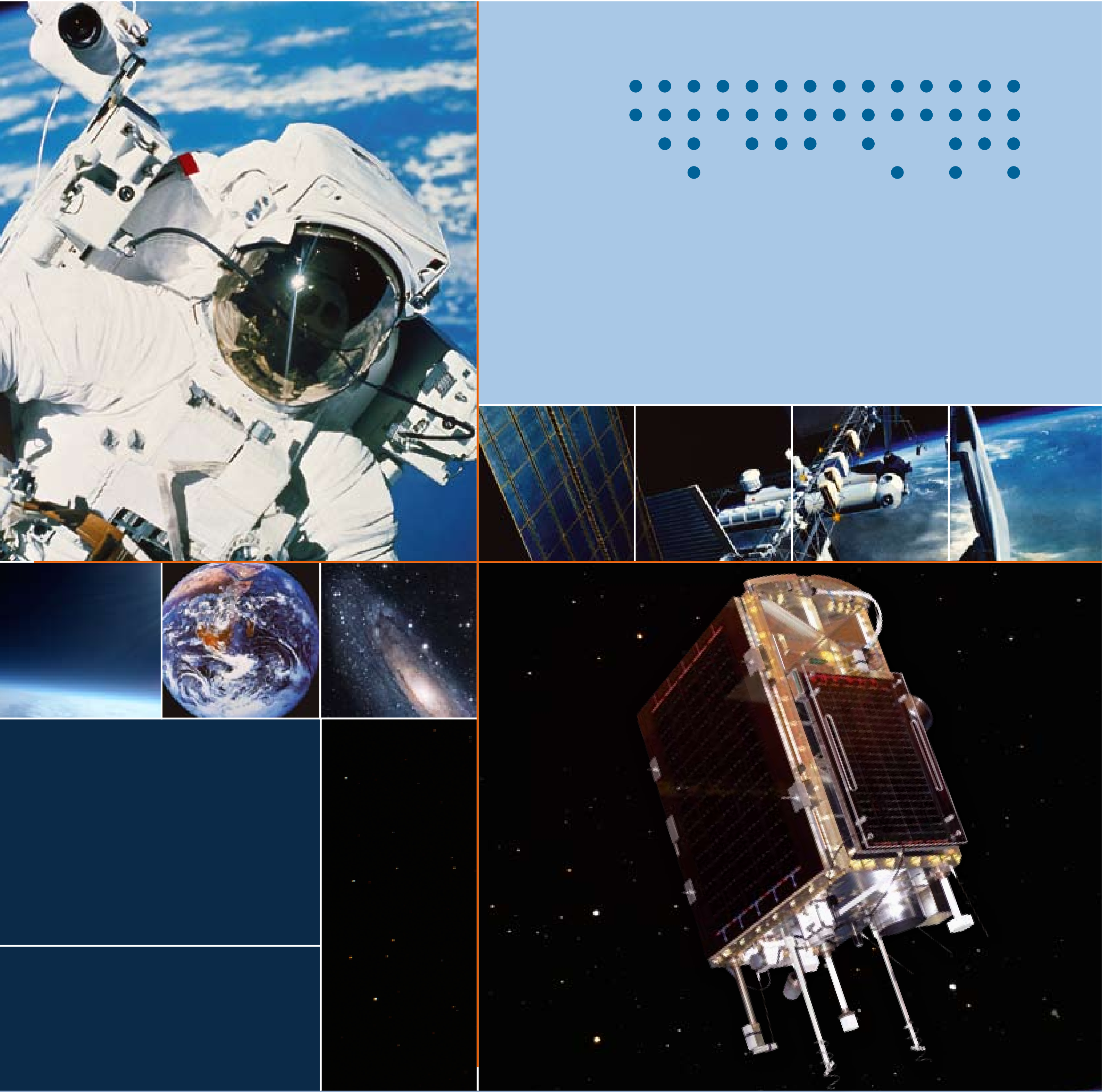


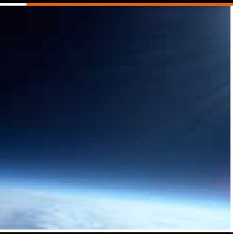
NATIONAL SPACE STRATEGY

To leverage the benefits of space science and technology for socio-economic growth and sustainable development

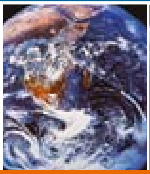
science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NATIONAL SPACE STRATEGY



To leverage the benefits of space science and technology for socio-economic growth and sustainable development



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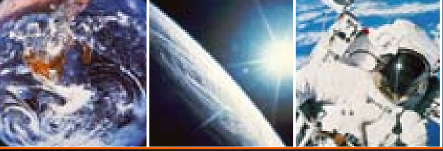
FOREWORD BY THE MINISTER

The South African space sector is today poised at a critical crossroad, with a number of activities set to transform the space landscape. The Cabinet-approved Department of Science and Technology Ten-Year Innovation Plan identifies space science and technology as one of the five grand challenges needed to promote a knowledge economy. The National Space Agency Bill has been approved, opening the way for the creation of a national space agency. It has, therefore, become necessary for South Africa to adopt a national strategy that will lead it towards a viable and sustainable space programme. To this end, the National Space Strategy has been developed as an implementation framework for a national space programme.

In preparation for a formal programme in the area of space science and technology, technology capability audits of potential stakeholders were recently commissioned by the Department. The results of the audits were promising in many ways, and it is clear that we have a basic potential which, if harnessed correctly, could yield significant social and economic benefits. However, the results also indicate that we cannot afford to delay in the development of the sector, and that the next five years will be critical in ensuring that South Africa does not slip off the radar screen given the eroding human capital and the ageing infrastructure.

The advantages to be derived from the establishment of a national space science and technology programme are far-reaching, and will assist us to leverage the benefits of space science for socio-economic growth and sustainable development. This strategy is driven by the most urgent user requirements, and is a direct expression of our national priorities. The current administration has adopted an outcomes framework that comprise of twelve key outcomes to be addressed in order to better strengthen and improve service delivery geared towards improving the quality of life of our citizens. It is interesting to note that the majority of these outcomes will have a reliance on space science and technology as part of the service delivery compact.



