critical mass R&D will be supported by an appropriate organisational form that will link existing researchers in the field and will bring new researchers, including post-doctoral researchers and international experts, on board.

Students in employment doing PhD research and Master degrees supported by the Advanced Human Capital Development Programme will work side by side with experienced researchers and academics on research tasks organised into a long-term research plan with a comprehensive research roadmap. Research spanning the innovation chain from strategic basic research through to applied research, experimental development and pilot deployment will be supported.

The intervention will support researchers working on long-term research plans providing for stability and continuity in funding. The intervention directly supports the advanced human resource development (HRD), focused world-class research and robust innovation chain objectives of the strategy.

A number of domains of intervention have been identified through various processes such as the foresight processes, SAITIS studies, the Meraka Institute planning process and the ICT Roadmap. The strategy initially plans to support 12 R&D domains as described in Table 6 below. Further planning processes will determine strategies for other domains.

Table 6: Critical mass research and development domains

1.Mobile, Wireless and Satellite Technologies
2.Computational Science and High-Performance Computing
3.Geomatics and Spatial Technologies
4.Open Source, Software Engineering and Software Architecture
5.Education
6.Health
7.ICT for Disability
8.Human Language Technology
9.e-Government and Service Delivery
10.ICT in Manufacturing
11.Information Security
12.Human Computer Interaction

The initial set of technology domains was selected on the basis of:

- the extent of existing strengths;
- support for addressing needs in society or industry;
- alignment with the National R&D Strategy and other relevant policies;
- support for multiple applications with a high likelihood of commercialisation; and
- the likelihood of reaching world-class status among and differentiation from developed world ICT players due to local conditions.

The selected application areas were chosen because of their significant impact on the quality of life, access to economic opportunity for communities, and the beneficial impact on the downstream creation of jobs and local industries.

In both cases the potential for migration of technology outputs to industry and their application in society were additional selection factors. These considerations will influence the direction of the research plans in the domains.

Critical mass research will be implemented according to the following models, depending on the specific circumstances and goals in the domain:

- **National Research Centre:** a central facility at an HEI or the Meraka Institute pursuing a research plan focused on a selected technology domain staffed by sufficient numbers of highly skilled people with world-class equipment and other infrastructure.
- **Technology Research Network (TRN):** a network of researchers pursuing a joint research plan focused on a selected technology domain consisting of a number of nodes at the Meraka Institute and various HEIs. Different nodes may specialise in particular aspects of the research plan.
- **Applied Research Network (ARN):** a network of researchers pursuing research focused on significant socio-economic challenges. A core of specialists, integrators, analysts, researchers and developers at the Meraka Institute will work with researchers in multiple disciplines located at HEIs and other research institutions. ARNs will also include industry research laboratories as nodes.

In all three models the existing capacity and institutional infrastructure at science councils, universities and in industry will be leveraged to accelerate the attainment of critical mass. The centre model will be particularly appropriate where research capacity is established in a new technology domain. The technology research network may be more appropriate where pockets of excellence already exist in a technology domain at geographically distributed nodes and where these can be harnessed to pursue a common research plan. Similarly, the expertise required to address a specific application domain may reside in different groups and institutions. The proposed network models can be considered distributed research centres. In all cases strong leadership and governance structures will be implemented. In line with the strategy's strong collaborative focus, linkage with international networks will be pursued.

The 12 domains are described in more detail in Table 8 in Appendix A, along with the proposed implementation of critical mass research activity for the domain. A process for setting up research centres, technology research networks and applied research networks is currently being developed. This will ensure a rigorous planning process to maximise the investments in the proposed domains and ensure appropriate participation in the planning process.

The success of the intervention will be managed and monitored through:

- International peer review of research plans and progress against these plans;
- Improvements in publication rates especially in peer-reviewed journals;
- Relative Citation Index as a measure of the quality and relevance of scientific output;
- Improvements in the numbers of rated researchers in ICT; and

- Downstream value created by research, such as patents, software and other intellectual property, technology ventures and products and services contributing to quality of life.

5.2.3 Intervention 3: International ICT R&D Collaboration Programme

Since 1994, considerable progress has been made in re-integrating South Africa into the global science and technology community. Bilateral and multilateral agreements have been concluded with a range of countries and considerable goodwill and desire for collaboration exists. International collaboration is an effective mechanism for rapid advances in local R&D. The ICT R&D collaboration programme will contribute to the objectives of the ICT R&D and Innovation Strategy through collaboration with countries with advanced ICT R&D capacity as well as with countries in the South facing similar challenges.

As highlighted in the SWOT analysis in Chapter 3 (see Table 4), there is scope for increasing collaboration with the leading R&D regions and countries, namely the US, EU and Japan. This should be assisted by South Africa's trade relationships with these regions and countries.

R&D collaboration will be driven by the DST's International Cooperation and Resources programme. It will be affected through three primary mechanisms: collaborative R&D programmes, researcher mobility, and science and technology networking. These are discussed below.

- **Collaborative R&D programmes:** International collaborative programmes allow researchers from different countries to work together on research and innovation projects that contribute to common goals. Benefits range from detailed technical skills exchange to learning new problem-solving and planning approaches. Knowledge and skills exchange between South African researchers and their overseas counterparts will be achieved by researchers and research groups working towards common goals and contributing in complementary ways on exciting research projects.
- **Researcher mobility:** A specific mechanism in conjunction with the broader HRD intervention is support for visiting overseas scientists working with South African research groups. Important injections of knowledge will be achieved and the development of such groups and their researchers accelerated. Similarly, the secondment of South African researchers and students to overseas research groups will contribute significantly to the development of new research competencies and the advancement of local skills.
- **Science and technology networking:** Advances in science and technology are to a large extent made through global collaborative effort. The strategy will support South African ICT researchers' participation, the organising of international conferences, and membership of the International Federation for Information Processing (IFIP) working groups, the Institute of Electrical and Electronics Engineers (IEEE), the International Telecommunications Society, the Internet Society and other standards and coordinating bodies in ICT.

- **Multinational Industry Collaboration:** A number of large multinational ICT companies are present in South Africa. Currently most of these do not undertake R&D in South Africa. The ICT R&D and Innovation Strategy will address a number of prerequisites enabling such investments including focus and direction in the technology and application topics that will be supported, the development of high-level skills and greater levels of publicly funded R&D. In addition to these enabling measures, specific measures will be taken to encourage investments by multinationals in local R&D centres and other forms of R&D cooperation.

Collaboration with different countries or regions will be tailored to their strengths and specific conditions. Some regions are discussed in more detail below:

- **Europe** – R&D collaboration with the EU is at an advanced stage, particularly through South African participation in the Framework Programmes³². This will be the key mechanism for R&D cooperation and the intervention will focus on supporting South African groups in building strong relationships with institutions in Europe, the preparation of joint project proposals and supplementing funding from the framework programme. Bilateral and multilateral collaboration with institutes will complement the work under the framework programme. Collaboration on R&D infrastructure through GEANT is an additional area of cooperation.
- **Japan** – R&D collaboration under the bilateral agreements between South Africa and Japan will focus on R&D infrastructure, long-term collaboration in specific ICT topics, exchange of people, and futures research. JICA can be a key vehicle for facilitating collaboration with Japan.³³
- **United States** – R&D collaboration with the United States under bilateral agreement and with the involvement of the National Science Foundation will enable joint projects, institution-to-institution relationships and exchange of people. The US is not only a big market, but a large percentage of global ICT R&D is undertaken there.
- **India** – India and South Africa share many challenges and opportunities, including language diversity, biodiversity, the need to eradicate poverty, and the achievement of socio-economic development goals. The two countries have complementary skills in ICT. To explore the potential for collaboration in ICT an Indo-SA workshop on Advanced Computing was held in October 2002. The workshop concluded with a recommendation for collaboration in areas such as human language technologies, open source software, bioinformatics, and high performance computing. Mechanisms for cooperation that are envisaged include: networks of researchers engaged in bilateral, multilateral and multi-disciplinary collaboration; collaborative projects that contribute significantly to the national strategies for social equity, poverty alleviation and economic development; information and resource sharing; exchange of people; regular meetings, symposia and conferences to promote dialogue between researchers; and development of policy and other support for the national system of innovation.

³² Example: the *European - South African Science and Technology Advancement Programme*.

³³ See for example: <http://www.jica.go.jp/english/countries/af/index.html>

- **Australia** – The Australian governments (Federal and State) have established a systemic approach to funding R&D and promoting innovation with a range of schemes including tax incentives, grant schemes for both business and research institutions, and financial incentives for industry and the research community to interact with each other. Over the past two to three years, national priorities have been established to further focus research expenditure on the role of ICT in enhancing productivity throughout the economy. Australia also supports the development of the Internet economy through a regulatory and policy environment conducive to the development of e-business (ranked in the top few globally).

Australia has a sophisticated ICT market (the eleventh largest ICT market in the world) characterised by rapid growth and a high level of implementation of ICT technology by governments, business and consumers. The Australian industry is highly regarded for its ability to develop integrated business solutions through applied ICT technology.

Australia is therefore in a relatively advanced position in ICT and R&D, and policy-level collaboration can contribute significantly to advancement of the ICT R&D and Innovation Strategy's goals.

