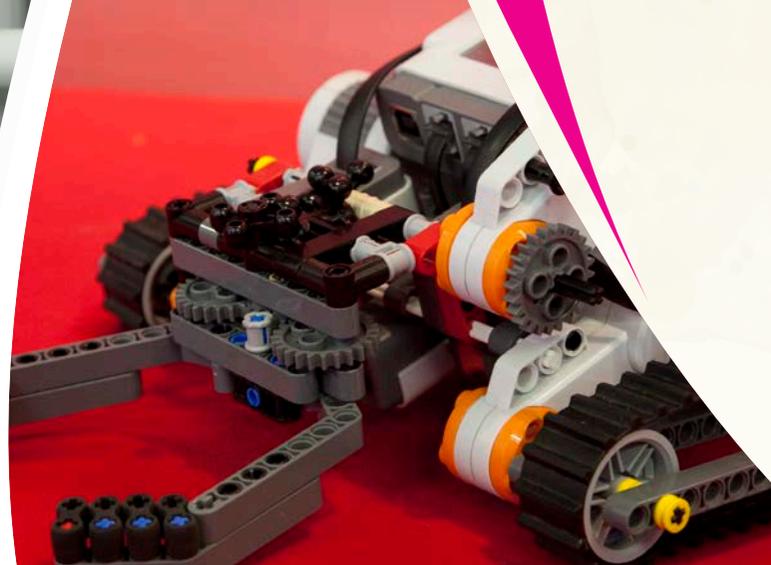




South Africa Yearbook 2018/19

Science and Technology



The Department of Science and Technology (DST) derives its mandate from the 1996 *White Paper on Science and Technology*, which introduced the concept of the national system of innovation, a set of interacting organisations and policies through which the country creates, acquires, diffuses and puts into practice new knowledge to help achieve individual and collective goals. A coordinated and efficient national system of innovation will help South Africa achieve its national development priorities by promoting change through innovation, enabling all South Africans to enjoy the economic, sociopolitical and intellectual benefits of science, technology and innovation.

The National Development Plan (NDP) acknowledges that science, technology and innovation are crucial to enabling broad-based socioeconomic development through a skilled and innovative population. This is expressed in terms of outcome 5 (a skilled and capable workforce to support an inclusive growth path) and outcome 6 (an efficient, competitive and responsive economic infrastructure network) of government's 2014 – 2019 medium-term strategic framework.

The department's strategic goals are to:

- develop the innovation capacity of the national system of innovation to contribute to socio-economic development,
- enhance South Africa's capacity for generating knowledge to produce world-class research outputs and turn some advanced findings into innovation products and processes,
- develop appropriate human capital in the science, technology and innovation (STI) sector to meet the needs of society,
- build world-class infrastructure in the STI sector to extend the frontiers of knowledge, train the next generation of researchers, and enable technology development and transfer as well as knowledge exchange, and
- position South Africa as a strategic international research and development, and innovation partner and destination through the exchange of knowledge, capacity and resources between South Africa and its regional and other international partners, thus strengthening the National System of Innovation (NSI).

Over the medium term, the department will focus on: producing new knowledge; developing human capital; funding research, innovation and infrastructure; and generating and

exploiting knowledge and innovation for inclusive economic development.

Legislation

The DST is governed by the following legislation:

- The Intellectual Property Rights from Publicly Financed Research and Development (IPR) Act, 2008 (Act 51 of 2008): Provides for the more effective use of intellectual property (IP) emanating from publicly financed research and development (R&D), through the establishment of the National Intellectual Property Management Office (NIPMO), the Intellectual Property Fund, and offices of technology transfer at institutions.
- The Technology Innovation Act, 2008 (Act 26 of 2008): Intended to promote the development and exploitation in the public interest of discoveries, inventions, innovations and improvements; and for that purpose establishes the Technology Innovation Agency (TIA).
- The South African National Space Agency (SANSA) Act, 2008 (Act 36 of 2008): Establishes the SANSA to promote space science research, cooperation in space-related activities and the creation of an environment conducive to the development of space technologies by industry.
- The Natural Scientific Professions Act, 2003 (Act 27 of 2003): Establishes the South African Council for Natural Scientific Professions, and legislates the registration of professional natural scientists, natural scientists-in-training, natural science technologists and natural science technologists-in-training.
- The National Research Foundation (NRF) Act, 1998 (Act 23 of 1998): Establishes the NRF to promote basic and applied research, as well as the extension and transfer of knowledge in the various fields of science and technology.
- The National Advisory Council on Innovation (NACI) Act, 1997 (Act 55 of 1997): Establishes the NACI to advise the Minister of Science and Technology on the role and contribution of science, mathematics, innovation and technology in promoting and achieving national objectives.
- The Africa Institute of South Africa (AISA) Act, 2001 (Act 68 of 2001): Establishes the AISA to promote knowledge and

understanding of African affairs by encouraging leading social scientists.

- The Human Sciences Research Council (HSRC) Act, 2008 (Act 17 of 2008): Provides for the HSRC, which carries out research that generates critical and independent knowledge relative to all aspects of human and social development.
- The Scientific Research Council Act, 1988 (Act 46 of 1988): Refers to the activities of the Council for Scientific and Industrial Research (CSIR), one of the leading scientific and technological research, development and implementation organisations in Africa, which undertakes directed R&D for socio-economic growth in areas including the built environment, defence, the environmental sciences, as well as biological, chemical and laser technologies.
- The Astronomy Geographic Advantage Act, 2007 (Act 21 of 2007): Provides for the preservation and protection of areas in South Africa that are uniquely suited to optical and radio astronomy, and for intergovernmental cooperation and public consultation on matters concerning nationally significant astronomy advantage areas.
- The Geoscience Amendment Act, 2010 (Act 12 of 2010), amends the Geoscience Act, 1993 (Act 100 of 1993), to mandate the Council for Geoscience (CGS) to be the custodians of geotechnical information; to act as a national advisory authority in respect of geohazards related to infrastructure and development; and to undertake exploration and prospecting research in the mineral and petroleum sectors.
- South African National Research Network (SANReN), which is responsible for the roll-out of a high-speed broadband network to all academic and research institutions in the country, was awarded a private electronic communications network licence exemption under the Electronic Communications Act, 2005 (Act 36 of 2005).
- The Science and Technology Laws, Amendment Act, 2014 (Act 7 of 2014) seeks to, among other things, streamline the process for the nomination and appointment of members of the boards or councils of such entities as well as the filling of vacancies on the boards.

Budget and funding

For the 2018/19 financial year, the department was allocated R8 billion. As part of government's broader objective to lower national expenditure and reprioritise funds appropriately, Cabinet has approved reductions to the department's baseline budget amounting to R322.8 million over the Medium Term Strategic Framework (MTEF) period. Nevertheless, the department's overall budget is expected to increase at an average annual rate of 3.8%, from R8.2 billion in 2019/20 to R8.9 billion in 2021/22. Of the department's total budget over the medium term, 92.5% (R23.8 billion) is expected to be transferred to the department's entities. Spending on compensation of employees is expected to increase at an average annual rate of 8.6%, from R339.8 million in 2018/19 to R435 million in 2021/22.

Policy mandate and strategies

The DST's major policy documents are the *White Paper on Science and Technology of 1996*, the 2002 National Development Research Strategy (NRDS), the New Strategic Management Model for South Africa's Science and Technology System (2004) – with its Policy on Governance Standards for Science, Engineering and Technology Institutions and Framework for the Development of a National Science and Technology Expenditure Plan – and the 2007 Ten-Year Innovation Plan (TYIP).

The DST is the custodial coordinator for the development of the NSI and influences this system through key strategies such as the NRDS and the TYIP. The latter, particularly, seeks to contribute to the transformation of the South African economy into a knowledge-based economy, in which the production and dissemination of knowledge will lead to socio-economic benefits and enrich all fields of human endeavour.

National Research and Development Strategy

The NRDS as the basis for the NSI and requires performance and responses in three key areas:

- enhanced innovation
- providing science, engineering and technology Human Resources (HR) and transformation
- creating an effective government science and technology system.

A prime objective of the NSI was to enhance the rate and quality of technology transfer from the science, engineering and technology sector by providing quality HR, effective hard technology transfer mechanisms, and creating more effective and efficient users of technology in the business and government sectors.