Space science and technology will be used as a platform to provide essential data and services to a wide array of applications ranging from research and development to commercial services. In addition, space science and technology will be used as a tool to monitor and evaluate critical resources in our terrestrial landscape that is deemed important for decision making and which lends support to sustainable socio-economic development. It is my fervent hope that the adoption of a national space programme will begin to make positive changes in the quality of the lives of our people, help preserve our natural heritage and assist in the sustainable utilisation of our resources It therefore gives me great pleasure to present to you the National Space Strategy.

NALEDI PANDOR
Minister of Science and Technology

EXECUTIVE SUMMARY

The South African Government recognises the potential role of space science and technology to deliver on a wide spectrum of our national priorities including job creation, poverty reduction, resource management and rural development. Given the relative importance and role of space technology in transforming our economic and social landscape, we need to urgently reflect on the state of our space arena and seek transforming strategies that could help leverage these assets to assist our nation in every facet of its economic and social endeavour.

To date, South Africa has primarily been a consumer and a net importer of space technologies. There is a need to develop systems and sub-systems to support our requirements and to grow the local industry. In particular, we would like to see this technology platform deliver on a wide array of our national priorities relating to our socio-economic development. With this in mind, there are three key priority areas that have been identified and these are:

1. ***Environment and resource management:*** A space programme that helps South Africa to understand and protect the environment, and develop its resources in a sustainable manner.
2. ***Health, Safety and Security:*** A space programme that strengthens developmental efforts through ensuring the health, safety and security of South Africa's communities.
3. ***Innovation and economic growth:*** A space programme that stimulates innovation, while leading to increased productivity and economic growth through commercialization.

Each of these priority areas is unpacked into user requirements, as expressed by a number of key national Departments who use satellite applications to support their own mandate. These requirements collectively represent the national priorities of the country and will form the central focus of the national space programme. In order to deliver on these priorities functional, thematic and support programmes will be needed and these are:

4. ***Thematic Programmes:*** Earth observation, navigation, communication, and space science and exploration.
5. ***Functional Programmes:*** enabling technologies, mission development, space mission operation and space mission applications.
6. ***Support Programmes:*** human capital development, infrastructure and international partnerships.

It remains a challenge, as we embark on these initiatives, to keep the general public engaged and excited about the transforming space landscape. What we need to avoid is implementing these initiatives without the support and understanding of the general public, as these initiatives have been motivated from a socio-economic development perspective which ultimately affect the broader population. For this reason space awareness targeted at the broader public will be advanced.

The strategy also identifies a number of projects that will need to be phased in during the implementation phase in order to realise the tenets of the strategy. These projects are also intended to address some of the shortcomings identified through the audit process that reflects on our space heritage. In order to assess the success of the implementation of this strategy a number of key performance indicators are proposed and these are broadly categorised under readiness factors (inputs), intensity (outputs) factors and impact factors (impact on society).

1. INTRODUCTION

Space is defined as the area beyond the Earth's measurable atmosphere that has very few particles of any size and is flooded with electromagnetic energy. It is generally agreed that the exploration of space (and the application of space technologies) is essential for solving many of the challenges that society is facing, or may face in the future. It is also agreed that space activities should be conducted only for the benefit of all mankind, and not to undermine international peace and security. Substantial progress has been made in considering the spin-off benefits of space exploration, ensuring that space is maintained for peaceful purposes, and demonstrating how space activities could enrich daily life.

Space applications have already been useful from a general social perspective, and they are expected to be of further assistance in the years ahead in addressing major social challenges related to the state of the environment, the management and use of natural resources, the increasing mobility of individuals and products and its consequences, growing security threats, and the shift towards the knowledge economy. These challenges can be grouped into three priority areas (environmental and resource management; health, safety and security; and innovation and economic growth), which will form the central focus of this strategy.

South Africa is increasingly reliant on space-based services and applications, particularly those in the domain of satellite Earth observations, communications, and navigational positioning and timing. These services and applications will be harnessed to respond to the priority areas. A decade from now South Africa should be a primary user of space-based products and services, be a thriving space nation and be an important contributor to the global space science and technology arena.

2. INTERNATIONAL OUTLOOK

Space activities have had, and continue to have, a positive and beneficial impact on everyday life and society. Despite the high costs of space activities there are tremendous returns to the community in terms of job creation, technological know-how, scientific knowledge, and space spin-offs.

Estimates of the size of the space economy vary widely owing to the lack of internationally comparable data. However, from institutional budgets and new commercial revenues from space-derived products and services, it appears that the underlying trend in the space economy is one of growth. Figure 1 shows the space budgets of selected Organisation for Economic Development and Cooperation (OECD) and non-OECD countries in 2005.

There are more downstream space activities (applications) than in the traditional upstream segment (manufacturing). In 2006, manufacturing revenues (e.g. satellites, rockets) were estimated at around USD12 billion, and space-related services (e.g. direct to home satellite television, GPS) were estimated at more than USD100 billion. As for human resources in the space industry, data are very fragmented; but in 2006 an estimated 120 000 people in OECD countries were employed in upstream sectors.

Capital stocks for space assets, as well as annual levels of investment in them, are very difficult to estimate. However, focusing on satellite values, a 2005 study estimated that the 937 satellites in the Earth's orbit at the time had a replacement value of USD170 to 230 billion.

Patent data are considered an indicator of technological innovation and the economic vigour of a given sector and, between 1990 and 2000, the number of space-related patents tripled in both Europe and the United States of America, with the USA, France, Germany and Japan accounting for a major portion.

The many derived space-based services have positive effects on economies and societies, although at this stage they are more qualitative than quantitative. For example, space assets make instantaneous telecommunication possible, allow us to disseminate information over broad areas, and give us a global vision of the world. Combining terrestrial facilities with space infrastructure can provide end-users with benefits such as decreased transaction time, cost savings, improved productivity and increased efficiency.