- **Canada** - The ICT sector contributed some C\$58 billion to Canada's GDP in 2001 - representing 6.2 per cent of the total economy. ICT is one of the most R&D-intensive sectors in Canada, as measured by R&D-to-sales ratio, and represents over one-third of all industry R&D spending. TRILabs is Canada's largest not-for-profit ICT research consortium. It is internationally recognised as a leading model for industry-university-government collaboration with research divisions in data networking, home technologies, network access, network systems, new media photonics and wireless communication. Collaboration with Canada through researcher mobility and collaborative projects can significantly contribute to the goals of the strategy and can build on existing cooperation with Canada through the International Development Research Centre (IDRC). The IDRC can also prove an important partner in ICT research collaboration in Africa.
- **China** – China is investing extensively in R&D capabilities and ICT manufacturing. In this regard, China and India are exploring synergistic opportunities in their respective strengths of hardware and software. Collaboration with China will be through the Chinese Academy of Sciences – Institute of Computing Technology with a view to building relationships between R&D institutions and engaging in joint R&D.
- **South Korea** – South Korea's ICT infrastructure rollout programme is the envy of the world. New innovative ICT devices are developed and first introduced in the Korean market before they make an appearance elsewhere, even in the attractive US market. This provides an excellent opportunity for studying the impact of ICT on society, to keep abreast of possible ICT futures research and to try out new technologies that can also find application in Africa and the rest of the developing world.
- **Africa** – NEPAD and the e-Africa commission specifically provide the framework within which collaboration with African researchers will be strengthened. Africa and the region

are crucial areas of impact for the ICT R&D and Innovation Strategy. The aim will be to develop areas of research, coordinate R&D competence building efforts between African nations, and ensure the diffusion of ICT innovations to address continental challenges.

The extent and quality of collaboration will be monitored by keeping track of joint projects, South African success in competitive processes such as the EU Framework Programmes (in particular, the information society technologies thematic area). The results and outcomes of the projects will also be monitored, including joint publications, patents and new products and services generating from ICT R&D.

5.2.4 Intervention 4: Large Innovation Initiatives and Grand Challenges

As the National R&D Strategy proposes, the gap between knowledge generation and the market, known as the innovation chasm, has to be addressed strategically. The problem is particularly severe in ICT as the sector is heavily skewed towards applying imported technology. A separate but related problem is that research groups often work in isolation and the potential discoveries that can be made through cross-fertilisation of ideas and disciplines are not exploited.

A number of large innovation initiatives will be launched and a grand challenges programme launched. This will assist the flow of technological research output into deployed systems, and stimulate broad collaboration across disciplines and among players operating at different points in the innovation pipelines.

The large, multi-year innovation projects will bring together researchers, entrepreneurs, local industry, multinational corporations and government at various levels in collaborative multi-disciplinary research and innovation activities aimed at solving complex local challenges.

The following initial set of projects has been identified:

- **Technology development for urban broadband deployment** - South Africa's lag in the deployment of affordable and pervasive broadband will be addressed through collaboration between telecommunications carriers, local government, universities and research institutions, entrepreneurs, industry and multinational corporations to develop technology and financing solutions.

Industry's participation in large innovation projects will be based on competitive bids that also address the exploitation of the technology in large infrastructure projects driven by the Department of Communications and local/provincial authorities.

Technology development requires a 'real-world' pilot that can serve as a test bed during long-term R&D. The intention is therefore that access and basic services should be provided early on in the project but that the operating procedures, standards and protocols used and the business model should allow continuous innovation, which will

in turn allow the introduction of new technologies and applications over an extended period.

The Department of Communications will be a key role-player in the project and will ensure appropriate regulatory support for the project. Science/technology parks and incubators are expected to play a key role in facilitating cooperation between the various role-players and they will also serve as the geographical focus of the activities.

- **Technology for large-scale rural connectivity** – Various rural connectivity projects have been undertaken in South Africa through the Under-Serviced Area Licensees (USAL), and provision has been made for the special circumstances that exist in rural areas. This project will build on the results of earlier work to ensure massification of these initiatives and work towards access for all. The project will involve researchers, telecommunications carriers, non-governmental organisations, provincial government, industry and local entrepreneurs in the development and deployment of technology that supports large-scale rural telecommunication access, including voice and Internet communication. Collaboration with researchers in other developing countries that face similar challenges, such as India and Brazil, will be explored as part of the project.

Grand Challenges Programme

Future projects will be identified through the Grand Challenges Programme, which will also serve to stimulate collaborative research before large innovation projects are launched. The programme will provide topics for collaboration between nodes in focused research networks. The Grand Challenges Programme is inspired by the European IST Grand Challenges Programme, which identified 11 challenges³⁴ that will drive their information society research programmes. The Grand Challenges Programme will be implemented as follows:

- **Definition** – a number of grand challenges will be defined through a rigorous and participative project to be undertaken in 2006. The grand challenges will set long-term goals (5 to 10 years) for ambitious scientific and technological achievements.
- **Seed funding** – funding will be provided to groups pursuing specific aspects of the grand challenges. This will be supplementary to funding received as part of the Critical Mass Research Programme or similar funding, and will enable the groups to undertake additional research and development activities.
- **Competition and annual prize** – to raise the profile of the Grand Challenges Programme and stimulate activity, a competition with an annual prize will be instituted to reward researchers and research groups and consortia that make the most progress towards achieving the goals of the grand challenges.
- **Launching large innovation projects** – where sufficient progress has been made and it has become clear that a specific challenge may be attainable if specific support is

³⁴ ftp://ftp.cordis.europa.eu/pub/ist/docs/2004_grand_challenges_web_en.pdf

provided, a large innovation project or initiative will be launched to pursue the attainment of the grand challenge.

5.2.5 Intervention 5: ICT R&D in Industry Programme

The current low levels of investment in ICT R&D and industry's low uptake of research results from academic and other research institutions will be addressed through a specific intervention targeting intellectual collaboration through joint research activities. The intervention will support:

- Increased in-house R&D by industry;
- Increased contract R&D by industry;
- Greater uptake of R&D by existing players;
- Increased collaboration between industry, academia and research institutions; and
- Establishment of new players through support for hi-tech ICT SMMEs.

The following mechanisms will be put in place to complement existing measures, such as SPII and THRIP.

- **Awareness and advocacy** aimed at creating a better understanding of the benefits of local R&D, information about progress in local R&D and the strategy will be disseminated through conferences, seminars and industry associations. This will be done in close cooperation with incubators, science and technology parks and local and provincial government. The ICT R&D Roadmap will be used as a vehicle for this.
- **Incentives for local ICT R&D** and for greater uptake of ICT R&D results will be designed and instituted. This includes tax incentives and specific funding schemes that address industry R&D.
- **Industry research collaboration** – Specific support will be provided for joint projects between industry and research institutions and HEIs. This will complement the existing Innovation Fund instrument but it will focus more on the earlier stages of the research value chain where the results are not guaranteed but where the benefits can be substantial.
- **Technology incubation through people mobility** implemented through entrepreneurships as a specific form of human capital development and supporting the secondment of researchers to industry. Entrepreneurships will be implemented as a joint programme between the incubators, the Meraka Institute, universities and industry. It will provide an important feed to the existing incubators, will be closely aligned with focused research and innovation activities, and will increase the technological depth and differentiation of the ventures supported. The secondment of researchers to industry will support the absorption of technology in industry and will expose researchers to the realities of industry, which will then be fed back into research programmes at universities and research institutions.

- **ICT R&D Roadmap Programme** – support for renewal and specific actions that have been identified through the current ICT R&D Roadmap exercise.

5.2.6 Intervention 6: ICT R&D and Society Programme

To realise the benefits of ICT R&D in terms of improved quality of life and the creation of an inclusive information society, a specific ICT R&D and society programme will be instituted. This will complement other interventions supporting technology and applied research, the creation of a strong and robust innovation chain and advanced human resource capital development. In particular, it will be aimed at taking the benefits beyond organisations and institutes into everyday life in places such as schools, hospitals, homes, shopping centres, the workplace and so on. This will be facilitated through technology transfer mechanisms, mechanisms that support collaboration between researchers and civil society, and by supporting interaction between society and researchers and research on the information society.

The specific mechanisms that will be implemented are:

- **Information society research programme** – Cross-disciplinary and multi-disciplinary research supporting the creation of an inclusive information society in South Africa and extending the benefits of ICT to the continent by building on technology and applied research. This will include research on appropriate information society indicators and on specific measures that need to be taken from a policy, regulatory or research point of view.
- **Market neglect innovation** – Collaborative projects between civil society groups, government agencies, research institutions and universities will be supported through a competitive programme similar to the existing Innovation Fund, but with criteria favouring social benefits and the sustainability of project results over the commercial value of the innovation projects.
- **Young Scientist and Engineer programme** – To popularise science and technology careers and to ensure a feed for the human capital development and critical mass research programmes, specific actions will be taken to expose and involve young people in ICT R&D and innovation. This will take the form of competitions and outreach programmes. The programme will in particular ensure the participation of girls and women in this process.

5.2.7 Intervention 7: R&D Infrastructure Programme

The strategy will ensure an effective research infrastructure to enable simulation, experimentation, collaboration and other research processes. This will be implemented through a number of specific infrastructures listed below and by supporting research groups through equipment grants as required.

- **SANReN** - The establishment of the South African National Research Network will provide an effective high-capacity network to support collaborative R&D and innovation

in general (not restricted to ICT R&D) in South Africa. In the case of ICT R&D and innovation, it will contribute not only to scientific collaboration between dispersed researchers and between South African researchers and their international counterparts, but it will also serve as a platform for research on new communication and networking technologies and ICT applications.

