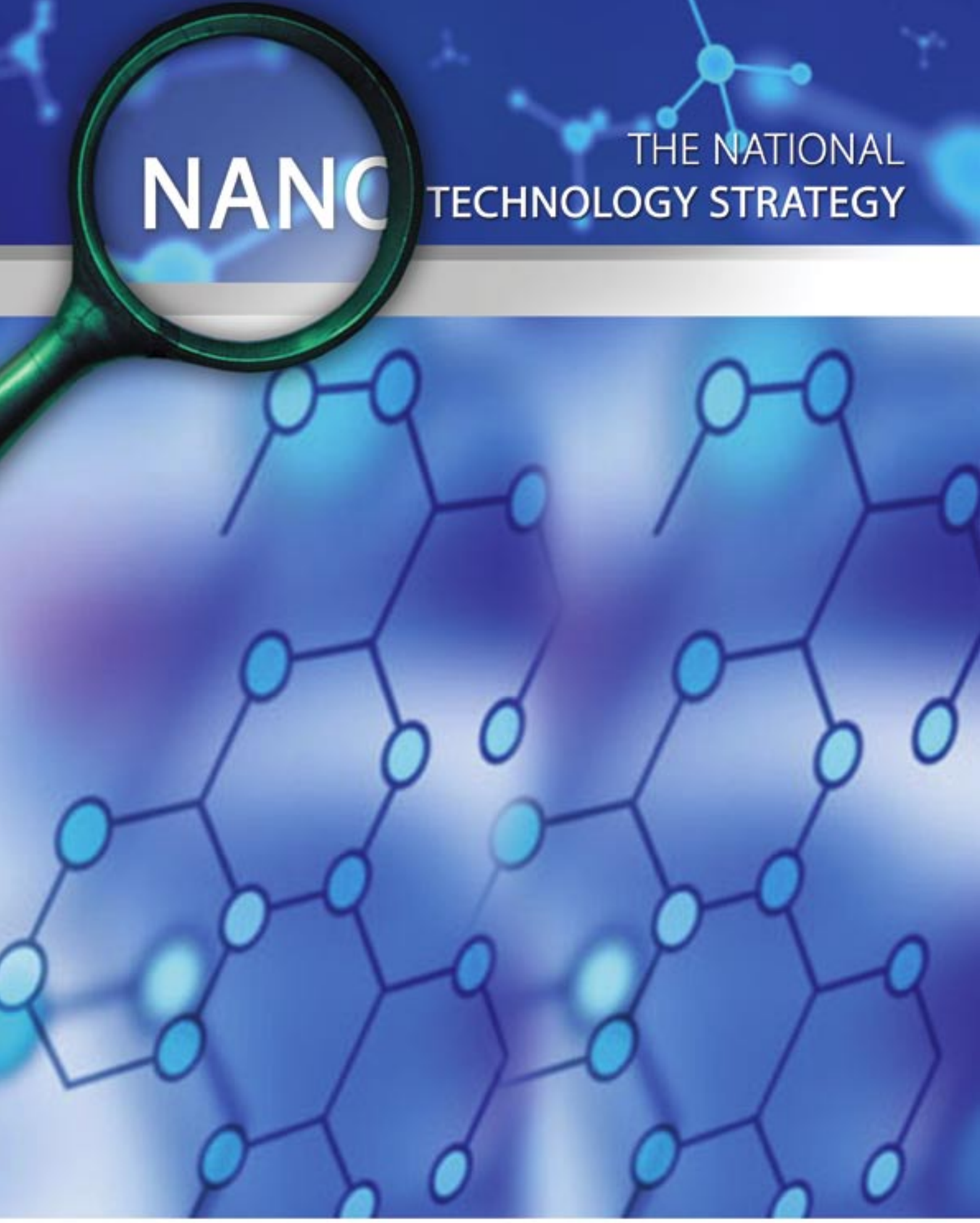
NANO THE NATIONAL TECHNOLOGY STRATEGY



science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

Our Vision

To create a prosperous society that derives enduring
and equitable benefits from science and technology

Our Mission

To develop, coordinate and manage a national system
of innovation that will bring about maximum human capital,
sustainable economic growth and improved quality of life for all.

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Foreword: The Honourable Minister of Science and Technology, **Mr Mosibudi Mangena**

In an increasingly competitive global economy marked by the technology divide between the developed and the developing worlds, it is even more urgent for science and technology to be a robust arbiter in advancing equitable human progress. This started with the digital divide and recently biotechnology faced the broadly ill-prepared developing world. In the near future Nanotechnology will be cause for another technology-based divide. Known as the technology of the very small Nanotechnology will see an upsurge in a variety of handy and cost-effective new technological devices and systems built. The building block for this new technology wave is Nanoscience. Nanoscience allows for the manipulation of matter at the atomic or molecular level resulting in materials and systems with drastically different physical, chemical, optical and biological properties.

Government believes that science and technology is pivotal for the country to successfully assuage unemployment, poverty, and underdevelopment, racial and gender inequities, among others. Since the publication of the White Paper in 1996, Government has made varied strides towards accelerating the integral role played by science and technology beyond the realm of research and innovation. We have been putting a multitude of practical measures that help position science and technology within the broader socio-economic imperatives of a country in transition and a country poised for excellence.