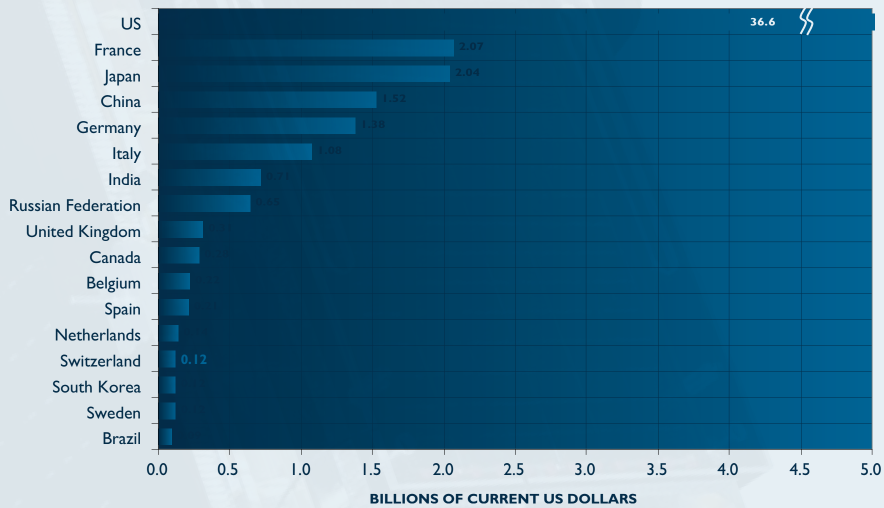


Figure 1: Space budgets of selected OECD and non-OECD countries for 2005

(Source: OECD Report – Space Economy at a Glance, 2007)

Studies show that being able to transfer and broadcast information worldwide instantaneously has been a significant multiplier of commercial revenues for phone and television companies since the 1980s. Employment in the space sector has led to the creation of jobs in "derived" sectors, in particular telecommunications. Figure 2 shows the revenues generated for different technology platforms in the space sector.

Governments play a key role in the space economy as investors, owners, operators, regulators and customers for much space infrastructure. As in other large, complex infrastructure systems (e.g. roads, energy), government involvement is indispensable for sustaining the overall space economy and dealing with the strategic implications of the system. Government involvement is also required in the case of space because space infrastructure and technologies are by nature dual-use (i.e. can be used for both civilian and military applications). Military developments often pave the way for the development of civil and commercial applications (e.g. today's rockets were developed from missiles).

In Norway, the "spin-off effect" of space programmes on space firms has been measured at 4.4, that is for every million Norwegian kroner (NOK) of governmental support, space sector companies have on average attained an additional turnover of NOK 4.4 million[1]. Although this impact measure may vary widely depending on the country and level of specialisation, it is indicative of possible increased competitiveness owing to space involvement. The benefits from space infrastructure are becoming more evident in the management of long-term and significant challenges faced by modern society. In the case of natural disaster management (e.g. floods), remote sensing from space can provide data for the whole cycle of information for flood prevention and mitigation, pre-flood assessment, response (during the flood), recovery (after the flood) and weather newscasts. Timely satellite imagery and communications links in hard-to-reach places can help stem catastrophic economic and human losses.

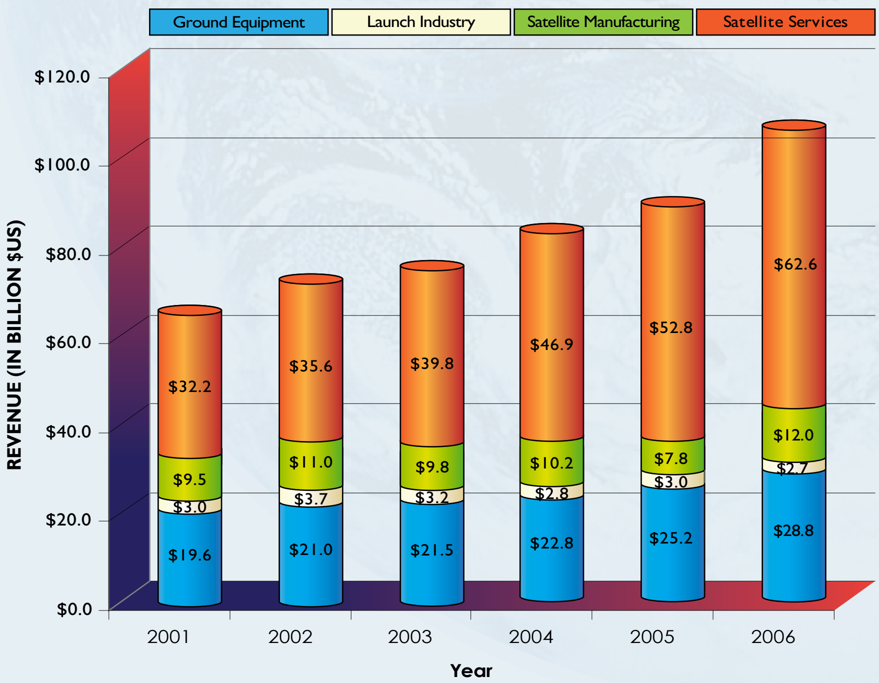


Figure 2: Worldwide revenues of space industry per sector

(Source: Futron, State of the Satellite Industry Report, 2006)

The key contributions of space technology to meeting society's challenges include:

- The ability to communicate anywhere in the world;
- The ability to observe any spot on Earth very accurately; and
- The ability to locate a fixed or moving object anywhere on the surface of the globe.

In the 21st century, nations that use space effectively will enjoy added prosperity and security, and will hold a substantial advantage over nations that do not. In order to increase knowledge, discovery and economic prosperity, and to enhance national security, it is essential for South Africa to develop robust, effective and efficient space capabilities.

1 *OECD Report, Space Economy at a Glance, 2007*

3. BUILDING ON SOUTH AFRICA'S SPACE HERITAGE

South Africa has a rich tradition of involvement in space science and technology. The country has been an active participant in the exploration of space since the dawn of the space age. From the 1950s to the 1970s satellites were tracked to determine the effects of the upper atmosphere on their orbits. Lunar and interplanetary missions were supported from a tracking station at Hartebeesthoek. This station received images of the planet Mars taken by the Mariner IV spacecraft - the first images of Mars (or of any planet besides Earth) to be returned to Earth from deep space.

From the mid-1980s to the mid-1990s South Africa pursued a space programme to develop an Earth observation satellite (known as Greensat) and the associated launch system and ground segment. The infrastructure and industrial capability to support these activities was developed in the country. However, in 1994, before the development was completed, the programme was terminated.

South Africa retains a residual space heritage from the Greensat programme in facilities and in latent industrial capability and know-how acquired while the programme was functioning. A fair number of the experts from the previous space programme are still in the country and active in technical fields. However, as these experts approach retirement, the window of opportunity for using their experience is narrowing to no more than 10 years.

Following the termination of the Greensat programme, the country developed capacity in microsatellite engineering at Stellenbosch University. The 64 kg Sunsat was built at the University and launched in 1999. South Africa's current microsatellite project is the 80 kg Sumbandilasat, built by SunSpace under contract to Stellenbosch University, on behalf of the Department of Science and Technology.