- **High-performance computing infrastructure** – Through the Centre for High-Performance Computing (CHPC), a central facility for high-performance software, hardware and ICT expertise will be developed for ICT and other researchers in the country. Tools to parallelise software and hardware to optimise cluster and other software development applications and porting tools will be provided. The CHPC will have dedicated laboratories in which all services and direct high-performance computing and scientific computing research will take place. The CHPC will actively establish geographically distributed nodes.
- **Wireless test-bed** – a test environment for experiments in wireless communication technology and demonstration of new approaches, especially where simulation is not feasible, expensive equipment is needed, or where exemption of spectrum regulation is required. The test-bed infrastructure will include simulators, radios (including software-defined capability), various network equipment, signal processing equipment, antennas, test measuring equipment, network monitoring equipment, radio frequency identification (RFID), ultra-wideband communications equipment and any other infrastructure that may be pertinent to wireless telecommunications research.
- **Next generation network test-bed** – This will incorporate state-of-the-art optical technology and simulators to stimulate, anticipate and design the future South African and continental network for multicast multimedia. The test-bed will address a broad array of problems driven by the needs and research goals of networking researchers. These include modifying and replacing network infrastructure components, protocols, middleware and applications.
- **Technology-enhanced learning laboratory** – A state-of-the-art technology-enhanced learning laboratory supporting R&D in the field by providing infrastructure for e-education experiments. Participants will include learners, educators, educational psychologists, pedagogical specialists, educational technologists and ICT researchers. The laboratory will be used to investigate, research and develop advanced teaching and learning technologies and approaches, such as multimedia and virtual reality-enhanced learning environments (such as gaming and multimodal techniques); active, hands-on and collaborative learning technologies supporting social constructivist approaches; innovative approaches to content creation (such as learning object repositories and development tools) and novel educational devices and networking infrastructure.
- **Tele-health laboratory** - A national tele-health research laboratory for the testing and development of cost-effective tele-health technologies will support tele-health networks across the African continent. The tele-health laboratory will focus on technology to be used in primary healthcare, together with the connectivity issues to be addressed in that

environment. The tele-health laboratory will provide support for a virtual hospital tele-medicine network to experiment with the provision of access to specialist care by rural and distant communities and support for developing new technologies associated with such services.

- **e-Government laboratory** - A facility that will allow the development and demonstration of e-Government solutions and testing of these solutions with the stakeholders of e-Government. This includes current research enabling future possibilities in areas such as human language technology, open source, and mobile and wireless.
- **Future village** – Infrastructure to test and enhance ICT is to be deployed in rural communities. The facility will support active involvement from the community in the development and adaptation of ICT to local circumstances and the development of innovative applications. The concept will support the showcasing of new technologies and applications as a precursor to large-scale rollout. In addition to testing technical feasibility, new business models supporting sustainable deployment will be developed.

Other infrastructure such as a speech technology laboratory, an accessibility laboratory and an electronic design facility will be supported as the need for these becomes clear through the planning of critical mass research groups.

5.2.8 Intervention 8: Futures Research, Future Technologies and Strategy Implementation and Renewal Support

To support the implementation and renewal of ICT R&D and to enable effective planning of ICT aspects of the NSI, the strategy will intervene through two mechanisms: ICT futures research and exploratory research in future and emerging technologies. It will support the implementation of the strategy through effective structures.

- **ICT futures research programme** – A number of futures research activities will be undertaken, including an ICT foresight process in 2009, research roadmaps and other strategic futures work in each of the critical mass research domains. This initiative will build on the work that was done during the national foresight process in the late 1990s and the ICT Roadmap, which is currently being finalised, and leverage international collaboration with leading countries in the field such as Finland and Japan.
- **Future and emerging technologies** – To ensure that South Africa keeps abreast of new developments in the rapidly changing ICT field, research on future and emerging technologies will be supported. Small groups of researchers will be supported in exploratory research in new and emerging technologies. As these become more mature, they could lead to new critical mass research areas or they could contribute to the renewal of existing areas.
- **ICT strategy support structures** - Implementation of the strategy will be supported through effective structures in the DST and its agencies. Key aspects of such support include:

- Oversight of the implementation of the strategy, including coordination of various aspects of the strategy and ongoing improvement in the strategy interventions;
- Support of government and institutional leaders in the execution of the strategy through regular and well-targeted overseas study tours to investigate at first hand significant ICT research infrastructure/services, tap into current experience, keep abreast of government policy, attend conferences for networking, and so on;
- Monitoring and evaluation of the effectiveness and impact of strategy interventions, including monitoring of the key performance indicators of the ICT R&D and Innovation Strategy;
- Provincial Intervention: The DST must ensure that provinces engage with the ICT R&D and Innovation Strategy and are helped in starting their initiatives in line with the national plan; and
- Management of funding.

5.2.9 Intervention 9: Funding the ICT R&D and Innovation Strategy

Implementation of the ICT R&D strategy requires increases in funding in line with the goals of the National R&D Strategy, of 1 percent of GDP by 2008 and 1.5 percent by 2012. The ICT R&D and Innovation Strategy will aim to achieve the same level in the ICT sector, which is expected to grow over the period as the economy becomes more knowledge intensive.

The strategy will therefore refine and increase the resourcing of funding instruments to ensure comprehensive support for the research and innovation chain to achieve the strategy's objectives. Existing instruments such as the Innovation Fund, THRIP and SPII address specific aspects of the innovation chain and these will continue to be needed. Areas that need to be addressed specifically through new funding include:

- Funding of the Advanced Human Capital Development Programme at HEI and in the Meraka Institute;
- Funding of directed critical mass R&D in identified technology and application domains. (The primary vehicle for management of this will be the Meraka Institute working closely with HEIs and the DST);
- International ICT R&D collaboration programmes;
- Competitive funding to support bottom-up initiatives. The Innovation Fund addresses this need for innovation where a product or service can already be well articulated and downstream sustainability of the innovation assessed. There may be a need for earlier stage research funding to feed the pipeline of innovations that this instrument can take forward. The exact need in this regard and the optimal design of appropriate instruments require further study, which will be undertaken in the next 12 months;
- Infrastructure support programme; and

- Support infrastructure, which enables the refinement and implementation of the strategy. This will support work commissioned by the DST and executed by the Meraka Institute and includes issues such as road mapping, fore sighting, and so on.

Further details on the funding requirement for specific interventions are detailed in Section 5.5.

5.3 ICT R&D and Innovation Strategy Key Performance Indicators

Implementation of the ICT R&D and Innovation Strategy will be measured with reference to a set of key performance indicators (KPIs), which will be cascaded to agencies responsible for the implementation of the strategy.

The KPIs for the ICT R&D and Innovation Strategy will measure key aspects of the strategy implementation including: 1) the extent to which the substantial increase in inputs to the ICT R&D system is realised 2) improvements in the efficiency of the system (outputs per input) and 3) improvements in the effectiveness of the system in terms of impact.

The strategy will use a small number of KPIs that relate directly to the first three objectives of the strategy: Human Capital Development, Focused Research, and Innovation. These three objectives represent the key outcomes that need to be achieved.

5.3.1 Human Resource Development Indicators

Two measures will be used to determine human resource development performance:

- **PhD graduation rate** - The strategy aims to increase the current figure of about 30 to 300 PhDs per year by 2015.

The PhD graduation rate is a composite measure that also indicates the matriculation pass rate in science and mathematics, enrolment at the Bachelors, Masters and PhD levels, and the pass rates and transfer rates between all of these.

Due to the lag that can be expected in the PhD graduation rate as an indicator of the success of the strategy, it will be supplemented by short term indicators such as the enrolment at Bachelor, Honours, Masters and PhD levels as early indications of the effects of the ICT R&D and Innovation Strategy.

- **ICT FTE researchers with PhDs** – The strategy aims to increase the number of ICT FTE researchers and to increase the proportion of ICT FTE researchers who have PhDs by 2015.

This provides an indication of a number of important issues, such as the availability of world-class supervisors and facilities for the research students, the health of incentives and attractions at all levels in the qualifications stream, the quality of coaches and support structures for the junior qualifications to ensure success.

This measure improves only if the numbers entering the FTE research arena exceed those who leave. The attraction, retention and deployment into ICT research employment are therefore of great importance.

Data collected in this regard will support desegregation by race and gender to measure the progress of transformation in the ICT R&D workforce.

The absorption of graduates into industry will also be monitored to ensure the relevance of postgraduate studies and the strategy's success in supporting increased R&D activity in industry.

5.3.2 Research Performance Indicators

Two measures will be used for research performance:

Global ICT publication share – The number of publications attributable to South Africa expressed as a percentage of the total number of publications in the ICT discipline recorded in the ISI database. This is a measure of the efficiency of the system.

Relative Citation Index for ICT publications attributable to South Africa. This is an indication of the relevance of South African ICT publications and therefore of the effectiveness of the system.

These two indicators provide a measure of the efficiency and effectiveness of disseminating important new research findings by the chain of people from students to professors and research staff. The strategy aims to increase the combined impact of these two figures according to the formula below from a current estimate of 2.55 to a stretching target of 4 by 2015.

$$\text{Research performance} = (1+p) * (1+c)$$

Where p = *Global ICT Publication Share* and c = *Relative Citation Index*

In addition to the above, the spread of publications in different ACM categories, publications density per person versus groups, publications in collaboration with different institutions and publications in collaboration with international partners will be monitored to track collaboration, focus and continuity.

Performance in publication output will also take account of peer-reviewed international conference publications and publications in on-line journals, where the turnaround time is much quicker both in terms of the dissemination of new ideas and their application and testing on the ground.