The White Paper also set out the institutions to be established to promote the development of a well-functioning NSI. These were to be the national Ministry and DST, the NACI, the NRF, the Innovation Fund and national research facilities managed by government.

The NRDS is aimed at being a key enabler of economic growth alongside other strategies, such as the HR Development Strategy, the Integrated Manufacturing Strategy and the Strategic Plan for South African Agriculture.

Ten-Year Innovation Plan

The TYIP, launched in 2008, aims to assist the establishment of a knowledge-based economy for South Africa, in which the production and dissemination of knowledge lead to economic benefits and enrich all fields of human endeavour.

The missions and platforms under the NRDS were expanded under the TYIP to include grand challenges in space science and technology, energy security, human and social dynamics in development, global change and the bio-economy.

The responsibility for addressing the grand challenges is spread across many government departments.

The TYIP includes long-term goals based on the challenges it identified, which includes:

- becoming one of the top three emerging economies in the global pharmaceutical industry, based on innovative use of South Africa's indigenous knowledge and rich biodiversity
- deploying satellites that provide a range of scientific, security and specialised services for all spheres of government, the public and the private sector
- achieving a 25% share of the global hydrogen and fuel cell market with novel platinum group metal catalysts
- becoming a world leader in climate science and responding effectively to the multiple challenges associated with global and climate change.

National Nanotechnology Strategy (NNS)

The NNS was implemented to ensure that South Africa is ready to optimally use nanotechnology to enhance global competitiveness and sustainable economic growth.

Nanotechnology promises smaller, cheaper, lighter and faster devices with greater functionality, using fewer raw materials and consuming less energy.

The strategy strengthens the integrated industrial focus of government and advances the national technology missions that have been identified in the NRDS.

Nanotechnology cuts across biotechnology, technology for manufacturing and information and communication technology (ICT) to improve the country's natural resources sectors and technology to reduce poverty.

The DST, in partnership with the NRF, seeks to promote nanotechnology research through the Nanotechnology Flagship Project (NFP).

The flagship project aims to ensure that South Africa is able to optimally use nanoscience and nanotechnology to enhance the nation's global competitiveness and to promote innovation and economic growth.

Nanotechnology Flagship Project

The NFP was established with the objective of accelerating national efforts to build the excellence pipeline in R&D capacity by attracting and retaining young scientists and professionals of the highest calibre.

The NFP is a fundamental pillar in the implementation of the NNS. The project ensures that South Africa is able to optimally use nanoscience and nanotechnology to enhance the nation's global competitiveness and to promote innovation and economic growth. It is geared towards demonstrating the benefits of nanotechnology and its impact on some of the key challenges facing South Africa, which relate to the areas of energy security, improved healthcare, water purification, mining and minerals, and advanced materials and manufacturing.

The investment in the NFP has yielded locally relevant and internationally competitive outputs in pursuit of research excellence and capacity development.

National Bio-Economy Strategy

The science-based Bio-Economy Strategy replaced the National Biotechnology Strategy.

Through the Bio-Economy Strategy, bio-innovation is used to generate sustainable economic, social and environmental development. The DST is aiming to have biotechnology make up 5% of the country's gross domestic product (GDP) by 2050.

The Bio-Economy Strategy focuses on three important economic sectors likely to benefit from key drivers on implementation, namely agriculture, health and industry, and environment.

The strategy also focuses on the coordination of numerous committees, government departments, R&D agencies, the private sector, public programmes and funding bodies to achieve its goals.

Role players

Academy of Science of South Africa (ASSAf)

ASSAf was formed in response to the need for an academy of science congruent with the dawn of democracy in South Africa – activist in its mission of using science for the benefit of society.

The mandate of the ASSAf encompasses all fields of scientific enquiry and it includes the full diversity of South Africa's scientists. The Academy of Science of South Africa Act, (Act 67 of 2001) came into operation in May 2002.

Since its inception, ASSAf has grown from a small, emergent organisation to a well-established academy.

The academy links South Africa with scientific communities at the highest levels in the Southern African Development Community (SADC) region, the rest of Africa and internationally; promotes common ground in scientific thinking across all disciplines; encourages and promotes innovative and independent scientific thinking; promotes the development of intellectual capacity in all people; provides effective scientific, evidence-based advice; and facilitates appropriate action in the public interest. The academy's total budget for 2018/19 was R32.2 million.

InterAcademy Partnership (IAP)

Academies of science and medicine have traditionally aligned themselves into three major global networks – the Global

Network of Science Academies, the InterAcademy Council and the InterAcademy Medical Panel – to build on and amplify their individual strengths when facing pressing global issues. These three inter-related organisations have now formed an umbrella organisation – the IAP – which was launched in March 2016.

The IAP unites more than 100 science academies worldwide. It provides high-quality independent information and advice on science and development to policymakers and the public. It also supports programmes on scientific capacity-building, education and communication. The IAP leads efforts to expand international science cooperation.

Africa Institute of South Africa

The AISA was first established in 1960 as a non-profit organisation. It is a statutory body following the Aisa Act of 2001.

Through an annual training programme that educates students from universities in research methodologies, the AISA has contributed to fostering a new generation of research specialists. The AISA has also been able to produce some of the finest research on contemporary African affairs by having its dedicated and highly qualified researchers conduct field research every year throughout Africa.

The African Unity for Renaissance International Conference and Africa Day Expo is an annual conference hosted by the HSRC, together with the the Tshwane University of Technology, the NRF, the Thabo Mbeki African Leadership Institute, the DST, the Department of International Relations and Cooperation, the International Council for Science, the Regional Office for Africa, BrandSA, the Kara Heritage Institute, the City of Tshwane and the University of Johannesburg.

Council for Scientific and Industrial Research

The CSIR is a world-class African research and development organisation established through an Act of Parliament in 1945. The CSIR undertakes directed, multidisciplinary research and technological innovation that contributes to the improved quality of life of South Africans. The organisation plays a key role in supporting government's programmes through directed research that is aligned with the country's priorities, the organisation's mandate and its science, engineering and technology competences.

Over the medium term, the CSIR will focus on conducting high-quality and relevant research, and pursuing technological innovation to foster industrial and scientific development. In its continuing effort to develop, renew and transform the science, engineering and technology base, the council plans to provide knowledge solutions for the inclusive and sustainable advancement of industry and society, and foster strategic partnerships for the development of innovative and technological capabilities for local industries. In addition, the council expects to build on current industrial development opportunities such as pharmaceutical innovation and agro-processing. As part of its strategic intent for innovation, the council will focus on striking the right balance between scientific development and industrial development.

To achieve these objectives, the council plans to implement a range of research, development and innovation programmes in areas such as health, energy, defence and security. Spending on these activities is expected to amount to R2.5 billion over the medium term.

As the nature of the council's work requires highly specialised skills and is labour intensive, spending on compensation of employees accounts for 56.5% (R5.4 billion) of total expenditure over the medium term. Spending on compensation of employees is projected to increase at an average annual rate of 5.7%, from R1.6 billion in 2018/19 to R1.9 billion in 2021/22, as the council capacitates the newly launched biorefinery industry development and photonics prototyping facilities.

Total revenue is projected to be R9.8 billion over the medium term, of which 40.2% (R4 billion) is derived from transfers from the department. Transfers from the department are expected to increase at an average annual rate of 3.5%, from R1.3 billion in 2018/19 to R1.4 billion in 2021/22. The remaining revenue is generated from services rendered and other revenue streams, which include contract research and development income from local and international public and private sectors, income from intellectual property, and proceeds from technology transfer proceeds. The council expects to achieve a net profit of R267 million over the medium term, which it plans to invest in property, plant and equipment.

Human Sciences Research Council

The HSRC was established in 1968 as South Africa's statutory research agency and has grown to become the largest dedicated research institute in the social sciences and humanities on the African continent, doing cutting-edge public research in areas that are crucial to development.

It's mandate is to:

- inform the effective formulation and monitoring of government policy
- evaluate policy implementation
- stimulate public debate through the effective dissemination of research-based data and fact-based research results
- foster research collaboration
- help build research capacity and infrastructure for the human sciences.

The council conducts large-scale, policy-relevant, social-scientific research for public sector users, non-governmental organisations and international development agencies.

Research activities and structures are closely aligned with South Africa's national development priorities.

The HSRC's integrated research programmes provide single points of entry – complete with a critical mass of researchers – for interdisciplinary and problem-orientated research.

The council's total budget for 2018/19 was R572 million.