South African astronomers, working at the South African Astronomical Observatory, the Hartebeeshoek Radio Astronomical Observatory and various universities, have access to some of the largest facilities for astronomy in the world. The Southern African Large Telescope at Sutherland in the Northern Cape is the largest single optical telescope in the southern hemisphere, while in neighbouring Namibia the High Energy Stereoscopic System, an array of gamma-ray telescopes, will be the largest such facility in the world. South Africa is also bidding to host the Square Kilometre Array, arguably the most important and most exciting project proposed for radio astronomy in the past 50 years.

South African space physicists, working at the Hermanus Magnetic Observatory, the South African base in Antarctica and various universities, have sought to understand the complex plasma environment of the Earth, shaped by the interaction of the solar wind with the Earth's atmosphere and magnetic field.

These initiatives, situated in academia, the science councils, national facilities, government departments and industry, have broad competencies in satellite applications, satellite engineering and space science, and their supporting technologies. The existing infrastructure and skilled workforce, both in these facilities and in the wider industry supporting them, can be used as a basis for strengthening ties with industry in established space-faring nations, and for developing links with other emerging national space initiatives, particularly in Africa, positioning South Africa as a regional hub of space science and technology.

In order to build on existing competencies, it was necessary to determine the current state of the South African space sector. The Department of Science and Technology therefore commissioned audits encompassing public and private sector entities, and selected academic institutions with a history of involvement in the development of space-related technologies. The audit involved a generic assessment of –

- quality and process maturity; and
- space technology capabilities.

The assessment of the quality and process maturity of the sector involved six criteria, namely, quality management/customer satisfaction, project management, design and development control, procurement control, product process control, and industrial ability. These criteria have been measured in terms of the following maturity levels:

- Level 1 is a low level of maturity, with quality and process not always defined or implemented. The quality of the product relies more on employee competence that on a repeatable process;
- Level 3 is a medium level of maturity, with quality system requirements defined and implemented, and product processes managed in an adequate environment; and
- Level 5 is a high level of maturity, with defined quality system standards adapted to the company objectives, product process performance managed throughout the life cycle, and commitment to continuous improvement by all employees.

The spider diagram in Figure 3 below shows the general state of the space sector with regard to quality and process maturity devolved into the six underlying criteria.

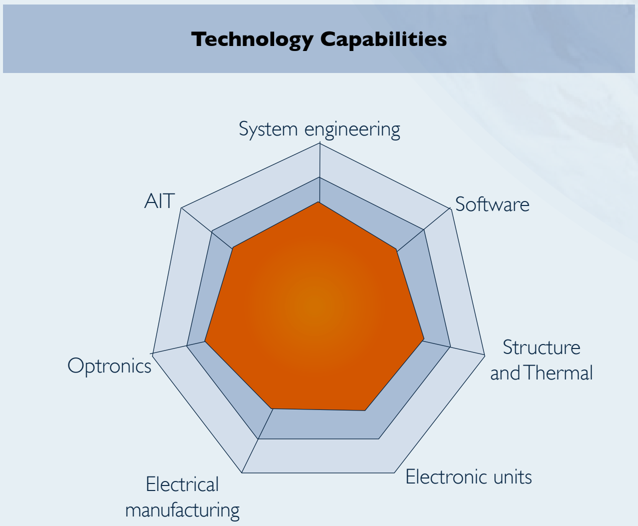


Figure 3: State of quality and process maturity

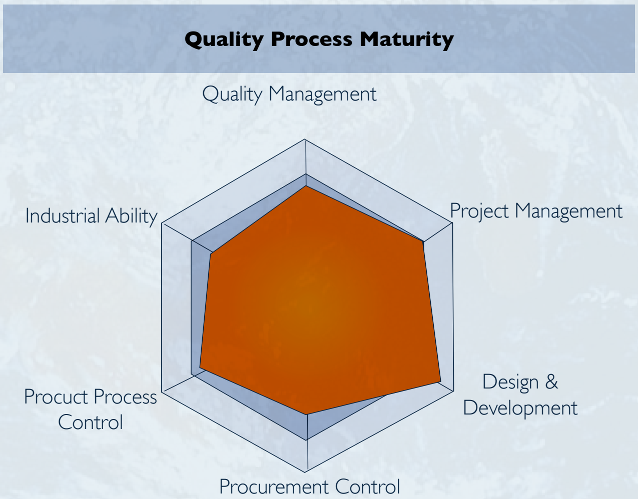


Figure 4: State of technology capabilities

The assessment of space technology capabilities also covered the key areas of system engineering, software, structure and thermal materials, electronic units, electronics manufacturing, optronics, and assembly, integration and testing.

For each area, a score was computed on the basis of experience, using the following ratings:

1. – For ground-fixed application only,
2. – For embedded ground/naval application,
3. – For embedded airborne application,
4. – For nano or microsatellite application, and
5. – For large operational satellite application.

Figure 4 presents the current state of the space sector with respect to technology capabilities in the key areas identified.

Both figures show key areas that need to be strengthened in order to maintain a viable and sustainable space programme. Strengthening the weak areas and building on those that are relatively strong will form a key focus of the implementation plan for the strategy.

In addition, the following results of a SWOT analysis provide insight into how we should respond to the dynamics of the space sector:

Strengths

- The heritage of numerous companies in space activities with a good experience in microsatellite design and development and long experience in satellite telemetry tracking and control operations, and image processing.
- The existence of a highly qualified industry, not necessarily in space activities, but in high-technology areas with the ability to support innovation and consolidate future space development in a high technology industrial context.
- The high motivation of personnel in respect of involvement in a future space programme. This promises dynamism in a challenging new space programme.
- In addition, the strong links between the technology centres, universities and industry will encourage the momentum for a new national programme.

Weaknesses

- The lack of formalised quality and reliability rules to be applied at system engineering level for space applications (due to the lack of know-how regarding space requirements in most companies); in other words the lack of common processes and applicable standards for designing and manufacturing space products.
- The organisation of the present space activities – the public entities driving budgets for space activities are dependent on various governmental departments.
- The lack of research and development (R&D) conducted by the private sector.