5.3.3 Innovation Performance

Innovation performance will be measured through two indicators:

- **ICT patent share** - South Africa's share of triadic ICT patents expressed as a percentage of total ICT patents. Increases in intellectual property output are an indication of efficiency, and the novelty requirement associated with patenting indicates the effectiveness of the system in producing quality intellectual property.

As performance as measured by the indicator improves, it contributes to the brand that is envisaged for South Africa as a place for R&D to be located and an effective investment vehicle for increased local R&D.

- **ICT BERD** – Business expenditure on ICT R&D is an effective measure of how successfully the innovation chasm is being bridged by the implementation of the ICT R&D and Innovation Strategy. This is because it implies greater utilisation of South African research outputs as inputs into industry's value chain. ICT BERD provides a measure of the increase in utilisation of South African research, patents and so forth directly by South African industry as opposed to the importation of products and services based on R&D conducted abroad. This measure may be combined with other measures such as the uptake of instruments that support industry participation in R&D, for example, THRIP and the Innovation Fund.

These measures do not measure all aspects of innovation performance, so further refinements will be made to KPIs to address the following issues:

- **Digital divide/information society measures** - The Presidential National Commission on Information Society Development is currently leading a process to develop a set of information society indicators for South Africa. Monitoring and setting targets against these indicators will be key in measuring the contribution that ICT R&D and innovation is making to quality of life and the creation of an inclusive information society.
- **Open source contributions** - The role that open source strategies play in technology transfer is becoming increasingly important and specific measures and targets are under development and will be incorporated in future KPIs.
- **Hi-tech SMME creation** represents a clear success output of the strategy and will be targeted in innovation performance KPIs.

5.3.4 Other Indicators and Review of Indicators

The effectiveness of the indicators will be reassessed in three to four years' time to ensure that they are measuring performance to support the strategy adequately. In addition to the above KPIs, a number of other variables will be monitored and qualitative targets set. Two categories of such variables have been identified:

- **Internal indicators** - measuring improvements in the enabling objectives. This includes international cooperation indicators, research infrastructure, ICT policy, institutional and other support and resourcing of the ICT R&D and Innovation system.

- **Other impact variables** – issues such as improvements in access, to which the strategy will contribute but which are influenced by too many other factors to be used as a way of measuring strategy implementation.

5.4 ICT R&D and Innovation Strategy Role-Players

Successful implementation of the ICT R&D and Innovation Strategy relies on cooperation among a range of actors in the NSI. Key role-players and their roles in the implementation of the strategy are highlighted below.

- **Government** - The DST has overall responsibility for implementation of the ICT R&D and Innovation Strategy. This includes coordination, monitoring and evaluation, management of funding, enrichment of the strategy and its interventions through targeted overseas study visits, facilitating international collaboration, and supporting provincial interventions. The DST will convene a steering committee comprising high-level representatives of the relevant government agencies, science councils, and ICT umbrella organisations to oversee the implementation and evaluation of the strategy. The steering committee will stay close to the strategy in order to coordinate activities as implementation progresses and to support the development and implementation of mutually supporting strategies in the context of macro- and micro-economic policy environment. Key government departments in this regard are: the Department of Trade and Industry (in areas such as small business development, equity, and sector strategies) the Department of Education (in areas such as ICT in education and human resource development) and the Department of Communications as the line department responsible for ICT.
- **The Meraka Institute** – is a specific intervention by government to stimulate focused research, innovation and human capital development in South Africa. It will play a national role in supporting the DST and other role-players in refining and implementing the ICT R&D and Innovation Strategy. Institutionally it will lead a number of critical mass research programmes and will support advanced human capital development through a high-throughput employment model. Students will be supported in employment pursuing postgraduate studies at existing universities while working on the institute’s research programmes. The institute’s strategy is guided by a strategic advisory board, with representation from industry, government, higher education, civil society and the international R&D sector.
- **The National Research Foundation (NRF)** has as its mandate the development of research capacity and knowledge development that will benefit the development of South Africa. It has core missions and strategic objectives that are aligned with the objectives of the ICT R&D and Innovation Strategy. In collaboration with the DST, the Meraka Institute and other role-players, it will design and implement processes in support of the strategy. The implementation of the strategy with regard to national research centres, technology research networks and applied research networks will be absorbed and added onto the existing research chairs for information society programmes coordinated by the NRF. It will manage the allocation of funding for the

measurement of progress, and implement international and other peer review mechanisms.

- **The Innovation Fund** - is an instrument of the Department of Science and Technology whose mandate is to promote technological innovation. It implements this mandate through investments in end stage R&D in any technology field, where a clearly defined new technological product or service can result from such R&D. Furthermore, support is provided for patenting and early technology commercialisation activities.
- **Higher education** – Universities have the dual role of developing the next generation of researchers and undertaking research, especially basic and fundamental research. Universities will work with the Meraka Institute and government in expanded research programmes and towards increased postgraduate enrolment in support of the research, innovation and people development objectives of the strategy.
- **Industry** – This strategy will be successful only when the products and services generated through R&D can be sold on local and global markets and when the investment can be realised through the commercialisation and sale of products and services on a large scale. The strategic objective of creating a strong and robust innovation chain specifically supports the migration of R&D results into the global ICT supply chain. Sectorised value chains include the primary sector (mining and resources), the secondary sector (manufacturing and construction), the tertiary sector (the services sector including public services) and the quaternary sector (high knowledge-intensive economic activities, e.g. other R&D and innovation). The strategy specifically provides for interaction with industry through collaborative programmes, people mobility and incentives. Industry will also influence the direction of programmes through its involvement on research advisory panels for research domains and through the strategic advisory boards of key structures such as the Meraka Institute. In the short to medium terms the strategy will benefit society and industry through enhanced local research capacity and an improved human resources profile, thereby increasing industry's ability to absorb new technology and become more competitive.
- **Science councils** – carry out directed research and development for the benefit of the economy and society in a number of disciplines of strategic importance. These institutions complement universities and industry and will be crucial in aspects not addressed by the Meraka Institute, whose activities are specifically aimed at ICT R&D. The role of other science councils will be crucial in applied research.
- **Incubators and science/technology parks** – South Africa has a small number of science parks situated in large metropolitan areas. These will serve as important geographically focused hubs in a number of aspects of the strategy, but in particular regarding a robust and strong innovation chain. Technology and business incubators that have been set up and are being expanded will support ICT start-ups to create a vibrant hi-tech ICT SMME sector.

- **Civil society** – organisations such as NGOs and CBOs complement the role of government and industry and are crucial to realising quality of life benefits of ICT R&D. As in the case of industry collaboration, mechanisms will be put in place by this strategy and civil society role-players will influence research through representation on advisory structures.
- **Professional bodies** will be leveraged to form a link between industry and researchers in academia and at research institutions. Examples of such bodies include the SA Institute of Computer Scientists and Information Technologists (SAICSIT), the SA Computer Lecturers Association (SACLA), the Computer Society of South Africa (CSSA), the South African Institute of Electrical Engineers (SAIEE) and the Black IT Forum (BITF)

5.5 Budget

The budget for the ICT R&D and Innovation Strategy is given in Table below.

Table 7: Proposed Budget

Area Programme	Budget		
	2007/8	2008/9	2009/10
ICT R&D strategy budget	176,254,914	203,459,733	254,851,543
Intervention 1: Advanced Human Capital Development Programme	19,707,500	24,604,200	36,623,333
PhD research bursaries	1,200,000	1,728,000	3,200,000
Masters Research Bursaries	1,400,000	2,016,000	3,733,333
PhD Internship programme	2,625,000	3,915,000	7,500,000
Masters degree Internship programme	2,600,000	3,816,000	4,800,000
Postdoc programme	7,000,000	6,930,000	6,930,000
Entrepreneurship programme	3,750,000	5,130,000	9,000,000
Scientific exchange programme	1,132,500	1,069,200	1,460,000
Intervention 2: Critical Mass Research Programme	122,561,530	141,996,714	176,937,798
R&D Professionals	87,750,000	94,200,000	118,000,000
<i>Core R&D professionals</i>	55,750,000	58,200,000	74,000,000
<i>Research Academics</i>	14,000,000	13,440,000	18,666,667
<i>Fellows</i>	18,000,000	22,560,000	25,333,333
Research Expenditure	28,066,680	39,947,517	48,833,583
Research Infrastructure Overhead	6,744,850	7,849,197	10,104,215
Intervention 3: International ICT R&D collaboration programme	6,740,884	7,809,819	9,731,579
Science and Technology networking	612,808	709,984	884,689
Researcher Mobility	1,225,615	1,419,967	1,769,378
International R&D project support	4,902,461	5,679,869	7,077,512
Intervention 4: Large Innovation Initiatives and Grand challenges	3,200,000	3,360,000	3,528,000
Grand challenges programme (research, definition, competition)	1,200,000	1,260,000	1,323,000
Large Innovation project seed fund	2,000,000	2,100,000	2,205,000
Intervention 5: ICT R&D in Industry Programme Technology Incubation programme	7,045,000	7,839,000	9,288,333
ICT R&D Roadmap programme	1,000,000	1,050,000	1,102,500
Industry research collaboration	5,000,000	5,250,000	5,512,500
Technology incubation programme	1,045,000	1,539,000	2,673,333
Intervention 6: ICT R&D and society programme	15,000,000	15,750,000	16,537,500
Information society research programme	5,000,000	5,250,000	5,512,500
Market neglect innovation	5,000,000	5,250,000	5,512,500
Young Scientist & Engineer programme	5,000,000	5,250,000	5,512,500
Intervention 7: R&D infrastructure programme	To be budgeted for separately		
Intervention 8: Futures research, Future technologies and strategy renewal	2,000,000	2,100,000	2,205,000