National Advisory Council on Innovation

The NACI Act of 1997 mandates the council to advise the Minister of Science and Technology and, through the Minister, the Cabinet, on the role and contribution of innovation (including science and technology) in promoting and achieving national objectives.

These national objectives include the improvement of the quality of life of South Africans, the promotion of sustainable economic growth and international competitiveness.

The advice should be directed at, among other things:

- coordination and stimulation of the NSI
- promotion of cooperation within the NSI
- structuring, governance and coordination of the science and technology system
- revision of the innovation policy
- strategies for the promotion of all aspects of technological

innovation

- identification of R&D priorities
- funding of the science and technology system.

National Research Foundation

The NRF is an independent statutory body established through the NRF Act of 1998, following a system-wide review conducted for the then Department of Arts, Culture, Science and Technology.

The entity incorporates the functions of research-funding agencies that were previously servicing various sections of the research community, namely the former Centre for Science Development of the HSRC and the former Foundation for Research Development, which comprised several national research facilities.

The foundation is mandated to support research through funding, HR development and the provision of research facilities to enable knowledge creation, innovation and development in all fields of science and technology, and promote indigenous knowledge.

The foundation executes its mandate through the National Research Foundation Strategy 2020, a five-year plan in its final year of implementation. Over the medium term, the foundation plans to continue striving to become a globally competitive institution by focusing on research and development in support of human capacity, knowledge generation and innovation.

The foundation provides support across the full spectrum of current and future knowledge workers' careers, particularly for highly qualified technicians. This is achieved through a human capacity development pipeline, which informs the support for next-generation researchers, emerging researchers and established researchers. Accordingly, the foundation expects to invest 36% (R2.8 billion) of its total human capital development budget over the medium term in developing the next generation of researchers. It intends to do this by awarding scholarships and bursaries; and offering academic development programmes to honours, master's, doctoral and postdoctoral students. A total of R880.6 million has been earmarked for this purpose in 2019/20, when the foundation expects to support 3 706 master's and 2 941 doctoral students.

Advanced infrastructure is a key enabler of globally competitive research, development and innovation. As such, an estimated R4.6 billion over the MTEF period will provide unique national research facilities in the nuclear sciences, biodiversity, astronomy and geosciences fields that require highly qualified technicians. A further R2.4 billion over the period has been earmarked for the Square Kilometre Array (SKA), which will be the world's largest and most sensitive radio telescope.

Over the medium term, the foundation expects to receive an estimated 79% (R11.2 billion) of its revenue through a parliamentary grant; and the remainder through contract funding from the DST, and other government departments and entities. The parliamentary funding includes an additional R167.9 million set aside for maintaining and enhancing the research and training activities of iThemba Laboratories in 2018/19. The foundation's total budget for 2018/19 was R4.1 billion.

South African National Space Agency

SANSA was created to promote the use of space and cooperation in space-related activities while fostering research in space science, advancing scientific engineering through the development of South Africa's human capital and providing support to industrial development in space technologies.

The objectives of SANSA are to:

- promote the peaceful use of space
- support the creation of an environment conducive to industrial development in space technology
- foster research in space science, communications, navigation and space physics
- advance scientific, engineering and technological competencies and capabilities through human capital development outreach programmes and infrastructure development
- foster international cooperation in space-related activities.

SANSA continues to provide state-of-the-art ground-station services to many globally recognised space missions, such as National Aeronautics and Space Administration (Nasa) from the United States (US) and Indian Space Research Organisation Mars missions, as well as Nasa's Orbiting Carbon Observatory-2, which is giving scientists a better idea of how

carbon is contributing to climate change, answering important questions about where carbon comes from and where it is stored.

In May 2016, SANSa launched the first remote sensing atlas in South. The atlas can be defined as the collection of data about an object from a distance.

Earth scientists use the technique of remote sensing to monitor or measure phenomena found on earth's surface and atmosphere, through satellite and camera technology.

The atlas was developed to cater for a wide range of audiences and has been simplified in such a way that it is easy to understand while getting the message across.

The 40-page atlas covers broad areas such as history of space technology in South Africa, local satellites, application of satellite images, geology, mining, agriculture, woody-cover mapping, water quality, urban planning, urban development and post-floods analysis.

In January 2019, SANSa was selected by the International Civil Aviation Organisation (ICAO) to become the designated regional provider of space weather information to the entire aviation sector using African airspace.

This means that every aircraft flying on the continent's airspace will rely on SANSa for the space weather information it needs to submit as part of its flight plan.

SANSa underwent an extensive assessment to earn the distinction of becoming one of the two ICAO-designated regional space weather centres – the other one being a joint Russia-China centre.

SANSa will partner with the Pan-European Consortium for Aviation Space Weather User Services, to provide ICAO with space weather information for the African region.

This comes shortly after the launch of the continent's most advanced nanosatellite so far, the ZACube-2, in December 2018.

South Africa's designation as a regional space weather information provider will grow the science, engineering, technology and innovation sector, offering opportunities to develop scarce skills and increase national research output, while ensuring that usable products are generated from the knowledge.

The selection presents an opportunity to further use the newly revamped space weather centre at Hermanus in the Western Cape, which was unveiled in April 2018. The centre's monitoring of the Sun and its activity has been providing the country with vital early warnings and forecasts on space weather conditions, and these benefits will now be extended to the international aviation community.

The agency's total budget for 2018/19 was R217 million.

Technology Innovation Agency

The TIA is a national public entity that serves as a key institutional intervention to bridge the innovation gap between R&D from higher education institutions, science councils, public entities and the private sector.

The mandate of the TIA is derived from the provisions of the Technology Innovation Act of 2008, which established TIA to support government in stimulating and intensifying technological innovation to improve economic growth and the quality of life of all South Africans by developing and exploiting technological innovations. The agency's total budget for 2018/19 was R536.6 million.

National Intellectual Property Management Office

The NIPMO provides support to the offices of technology transfer at publicly funded research institutions. This has led to significantly improved IP management in State universities and other research institutions.

The NIPMO operational functions is set out in the the IPR Act of 2008. The act allows NIPMO to function independently of the department but operate as a subprogramme within the department in terms of support functions such as HR and ICT.

With the objectives of the IPR Act of 2008 being to ensure that IP resulting from publicly financed R&D is identified, protected, utilised and commercialised for the benefit of the people of South Africa, NIPMO employs numerous tools to enable this mandate. These includes providing support to offices of technology transfer (OTT) at publicly funded research institutions (i.e. higher education institutions and science councils). These OTTs are regarded as extensions of NIPMO and implement the Act in their own environment. This intervention has led to

significant improvements in the management and utilisation of IP in these institutions. NIPMO also provides financial support to the institutions for the protection of their IP.

Since the IPR Act of 2008 came into effect in 2010, the number of disclosures made by technology transfer agencies has tripled, with the number of patents being managed by these agencies doubling. The absolutely number reveal that 1500 disclosures have been received

IP rights related to South Africa's valuable IKS will be better protected through the Indigenous Knowledge Systems Bill. This should facilitate economic growth and spin-offs resulting from the application of such knowledge.

Agricultural Research Council (ARC)

The ARC was established in 1990 through the Agricultural Research Act, 1990 (Act 86 of 1990), as amended by the Agricultural Research Amendment Act, 2001 (Act 27 of 2001), and it is the principal agricultural research institution in South Africa.

It is a Schedule 3A public entity in terms of the Public Finance Management Act, 1999 (Act 1 of 1999), as amended by the Public Finance Management Amendment Act, 1999 (Act 29 of 1999).

Its core mandate is to act as the principal agricultural research institution in South Africa to conduct research, drive R&D, drive technology development and the dissemination of information to:

- promote agriculture and related industries
- contribute to a better quality of life
- facilitate and ensure natural resource conservation to alleviate poverty.

The ARC's main functions are to:

- undertake and promote research, technology development and technology transfer
- use the technological expertise in its possession and make it generally available
- publish information concerning its objectives and functions, and establish facilities for the collection and dissemination of information in connection with R&D
- publish the results of research

- establish and control facilities in the fields of research, technology development and technology transfer
- cooperate with departments of government, institutions, persons and other authorities for the promotion and conduct of research, technology development and technology transfer
- promote the training of research workers by means of bursaries or grants-in-aid for research, technology development and technology transfer
- support research, development and technology transfer programmes
- cooperate with persons and authorities in other countries conducting or promoting research, technology development and technology transfer in agriculture.