Opportunities

- The high level of system design and integration capabilities of key industries is an asset to start a new space programme involving a larger group of industries.
- An optimised organisation of future space activities can bring joint venture opportunities with international industrial partners or international space agencies.
- Beyond the space activities of South Africa, some companies have the capabilities to develop an export market for specific satellite equipment or services offered by existing facilities.
- In order to support industry development in the space domain, universities could develop training dedicated to this aspect.

Threats

- The turnover in military business for many companies decreased drastically in 2006 and this may prevent companies from taking the risk of entering a new business domain, like space, where dedicated investment is required to reach a necessary performance level.
- There are insufficient qualified people available in South Africa and companies may find it difficult to recruit the foreign specialists required. This situation will be exacerbated by the continued emigration of highly skilled South Africans.

4. STRATEGIC CONTEXT

4.1 Vision

For South Africa to be among the leading nations in the innovative utilisation of space science and technology to enhance economic growth and sustainable development and thus improve the quality of life for all.

4.2 Mission

To address and inform national imperatives and policies through stimulating a sustainable space science and technology capability, growing human capital and applying scientific knowledge.

4.3 Goals

The space science and technology programme will be aligned with three primary goals, namely –

- to capture a global market share for small to medium-sized space systems in support of the establishment of a knowledge economy through fostering and promoting innovation and industrial competitiveness;
- to empower better decision making through the integration of space-based systems with ground-based systems for proving

the correct information products at the right time; and

- to use space science and technology to develop applications for the provision of geospatial, telecommunication, timing and positioning products and services.

4.4 Objectives

To achieve the primary goals a number of objectives have to be realised. These include –

- developing the local private space science and technology industry sector;
- developing services and products that can respond to user needs;
- developing an export market for specific equipment for satellite or services offered from existing facilities;
- organising some of the current space science and technology activities into strategic programmes;
- optimising the organisation of future space activities to respond to opportunities with international industrial partners or international space agencies;
- partnerships with established and developing space-faring countries for industrial and capacity development purposes;
- strengthening training and technology transfer programmes, including the sharing of experience and expertise;
- promoting space science and technology in academic institutions and science centres and the provision of opportunities for both short-term and long-term training and education;
- responding to challenges and opportunities in Africa;
- advocating the importance of space science and technology as a priority measure for meeting national development needs; and
- building local awareness of space science and technology and its benefits.

5. KEY PRIORITY AREAS

To date, South Africa has primarily been a consumer of space technologies and their applications. There is a need to develop systems and subsystems to support our user requirements and to grow the local industry. In particular, we would like to see this technology platform deliver on three key priority areas, namely –

- environmental resource management – A space programme that aids in understanding and protecting the environment, and developing and maintaining its resources in a sustainable manner;
- health, safety and security – A space programme that strengthens development efforts, through ensuring the health, safety and security of society; and
- innovation and economic growth – A space programme that promotes an R&D culture that stimulates innovation, while leading to increased productivity and economic growth and at the same time responding to the social needs.

Responses to these priority areas will be done in an integrated fashion so that as many of these requirements are catered for in any one mission.

5.2 Environmental resource management

Environmental and geospatial monitoring. A key factor in sustainable development is the knowledge and understanding of the nature and dynamics of existing resources so that appropriate management strategies can be formulated. Remote sensing satellites provide more frequent information on the effect of changing climate and weather patterns, as well as human activity, on a variety of critical resources such as land, water and air. Such monitoring allows for the rapid assessment of the impact of various policies, so that changes can be made where necessary.

Ocean, coastal and marine management. Data obtained from satellite observations can be used with increased accuracy to monitor ocean current circulation, wind velocity and wave height and direction. The use of satellite platforms have spawned a number of new applications, such as providing information for climate and weather forecasting, fishing, ensuring the safety of shipping vessels and monitoring pollution. This ensures sustainability and the protection of coastal and marine wildlife.

Land management. Land degradation is increasing as a result of the cycle of poverty, population growth, deforestation, unsustainable agricultural practices, environmental pollution and natural disasters. Remote sensing data are recognised as a valuable tool for sustainable land management. With the aid of state-of-the-art technology it can be processed, interpreted and applied in the planning of the utilisation of land resources, as well as monitoring changes in land use and land cover activities.

Rural development and urban planning. Population growth combined with shrinking resources is bound to alter demographic dynamics, and result in large-scale informal expansion in and around urban areas. The provision of adequate health care and social services, and the disposal of waste water and industrial effluent will become increasingly challenging. As far as health care is concerned, the development and use of telemedicine to space technology will help us reach rural populations. The development of a strong information base of socio-economic parameters, as well as the constant monitoring and updating of that information is a prerequisite for a better quality of life for all.

Topographic mapping. Appropriate maps are necessary for a wide range of planning and development activities. Such maps are difficult and costly to produce using traditional methods, but the increasing availability of satellite remote sensing imagery is modifying the way in which maps are prepared and used. This imagery is a cost-effective alternative to aerial imagery and reduces the turnaround times in the production of maps.

Hydrological monitoring. In addition to irrigation, one could address problems associated with the development, planning and construction of hydroelectric power plants, engineering works on river beds and the creation of water reservoirs to ensure the provision of drinking water to local communities. The optimal management of water resources in dry regions, where most of the precipitation occurs in a short time, is particularly critical. Satellite data can also be used to detect deep groundwater, which is considered safer for human consumption than surface water.

Climate change mitigation and adaptation. The possibility of unprecedented global climate change, driven largely by human activity, is a subject of considerable concern worldwide. Although the African continent contributes the least to global climate change, the effects of such change will be most evident on this continent. In most instances proposed efforts to reverse or stabilise adverse changes are expected to have long lead times, which have made it necessary for adaptation measures to be identified and implemented.

Meteorological monitoring. Data from polar and geostationary orbiting meteorological satellites have proved useful for monitoring meteorological systems for better forecasting. The data generated from such satellites have made it possible to understand the evolution of atmospheric systems and their interaction with global and regional disturbances better. One of the best known uses of such satellite platforms is the monitoring of the location and intensity of meteorological phenomena, especially natural disasters such as tropical cyclones, severe thunderstorms, floods and bush fires.

5.2 Health, safety and security

Disaster monitoring and relief. Given the significant cost of disasters, disaster management should be viewed as part of the socio-economic development activities. Sustainable development could therefore be considerably enhanced by reducing the impact of natural and man-made disasters. Disaster management involves a series of information-intensive phases: response, recovery and reconstruction. Space applications play a critical role in furnishing the required information required in each of these phases.