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Appendix A Domains of Intervention

Table 8: Critical Mass Research Domains and Implementation Proposals

Description of the domain	Implementation
<p>Human Language Technology (HLT) holds immense promise for bridging the digital divide, since it provides the means for people with limited literacy to interact with modern information sources. Research focusing on HLT (text-based language processing and speech processing) will support innovations in our multilingual society to serve the developing world context and other multilingual societies (including, e.g., the EU).</p>	<p>An HLT Technology Research network will facilitate collaboration on a focused research plan by institutions that are currently doing research and development into speech technologies and applications, translation and human factors in South African languages.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> • Speech processing including speech recognition and speech synthesis in local languages. • Natural Language Processing including statistical translation in local languages. • Human factors in speech applications. • HLT resource collection. • Application of HLT, e.g., to extend access or to support multilingualism.
<p>Mobile, Wireless and Satellite Technologies – The need for low-cost access and the creation of the Information Society in South Africa are drivers of innovation in communications technologies including cellular networks, mobile Internet and mobile e-Commerce, voice and data services, broadband Internet services, IP and digital video broadcast services on fixed satellite systems, and digital broadband entertainment.</p>	<p>A Mobile, Wireless and Satellite Technologies Research Network conducting long-term interdisciplinary research in appropriate mobile, wireless and satellite technology will be initiated through development of a research roadmap by the top researchers and leaders in the field. The technical focus areas will be agreed and implemented through appropriate R&D projects. One focus of the initiative will be affordable broadband for all. Another focus will be the fast-growing field of Radio Frequency Identification (RFID). The network will grow leadership capacity by recruiting local and international leaders into research and facilitate collaboration with international researchers and research programmes, in particular joint projects in the EU framework programmes and with India and Brazil as well as with African partners. It will receive input from industry on a research plan including support for the SNO and USAL needs.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> • Ad-hoc wireless networks. • Software defined radios. • Mobile applications (e.g., geomatics applications and applications in government). • Information Security in wireless networks. • RFID in manufacturing, supply chain, logistics and asset tracking.
<p>High-Performance Computing - The handling of very large data sets and volumes of data that characterise the problem domains in computational science are demanding increasing computing capacity. Such growth has been described as “explosive at a stunning almost disruptive rate”, and spans raw processing power, storage</p>	<p>The creation of a Centre for High-Performance Computing (CHPC) will permit South African scientists to be active at the cutting edge of scientific computing, fostering research and grand challenges within a vibrant intellectual atmosphere which has the potential for significant regional, national and even continental innovation.</p> <p>The CHPC will be a central holding house of scientific computing and HPC research activities. The Centre of Excellence will develop and nurture the expertise required to address grand challenges and grow computational research alongside experiment and theory across all academic disciplines.</p> <p>In addition to the project areas of the previous section (Computational science), the CHPC will focus on the following areas:</p> <ul style="list-style-type: none"> • Image and visualisation technologies.

Description of the domain	Implementation
<p>capacity, high-bandwidth networks, and algorithms for parallelisation, GRID computing and visualisation.</p>	<ul style="list-style-type: none"> • Data mining and optimisation. • GRID technology and systems. • Massive parallelisation. <p>The CHPC will have symbiotic relationships with GRID computing, the National Bioinformatics Network (NBN) and the Square Kilometre Array Telescope.</p>
<p>Computational Science – According to one explanation, computational science is a multi-disciplinary field that embodies scientific models, mathematical algorithms, computer architecture and scientific software engineering. It brings together teams of scientists, engineers, mathematicians, computer scientists, and support personnel centred around large computers offering teraflops of processing power, petabytes of storage, visualisation facilities, and high-bandwidth networking.</p> <p>At its core is computational simulation – a means of scientific discovery that is now accepted as a peer methodology alongside traditional experimental and theoretical approaches. Also referred to as “in-silico” simulation, it is leading to fundamental scientific discoveries being achieved from a broader and deeper systems perspective. In some scientific fields, even traditional techniques are undergoing radical change or replacement. For example, in industrial design it can complement or even replace costly prototype and benchmark testing alongside computational simulations.</p>	<p>The optimum organisational form to support R&D in computational science, which is closely associated with High-Performance Computing described above, will be determined and implemented. As presently envisaged, the primary project areas will include:</p> <ul style="list-style-type: none"> • Computational Mechanics: Materials modelling and minerals processing and computational fluid dynamics. • Bioinformatics and medical imaging technologies. • Geophysics, with potential impact on the oil exploration industry. • Computational chemistry, drug discovery and design, HIV/AIDS research and molecular modelling to improve process mining. • Short and long-term climate systems modelling. • Modelling and simulation in the social sciences and economics. • Radio-astronomy and astrophysics, with particular reference to the SKA project. • Defence applications. • Computer engineering: Radar Signal Processing and Machine Vision. <p>Manufacturing: refer to “ICT in Manufacturing” Critical Mass Research.</p>
<p>Geomatics and Spatial Technologies – A well-developed national information infrastructure, enabling the dissemination and sharing of valuable, geographically referenced information is widely accepted as an essential asset for any country to maintain and to advance its social and economic well-being. These technologies are developing rapidly and undergoing convergence with other application areas, providing new services to</p>	<p>An Interdisciplinary Geomatics Research Group will be established to conduct collaborative research in computational domains in support of spatial applications (and later environmental and biomedical informatics). The group will facilitate collaboration between the spatial and computer science communities and will work closely with other groups in the fields of high-performance computing and domain groupings focused on the application of cyber infrastructure. The focus of this group will be on research leading to the development of technology domains in support of the broader geomatics area, but with application potential in other emerging fields dealing with the same challenges. The group will concern itself initially with the computational issues in spatial and geographic information science.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> • Integrated spatial data handling. • Automation of monotonic processes. • Scale and scope of spatial data and computation.

Description of the domain	Implementation
citizens and governments.	<ul style="list-style-type: none"> Dealing with complexity and non-monotonic reasoning in drawing conclusions from spatial data.
<p>Open Source, Software Engineering and Software Architecture – software forms the basis of the Information Society and much of ICT. Supporting the development of strong skills in computer science and software engineering will enable the development of indigenous technology and applications. Open source software is an important tool that can reduce our dependence on important technology and lower the barriers to entry for South Africans as developers of robust software solutions.</p>	<p>A Research Network in Advanced Software will be established by building on existing expertise at universities and the Meraka Institute. The CMRU will also work closely with the incubators, local industry and research laboratories of multinational corporations that are being established. It will incorporate and build on the awareness, advocacy and networking activities of the Open Source Centre. The network will conduct research and development, facilitate human capital development and promote innovation in software. It will also act as a key competency underpinning the work in ARNs focused on socio-economic issues such as health, education and disability.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> Software engineering. Software architecture. Distributed processing. Artificial Intelligence. Open Source. Human-computer interfaces.
<p>Education – Across a range of educational applications, ICT can be harnessed to improve the efficiency, accessibility and quality of the learning process in developing countries. One of the most clearly demonstrated applications is distance education. Distance education has been a particularly successful model in developing countries where affordability and geography have been real barriers to access. The development of scientific research networks on a worldwide basis, usually over the Internet, is also helping to empower indigenous research and development programmes in developing countries. ICT-enabled solutions also present significant opportunities for enhancing the efficiency and effectiveness of education administration.</p>	<p>An Applied Research Network in ICT for education will be established to undertake a set of research and innovation projects addressing challenges in education in South Africa. This will include multi-disciplinary R&D that supports the development and application of new technologies in education. In order to provide a framework for the research projects, a 5-year research plan working towards a set of specific objectives will be developed as the first step. This will allow researchers and students in employment to work on specific components of the research plan. The network will support the involvement of private sector, donor-funded projects, NGOs and not-for-profit companies. The outcomes of the intervention will be advanced knowledge of both the theory and the application of innovative ICTs in education.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> e-Learning solutions and platforms (using advanced cognitive science and learning theory). State-of-the-art educational technology (learning objects, object repositories, collaborative learning environments, etc.) to support instructional design and content-creation. Advanced infrastructure to support education (next generation networks, devices, services). Multimedia- and multimodal-enhanced learning environments. Application of human language technologies in education. Virtual reality in education. Gaming paradigms to support learning and educational content development. Mobile learning environments. Robotics and other technology building blocks to support hands-on learning (particularly in the fields of computer science, engineering and mathematics).
<p>ICT for Disability – In South Africa, more than four million people are permanently disabled, of whom fewer than one per cent are economically independent. Interactions between various role-players, including the CSIR, national disability organisations and relevant government departments, have indicated that access to information,</p>	<p>A National R&D Network will be established with strong international linkages, undertaking and facilitating multidisciplinary research on ICT for Disability. The network will work closely with disabled persons organisations and the ICT industry. The focus of the initiative will be on harnessing advances in miniaturisation, mobile computing and communication, Radio Frequency Identification devices (RFID), Global Positioning Systems (GPS) and other spatial technologies, smart materials, human-computer interfaces and human language technologies to enable independent living for persons with disabilities in South Africa and the continent through affordable,</p>