Council for Mineral Technology and Research (Mintek)

Mintek, South Africa's national mineral research organisation, is one of the world's leading technology organisations specialising in mineral processing, extractive metallurgy and related areas. Working closely with industry and other R&D institutions, Mintek provides service test work, process development and optimisation, consulting as well as innovative products to clients worldwide.

Mintek is an autonomous statutory organisation that reports to the Minister of Mineral Resources. About 35% of the annual budget is funded by the State Science Vote.

As a global leader in minerals and metallurgical innovation, Mintek provides world-class R&D expertise, test work and process optimisation for all mineral sectors at international level. The activities range from initial bench-top investigations to full process flow-sheet development, pilot and demonstration plant design and optimisation of industrial plants.

Externally focused programmes are aimed at developing Mintek's future pipeline of science and engineering candidates by providing undergraduate and postgraduate bursary programmes for full-time study and internships supported by mentoring.

South African Medical Research Council (SAMRC)

The SAMRC is an independent statutory body that coordinates health and medical research activities throughout South Africa.

The SAMRC's objectives are:

- promoting the health and quality of life of the population of South Africa
- performing such functions as may be assigned to the SAMRC by or under the MRC Act, 1991 (Act 58 of 1991).

The scope of the organisation's research projects includes tuberculosis, HIV and AIDS, cardiovascular and non-communicable diseases, gender and health, and alcohol and other drug abuse.

With a strategic objective to help strengthen the health systems of the country – in line with that of the Department of Health – the SAMRC constantly identifies the main causes of death in South Africa.

By analysing the causes and categories of death, data would become available to formulate suitable interventions to either prevent diseases in a certain population group or improve the standard of living of people living with existing medical conditions.

In addressing the ills of the people, the MRC, has set up a dedicated funding department to pay for the development of novel treatment regimens, especially vaccines, as well as improved diagnostic tools.

This project is intended to localise the production of new drugs and devices, and thereby allow the South African economy to grow.

The MRC awards scientific excellence with its annual Scientific Merit Awards Gala Ceremony. These awards acknowledge the contributions of established scientists as well as fresh scientists with ground-breaking efforts in their individual fields of science, engineering and technology.

Council for Geoscience

The CGS is one of the national science councils of South Africa and is the legal successor of the Geological Survey of South Africa, which was formed in 1912 by the amalgamation of three former surveys, the oldest of which – the Geological Commission of the Cape of Good Hope – was founded in 1895. The Geoscience Act of 1993 established the CGS in its present form. The Act was later amended in 2010 to establish the Geoscience Amendment Act of 2010.

As a scientific research council, the CGS is mandated to provide for the promotion of research and the extension of knowledge in the field of geoscience as well as the provision of specialised geoscientific services. The CGS's head office is located in Pretoria, with regional offices in Polokwane (Limpopo), Cape Town (Western Cape), Pietermaritzburg and Durban (KwaZulu-Natal), Port Elizabeth (Eastern Cape) and Upington (Northern Cape).

The CGS provides the following substantially different professional services:

- geophysical airborne and ground surveys
- geophysical data acquisition, processing and interpretation (airborne and ground)
- engineering geosciences, including geotechnical services
- mineral resources development, including mining and minerals services
- water geoscience/hydrological services
- environmental management and rehabilitation
- marine geology, including port surveys
- spatial data and GIS services
- regional geological surveys and map compilations, including core-drilling services.

As the custodian of South Africa's geoscience data, the CGS has regional aeromagnetic, radiometric and gravity coverage of the country.

The CGS is involved in collaborative research projects that form part of its annual programme. These projects keep the CGS abreast with developments in the international geosciences field.

South African Bureau of Standards (SABS)

The SABS is a statutory body that operates as the national institution for the promotion and maintenance of standardisation and quality in connection with commodities and the rendering of services. The SABS:

- publishes national standards, which it prepares through a consensus process in technical committees
- provides information on national standards of all countries as well as international standards
- tests and certifies products and services to standards
- develops technical regulations (compulsory specifications)

based on national standards, and monitors and enforces compliance with such technical regulations

- monitors and enforces legal metrology legislation
- promotes design excellence
- provides training on aspects of standardisation.

To maximise its service delivery to the industries it serves, the SABS aligned its activities with seven different industry sectors, each housing the whole range of the SABS services pertinent to a particular industry.

This change ensures easy access to products, faster reaction and turnaround times, and the creation of centres of knowledge excellence that will be easily available to clients.

The seven industry sectors are:

- chemicals
- electrotechnical
- food and health
- mechanical and materials
- mining and minerals
- services
- transportation.

Eskom

The electricity supply industry in South Africa consists of the generation, transmission, distribution and sales, as well as the import and export of electricity. Eskom is a key player in the industry, as South Africa operates most of the base-load and peaking capacity. The enterprise sells electricity to a variety of customers, including municipalities, who distribute power to end users under licence.

Sasol

Sasol's culture of innovation began in the 1950s when it developed its unique blend of coal gasification and Fischer-Tröpsch (FT) technology for its original coal-to-liquids operations at Sasolburg. It has since evolved these operations into fully fledged R&D facilities that form the heart of the Sasol technology R&D group.

Focused FT R&D in the 1980s and 1990s led to the development of the low temperature FT Sasol Slurry Phase process used at Sasolburg, and the high-temperature Sasol Advanced Synthol process used at Secunda.



In August 2019, government established a new digital resource centre for all South Africa's official languages, opening up a number of possibilities for the creation of language-based applications in many fields, including health care.

The South African Centre for Digital Language Resources (SADiLaR) is a platform that creates and manages digital resources and software supporting research and development in language technologies and related studies in all the 11 official languages.

It is a multi-partner distributed research infrastructure, comprising the Council for Scientific and Industrial Research, the University of South Africa, the University of Pretoria, the Inter-institutional Centre for Language Development and Assessment, and the NWU's Centre for Text Technology, and is hosted by North-West University at the Potchefstroom Campus.

SADiLaR is one of eight research infrastructures established through the Department of Science and Innovation under the South African Research Infrastructure Roadmap, which is intended to provide research infrastructure across the public research system.

Sasol Technology's Fuels Technology Division carries out work concerning fuels, lubricants, heating-fuel and road-binding material, R&D as well as new product formulation and testing.

In addition, Sasol opened the Sasol Fuels Application Centre (SFAC), a state-of-the-art engine and exhaust emission testing and research facility in Cape Town. The SFAC enables Sasol to conduct sea-level engine and emission tests in line with international standards.

The Mozambican gas industry is playing an increasingly important role in the regional energy landscape, and this project represents a major milestone in further developing natural resources, which will significantly benefit southern Africa.

ArcelorMittal

ArcelorMittal is a global steel-maker and with some 210 000 employees across 60 countries, the organisation is considered the world's leading steel and mining company.

ArcelorMittal is also the leader in all major global steel markets including automotive, construction, household appliances and packaging; with leading R&D and technology, sizeable captive supplies of raw materials and outstanding distribution networks.

The company has five main operations in South Africa.

National Health Laboratory Service (NHLS)

The NHLS is the largest diagnostic pathology service in South Africa with the responsibility of supporting the national and provincial health departments in the delivery of healthcare. The NHLS provides laboratory and related public health services to over 80% of the population through a national network of laboratories. Its specialised divisions include the National Institute for Communicable Diseases (NICD), the National Institute for Occupational Health, the National Cancer Registry, and the South African Vaccine Producers, as its subsidiary.

Bureau for Economic Research (BER)

The BER monitors and forecasts macroeconomic economic and sector trends, and identifies and analyses local and international factors that affect South African businesses.

The organisation has built up and continues to expand its business tendency surveys and macroeconomic forecasting capabilities. Both are used for analysing and projecting South African macroeconomic trends. The BER uses a variety of internationally accepted methodologies and econometric models for the generation and analysis of the data, as well as techniques developed specifically for the unique South African environment. Other activities include commissioned research, courses, conferences and training.

The BER's respected economic analysis and forecasting services are used by a wide range of clients, ranging from small to medium-sized firms up to very large Johannesburg Stock Exchange-listed companies, as well as public sector bodies and non-governmental organisations. Financial and investment companies, local and overseas banking groups, multilateral organisations and academic bodies all make use of the impartial economic information available from the BER.