Hazard forecasting and early warning. This can be viewed as the pre-disaster phase which, if efficiently implemented, can help reduce the risks of natural and man-made disasters. Risks are assessed through an objective, information-intensive process requiring the evaluation of the characteristics of the hazards, such as the probability of their occurrence and their severity and location, as well as the vulnerability of life and property. Effective early warning protocols and a certain level of disaster preparedness are required.

Cross-border risks. The use of high-resolution satellite imagery for the efficient monitoring of trafficking and distribution networks can assist in reducing human trafficking, drug smuggling and the movement of prohibited materials across borders. Improving communications and information technology networks between decision-making and executive bodies will also assist in efforts to reduce these risks.

Disase surveillance and health risk. Direct links between the environment and health are well understood. The adverse impact of climate change on human health also needs to be assessed and satellite data provide a convenient source of information to make this linkage. Satellite data can be used to assess the linkages between health and the environment more effectively, enabling more effective national and regional policy responses to environmental risks to human health.

Asset monitoring. Many companies maintain large fleet of vehicles and to do so effectively need to know the current location and physical condition of any given vehicle at any given time. Fleet tracking systems consist of satellite-linked location and communication devices, which can also be used to track other movable assets like high value commodities and agricultural products, as well as South Africa's valuable marine and animal heritage.

Regulatory enforcement. Space applications can make meaningful contributions to enforcing the laws of the country. For example, remote sensing data can be used to identify and monitor illegal activities, and global navigation services can pinpoint the exact location of an incident and the relative location of the nearest response service to the incident. With clear visual pictures of the situation, dispatchers can react immediately and confidently.

Defence, peacekeeping and treaty monitoring. Use of space applications in this regard include monitoring activities for crisis prevention and resolution. Opportunities for the cooperative use of national space assets in multinational peacekeeping operations are increasing. On the regional front, regional stability is vital for sustainable and progressive socio-economic development efforts, which puts additional pressure on countries in the region to respond to potential threats collectively.

5.3 Innovation and economic growth

Tourism and recreation. In an environment where tourism and recreation is fast becoming a source of socio-economic benefit to local communities, space applications can provide valuable information with respect to sustainable tourism, for example around fragile world heritage sites, and for identifying tourism and ecotourism potential. Navigation applications for recreation purposes have also vastly increased in the recent past.

Communications. Satellites enable long-distance communications, television broadcasting, distance learning and health education, data networks, maritime communications and disaster relief networks. The establishment of satellite systems provides a cost-effective and efficient solution for communication services. There is a strong correlation between telephone density and the rate of development, which clearly highlights the contribution of communications infrastructure as a key to the socio-economic development of the country.

Space science and exploration. Achievements in this area have captured the world's attention, interest and imagination. The primary benefits of these activities are how they increase our appreciation of our existence in the context of the solar system and beyond. Ongoing basic and applied space research will contribute immensely to a sustainable national space programme. As space captures the imagination of young and old alike, such activities could be used to educate the general public.

Space technology transfer and spin-offs. Thousands of spin-off products have resulted from the development and application of space technology platforms in such diverse fields as advanced manufacturing, telecommunications, public health, public safety, computers and information technology, and transportation. Technology transfer and spin-off products are collectively expected to make significant contributions to the national economy by the creation of new jobs and in increasing industrial productivity and opportunities.

Development of the space industry. The National Industrial Policy Framework and the Industrial Policy Action Plan promote long-term intensification of the industrialisation process with a movement towards a knowledge-based economy. The space sector is regarded as one of the knowledge-based sectors, which require increased R&D in areas in which the country has a potential advantage, as well as improved innovation using domestic technologies. It sees skills and education for industrialisation, traditional and modern infrastructure, and innovation and technology as the necessary conditions for successful industrialisation, as well as for the space industry to thrive and compete internationally and within African markets.

6. DELIVERING ON THE PRIORITIES

The realisation of the strategic objectives will depend on a number of key elements, as shown in Figure 5 below.

6.1 Thematic areas

Four thematic areas have been identified as important for a viable space programme.

Earth observation: Earth observation involves all activities connected with the collection of information on the Earth's surface or atmosphere from instruments on board satellites and in-situ ground sensors. On a global scale, space-based systems make a considerable contribution to the collection of data, providing high quality, consistent, global datasets over long periods. This area will focus on two key missions: understanding the planet and providing data for decision making. These will be developed in support of implementing South Africa's Earth Observation Strategy. With the recently completed microsatellite project, the country will continue to increase knowledge and expertise in satellite design and manufacture, and to develop applications to support government objectives.

Navigation: This area will focus on the development of augmentation technologies, applications and services in navigation, timing and positioning. Attempts will be made to explore and exploit synergies with other competency areas like Earth observation and communications. The most promising application areas include fleet and traffic management, location-based services, and search and rescue.

Earth observation programmes

- Establish an earth observation data centre
- Develop a platform to integrate satellite and in-situ data
- Develop medium to high resolution payloads
- Establish centres of competence for optronics and synthetic aperture radar
- Develop the African Resource and Environmental Management Constellation in partnership with other African countries
- Consolidate the acquisition of space data for government

Space science and exploration: Space science and exploration achievements in the past few years have captured the world's attention, interest and imagination. The primary

Navigation programmes

- Develop a navigation augmentation system
- Develop navigation applications to support user requirements

benefits of this new age discovery are in their impact on humanity's appreciation of its own global habitat in the context of the terrestrial environment, the solar system and the universe beyond. A new appreciation of the interdependence of human beings and their natural environment has inspired vast interest in and study of the natural environment, including other planets. Basic space science, in this light, is therefore critical to a nation's sustained prosperity. Mission-driven space science and exploration projects will be fostered and supported where they are of strategic interest and in line with the objectives of this Strategy.

Communication: This competency area will focus on the development of technologies and applications in collaboration with the end users, primarily the Department of Communications. Investing in satellite communications has many benefits including, stemming the tide of capital outflows to foreign satellite operators, allowing for backbone connections in areas where fibre networks cannot provide these, backup and emergency restoration for terrestrial telecommunications infrastructure and flexible interim extensions for the terrestrial network expansions. The technologies will be tested as secondary payloads on low Earth orbiting Earth observation satellites.