Description of the domain	Implementation
<p>effective communication tools and the ability to network and share data are key needs. ICT can provide those links and opportunities through the Internet, broadband, wireless communication and a variety of specialised assisting devices and software solutions. A number of challenges in the South African and broader developing world context require research and development of specific technologies, platforms and applications. These need to address affordability, local languages and needs that may not exist in the developed world.</p>	<p>appropriate and distributable solutions.</p> <p>The network will be led by the Meraka Institute in collaboration with selected academic and R&D institutions. It will build leadership through appointment of experts and by facilitating collaboration with international researchers and research programmes, in particular joint projects in the EU framework programmes, with African partners and the developing world at large. Technology transfer and sustainability will be enabled through cooperation with government at provincial and local level and through close interaction with the local ICT Industry.</p> <p>R&D areas include:</p> <ul style="list-style-type: none"> • Human-computer interface technology including alternative interface technologies. • Application of human language technologies and research on sign language to support access to information and to enable communication. • Spatial technology and applications. • Smart infrastructure supporting physical access and autonomous movement of people with disabilities. • Tele-health applications addressing disability. • Technology and applications that support community development for people with disabilities. • Open Source software and open hardware. • Virtual and augmented reality for rehabilitation and to support independent living.
<p>Health – ICT has great potential in developing countries and communities to facilitate remote consultation, diagnosis and treatment, and also to facilitate collaboration among physicians. The principle of ICT-facilitated collaboration also extends to medical research. In addition, centralised data repositories connected to ICT networks can enable remote health care professionals to keep abreast of the rapidly evolving stock of medical knowledge. Mobile technologies are a key domain for ICT innovation in support of the health environment and, together with challenges related to low-cost access, present significant ICT research opportunities.</p>	<p>An ARN (Applied Research Network) model is proposed which will link science councils, various HEIs, academic hospitals, NGOs, the Department of Health and international organisations in medium to long-term R&D projects. These projects will seek to improve knowledge and all aspects of the health care process. The ARN will identify areas of ICT R&D and provide the means for a consolidated and concerted effort to address them.</p> <p>R&D areas include:</p> <ul style="list-style-type: none"> • Epidemiology in Africa. • Medical informatics. • Medical pattern recognition. • Mental, cognitive and physical disability. • Patient monitoring and education systems. • Diagnostic decision support. • Tele-medicine and e-Training systems.
<p>e-Government and Service Delivery – ICT can contribute to fostering empowerment and participation and making government processes more efficient and transparent by encouraging communication and information sharing among people and organisations and within government. ICT is playing an increasingly important role in streamlining and improving service delivery, particularly in</p>	<p>An ARN model is proposed linking CPSI, policy researchers, cognitive and behavioural scientists, political scientists and public administration researchers. The R&D space will cover the interfaces between politicians and the people, politicians and government administration, and between administration and the people. Key issues that will be addressed include trust, privacy, transparency and the interdependence of interconnected socio-technology systems. Cooperation with industry through incubators and science/technology parks will help change the current bias towards imported technology as indigenous innovation builds on the network's R&D outputs.</p> <p>R&D areas include:</p> <ul style="list-style-type: none"> • Pattern recognition, data mining. • Administrative systems, training systems. • Human language technologies.

Description of the domain	Implementation
<p>the public sector. Many countries are pursuing government gateway initiatives, providing citizens with single-point access to government services. Using ICT, governments can improve the quality and responsiveness of the services they provide to their citizens as well as expand the reach and accessibility of services and public infrastructure. This is facilitated by e-Government applications that provide services and information to citizens over the Internet and other communication networks.</p>	<ul style="list-style-type: none"> • GIS, simulation and modelling and decision support. • Policy and legislation tools. • Citizen participation and interactivity in democratic processes. • Personalised services through intelligent interfaces. • Information security. • It architecture for e-Government. • e-Government standards. • SADC and AU integration.
<p>ICT in Manufacturing – Support for networks of excellence to ensure that existing initiatives and partnerships are utilised efficiently to empower the manufacturing industry. Other important areas are: grid manufacturing concepts, advanced computing and modelling capabilities and next-generation manufacturing ICT systems. Open source manufacturing software could create a pool of skills useful for further R&D and drive down the cost to the benefit of African manufacturers. Key areas will be high-performance computing, human computer interface (virtual reality, artificial intelligence, etc.).</p>	<p>An ARN model is proposed linking relevant engineering faculties in HEIs, science councils, science parks, incubators and industry. The automotive industry and associated industry structures are key stakeholders and partners in this domain. The Advanced Manufacturing Technology Strategy has specific ICT R&D requirements which will be supported by this ARN.</p> <p>R&D areas include:</p> <ul style="list-style-type: none"> • Collaboration, modelling and simulation tools. • 3D modelling and printing. • Data visualisation, virtual and augmented reality. • Automation, networks, process control and communication. • Sensor and item tracking systems. • Open source software and manufacturing ERP systems. • Quality control and training.
<p>Information Security - As ICT penetrates ever deeper into society, the need for information security grows in importance. Local expertise in such security is crucial, since recent experience shows that security is only achievable when an overarching systems approach is followed. This requires intimate knowledge of the context within which the systems are deployed, and imported solutions will inevitably fall short of that goal, especially when the systems are to be deployed within a developmental</p>	<p>A TRN model is proposed linking various groups doing research and development in information security.</p> <p>R&D areas include:</p> <ul style="list-style-type: none"> • Theory, design and evaluation of cryptographic algorithms and protocols. • Integration of security techniques into devices and systems to support applications in electronic commerce, secure cooperation, e-Voting, etc. • Security management. • Mobile telecommunications security. • Public key infrastructures and digital evidence.

Description of the domain	Implementation
environment.	
<p>Human-Computer Interaction - The effectiveness of ICT systems depends crucially on interfaces between humans and computers. The study of such interfaces is a significant activity worldwide, and South Africa has developed expertise in areas such as usability and ergonomics, data visualisation and virtual reality. Such “traditional” HCI research can be combined with a strong multi-cultural focus to extend the usability of ICT systems in a variety of ways that will serve our people and their needs.</p>	<p>An HCI Technology Research network will facilitate collaboration on a focused research plan by institutions that are currently doing research and development on human-computer interface technologies and applications. Researchers in the network will work closely with researchers in ARNs doing applied research in domains such as ICT in education, disability and health.</p> <p>Research areas will include:</p> <ul style="list-style-type: none"> ● Cultural factors in HCI, including inter-cultural and multi-cultural issues. ● Application of HCI to address barriers to access and use. ● Visualisation. ● Non-visual interfaces. ● Accessibility. ● Education (curricula for HCI). ● Kids and computers. ● HCI and the World Wide Web. ● HCI design, evaluation and test processes. ● Virtual and augmented reality.

Appendix B Current status data

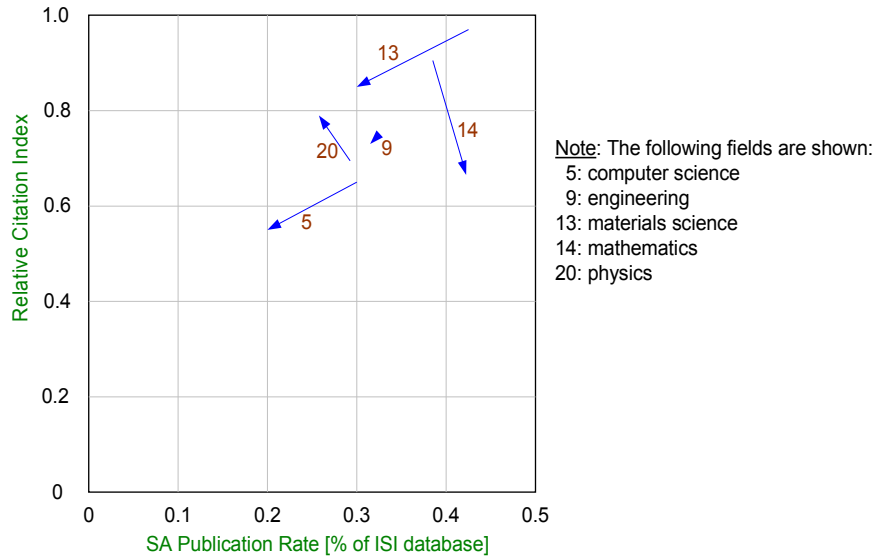


Figure 13: Importance and share of the ISI database in fields relevant to ICT³⁵

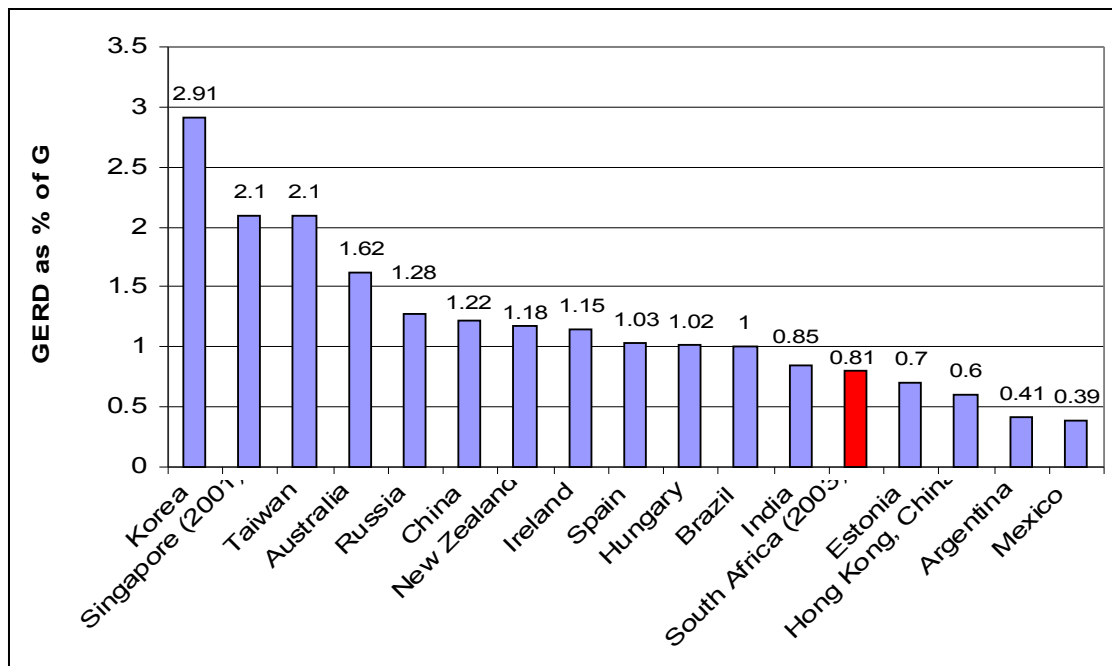


Figure 14: GERD as a percentage of GDP (2002)