The South African Nanotechnology Strategy addresses itself to the opportunities presented by this new wave of technology. In line with our constitutional mandate as the custodian of innovation, the Ministry of Science and Technology seeks to ensure that South Africa is ready to optimally use Nanotechnology to enhance her global competitiveness and sustainable economic growth. Nanotechnology promises more for less - smaller, cheaper, lighter and faster devices with greater functionality, using fewer raw materials and consuming less energy. This technology is also an even improved response to the demands of improving economic growth conducive to best practice in environmental sustainability.

The strategy strengthens the integrated industrial focus of Government and advances the national technology missions that have been identified in the National R&D Strategy. Nanotechnology crosscuts biotechnology, technology for manufacturing, information technology and can improve our natural resources sectors and technology for poverty reduction.

Government realises that to optimise the opportunities of Nanotechnology and to achieve the goals of the strategy, the following key interventions are vital:

- Develop human resource capacity that focuses on Historically Disadvantaged Institutions(HDIs), women and people with disabilities,
- Accelerate Government efforts to build excellence in research and development capacity,
- Establish networking and shared resources,
- Stimulate innovation, incubation and technology transfer,
- Create transparency, public awareness and acceptance of Nanotechnology.

As Government moves the frontiers of poverty and underdevelopment in the Second Decade of Liberation, the Nanotechnology Strategy moves us even closer to the realisation of a knowledge-based economy. The Ministry of Science and Technology believes that Nanotechnology will drive the industrial revolution in the 21st century. We are determined to ensure that South Africa joins the quest for advanced international competitiveness that Nanotechnology can provide.

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Executive Summary

South African industry and researchers have been players in Nanoscience and Nanotechnology for a considerable time. Although we have many Nanotechnology-based industrial processes and products, new generations of Nanotechnology-based products that are rapidly emerging in the world today, require that South Africa develops the ability to derive benefits from global advances in this area.

The Nanotechnology Strategy positions South Africa as a player in this emerging area of science and technology and seeks to strengthen the integrated development focus of Government. The strategy takes cognisance of the needs of local industry and society and compliments the national technology missions that have been identified in the National R&D Strategy. It focuses on essential building blocks of Nanoscience which are synthesis, characterisation and fabrication. Nanotechnology in South Africa would create opportunities for human capital development, particularly for historically disadvantaged individuals (HDIs), women and people with disabilities. It would drive research and development; innovation; education, training and curriculum development; innovative entrepreneurship and improved opportunities for BEE.

The vision of the strategy is to draw upon the existing strengths of the national system of innovation while addressing the need to enhance its research infrastructure and to create a workforce for advanced technology businesses that support the country's future competitiveness and enhanced quality of life. The main objectives of the strategy are to:

- Support long-term nanoscience research that will lead to the fundamental understanding of the design, synthesis, characterisation, modelling and fabrication for nanomaterials.
- Support the creation of new and novel devices for application in various areas.
- Develop the required resources human and supporting infrastructure to allow the development
- Stimulate new developments in technology missions such as advanced materials for advanced manufacturing, nano-bio materials for biotechnology, precious metal-based nanoparticles for resource-based industries, and advanced materials for information and communication technologies.

Key initiatives to support the vision are:

- The establishment of dedicated funding for supporting the implementation of the strategy.
- Encourage multidisciplinary and multi-institutional cooperation required to advance nanoscience and nanotechnology
- Create the physical infrastructure to enable first-class basic research, exploration of applications, development of new industries, and commercialisation of innovations.
- Fostering the creation of interdisciplinary and inter-institutional postgraduate Nanoscience and Nanotechnology programmes.
- The creation of an environment conducive to collaborative, pre-competitive Nanotechnology Research and Development activities in industry.
- Supporting the creation of strategic networks in the field of Nanotechnology.
- Analysis and introduction of legislative instruments to ensure that Nanotechnology is applied according to international best practice in industrial and environmental safety standards.
- Ensuring that the implementation of the Nanotechnology strategy occurs in a manner that fosters open debate and public access to information.

The strategy proposes the establishment of nanotechnology characterisation centres, research and innovation networks, capacity building program and flagship project program.

Acronyms and Abbreviations

AMTS	Advanced Manufacturing Technology Strategy
BEE	Black Economic Empowerment/Enterprises
BSD	Biotechnology and Skills Development
DST	Department of Science and Technology
EU	European Union
HDIs	Historically Disadvantaged Individuals/Institutions
HRD	Human Resource Development
ICT	Information and Communication Technology
IMS	Integrated Manufacturing Strategy
NEPAD	New Partnership for African Development
NMS	National Microeconomic Strategy
NRDS	National Research and Development Strategy
NRF	National Research Foundation
PGM	Platinum Group Metals
R & D	Research and Development
SADC	Southern African Development Community
SANI	South African Nanotechnology Initiative
SET	Science, Engineering and Technology
SMMES	Small, Micro and Medium Enteprises
S&T	Science and Technology
USA	United States of America

Background

Realising that extensive R & D spending in Nanotechnology was fast becoming commonplace internationally, the Department of Science and Technology (DST) commissioned the South African Nanotechnology Initiative (SANi) to develop a South African Nanotechnology Strategy.