Space Science programmes

- Develop joint partnerships in space science payloads
- Establish and support centres of competence
- Establish and support research chairs

Communication programmes

- Develop technologies for low data rate payloads
- Develop technologies for applications in e-education, telemedicine and rural communication and disaster support
- Develop a geostationary (GEO) communications system
- Launch a small GEO satellite

6.2 Supporting platforms

The supporting platforms will include three areas that are critical for the realisation of the programmatic functions. These are –

- **Human capital** – the appropriate expertise and skills necessary for a space programme will be an area that will receive priority attention, as without them all existing and envisaged programmes and infrastructure will be useless;
- **Infrastructure** – appropriate infrastructure is the cornerstone of an effective space programme, enabling technology transfer and human capacity development initiatives;
- **International partnerships** – strategic partnerships with foreign partners are necessary for tangible and intangible technology transfer and a viable and sustainable space programme.

6.3 Space awareness

In order for South Africa's space programme to be meaningful to the general public, public awareness of the benefits of space technology and its manifold application products and services will have to be created. No technology platform is embraced without wide understanding of the platform, and awareness and advocacy programmes will therefore be be vital to the development of South Africa's space programme.

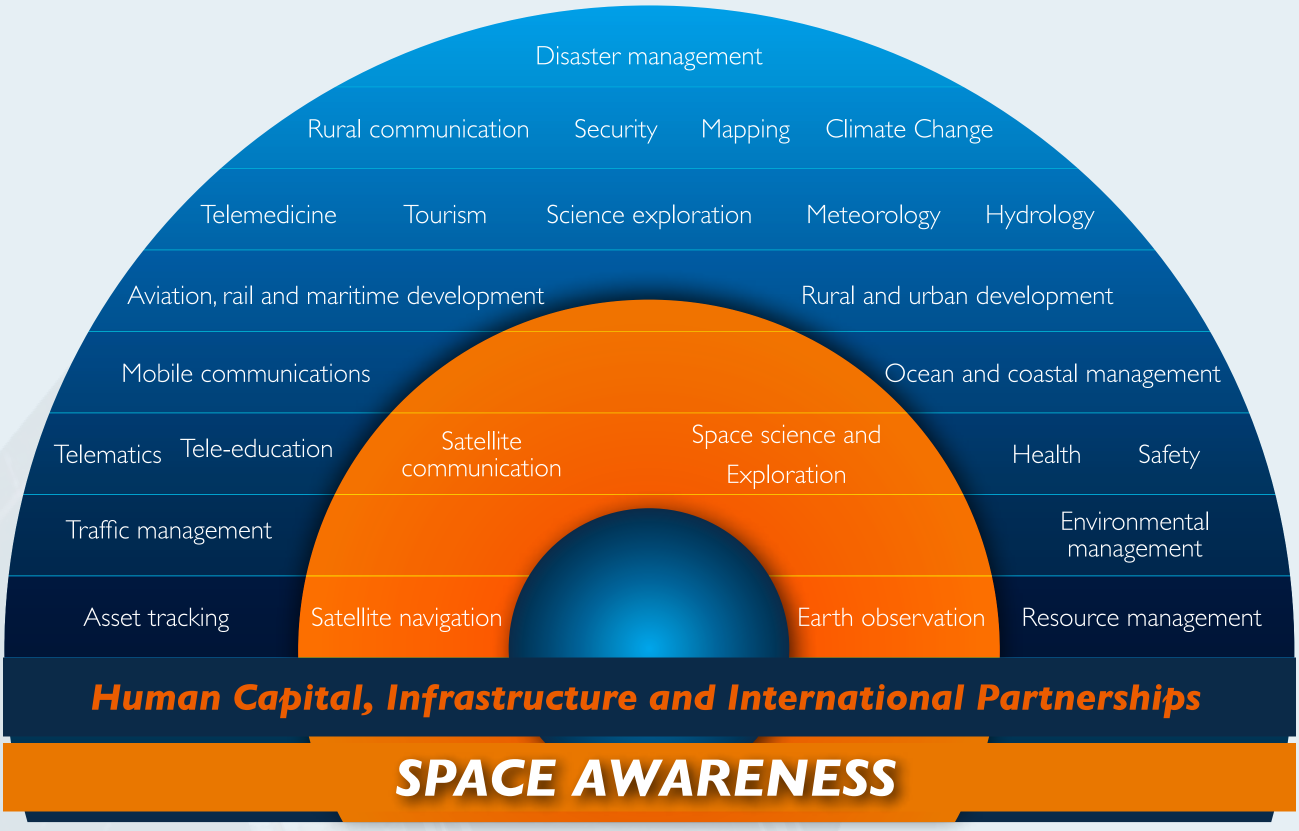


Figure 5: Elements needed for a viable space programme

7. FUNCTIONAL PROGRAMMES

Each of the thematic areas is supported by functional programmes. These are organised into four large clusters within the scientific and engineering disciplines, namely, enabling technologies, mission development, space mission operations, and space mission applications. Each cluster carries out a specific function, which can be summarised as follows:

- Through **enabling technologies**, provision is made for leadership, coordination and support for applied research in order to increase the knowledge base, devise new applications through space missions, and allow the transfer of intellectual property and proven technologies to local industry, academia, and government organisations;
- Through **mission development**, provision is made for coordination and support for the development of space missions through the definition, critical design, manufacturing, integration, testing and delivery phases leading to the launch and early operations of space systems;
- Through **space mission operations**, support is given to space missions through ground support, personnel training, mission analysis and planning, in-orbit ground-control operations, system monitoring, maintenance and logistical support, and data handling and delivery; and
- Through **space mission applications**, value is delivered to stakeholders, with best practices used to develop new and advanced applications to support stakeholder user requirements.

8. PROPOSED PROJECT PHASING

Figure 6 below summarises the phasing of the implementation of the strategy. It should be noted that each initiative will have an aspect of industrial development, international partnership, capacity building and applications.