Table 9: International Examples of Research Infrastructures

³⁵ Adapted from source document [Pouris, 2003]

<p>GEANT. Cost: 50 M€ - 250 M€. (http:// www.geant.net) – Europe</p> <p>GEANT is a multi-gigabit pan-European data communications network, dedicated to research and education use. The project also covers a number of other activities relating to research networking such as network testing, development of new technologies and support for research projects with specific networking requirements. The major facilities and services offered are: Optical communication and data network infrastructure, network services (unicast, multicast, IPv6, Premium IP, Quality of Service - QoS, Layer 2 Virtual Private Networks - VPNs, network test-bed facilities, research and development), general permanent network connectivity to all European research networks (Cordis, 2005d)</p>
<p>The Agora Center: Cost: €20 M - €50 M. (www.jyu.fi/agora) – Finland</p> <p>Agora “organises research intersecting the social sciences, including psychology, education, the humanities, sport and health sciences, and economics with information technology in order to develop the future information society from a human point of view.” (Finland RI). The major facilities and services offered comprise a number of interdisciplinary thematic working environments spanning topics such as Game Laboratory, Learning Laboratory, Industrial IT Group and the Psykocentre network for social and human research in the information society.</p>
<p>Center for Scientific Computing (CSC) Cost: : €20 M - €50 M. (www.csc.fi) - Finland.</p> <p>CSC is the Finnish IT centre for science, governed by the Ministry of Education. CSC provides modelling, computing and information services for universities, polytechnics, research institutions and industrial companies. Funet communication links, maintained by CSC, provide research workers with Finland's widest selection of scientific software and databases and Finland's most powerful supercomputing environment. The major facilities and services offered are: supercomputers, storage, databases and scientific applications, FUNET (Finnish University and Research Network), scientific consultancy, training.</p>
<p>Radio Laboratory/SMARAD and MilliLab. Cost: €20 M - €50 M (www.hut.fi/Units/Radio/, www.hut.fi/Units/Radio/smarad) - Finland.</p> <p>The Radio Laboratory at the Helsinki University of Technology (TKK) forms the core of two research units, namely SMARAD and MilliLab. SMARAD (Smart and Novel Radios Research Unit) is aiming at world-class research and education in radio engineering and signal processing in radio transceivers. MilliLab is a European Space Agency (ESA) External Laboratory (Centre of Competence) for millimetre wave technology. MilliLab offers services for millimetre wave technology related to components, device and system measurements, modelling and research. The major facilities and services offered are: measurement equipment for the frequency range, passive waveguide hardware, phase-locked Gunn oscillators, BWO sweepers, frequency multipliers, mixers and detectors, power meters, vector network analysers, scalar network analyser, spectrum analysers, vector spectrum analyser, signal generators, frequency synthesisers, oscilloscopes and frequency counters.</p>
<p>Telecommunications Research Centre, Limerick. Cost: < €20 M (www.ece.ul.ie/trc) - Ireland</p> <p>The University of Limerick's Telecommunications Research Centre is a focus of research and development expertise and excellence in a range of information and communication technology (ICT) fields. The major facilities and services offered are: CISCO-based lab, wireless communications test-bed, network/protocols simulation packages/tools. (Ireland RI)</p>
<p>Cosmogrid – GridIreland. Cost: < €20 M (www.cosmogrid.ie - www.gridireland.ie) - Ireland</p> <p>Cosmogrid is a virtual organisation that encompasses all the major universities and institutions involved in grid technology and high-performance computing in Ireland. They are connected through GridIreland which is also a virtual organisation. All the institutions share their computing facilities and expertise at a national level. (Ireland RI) The major facilities and services offered are: Computing facilities, databases, grid technology expertise. (Ireland RI)</p>
<p>National Microelectronics Research Council (NMRC) Cost: > €100 M - Ireland</p> <p>The National Microelectronics Research Council (NMRC) is today the largest ICT Research Centre in Ireland, with a staff of 240 and an ICT research infrastructure currently valued at over €100 M. The NMRC is recognised as a centre of excellence in selected ICT fields. The NMRC provides European academic researchers access to advanced analysis and characterisation facilities to support their R&D programmes (NMRC, 2000)</p>

Table 10: SA R&D expenditure by ICT industry grouping and research field³⁶

Industry	ICT manufacturing Industry	Telecom- munication Services Industry	Computer Services Industry	Total ICT Industry	Total All Industries
Research Field	R 000's	R 000's	R 000's	R 000's	R 000's
Information systems	22,701	1,988	123,093	147,781	406,458
Hardware	22,686	3,331	16,449	42,466	58,266
Software	40,575	20,231	241,987	302,793	402,782
Current IT	5,529	1,388	7,000	13,917	38,559
Communication	16,158	99,756	34,293	150,206	177,214
Security system	2,532	13,870	3,771	20,172	44,827
Other ICT	11,998	1,575	33,913	47,486	136,502
Total ICT Research Fields	122,178	142,137	460,506	724,822	1,264,610
Other Fields	160,494	7,542	48,254	216,289	5,501,751
Total All Research Fields	282,672	149,679	508,760	941,111	6,766,361

³⁶ Source: [National Survey on Inputs to Research and Experimental Development, 2004/05]

Appendix C Strategy Development and Consultation Process

The cross-cutting nature of ICT and the complex R&D and Innovation for South Africa required that a thorough and consultative process be followed in developing the strategy. The strategy development process and final consultation process are described below.

C.1 Strategy Development

The development of the Strategy involved several stages and participation by various people as outlined below. The key people involved were categorised into four groups: namely, the Core Group, the Strategy Working Group, the Expert Reference Panel and the ICT R&D Strategy Secretariat. The involvement of the groups is outlined below followed by a table indicating membership of the various groups.

1. The Core Strategy Group (CG)

The main functions of this group included the following:

- Study previous strategies and relevant documents (see page 81) in order to lay the ground for the development of the strategy.
- Undertake preparatory work, develop the framework of the strategy, propose the document structure through diagrammed information and a table of contents and agree on key success factors, scheduled meetings and sessions and process outputs.
- First meeting held in mid-May 2004. The output of this meeting was the draft outline (table of contents of the strategy framework). Draft 0.1 of the National ICT R&D and Innovation Strategy.

2. The Strategy Working Group (SWG)

- The Strategy Working Group was responsible for developing the main ideas which would later form the crux of the draft ICT R&D and Innovation Strategy.
- Scheduled Meetings: A workshop was held from 3–5 July 2004 and included two members of the Expert Reference Panel: Ms. Lucy Abrahams and Dr Vijay Bhaktar.

- Output: Draft 0.1 populated and refined.

3. The ICT R&D Strategy Secretariat (R&D SS)

The main function of the R&D SS included:

- Editing of the draft ICT R&D strategy documents.
- Preparation of baseline document that summarised the referenced data from various sources, including national and international statistical data.
- Conducting checks and counter-checks during draft stages of the strategy.
- Scheduled meetings: Regularly for three months after the SWG session of 3-5 July 2004.
- Outputs: Refined and edited draft strategy.

4. The Expert Reference Panel (ERP)

- The main function of the ERP was to review and make expert inputs and provide advice on various drafts of the strategy as it evolved.
- The ERP was consulted on an ad-hoc basis during various stages of the development of the strategy. It was represented by two members at the first working group session (3-5 July 2004).
- Scheduled Meetings: Consulted regularly during the development process.

5. AIPEX (PTY) Ltd

- AIPEX is an Australian Consulting company appointed for the purpose of ensuring that the developed draft strategy addressed major issues as expected and to ensure that international aspects alluded to in the strategy document are not biased. AIPEX's role was also to ensure independence of the strategy, as well as fulfil a quality assurance and peer-reviewing function.
- Funding for AIPEX participation was sourced from AUS-AID, an Australian government agency. AIPEX worked closely with DST following wrapping up of the SWG and handing over of the final draft.

In addition to the groups listed above, inputs were made on specific aspects of the strategy by a number of other individuals. Discussions were also held with the National Research Foundation (NRF) and the Innovation Fund regarding the strategy.