Due effort was taken to emerge with a broadly representative strategy. A wide range of experts from the private sector, academia, labour and Government worked as a multidisciplinary team to develop base documentation leading to the Nanotechnology Strategy.

Nanoscience and Nanotechnology

A nanometre is a billionth of a metre, that is, about 1/80,000 of the diameter of a human hair, or 10 times the diameter of a hydrogen atom. Nanoscience essentially marks the dawn of a new way of life as regards to how society will make its products and benefit from science and technology. The term refers to a wide range of technologies, techniques and processes that are informed by a new way of interpreting and applying them. It is not necessarily a distinct area of science but rather a radical redefinition of the combined power of science and technology.

Associate director of the University of Pennsylvania's Center for Bioethics, Glenn McGee describes Nanotechnology as a generic term for activities at the level of atoms and molecules with applications in the real world.

To develop the technology, science programs need to be strengthened to overcome the scale and complexity of systems at the nano-scale. It is therefore, more appropriate to overlap nanotechnology-targeted programs with discipline related research.

Another outstanding attribute of Nanotechnology is that it is multidisciplinary. Research at the nanoscale is unified by the need to share knowledge on tools and techniques, as well as information on the physics affecting atomic and molecular interactions. It is widely acknowledged that many aspects of this field of science existed before, however, the coherence came about due to the convergence of new and improved control of nano-sized material, new and improved characterisation of nano-sized material as well as a better understanding of the relationships between nanostructure and properties and how these can be engineered.

Materials scientists, mechanical and electronic engineers and medical researchers are now forming teams with biologists, physicists and chemists. It's a brand new Nanotechnology world!

Some of the areas in which this technology is applied include; structured applications for instance in aerospace and automotive industries, energy conversion, storage and distribution, defence, chemical applications, information processing, storage and transmission and nano-biotechnology

Developments in Nanoscience

Developments in Nanotechnology can be categorised according to expected time they will reach the market, namely; first, second and third. Fig. 1.1 below illustrates how these phases are related to the overall development chain from idea to product. For comparison purposes the approximate status and not the relative size of both the global and South African activities are shown.

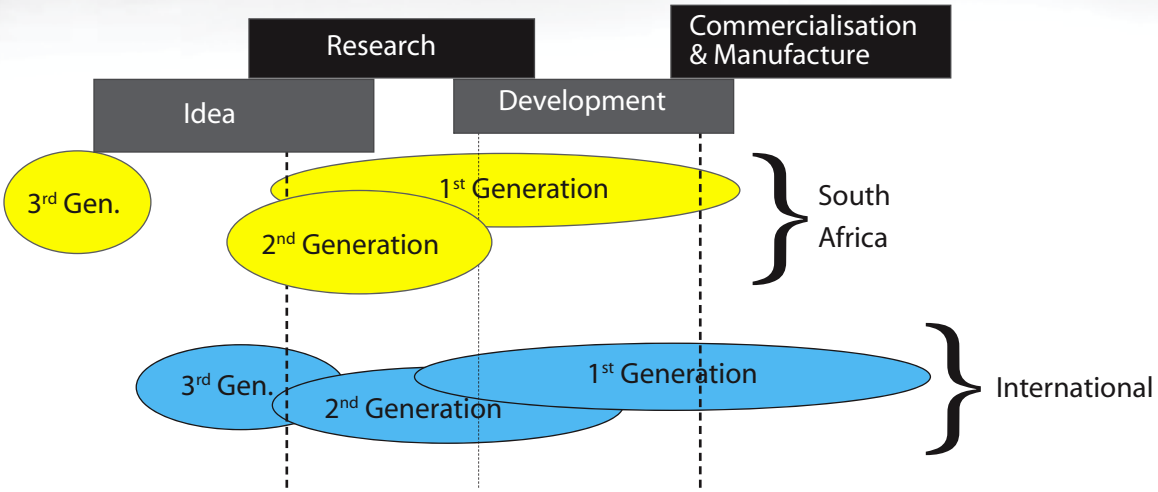

Figure 1: *Schematic Indication of the Progress Nanotechnology in South Africa relative to the World.*

First Generation Nanotechnology is already in use in the form of continued improvements on current technologies or products that manipulate matter on the nanoscale or use nanomaterials. A good example of first generation Nanotechnology is chemical processing by catalysis as already done by SASOL and is common in the local manufacturing sector. Other examples are nanoparticles used in coatings, paints, cosmetics and sunscreens as well as nanomembranes for water filtration and desalination.

Second Generation Nanotechnology is about new ways of making products or enhancing existing processes. It is expected to have a major impact in the next decade especially in sectors such as energy storage, conversion and distribution, aerospace, medicine, electronics, ICT and associated technologies. In energy storage and distribution, Nanotechnology holds much hope for the creation of viable industries with portable and sustainable power. Nanotechnology could also drive major advances in drugs delivery systems and in bioanalysis. In electronics there is enormous revenue potential in processor, memory and display technologies.