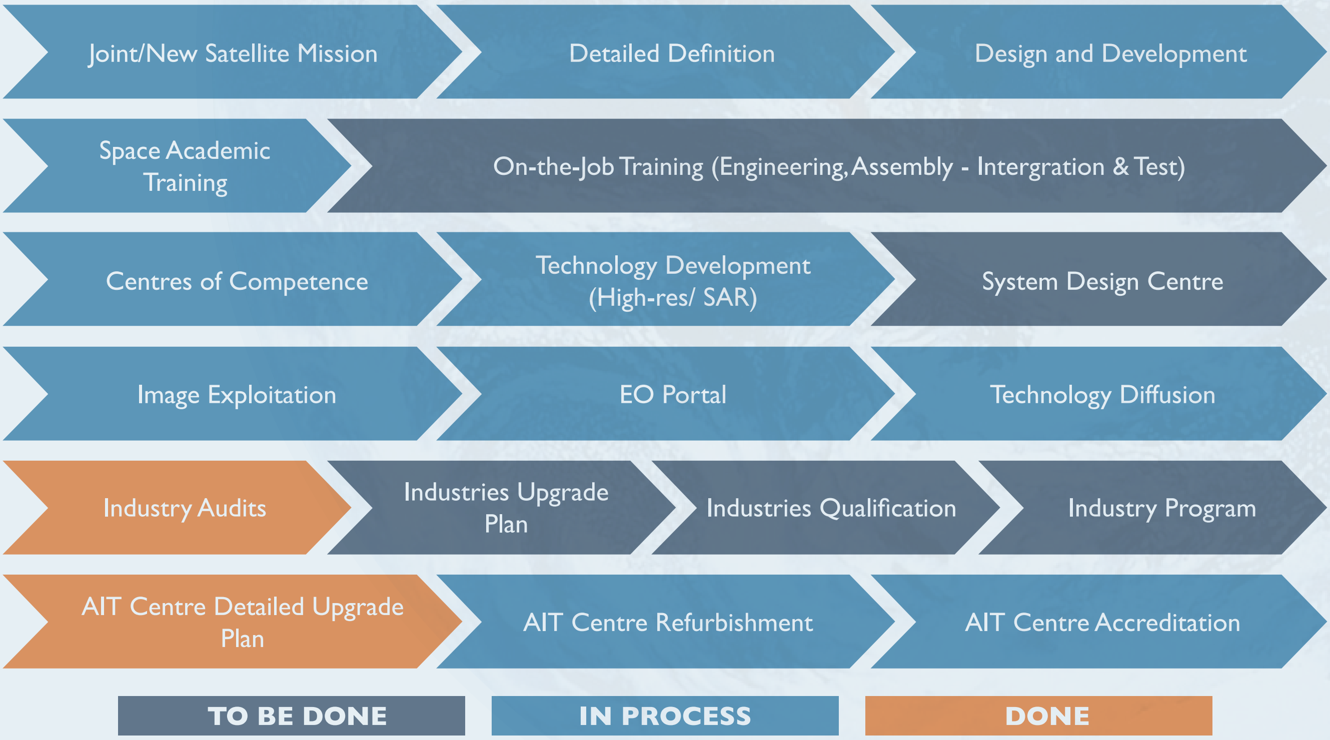


Figure 6: Phasing of satellite projects

9. INDICATORS

In developing the indicators for the development of the space economy, we used the methodology applied by the OECD on emerging economic areas such as the information society. The indicators are presented in a framework that consists of three stages: readiness (inputs), intensity (outputs), and effects. Each stage, as illustrated in Figure 7, provides an indication of the maturity of the sector. It should be noted that some space applications (e.g. satellite telecommunications) are more developed than others, and are already having a significant impact.

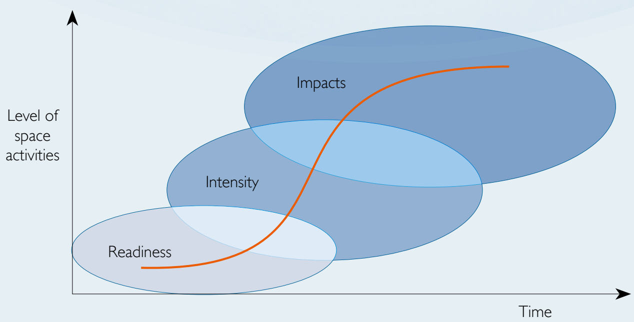


Figure 7: Steps from readiness to impact for the space sector

(Source: OECD, Working Party on Indicators for the Information Society, 2006)

The readiness factors (inputs) of the space economy are the overall technical, commercial, and financial infrastructures necessary to engage in pertinent space activities. This deals with the financial and human resources that are employed in producing space-related hardware and the provision of relevant services. It examines R&D, financial support for space programmes, and human capital.

The intensity factors (outputs) of the space economy are the uses made of space activities - the specific space-related outcomes derived from the inputs. Thus, outputs include products or services that are produced or provided in the space sector, financial benefits such as sales and trade revenues, and indications of future financial benefits such as patents.

The impacts of the space economy, which is more qualitative than quantitative, are the benefits to society created by space activities. In the table below is a list of key indicators proposed for the strategy. These indicators are meant as a guide only and are meant to indicate the potential of the space sector in a number of areas, if implemented effectively.

Table 1: key proposed indicators

FACTOR	TARGET (2012)	TARGET (2017)
Readiness factors		
Public institution budget	R350m per annum (0,06% GDP)	R500m per annum
Research and development	R420m (3,8% of GBAORD)[1]	R1 800m
Capital stock	2 satellites	6 satellites
Human capital	400 space professionals 2 centres of competence	600 space professionals 4 centres of competence
Intensity factors		
Revenues		
Manufacturing	R510 million	R1.52 billion
Ground segment	R880 million	R2.64 billion
Space-related services	R2.11 billion	R6.30 billion
International trade	R770 million	R2.3 billion
Patents	2	5
Impact factors		
New revenues	R3.08 billion	R9.20 billion
Commercial revenue multiplier effect:		
National economy	0.56 % of National GDP	1.44 % of National GDP
Space firms	Spin-off factor ≥ 2	Spin-off factor ≥ 2

1. Government Budget Appropriations and Outlays on R&D.

CONCLUSION

The strategy is primarily driven by the most urgent user requirements, which is a direct expression of national priorities. These requirements give strategic direction and on the basis of which a number of building blocks are identified. These building blocks form the foundation on which a national space programme will be positioned and indeed provide a measure of success if effectively implemented. The implementation plan for this strategy, which will include work plans in support of the user requirements and associated budgets, will span a 10 year timeframe, as the foundational phase, followed by a longer term maturity phase.

NATIONAL SPACE STRATEGY

DEPARTMENT OF SCIENCE AND TECHNOLOGY
Building 53, Meiring Naude Road
Scientia Campus, (CSIR) South Gate Entrance
Brummeria, Pretoria, 0001, South Africa
Tel. +27 (12) 843 6300
Fax. +27 (12) 349 1030

www.dst.gov.za

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