Although the BER is part of the University of Stellenbosch, it has to fully fund all its expenses (such as salaries, a university levy, office rent, travel costs and other) from the sale of forecasts, sponsorships and customised research.

National Institute for Communicable Diseases

The NICD is a major global player in infectious disease intelligence. It is a resource of knowledge and expertise in regionally relevant

communicable diseases to South Africa, SADC countries and the African continent.

The NICD assists in the planning of policies and programmes and supports appropriate responses to communicable disease problems and issues.

Control methods are assessed and recommendations are made to the appropriate authorities regarding equipment, insecticide usage and application.

Institute for Economic Research on Innovation (IERI)

IERI was established as a public-good research organisation with a core competence in the analysis of systems of innovation. Its mandate is to provide research, capacity-building and community engagement in this field of study.

Its tasks involve:

- conducting research into the political economy and policy dimensions of innovation and development
- contributing thought leadership on the relationship between knowledge and development across economic, social and political domains
- building capabilities and competencies in the understanding of the political economy and policy dimensions of innovation and development
- focusing across local, provincial, national, regional and international geographies.

Institute for Security Studies (ISS)

The ISS aims to enhance human security to enable sustainable development and economic prosperity in Africa. It works across the continent, doing authoritative research, providing expert policy advice and delivering practical training and technical assistance.

The ISS achieves its goal through the work of the following divisions and projects:

- governance, crime and justice
- conflict prevention and risk analysis
- peace operations and peacebuilding
- transnational threats and international crime.

The ISS is registered as a non-profit trust in South Africa and

is accountable to a board of trustees. An international advisory council meets annually to advise the ISS on strategic policy and management issues.

South Africa's National Energy Development Institute (Sanedi)

The DST and the Department of Energy are joint custodians of Sanedi and assist in providing political and strategic focus for the company.

The institute is entrusted with the coordination and undertaking of public interest energy research, development and demonstration.

As such, it is responsible for enabling and implementing the energy technology roadmaps, which support long-term energy policies developed by the Department of Energy.

Safety in Mines Research Advisory Committee

The activities of the Safety in Mines Research Advisory Committee are aimed at advancing the safety of workers employed in South African mines.

The committee is a statutory tripartite committee of the Mine Health and Safety Council. It has a permanent research-management office managing the rock engineering, engineering and mine occupational health fields of research.

National Agricultural Research Forum (NARF)

The mission of the NARF is to facilitate consensus and integrate coordination in the fields of research, development and technology transfer to agriculture to enhance national economic growth, social welfare and environmental sustainability.

NARF's activities are implemented by the NARF Secretariat, which is situated in the national Department of Agriculture.

The NARF Secretariat is responsible for providing sectoral support to the NARF Plenary and Steering Committee, composed of representatives of NARF's stakeholders headed by a chairperson who, in turn, is responsible to the NARF Plenary session. The Plenary is the highest organ of the NARF.

Water Research Commission (WRC)

The WRC was established in 1971 following a period of water

shortages. The WRC is responsible for:

- promoting coordination, cooperation and communication in the area of water R&D
- establishing water-research needs and priorities
- stimulating and funding water research according to priority
- promoting the effective transfer of ICT
- enhancing knowledge and capacity-building within the water sector.

The WRC focuses on five key strategic areas:

- water-resource management
- water-linked ecosystems
- water-use and waste management
- water use in agriculture
- water-centred knowledge.

The main areas of research are surface hydrology, groundwater, hydrometeorology, agricultural water use, water pollution, municipal effluents, industrial water and effluents, drinking water, membrane technology, water ecosystems, hydraulics, mine-water management, water policy, developing communities and the transfer of technology.

Institute for Water Research

The Institute for Water Research is a multidisciplinary research department of Rhodes University in the Eastern Cape. Its main objective is to contribute to sustainable water-resource management in southern Africa.

This is achieved through scientific research into the structure and function of aquatic ecosystems; the application of research through specialist consultancy services; tertiary-level teaching and training; capacity-building for community development; and service on national and international management and policy-making committees.

South African National Biodiversity Institute (SANBI)

SANBI leads and coordinates research, and monitors and reports on the state of biodiversity in South Africa.

The institute provides knowledge and information, gives planning and policy advice and pilots best-practice management models in partnership with stakeholders.

SANBI engages in ecosystem restoration and rehabilitation, leads the human capital development strategy of the sector and manages the National Botanical Gardens as “windows” to South Africa’s biodiversity for enjoyment and education.

South Africa is one of the most biologically diverse countries in the world, after Indonesia and Brazil. South Africa is surrounded by two oceans, occupies only about 2% of the world’s land area, but is home to nearly 10% of the world’s plants, 7% of the reptiles, birds and mammals as well as 15% of known coastal marine species. The country has nine biomes, three of which have been declared global biodiversity hotspots.

Coastal and marine research

The NRF supports marine and coastal research in partnership with the Department of Environmental Affairs and the South African Network for Coastal and Oceanic Research.

The Chief Directorate: Marine and Coastal Management advises on the use of marine living resources and the conservation of marine ecosystems, by conducting and supporting relevant multidisciplinary scientific research and by monitoring the marine environment.

Sustainable use and the need to preserve future options in using marine ecosystems and their resources are guiding objectives in the research and advice provided by the chief directorate.

National research facilities

The national research facilities managed by the NRF are clustered on the basis of their areas of specialisation aligned to the science missions of the NRDS.

South African Astronomical Observatory (SAAO)

The SAAO is the national centre for optical and infrared astronomy in South Africa. Its prime function is to conduct fundamental research in astronomy and astrophysics by providing a world-class facility and by promoting astronomy and astrophysics in southern Africa.

The SAAO contributes to South Africa’s future development by creating and disseminating scientific knowledge, providing

research infrastructure and providing an interface between science and society. It is also responsible for managing the operations of the South African Large Telescope.

Hartebeesthoek Radio Astronomy Observatory (HartRAO)

HartRAO is a national facility of the NRF. Its radio astronomy research focuses on stellar evolution, pulsars and masers; and its Space Geodesy research uses space-based techniques to study the earth. The facility is also used by university students for carrying out research, it also undertakes science awareness programmes for schools and the general public.

In 2016, the DST merged the HartRAO and the SKA project into a new South African Radioastronomy Observatory.

South African Institute for Aquatic Biodiversity (SAIAB)

A national facility of the NRF, the SAIAB is famous for its association with the discovery of the enigmatic coelacanth and is internationally recognised for ichthyological research, dynamic research staff and active postgraduate school. The SAIAB provides unique skills and infrastructure support in marine, estuarine and freshwater ecosystems research, molecular research, collections and bioinformatics.

South African Environmental Observation Network (SAEON)

The SAEON is a business unit of the NRF and serves as a national platform for detecting, translating and predicting environmental change through scientifically designed observation systems and research. The SAEON also captures and makes long-term datasets freely accessible, and runs an education outreach programme. The SAEON has six nodes dispersed geographically across the country.

National Zoological Gardens (NZG)

The NZG is a rapidly transforming facility reporting to the NRF. It has an impressive animal collection, conservation centres, a Centre for Conservation Science as well as an NZG Academy. The NZG is well placed as an education and awareness

platform for visitors comprising educators, learners, students, special interest groups and the general public.

iThemba Laboratory for Accelerator-Based Sciences

The iThemba Laboratory for Accelerator-Based Sciences is the continent’s largest facility for particle and nuclear research as well as one of only a handful of facilities in the world producing radionuclides for commercial, research and medical applications. In addition, its facilities include a full radiotherapy clinic for the treatment of certain cancers using both proton and neutron therapy.

South African Council for Natural Scientific Professions (SACNASP)

The SACNASP’s mandate is to provide a credible professional registration and regulatory body that allows natural scientists to establish, direct, sustain and ensure a high level of professionalism and ethical conscience in the natural scientific professions sector.

Programmes and projects

Alternative energy solution

In 2014, the DST officially launched the innovative 2,5 kW hydrogen fuel cell power generator prototype unit at the University of the Western Cape.

The generator demonstrates South Africa’s innovative capabilities in the emerging hydrogen and fuel cell technologies space. The prototype was developed by the HySA Systems Integration and Technology Validation Centre of Competence.

The partners have been testing the unit at the Cape Flats Nature Reserve, at the Bellville campus of the University of the Western Cape.

All electrical power used in the reserve is generated from a bank of hydrogen cylinders, instead of from the national grid. The cylinders release hydrogen in the presence of a platinum catalyst (mined in North West) and a series of proton exchange membranes.