Third Generation Nanotechnology refers to new ways of making entirely new products and is expected in the longer term (10 years and longer). Examples include minute intelligent sensors and devices that can monitor body functions, detect pathogens and environmental conditions. This technology could also lead to advanced fabrics that release chemicals in response to a stimulant or which can regulate temperature. The mass media especially in entertainment has also created wildly futuristic scenarios, usually involving nanorobotics. This could mark a new and exciting trend in the realm of science fiction. Nano-assembly by self-replication at a molecular level is as old as Mother Nature - the miracle of life is a prime example of self-replicating systems based upon nanoscale self-assembly.

International Context

Nanotechnology has been benefiting humanity for the better part of the twentieth century even though efforts at serious positioning are only beginning now. Recent reports now suggest an explosion of this technology in the next decade. The USA-based Freedonia Group predicts a growth for nanomaterials, from a market value of US$ 125 million at the end of the 20th century to US$ 35 billion at the end of the second decade of the 21st century. This report estimates that the early phase of this growth will be dominated by various niche applications for nanomaterials across manufacturing sectors. Long-term growth however will mostly be sustained by the health and electronics sectors. This explosive growth also partly explains the reasons for EU countries and economic giants like Japan and the US are investing heavily in Nanoscience and Nanotechnology.

Some of the key application areas for the Nanotechnology are:

- Nanomaterials for structured applications for instance in the aerospace and automotive industries.
- Energy conversion, storage and distribution.
- Defence technologies.
- Information processing, storage and transmission.
- Chemical applications.
- Environment remediation.
- Sensor applications.
- Nano-biotechnology.
- Long-term research with generic applications.
- Instruments and techniques supporting Nanoscience and Nanotechnology.

National Context

A number of South African universities, science councils and industrial companies have been active in Nanotechnology for some time. Equally noteworthy is that some universities have strong working relations with industrial companies and it is largely this relationship that gave birth to SANi in May 2002. SANi has close to 100 registered members comprising twelve universities, ten industrial companies and four science councils.

The Nanotechnology Strategy is in line with the broad development goals of South Africa. Figure 2 illustrates the relevant strategic landscape in South Africa, with the interrelationships between different strategies indicated. The main context starts with the National Microeconomic Strategy that outlines the year 2014 vision. Furthermore the National Research and Development Strategy (NRDS) and the Integrated Manufacturing Strategy (IMS) of the departments of science and technology and trade and industry respectively, further support the vision.

The NRDS has prioritised the following four innovation missions:

- Poverty reduction
- Key technology platforms (including biotechnology and ICT)
- Advanced manufacturing
- Leveraging resource-based industries.

The Nanotechnology Strategy therefore seeks to directly and indirectly contribute to the innovation missions and goals of these strategies. It also compliments other current strategies within the technology missions such as Advanced Manufacturing Technology Strategy (AMTS), Biotechnology Strategy and the Skills Development Strategy.