In addition to sources listed under REFERENCES (page 68), documents consulted during development of the strategy include: the National R&D Strategy, White Paper on Science & Technology, National HRDS, National Biotech Strategy, Integrated Manufacturing Strategy, NACI Growth & Innovation document, ICT Road mapping documents, documents that were developed as part of the AAICT (Meraka) planning process, SAITIS from DTI, DTI's ICT Diffusion studies, National e-Strategies document, E-Government Gateway documentation, Draft Convergence Bill, ICT Foresight report, OSS and Open Standards report by NACI, National R&D Survey 2003/4 and 2004/5, The White Paper on e-Education, etc.

From the international literature, documents consulted included: BMBF document of the German Ministry of Science, FISTERA – a foresight study by EU, Australian ICT Industry Framework report, Final Report on Digital Opportunities 2003, WSIS Declaration of Principles and Plan of Action, and others.

Membership of the various groups involved in the strategy process is outlined in the table below:

Table 11: Membership of various groups involved in the strategy development process

Group Category	Names	Organization	Designation/ Other Positions	Local/ International
CG	Prof Cheryl De La Rey (Chairperson)	University of Cape Town	Dep. Vice Chancellor: Research Member of NACI, CSIR Board	Local
	Dr B. Sehlapelo	DST	Group Executive	Local
	Mr Imraan Saloojee	DST	Manager: ICT	Local
	Mr Llew Jones	CSIR ISTC (AAICT)	Director	Local
	Prof Elisabeth Botha	University of Stellenbosch	Academic	Local
	Mr Envir Fraser	DoC	Manager	Local
	Mr Johan Eksteen	CSIR ISTC (AAICT)	Manager	Local

SWG (Include All CG Members)	Prof Etienne Barnard	University of Pretoria	Academic	Local
	Mr Roy Volkwyn	Telkom SA	Representing Mr. Thami Msimang	Local
	Mr Jonas Manamela	University of Limpopo	Academic	Local
	Ms Trudy van Wyk	DoE	Director	Local
	Mr Francois Denner	DTI	Chief Director	Local
	Mr Aubery Malabi	SMEs	Representative of SME ICT Sector	Local
	Dr McKay Motshabi (Late)	SITA (DPSA)	General Manager: R&D	Local
ERP	Prof Daya Reddy	NRF	Chairman	Local
	Prof Vijay Bhaktar	India	Previously	International
	Prof Dr Stefan Jahnichen	Fraunhofer Institute (Germany)	Research/ Academic	International
	Ms Lucy Abrahams	Link Centre – Wits	Director Also served on NACI, SITA board	Local
	Dr Sibusiso Sibisi	CSIR	President & CEO	Local
	Dr Bob Day	UNISA	Academic	Local
R&D SS	Mr Laurens Cloete	CSIR ISTC (AAICT)	Manager	Local
	Ms Ndellie Mwanangulu-Massey	CSIR ISTC (AAICT)	Project Manager	Local
	Mr Sherin Isaac	CSIR ISTC (AAICT)	Project Manager	Local
	Mr Gerry Le Roux	CSIR ISTC (AAICT)	Project Manager	Local
	Mr Linley Nadison	DST	Deputy Director: ICT	Local
	Ms Nondzwakazi Gumede	DST (Alternate to Linley Nadison)	Deputy Director: ICT	Local
	Ms Ronel Smith	CSIR ISTC (AAICT)	Project Manager	Local

C.2 Final Consultation Process:

Subsequent to development of a draft strategy a final consultation process was undertaken in which the following government departments were consulted: Public Enterprises (DPE), Department of Education, Trade and Industry (the dti), Public Service and Administration (DPSA), Department of Provincial and Local Government (the dplg), and the Presidency.

The consultation process confirmed support for the strategy and the following issues were highlighted by the departments consulted:

- The strategy was seen as a commendable initiative enabling service delivery and will position South Africa to compete effectively in the global market.
- Support was expressed for the three strategic objectives and four supporting objectives as outlined in the strategy and the complementarities of proposed interventions with existing initiatives was indicated.
- Support was expressed for the technology and application domains proposed with specific mention of: Mobile and Wireless, Human Language Technology, Open Source Software and tele-medicine.
- Agreement was reached that South Africa must establish a strong research and development platform leading to innovations in the ICT industry.
- Emphasis of the central role of information and communication technologies to enhance productivity and competitiveness in all our industrial sectors.
- Underlining of the importance of the ICT sector as a key sector for potential economic growth and substantial job creation in developing countries.
- Stressing of electronic communications as a key commercial and social infrastructure as indicated in ASGISA.
- Support was expressed for the strategy's intention to involve role players such as other government departments, Higher Education Institutions and Meraka to align and coordinate ICT research according to socio-economic needs, priorities and areas of neglect.
- PNC on ISAD Plan not reference in the ICT R&D and Innovation Strategy: At the time of developing the National ICT R&D and Innovation Strategy, the PNC on ISAD Plan was also in the process of being developed. The DST is actually part of the National Working Group of the PNC on ISAD Plan. The PNC on ISAD Plan

recognises the importance of the development of capacity to compete in the knowledge economy of the global Information Society. According to the PNC on ISAD Plan, capacity development involves the expansion of information and knowledge resources through increased research and development, as well as improved cooperation between government, business and the higher education sector to support the knowledge intensive industries. In this regard, DST is explicitly recognised in the PNC on ISAD Plan as the lead department that will ensure the building of this capacity through the National ICT R&D and Innovation Strategy. The two initiatives (National ICT R&D and Innovation Strategy and the PNC on ISAD) should therefore be seen as complementary to each other and not contradictory.

The consultation process also highlighted a number of issues that needed to be clarified or otherwise required attention. These were addressed in this amended version of the document as follows:

- Mid-level skills - The strategy has been updated to address the inputs made by the departments to reflect the importance of the mid-level skills and to clarify the role of the strategy relative to mid-level skills. The need for mid-level skills to complement advanced level skills to industrialise ICT Innovations and address affordability of ICT services as well as the need for a pipeline leading to advanced skills required for R&D and Innovation is recognised in various sections of the current version of the strategy.

The ICT R&D and Innovation Strategy will complement existing and planned initiatives that explicitly address mid-level skills such as the ICT skills plan currently being developed by DoC. The DST will continue to engage with DoC, DoE, DTI and others in supporting such issues. It is believed that the private sector, the Universities of Technology and various internship and other programmes can contribute to alleviating the mid-level skill shortage. The strategy can also benefit mid-level skills efforts by assisting in identifying future growth areas in the ICT sector through the direction it brings to R&D efforts and the road mapping, foresighting and other futures exercises envisaged.

- Private sector role - The strategy has been updated to reflect the inputs made by and address the inclusion of multinationals in the implementation of the strategy and highlighting support for innovative smaller South African firms in realising the objectives of the strategy. Multinationals will be leveraged for implementation of the strategy in support of all three strategic objectives (research, Innovation and HCD). DST's MESIP programme provides seed funding and other support to enable

investments by multinationals to invest in local R&D centres. Cooperation with SAP, Intel, Cisco and Nokia are examples where significant progress has already been made in this regard. The Innovation Fund promotes economic competitiveness of South Africa by investing in near market, technological innovations that lead to the establishment of commercially viable start-up companies. The dti's SEDA Technologies programme has established support mechanisms such as incubators that enhance the viability of technology based SMEs. These existing instruments are seen as key to the success of the strategy and efforts to establish a robust innovation chain will be coordinated with these agencies. Industry involvement should also be considered in the design of mid-level skills interventions through for instance courses at Further Education and Training (FET) colleges to support SMME involvement.

Realising the importance of ICT in industry, the dti has established the South African Technology Vanguard (SAVANT), which is a public-private partnership between the dti and several key players in industry. It forms part of the collaborative marketing and branding campaign in the ICT and electronics sector and currently has nearly 500 members. The DST will collaborate with DTI and SAVANT to create awareness and engage with industry relative to the strategy.

- HRD KPI – The document has been updated to include measures at levels other than PhD graduation due to the lags that can be expected in achieving desired PhD graduation rates
- Bursaries for PDI matriculants - The Advanced skills programmes of this strategy will support postgraduate studies by historically disadvantaged candidates through bursaries, studentships and internships. DST will also engage with DoE, DoC and other stakeholders, public and private, to ensure that measures are in place for an adequate supply of ICT graduates that can feed into the advanced skills programmes of this strategy.
- Interdepartmental cooperation - interdepartmental cooperation at a national level is crucial to the success of the strategy. Cooperation in implementation of the strategy will be supported by clarity of roles between the different departments and through specific mechanisms that are being put in place. In this regard, the DST is currently in the processes of signing Memoranda of Agreement (MoAs) with relevant government departments on areas of cooperation. The cooperation include joint development of programmes on practical demonstrations, basic and applied research projects and addressing joint approaches towards leveraging international resources for ICT and international science programmes.

- Awareness at school levels for career guidance - Discussions will be held with the DoE to ensuring that appropriate measures are taken in terms of Career Guidance at school level. This will be supplemented through interventions such as the Youth in Science initiative, Kids Technology Clubs etc. Moreover, the DoE will be encouraged to expand programmes such as Dinaledi Schools that aims to bring about an increased throughput of learners who leave school with Mathematics at higher grade. This will indirectly boost the levels of intakes for ICT learners at HEIs.
- Refinement of service delivery (and other) domain/s – The DST is planning a series of detailed planning workshops on each of the domains in which the strategy will invest, subsequent to approval of the strategy by Cabinet. This will bring together stakeholders from government, industry, academia and the National System of Innovation. These workshops will be aimed at agreeing on the goals and research plans in the different domains. In the case of service delivery this will, for instance, include DPLG, DPSA, the provinces, metros, SITA and others involved in service delivery.