The hydrogen fuel cell power generator unit uses hydrogen to generate electrical power, with water vapour being the

only byproduct. In this way, electricity is produced in an environmentally friendly way without pollution or noise.

Furthermore, hydrogen can be used to produce electricity in remote areas that do not have access to the national grid. The decentralisation of energy generation by using hydrogen fuel cell systems is one of the few possibilities for providing efficient and cost-effective access to electricity.

South Africa has rolled out several energy and energy-efficiency programmes and initiatives, such as HySA, with an emphasis on alternative energy opportunities and off-grid renewable energy solutions.

South Africa is one of the primary suppliers of platinum group metals to the world, but not much beneficiation is being done in the country.

The rise of hydrogen fuel cell technologies in various markets is about to change the global platinum landscape with the anticipated increase in platinum usage in this emerging market. There are significant opportunities for South Africa to partner with international fuel cell producers. These partnerships have the potential to make the country an established hub for the production of fuel cell components.

Subprogrammes

The DST also has a number of subprogrammes that play a pivotal role in ensuring that the department meets its targets. They are:

- **Human Capital and Science Promotion:** formulates and implements policies and strategies that address the availability of human capital for STI, and provides support for research activities.
- **Science Missions:** promotes the development of research, the production of scientific knowledge, and the development of human capital within science areas in which South Africa enjoys a geographic advantage.
- **Basic Science and Infrastructure:** facilitates the strategic implementation of research and innovation equipment and infrastructure to promote knowledge production in areas that are of national priority and to sustain innovation led by R&D.
- **Astronomy:** supports the development of astronomical sciences around a research strategy on multi-wavelength

i South African scientist Professor Robert Millar won the prestigious 2018 African Union (AU) Kwame Nkrumah Award in the Life and Earth Sciences category. The accolade was awarded during the opening ceremony of the 30th Assembly of Heads of State and Government of the AU which was held from 22 – 29 January 2018 in Addis Ababa, Ethiopia. The awards which have been running since 2008, are in memory of Pan-Africanist and Ghana's first President Dr Kwame Nkrumah. Each winner received US\$100 000 in prize money. Collaboration with Hot Platinum (Pty Ltd), a local company involved in power management and control electronics.

astronomy, provides strategic guidance and support to relevant astronomy institutions in the implementation of the DST's astronomy programmes.

- **Sector Innovation and Green Economy:** provides support in policy, strategy and direction setting for R&D-led growth in strategic sectors of the economy; supports the transition to a green economy.
- **Innovation for Inclusive Development:** supports the development of science and technology-based innovations for tackling poverty, including the creation of sustainable jobs and sustainable human settlements, as well as the enhanced delivery of basic services.
- **Science and Technology Investment:** leads and supports the development of indicators and instruments for monitoring investments in science and technology and the performance of the NSI, as well as ways of strengthening policy in relation to the NSI.
- **Technology Localisation, Beneficiation and Advanced Manufacturing:** advances strategic medium and long-term priorities for sustainable economic growth and sector development, and public service delivery.

Research, Development and Support

The aim of the programme is to provide an enabling environment for research and knowledge production that promotes the strategic development of basic sciences and priority science areas through the promotion of science, human capital development, and the provision of research infrastructure and

relevant research support, in pursuit of South Africa's transition to a knowledge economy.

The programme is expected to contribute to the development of representative, high-level human capital able to pursue locally relevant, globally competitive research and innovation activities over the medium term by awarding 9 300 bursaries to doctoral students, 32 400 bursaries to postgraduate (Bachelor of Technology, honours and master's) students and placing 1 750 graduates and students in work preparation programmes funded by the department in science, engineering and technology institutions.

The department also plans to ensure the availability of and access to internationally comparable research and innovation infrastructure in order to generate new knowledge and train new researchers per year over the medium term by maintaining the number of research infrastructure grants at 20, and maintaining the total available broadband capacity provided by the SANReN to 3 500 Gbps.

It will support and promote research that develops basic sciences through the production of new knowledge and relevant training opportunities over the medium term by maintaining the total number of researchers awarded research grants through programmes managed by the NRF at 13 500 or above and the number of research articles published by researchers funded by the NRF and cited in the Thomson Reuters Web of Science citation database at 21 000.

It will develop strategic priority science areas in which South Africa enjoys a competitive advantage through promoting research and training activities and outputs by installing eight large survey projects correlators in 2019/20, and 64 S-band science mode receivers on the MeerKAT telescope by 2020/21.

Space science and technology Square Kilometre Array

The multibillion-rand SKA, to be hosted in South Africa and Australia, will eventually extend into eight African countries and will be the world's biggest telescope. It is also one of the biggest-ever scientific projects and multinational collaborations in the name of science.

The radio telescope should be operationally mature by 2020.

With thousands of linked radio wave receptors in Australia and in southern Africa, the SKA radio telescope will constantly scan space and feed the data to astronomers around the world.

The amounts of data being collected and transmitted by the SKA in a single day would take nearly two million years to play back on an iPod. This means the project requires supercomputing power and Big Data Management and Analytics capabilities on an unprecedented scale. The SKA is working with the world's most significant ICT powerhouses on the project.

One aspect of the project will see the Netherlands Institute for Radio Astronomy and IBM collaborating to research extremely fast, but low-power exascale computer systems, data transport and storage processes, and streaming analytics that will be required to read, store and analyse all the raw data that will be collected daily.

The SKA project will also have unprecedented data-connectivity needs. Meeting the advanced technological and engineering needs of this project will result in significant local skills development, revolutionise science and technology research and enable innovative new businesses and employment in the science, technology and engineering fields.

Aside from the benefits to African science, Big Data Management and Analytics capabilities could be the biggest spin-off from the SKA project.

The innovations, skills development and commercial potential emerging as a result of the project are huge. The potential is not just academic – the taxpayer-funded IP is developed to a point where it is ready to become commercialised and benefit the economy.

Human capital development is already taking place as a result of the SKA project, with bursaries and scholarships being granted to allow students to learn the necessary cutting-edge science, technology, mathematics and engineering skills to support the project. Because the SKA is a long-term project over decades, its effect will increase.

The Centre for High Performance Computing is a member of the international SKA Science Data Processing Consortium. With funding from the DST, it is also supporting eight African SKA partner countries through an initiative where they have

installed its new supercomputer to provide 1 000 teraflops (1 petaflop) of computing power to researchers. The facility was upgraded to meet the growing demand for use by university and industrial researchers. The SKA remains a major platform for cutting-edge innovation in domains such as supercomputing the high-speed transmission and processing of massive data sets.

Going forward, there will be a strong drive to leverage the SKA as a spearhead for other programmes – including next generation high performance computing challenges and Big Data challenges.

For the last five years, two engineering consortia have been hard at work at their sites in Murchison, Western Australia and the Northern Cape, South Africa respectively, designing all the essential infrastructure required for construction of this complex global project to get under way. This includes access roads, power, water and sanitation, buildings, antenna foundations, and the communication, security and site monitoring equipment required to support the SKA telescope.

The South African consortium, Infrastructure South Africa was led by the South African Radio Astronomy Observatory, which designed, built and operates the 64-dish SKA precursor telescope, the MeerKAT.

In June and July 2018, after nearly five years of collaboration both within and between the two consortia, both teams had successful critical design reviews, and subsequently made final refinements to their designs. In order to pass the critical design review, the proposed designs had to demonstrate compliance with SKA "Level 1" requirements.

Following the successful review of the key infrastructure components of the SKA – considered a major engineering victory – the project will now move on to the bridging phase. This phase will bring together all the individual detailed designs of elements of the SKA and integrate them on a system level. A system critical design review will be conducted in December 2019, after which the project will enter the procurement phase, followed by construction once the establishment of the SKA Organisation as an intergovernmental organisation has been concluded.

The DST has already invested more than R760 million in infrastructure for the MeerKAT radio telescope, which was

completed and launched in July 2018, at the site 90 km from the town of Carnarvon in the Northern Cape.

Information and communications technology

The DST is leading the implementation of the national ICT Research, Development and Innovation Strategy. Its main purpose is to create an enabling environment for the advancement of ICT research, development and innovation in South Africa.

South Africa's research capacity in the ICT field has become a strong competitive advantage.