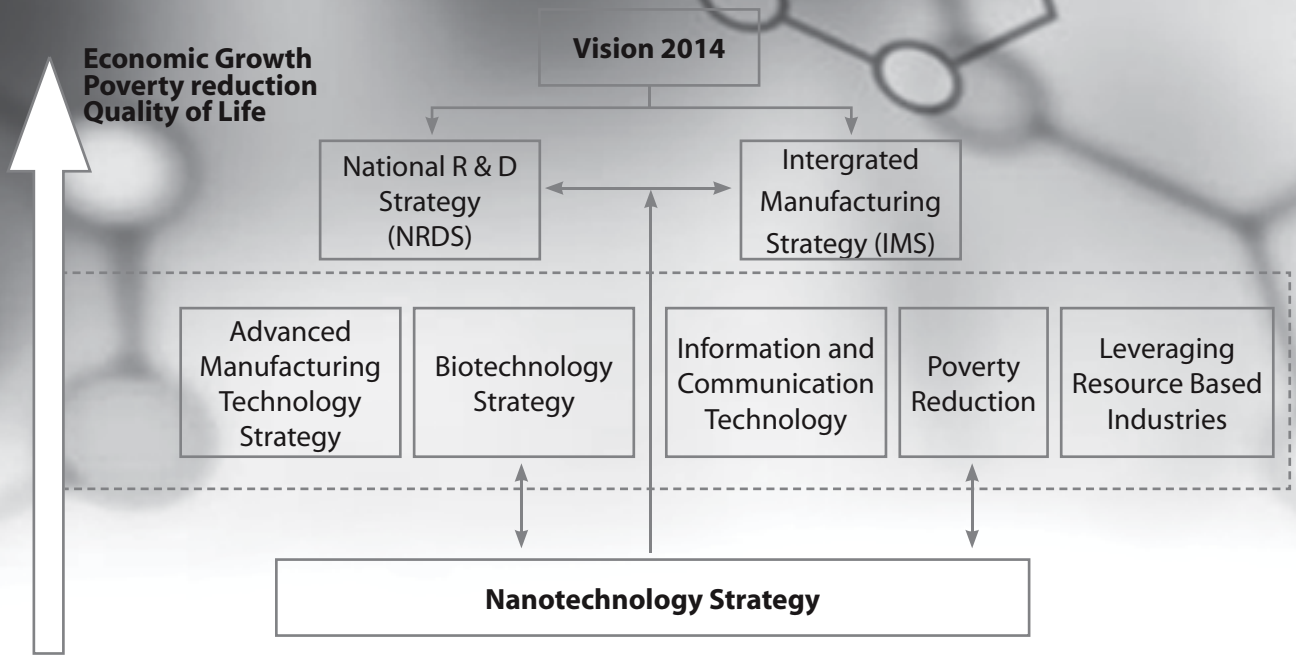

Figure 2: *The positioning of the Nanotechnology Strategy in the South African Strategy landscape*

In many ways the strategy is strongly linked to the AMTS as it is recognised as a major driver in both advanced polymer and ceramic materials development. It is thus critical to see Nanotechnology as belonging to a wide set of mutually supporting technologies.

Strategic Plan

Strategy Process

Figure 3 below illustrates the process used in developing the Nanotechnology Strategy, starting with the initial consultation process in April 2003. The formation of the expert group coincided with the second SANi workshop held on 20 June 2003.

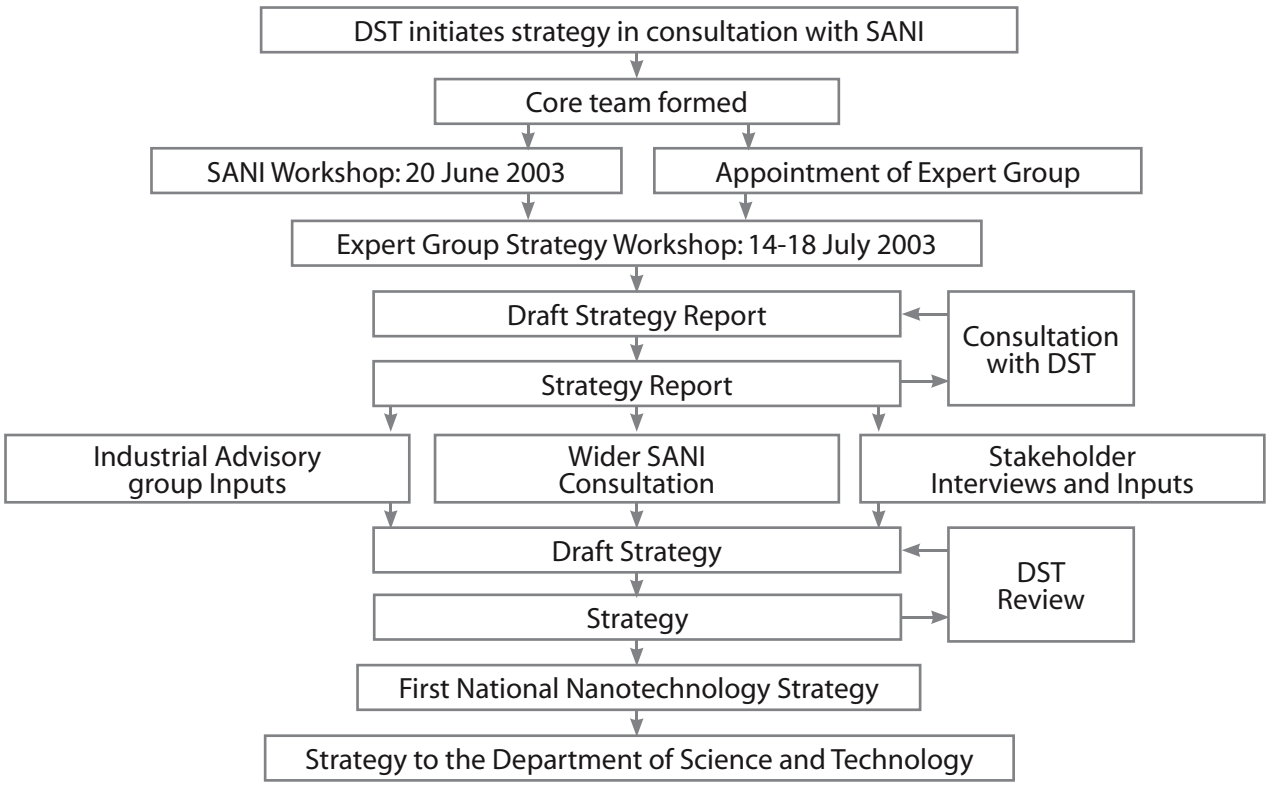

Figure 3: *Strategy Development Process*

Vision of Strategy

The vision of the strategy is to draw upon the existing strengths of the national system of innovation while addressing the need to enhance its research infrastructure and to create a workforce for advanced technology businesses that support the country's future competitiveness and enhanced quality of life.

Strategic Objectives

The main objectives of the strategy are to:

- Support long-term nanoscience research that will lead to the fundamental understanding of the design, synthesis, characterisation, modelling and fabrication for nanomaterials.
- Support the creation of new and novel devices for application in various areas.
- Develop the required resources human and supporting infrastructure to allow the development
- Stimulate new developments in technology missions such as advanced materials for advanced manufacturing, nano-bio materials for biotechnology, precious metal-based nanoparticles for resource-based industries, and advanced materials for information and communication technologies.