The ICT Research, Development and Innovation Strategy aims to achieve a marked increase in advanced HR capacity, promote world-class research and build robust innovation chains for the creation of new high-tech ICT small enterprises. Implementing the strategy demands partnership involving government, the private sector, higher education institutions and science councils.

The Meraka Institute of the CSIR manages and coordinates the implementation of the strategy. An important envisaged outcome is a vibrant, sustainable and innovative indigenous ICT industry that addresses a significant portion of the country's ICT needs and attracts investments by overseas-based multinational ICT corporations in research, development and innovation and manufacturing facilities and resources in South Africa.

The Centre for High-Performance Computing (CHPC), SANReN and the Very Large Databases are the three pillars of cyberinfrastructure that the DST supports. Hosted by the University of Cape Town and managed by the CSIR's Meraka Institute, the CHPC was the first of its kind in South Africa and is making scientific supercomputing a reality for South Africa.

A major project for SANReN is the national backbone network, which aimed to connect all major metros in the country with a 10 gigabyte per second link.

SANReN, linking 215 research sites, consists of 1 500 km of dark fibre and 5 000 km of managed bandwidth. This network is complemented by significant international broadband capacity on the West Africa Cable System and the east coast SEACOM system, ensuring that the DST's projects support competitive

research and innovation as it prepares the national innovation system for the future.

SANReN connects more than 200 sites from Thohoyandou to Cape Town. This includes all the main campuses of all South African universities and most public research institutions, as well as global projects such as the SKA and the MeerKAT.

Indigenous knowledge systems (IKS)

The IKS Policy serves as a guide for the recognition, understanding, integration and promotion of South Africa's wealth of indigenous knowledge resources.

One of the areas of action identified by the policy is the protection of indigenous knowledge and the holders of such knowledge against exploitation.

This includes ensuring that communities receive fair and sustained recognition and, where appropriate, financial remuneration for the use of this knowledge.

The indigenous knowledge of many communities embodies a deeply spiritualised and ancient relationship with the Earth's systems and cycles.

Traditional songs and languages, clothing, architecture, foods, motifs, daily rituals and mythological epics contain local survival information. Moreover, the diversity of indigenous cultures provides unique insights into how to live harmoniously within nature.

By sharing indigenous stories of vulnerability and adaptation, people learn how communities share ideas on how ancestral wisdom is being incorporated into climatic adaptation strategies.

By cherishing the value of indigenous knowledge, people can discover how best to adapt to a changing climate.

The DST has three IKS priorities:

- The development of a regulatory environment for the protection of IKS.
- The development of the National Recordal System for the collection, recording, documenting, storage and management and dissemination of IKS in communities in the nine provinces of the country. Until orally transmitted and rapidly disappearing indigenous knowledge is recorded, it will be difficult to protect. The National Recordal System is the largest fingerprint initiative of the region to document and record indigenous knowledge.

- Applied research, specifically bio-prospecting activities. An example would be the Moritela Tshwene Tea Project near Zeerust in the North West.

A major achievement was to put in place an information infrastructure that would hold IKS in oral format.

In addition, two UK-South Africa bilateral research chairs have been awarded for research into food security one co-hosted by the universities of the Western Cape and Pretoria, and the other based at the Nelson Mandela Metropolitan University.

The DST also established indigenous knowledge studies centres of excellence at some of the country's universities. The centres will play a defining role in generating highly qualified HR capacity in IKS.

Producing new knowledge

The department is committed to strengthening research and innovation competencies and programmes that form the strategic foundation for scientific innovation. The department plans to invest an estimated 15.1% (R3.9 billion) of its total budget over the medium term towards the production of new knowledge, and the development and commercialisation of technology.

The department's investment in the industrial, health and agricultural sectors, as well as in the development of indigenous knowledge applications, is reflected in an allocation of R616.3 million over the medium term. This investment will particularly seek to find solutions to the disposal of industrial and municipal waste; facilitate the development of biopharmaceuticals, vaccines and biofuels; and improve crop production. An estimated R564.7 million over the medium term is allocated for developing hydrogen fuel cell technology, renewable energy technology and energy storage applications.

To ensure that publicly funded intellectual property is protected and used to create products, processes and services that improve the quality of life in South Africa, the department plans to spend R170.4 million over the medium term in the NIMPO subprogramme in the Technology Innovation programme. Activities in the subprogramme provide support to institutions to protect and maintain their intellectual property through the Intellectual Property Fund.

The National Space Strategy aims to promote the peaceful use of space; support the creation of an environment conducive to industrial development in space technology; foster research in space science, communications, navigation and space physics; and advance scientific, engineering and technological competencies in space-related activities. As such, in implementing the strategy towards ensuring that South Africa captures a reasonable share of the global space market, which involves economic activities related to manufacturing components that enter the earth's orbit or go beyond, R597.9 million over the MTEF period is allocated in the Space Science subprogramme.

Generating and exploiting knowledge and innovation for inclusive economic development

The work carried out in the Socioeconomic Innovation Partnerships Programme is targeted at generating and exploiting knowledge and innovation that aligns with government's priorities for inclusive economic development. Over the medium term, R123.6 million is expected to be invested in a range of ICT initiatives such as artificial intelligence, nanotechnology, quantum computing and biotechnology, many of which are essential for South Africa to exploit the opportunities associated with the fourth industrial revolution.

An estimated R3.3 billion will be used to advance a set of technology-based interventions. These interventions include the sector innovation funds, a partnership between industry and government formed to enhance South Africa's economic competitiveness with the aim of improving economic competitiveness and addressing local needs, with an emphasis on increased market share for exports. The overarching objective of the initiative is to create an environment where government can effectively partner with industry to co-fund research, development and innovation. In addition, to fund activities related to advancing the development of a joint industry-government mining research and development hub, R150 million in 2019/20 is allocated in the Socioeconomic Innovation Partnerships programme.

Funding research, innovation and infrastructure

The availability of adequate infrastructure is vital for the national system of innovation to be globally competitive. This infrastructure includes research equipment, pilot plants (small production plants that test processes before they are commercialised), technology demonstrators (proof concepts to showcase possible applications, feasibility, performance and methods of ideas for new technologies), and facilities for specialised sectors such as aerospace. To provide infrastructure for research and development across the national system of innovation, the department has earmarked R2.2 billion over the MTEF period in the Research, Development and Support programme.

An estimated R798 million will enable the implementation of the national integrated cyber-infrastructure system by the CSIR. The system supports the successful and sustainable implementation of national projects such as MeerKAT and the SKA, as well as large research infrastructure dependent on the presence of a robust cyber-infrastructure system. Funding for the system constitutes 40% of the total allocation to the CSIR over the medium term. In addition, funds allocated to the Basic Science and Infrastructure subprogramme in the Research Development and Support programme will continue to enable students and researchers to access international infrastructure such as the Large Hadron Collider in Switzerland, the Joint Institute for Nuclear Research in Russia, and the European Synchrotron Radiation Facility in France.

To support scientific research in strategic research areas defined by South Africa's geographic advantage, such as palaeosciences, astronomy, climate change, marine and polar research, and indigenous knowledge, R748.8 million over the MTEF period is allocated in the Science Missions subprogramme in the Research, Development and Support programme. Of this amount, R258.4 million over the medium term is earmarked to promote science through engagements such as exhibitions and festivals. This is expected to be done through the South African Agency for Science and Technology Advancement with the aim of advancing the South African public's awareness of, appreciation for and engagement with science, engineering and technology.

Cooperation with other national state departments and role players

The DST continues to collaborate with district municipalities to build and strengthen science capacity to advance local economic development.

The DST will continue to collaborate with the South African Local Government Association through a partnership with the WRC on the WADER technology demonstration programme: R12,6 million has been allocated for the implementation of the Water Research, Development and Innovation Roadmap.

Private-sector involvement

South Africa's gold-mining industry works at deeper levels and under more difficult conditions than any other mining industry in the world.

The research into gold mining conducted by the CSIR's Mining Technology Group is concerned primarily with ensuring the health and safety of the workforce.

It includes those working in the areas of rock engineering and the underground environment.

Mining Technology's coal-mining research takes place on a smaller scale than that of gold mining, because the coal-mining industry is able to make use of various developments overseas.

Areas in which research is undertaken include strata control, mining, maximising the extraction of coal and the underground environment.

Research is also carried out by a large number of industrial companies with facilities to meet their specific needs.

The DST continues to invest through Pelchem in the Fluorochemical Expansion Initiative.

Success will allow Pelchem to develop promising new technologies and fluorochemical products and to double their turnover to R400 million a year by 2019.

The Auckland Park-based Mining Precinct, in Johannesburg, aims to safeguard the future of South Africa's mining industry through developing new people-centred technology and techniques to empower mines and prepare them for modern mining methods.

The Mining Precinct aims to arrest the current general decline in the local mining industry in South Africa and to help

it overcome significant obstacles in the future, which stem from narrower ore bodies and mines having to venture to deeper depths to find reserves.

The Mining Precinct is situated at a CSIR site, meaning that the public and private sectors are under one roof. Cooperation between public and private sectors is one of the great outcomes of the Mining Phakisa, forming a coalition of the willing to take the South African mining industry into a modernised future.

The Mining Precinct model creates an environment where "like-minded" people can work in close proximity and share ideas. It will host different hubs that will focus on mining technology, manufacturing and sustainable development.

In addition, the Mining Precinct is complemented by the equipment-focused representative organisation Mining Equipment Manufacturers South Africa (Memsa), which was launched by the Department of Trade and Industry.

Memsa is hosted within the Mining Precinct and is working in close collaboration with the mining (R&D) hub and local mining companies to determine their current equipment stocks, future needs and potential future order quantities to develop a better understanding of the possibilities related to future mining equipment.

This collaborative effort aims to link to other institutions, such as universities and research entities nationally and internationally.

Natural resource development

To reinvigorate the South African mining sector and to harness the vast amounts of existing and potential opportunities for industrial and manufacturing growth, it is crucial for the country to create the technologies and mining methods to push mining deeper in a commercially viable manner. Now, more than ever, South Africa needs a competitive mining industry. This will only be possible if science and technology plays the quintessential role of changing the cost and exploitation horizons of the sector. None of the existing mining stakeholders (publically funded research institutions, private sector companies, universities, unions or government) have the scale to impact the situation alone over the long run. To achieve this, a critical mass of science and knowledge to push the frontiers of mining

will require a national effort consisting of deep partnerships and collaborations across institutions and industries.

Human capital development

The DST's Human Capital and Science Platforms Subprogramme conceptualises, formulates and implements programmes aimed at developing and renewing science, engineering and technology human capital to promote knowledge generation, protection and exploitation.

South African universities train more and more scientists each year, with whose help the country will be able to provide top-notch R&D and thus reaching its target for gross expenditure on R&D of 1.5% of GDP.

Food security and access to clean water remain among government's top priorities – the department is therefore also focusing on using science and technology to ensure that existing water supplies are clean and is playing an active role in ensuring food security into the future.

Highly skilled human capital is essential to developing a national system of innovation that is globally competitive and responsive to South Africa's developmental needs. Accordingly, the department has allocated R8.2 billion over the medium term for postgraduate bursaries and scholarships, internships, and support for emerging and established researchers; and towards strategic instruments such as the South African research chairs initiative and centres of excellence programmes.

Over the medium term, the department aims to award 9 300 bursaries to PhD students, 32 400 bursaries to postgraduate students and place 1 750 graduates in department-funded work preparation programmes in science, engineering and technology institutions.

To date, the department has established 216 research chairs and 15 centres of excellence across South Africa. Research chairs are designed to attract and retain excellence in research and innovation at South African public universities by expanding scientific research and innovation capacity; and centres of excellence bring together a range of universities and science councils in partnerships to tackle challenges in areas such as health, food security, human development, energy and biodiversity.

International Cooperation and Resources

The programme aims to strategically develop, promote and manage international partnerships that strengthen the national system of innovation. Enable an exchange of knowledge, capacity and resources between South Africa and its international partners, with a focus on supporting science, technology and innovation capacity building in Africa. Support South African foreign policy through science diplomacy. Its objectives are to:

- complement South Africa's national investments in science, technology and innovation, including access to resources for departmental initiatives that require external investment, by securing international funding of R1.4 billion over the medium term;
- enhance South Africa's national science, technology and innovation capabilities to contribute to the attainment of the department's targets for human capital development by accessing international knowledge and resources through securing the participation of 2 080 South African researchers in international postgraduate training programmes by 31 March 2022;
- build capacity in and support initiatives for the SADC and AU to advance Africa's growth and development agenda by strengthening cooperation in science, technology and innovation through technical and financial support for 66 approved SADC and AU science, technology and innovation initiatives and programmes by 31 March 2022;
- support South Africa's foreign policy objectives of creating a better South Africa, a better Africa and a better world by maximising South Africa's strategic interests in international science, technology and innovation cooperation through interventions that ensure South Africa occupies 12 new leadership positions in international science, technology and innovation governance structures by 31 March 2022.

South Africa is regarded by many countries and private sector partners as a preferred and privileged partner for international cooperation in STI. On average, approximately 15% of annual R&D funding in South Africa comes from international investors.

Cooperation with other African partners and support for STI capacity-building in Africa remains a strategic priority for the DST.

In this context, accessing its extensive network of international partners, the DST managed to secure R113 748 000 from international partners to support collaborative projects in Africa.

The DST itself has invested in 61 jointly funded projects with African partners, for example Egypt, Kenya, Tunisia and Zambia. In the multilateral context, the DST actively supported 13 AU and SADC partnership initiatives.

The DST's International Cooperation and Resources branch has been allocated R124 million to enhance its science diplomacy work. This is to support strengthening and managing the DST's dynamic and diverse portfolio of relations with a range of international partners.

Several major multinational companies such as Pfizer, Nestlé and Hitachi have invested in research, innovation and human capital development activities in South Africa in partnership with the DST.

South Africa is also an important strategic partner for such major philanthropic organisations as the Bill & Melinda Gates Foundation, which has invested in programmes to harness STI for poverty alleviation.

South Africa participates successfully in competitive international research funding programmes. In the European Union's prestigious Horizon 2020 Framework Programme for Research and Innovation, South Africa's success in terms of the number of projects involving the country's researchers is, among countries outside Europe, bettered only by the US and Canada.

South Africa continues to provide leadership in the science structures of organisations such as the AU and the SADC.

The DST led the preparation of the first Brazil, Russia, India China, South Africa multilateral framework programme for collaborative research and innovation.

Women in Science Awards

The DST rolled out the red carpet for women achievers in science, technology and innovation at a gala dinner held in Limpopo on 23 August 2018.

The awards ceremony was held under the theme, "100 years of Mama Albertina Sisulu: Women united in moving South Africa forward", emphasising Sisulu's great courage

as a unifying leader during the apartheid era. The 2018 Awards saw the introduction of an astronomy category for Distinguished Young Women Scientists, which was won by Professor Susan Ilani Loubser, an associate professor at the Centre for Space Research and incumbent of the Research Chair of Physics at North-West University.

The full list of winners is as follows:

- Distinguished Women Scientists, Natural (Physical and Life) and Engineering Sciences: Dr Mathabatha Evodia Setati.
- Distinguished Women Scientists, Humanities and Social Science: Professor Maureen Nokuthula Sibiya.
- Distinguished Young Women Scientists, Natural (Physical and Life) and Engineering Sciences: Professor Adrienne Edkins .
- Distinguished Young Women Scientists, Humanities and Social Sciences: Professor Nicolene Barkhuizen.
- Distinguished Young Women Scientists, Astronomy: Professor Susan Ilani Loubser.
- Commemorative MeerKAT Award: Professor Renée Kraan-Korteweg-Winner.
- Distinguished Young Women Scientists, Research and Innovation: Professor Keolebogile Shirley Motaung and Dr Lucia Steenkamp.
- DST-Albertina Sisulu Fellowships (Doctoral), Natural (Physical and Life) and Engineering Sciences: Isa Lambrechts, Tiisetso Mpai and Danielle Roodt.
- DST-Albertina Sisulu Fellowships (Doctoral), Humanities and Social Sciences: Zakeera Docrat
- DST-Albertina Sisulu Fellowships (Master's), Natural (Physical and Life) and Engineering Sciences: Innocensia Mokgohlwe Mangoato, Kelly Schwarz and Kgothatso Tlhapi.
- Tata Scholarships (Doctoral): Edith Phalane, Mapula Razwinani and Sinenhlanhla Precious Sikhosana.
- Tata Scholarships (Master's): Olayile Ejekwu, Kahiomba Sonia Kiangala and Sikelelwa Ndiweni.