Key Initiatives

The key initiatives to support the vision are:

- The establishment of dedicated funding for supporting the implementation of the strategy.
- Encourage multidisciplinary and multi-institutional cooperation required to advanced nanoscience and nanotechnology
- Create the physical infrastructure to enable first-class basic research, exploration of applications, development of new industries, and commercialisation of innovations.
- Fostering the creation of interdisciplinary and inter-institutional postgraduate Nanoscience and Nanotechnology programmes.
- The creation of an environment conducive to collaborative, pre-competitive Nanotechnology Research and Development activities in industry.
- Supporting the creation of strategic networks in the field of Nanotechnology.
- Analysis and introduction of legislative instruments to ensure that Nanotechnology is applied according to international best practice in industrial and environmental safety standards.
- Ensuring that the implementation of the Nanotechnology strategy occurs in a manner that fosters open debate and public access to information.

Recommendations

Implementation Plan

Nanotechnology is highly multidisciplinary and requires a variety of techniques and expertise often widely dispersed geographically and institutionally in South Africa. For this reason a Technology Innovation Network is proposed to help support the implementation of the Nanotechnology Strategy. The finer detail of the strategy implementation will be dealt with in the implementation plan or business plan once the strategy has been accepted. An overview of the implementation follows.

- **Characterisation Centres**

The aim is to establish and maintain geographically distributed multi-user facilities to provide researchers with advanced instruments for design, synthesis, characterisation, modelling and fabrication.

- **Research and Innovation Networks**

Collaboration among traditional disciplines, research teams and institutions is critical for both progress in understanding nanoscale phenomena and developing nanotechnology applications. The research and innovation networks will initially be established on basic research themes, for example, nano characterisation of non-carbon based nanoparticles, nano synthesis techniques, modelling of nanoparticles, etc.

In the South African academic and research spheres, it is also important that collaborative networks help improve the research capacity inequalities between historically white institutions and the historically black institutions.

Equally important is for South Africa to cooperate with the Southern African region and the continent through institutions such as the Southern African Development Community (SADC) and the New Partnership for Africa's Development (NEPAD) respectively. The networks will also provide a link for our researchers with similar networks that have been established in India, Brazil, Europe and the rest of the world.

- **Capacity Building Program**

The case for investing early in the development of a highly trained human resource base with requisite R&D expertise would encourage the private sector to develop Nanotechnology-based products and services. New markets arising from this area of market diversification would in turn drive societal development, particularly in education and job creation.

Particular areas that need Government and private sector investment include the following:

- Final year undergraduate and post graduate bursaries and other incentives that will lead to a human resource explosion in Nanoscience and Nanotechnology.
- Strengthen industrial HR Nanotechnology capacity with training programmes and internships to current and new entrants in the field.
- Encourage interdisciplinary and inter-institutional postgraduate programmes in Nanoscience and Nanotechnology.
- Encourage collaborative R&D in Nanoscience and Nanotechnology.
- Contribute in the creation of strategic support networks in South Africa and in some instances, regionally.

In the knowledge economy the priority is technical information and expertise as distinct from specific products. Although the industrialisation of products and processes beyond prototype stage and commercialisation falls outside the scope of this strategy, it is pleasing to note that several industrial partners already support aspects of nano-related research and have their own industrialisation strategies in place. Their commitment to the Nanotechnology Strategy is already demonstrated through cost-sharing and a pledge to commercialise the technology when the strategy begins to realise its objectives.

In Nanotechnology, similar to biotechnology, the formation of start-up companies is a great opportunity. In order for South Africa to benefit from the whole value chain a critical path should be established from idea through research and development via incubation to commercial manufacture in start-up companies as is illustrated in Figure 4.

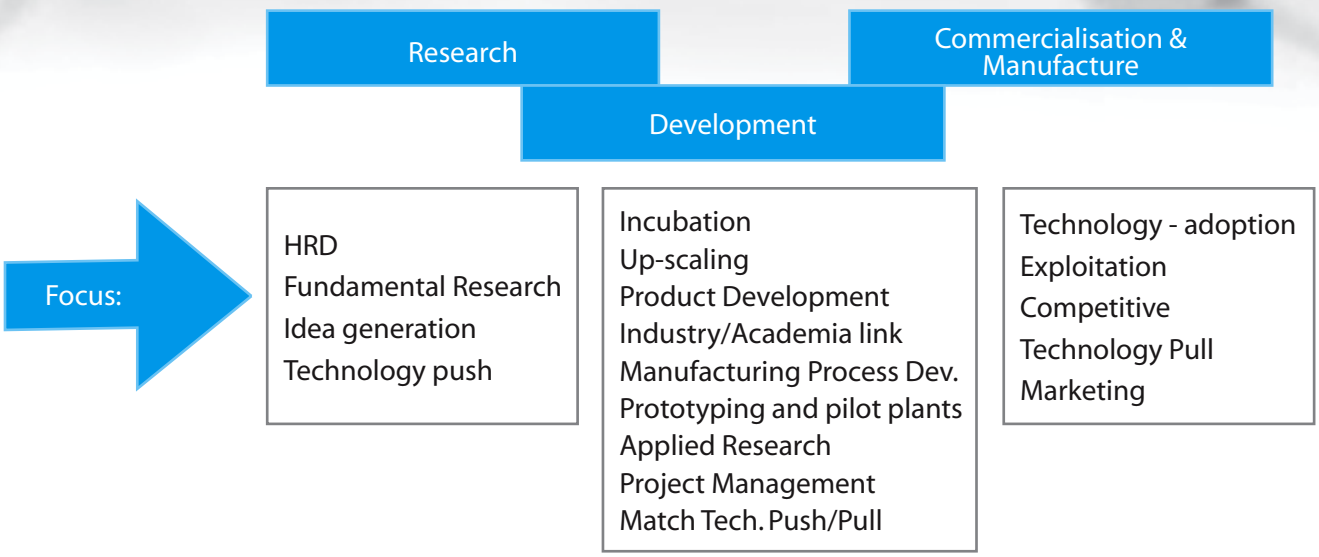

Figure 4: *Actions required to bridging the Innovation Chasm*

Thus the strategy should also include a component that focuses on commercialisation and matching research offerings with industrial manufacturing and processing capacity.

Mechanisms for the conception and incubation of new Nanotechnology-based industries and the transfer of new technologies to existing industries are critical. To do so, it has to liaise extensively with the other management functions, with governmental departments (especially Trade and Industry, and Labour), with industry, funding bodies and with third parties such as independent venture capitalists and technology incubators.

- **Flagship Projects**

To demonstrate the benefits of Nanotechnology within a reasonable period, it is important that selected visible projects are devised in the form of Nanotechnology Flagship Projects. Driven by the main objectives of the R&D strategy which are to enhance quality of life and increase economic growth, these flagship projects should target relevant impact areas. Considering the status of Nanotechnology in the world and how South Africa relates to it and the needs and opportunities identified the areas where Nanotechnology can generate most benefits for South Africa can be grouped into the following six focus areas:

- **Water**
- **Energy**
- **Health**
- **Chemical and Bio-Processing**
- **Mining and Minerals**
- **Advanced Materials and Manufacturing.**

The flagship projects can be grouped into two development clusters: industrial and social. In the industrial cluster, mining and minerals, chemical and bioprocessing and materials and manufacturing, could benefit tremendously form local strengths in Nanotechnology. For the social cluster, benefits would arise from new developments in the provision of clean and purified water, affordable and renewable energy and improved primary health care.

Projected Impact

Monitoring And Evaluation

Mid-term annual reviews of the Nanotechnology Strategy are recommended, followed by three-year rigorous monitoring and evaluation reports. Although this strategy sets the vision for Nanotechnology endeavour in South Africa to beyond 2014, the exercise would help in ensuring that the strategy is sustainable through objectively verifiable performance. It would also help to recommend appropriate responses to the rapidly changing Nanotechnology environment.

The continuous strategic planning should consider the main application areas of Nanotechnology and reconsider their appropriateness and the specific needs that should be addressed.

Critical Success Factors

The success of the Nanotechnology Strategy includes the following critical factors:

- Sustainable strategy for public support of Nanotechnology applications in industry and in a manner that addresses key societal imperatives.
- Availability of innovative public and private sector funding instruments for implementing the strategy and investigate the viability of establishing a Strategic Nanotechnology Fund.
- Ensure that Nanotechnology generates requisite critical mass in South Africa's R & D activities.
- Improve access to technology and business incubation thereby encouraging an environment conducive to the growth of SMMEs and BEE.
- Introduce human resource development and recruitment programmes to help deliver Nanotechnology services through local expertise.
- Enhance public understanding of Nanotechnology and its benefits.
- Create a formidable policy-making and administrative leadership core to bolster Nanotechnology implementation.

Short-Term Impact (1-3 Years)

First Generation Nanotechnology products already generate wealth in South Africa by improving existing processes for instance in the field of catalysis. Furthermore knowledge to manipulate technology at the nanoscale is used extensively in the chemicals processing industry.

Nanotechnology products are in use as well to treat water and effluent. It is also applied in ultra hard nano-materials for wear resistance in mining and in protective coatings and paints that rely on nano-particles to enhance their performance. Internationally, display technologies, cosmetics and nano-composite plastics are areas where Nanotechnology holds promise for consumer products within three years.

Medium-Term Impact (3–10 Yrs)

In the medium term new developments in Second Generation Nanotechnology applied to existing processes will impact enormously in the following areas:

- Developments in water treatment systems and the secondary use of effluents to make low-cost nanoporous absorbents for brine stabilisation and water purification.
- Low-cost solar and fuel cells-based, portable power based on nano-materials are expected to reach the market at this stage, as are intelligent materials for energy savings and thermal regulation.
- In medicine, drug delivery and bio analysis will lead the way in the application of Nanotechnology, followed by biopharmaceuticals, prosthetics, bio mimetic systems, cheaper and more portable nano-analysis tools and systems.

- Value addition by beneficiation of gold, platinum group metals (PGM) and other mineral resources as high performance catalysts, absorbents in polymer nano-composites and in energy-saving materials.
- Cleaner process engineering will produce value-added chemicals and speciality products including bio catalytic systems and novel heterogeneous catalysts.
- Smart and functional materials including lubricants and barrier coatings, ultra-hard and super-strong materials, electro and photo-chromic materials with applications in all manufacturing sectors, industry, medical and domestic markets.

Long-Term (10 Years and Longer)

Advances in all sectors are expected particularly through the convergence of Nanotechnology, biotechnology, informatics and cognitive science. In general the anticipated long-term impact includes the following:

- Evolution of self-assembly sensors to monitor our health, food and environment thereby pre-empting possible danger.
- Cheap and powerful electronic devices incorporated in many household appliances including more fridges with Internet connectivity.
- Cheap and flexible solar cells that would easily cover many surfaces in our homes.
- "Intelligent" medication for curing cancer and other killer diseases.
- Light and super strong materials for vehicles, aircrafts and many new applications.

Potential Risks Of Ignoring Nanotechnology

Internationally there is generally consensus that Nanotechnology's major benefits include the following:

- The development of cheap, efficient solar cells for the provision of clean energy that can reduce time spent collecting wood for fuel thereby reducing exposure to health hazards such as lung cancer which is commonly attributed to wood for fuel.
- Nanotechnology-based water purification systems could help reduce exposure to water-borne diseases such as cholera.
- Improved drug delivery systems, including traditional medicine through packaging medicine for ailments such as TB, HIV/AIDS and Malaria in nano-capsules.

Whilst Governments continue to investigate and consider best options for bold national efforts at enhancing the country's Nanotechnology capacity, it is clearly that South Africa cannot afford to ignore Nanoscience. Some of the factors that militate against non-action are the following:

- Potential increases in "brain-drain" among local experts eager to optimise international opportunities.
- Decline in competitiveness within the South African industry especially manufacturing.
- General technology gaps in the country with potentially adverse effects on service delivery standards.
- Widened innovation chasm and potential retrogression on national science and technology progress.
- Non-compliance with advances in world technology thereby indirectly affecting international investor confidence towards South Africa.

Proposed Funding

In order for South Africa to share in the benefits of Nanotechnology, substantial investment will be required. It has been recommended that this strategy be supported by a strategic fund to be utilised for human resource and research capacity development as well as the commercialisation of Nanotechnology innovation products.

The budget for the successful implementation of the Nanotechnology Strategy for the first 3 years is estimated at R 450 million as shown in Table below. This is only indicative based on the recommendations of this strategy. The projected time-lines and realistic resource allocation would be based on project-specific implementation plans.

Key Interventions	2006/7 (R000's)	2007/8 (R000's)	2008/9 (R000's)
Cross-cutting S&T and Frontier Programmes			
Capacity Building (R&D and HRD)	30 000	60 000	80 000
Research and Innovation Networks	10 000	20 000	20 000
Flagship Projects	20 000	30 000	50 000
R&D Infrastructure			
Characterisation Centres	40 000	40 000	50 000
Total per year	**100 000**	**150 000**	**200 000**
TOTAL FOR 3 YEARS			**450 000**

Success Indicators

The following success indicators have been identified for the medium to long-term time frame:

- Impact of Nanotechnology on the quality of life of previously marginalised sectors of the community such as HDIs, women and people with disabilities.
- Commercial impact of Nanotechnology, including local (foreign) direct investment and return on investment, and contribution to the treasury.
- Number and quality of unique South African Nanotechnology-based products that are launched.
- Rate of the technology transfer of Nanotechnology into existing industry, BEE and the establishment of SMMEs.
- Impact of Nanotechnology-based solutions on community upliftment and quality of life.
- Number of current and graduating students and the effectiveness of Nanotechnology outreach programmes in schools and mass media.
- Quantity and quality of South African Nanoscience and Nanotechnology contributions in respected national and international journals, books and conferences.
- Quantity and quality of intellectual property, (patents, designs and trademarks) held by South African institutions or companies in Nanotechnology.

Conclusions

This document sets forward an ambitious long term strategy for Nanotechnology in South Africa. The areas of health, water and energy have been identified as a cluster of activity where social impact will be largest. The industrial cluster is made up of mining and minerals, chemical and bio-processing as well as materials and manufacturing activities in Nanotechnology.. The emerging aspects of Nanotechnology should be taken up and human resource capacity and R&D capacity should be built in a way that the country is well positioned in the next decade as a major player in Nanotechnology and a recognised implementer of Nanotechnology solutions. This strategy provides a realistic vision for such a Nanotechnology future.

It is critical that Nanotechnology research is conducted within an ethically sound framework and is rigorously subjected to international best practice in norms and standards such as peer reviews and other objective accountability instruments. Environmental impact assessment studies should also be compulsory in instances where Nanotechnology activity could have far-reaching socio-economic on people and their environment.

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

(South African Micro-Economic Strategy)

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