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African Space Strategy

Towards economic, political and social integration

Version 7

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Executive Summary

[To be completed after consultation]

1 Introduction

Africa has an opportunity to exploit her geographic position and natural resources to promote economic growth, improve the quality of life and contribute to scientific knowledge. At the same time, Africa is facing major challenges in food security, rapid urbanisation, sustainable use of its environment and educating a growing population. Economic, political, environmental and social reforms and progress can only be impactful if there is concerted effort towards building indigenous skills and technological capabilities that provide effective solutions to these challenges. More specifically, the active participation of Africa in the development of space-related applications and services will enable the continent to address these challenges, meet the objectives of the African Union (AU) Agenda 2063, form an integral part of the implementation of the Science, Technology Innovation Strategy for Africa (STISA), take advantage of new opportunities offered by our geographic advantage and become a global space player.

Societal Needs	Policy Framework	Indicative Information & Products
Food Security	• Comprehensive Africa Agriculture Development Programme	Rainfall, yield, production, Crops Distribution, Soil, land suitability
Water Resources	African Water Vision 20125	Hydrography, Aquifers, Water bodies, Quality, waste water and use
Marine and Coastal Zones	2050 Africa's Integrated Maritime Strategy	Coastal zones degradation, Fisheries potential
Environment	NEPAD –Environment Action Plan (EAP)	Ecosystems, biodiversity, Vegetation, Land cover
Weather and Climate	• Climate Development Africa • Integrated African Strategy on Meteorology	Rainfall, temperature, wind, aerosol, climate trends & extremes
Security and Emergency	• Africa Regional Strategy on Disaster • Convention on Cyber Security and Personal Data Protection	Vulnerability, Risk
Health Planning	Africa Health Strategy	Disease vectors, environmental factors, population distribution
Governance and Commerce	e-Government Strategy	Location- based mobile services, mapping of Government ICT infrastructures
Infrastructure	Programme on Infrastructure Development (PIDA)	Spatial information on key infrastructure, such as transport infrastructure, energy sources and power systems and distribution networks.
Information and Communications	• Reference Framework for Harmonization of Telecommunications and ICT Polices & Regulation in Africa • African Regional Action Plan for Knowledge Economy (ARAPKE)	Telecommunications, Internet, TV Broadcasting, Mobile Communications, e-Commerce, e-Government, e-Learning
Innovation	• Science, Technology and Innovation Strategy for Africa	Food security, disease prevention, communications, security

Table 1: Policy Frameworks that respond to key challenges on the African continent.

These challenges have long been recognised and many policy frameworks, as mapped out in Table 1 above, have been developed in response. In all instances, the success of implementing these policy frameworks is highly reliant on space technologies and applications. The access, security and integrity of spatial data used for decision-making are critically dependent on an indigenous space programme and the requisite capabilities. The lack of an indigenous space capability will severely hamper progress and our effective response to these challenges.

Africa certainly cannot afford to remain a net importer of space technologies, as the long-term prognosis of doing so is to limit socio-economic development and negate the African Union vision of 'An integrated, prosperous and peaceful Africa that is driven by its own citizens and represents a dynamic force in the global arena'.

The entry barriers in developing a regional space capability, to adequately respond to the highlighted challenges, has been the capital intensive nature of the space sector and the lack of a formal governance structure to advance a collective effort. This situation must be circumvented given the strategic value of a regional space sector in advancing the economic, political, environmental and social agenda of the continent. For instance, over 90% of the Strategic Objectives across the eight Commissions of the African Union, are reliant on space applications for its effective implementation. In addition, progress on the Millennium Development goals could have been positively impacted through the use of space-based products and services to provide critical spatial information for decision-making processes.

Even though Africa represents 20% of the earth's land surface, more than the USA, India, China and Europe put together, yet these countries/region spent more than $50 billion on space activities in 2013 compared to less than $100 million spent by the African continent in the same period. In terms of performance in the space sector, on the African continent only South Africa ranked in the top thirty in 2013– ranking 23rd in terms of a space budget ($41 million) and 30th in terms of scientific production in satellite technology (accounting for 0.87 of global publications in the domain). These comparisons highlight significant shortcomings in terms of under-investments and suboptimal activities in the space sector, which limit Africa's potential in a fast growing sector that in turn is vital to addressing its challenges.

Hence, overcoming Africa's economic, political, environmental and social challenges is contingent upon a collective effort to formalise and sustain an indigenous space sector that is responsive to these challenges. Such efforts will promote commercial activities, ensure productivity and efficiency gains in diverse sectors and facilitate cost avoidance measures that support a broader public good. This Strategy provides a strategic framework for developing and operationalising continental-level space initiatives. It clearly spells out the strategic goals and objectives of a long-term collective space vision for the continent. The Strategy hinges off the African Space Policy, which provides a guiding framework, for both the African pubic and private sectors, on the underlying principles to be adopted on route to a formal African space programme.

2 How space can address Africa's challenges

Space science and technology has and continues to contribute to sustainable development and offers many benefits to mankind. Depending on their mission, satellites have different orbits. Weather and communication satellites are placed in geostationary orbits (altitude of 36,000km) above the equator, from which they have a constant gaze on the same hemisphere of the Earth by completing one orbit around the Earth every 24 hours. Other satellites are placed in Low Earth Orbits (LEO), which complete on average one orbit around the earth every 100 minutes. Because the Earth rotates in the plane of the orbit, such a satellite eventually covers the whole Earth's surface. Such orbits are used for remote sensing, and navigation and positioning applications. 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.

Earth observation/remote sensing satellites use modern instruments to gather information about the nature and condition of the land, sea, and atmosphere. Located in various orbits, these satellites use sensors that can "see" a broad area and report very fine details about the weather, the terrain, and the environment. The sensors receive electromagnetic emissions in various spectral bands, which show objects that are visible, such as clouds, hills, lakes, and many other features. These instruments can detect an objects temperature and composition, the wind's direction and speed and environmental conditions, such as erosion, fires, and pollution.

Satellite communications is the key technology that could bring developing countries to participate in the build up of the global information infrastructure. Research indicates that wireless systems are the most cost effective way to develop or upgrade telecommunications networks in areas where user density is lower than 200 subscribers per square kilometre. Such wireless systems can be installed 5-10 times faster and at a 50% lower cost than landline networks.

Satellite navigation uses satellites as reference points to calculate positions accurate to within a few meters. With advanced techniques and augmentations, satellite navigation can make measurements down to centimetre levels. Navigation and positioning receivers have been miniaturized and are becoming economical thus making the technology accessible to everyone. For example, GNSS (Global Navigation Satellite Services) receivers are currently built into cars, boats, planes, construction equipment and even laptops to provide accurate geographic coordinates of these valuable assets.

The exploration of the universe from our solar system to the most remote parts represents one of the greatest intellectual quests of humankind. The last few decades have shaped our views of the universe, the implications of which are still to be fully realised both from a scientific and a practical point of view. Space exploration achievements of the last five decades have captured the world's attention, interest and imagination. People have shared the excitement of discovering and exploring the new worlds of our solar system. The perspectives gained from space science also help us to understand the challenges facing the Earth.

In what follows we attempt to demonstrate the value that space science and technology brings to the four key areas of space science and technology, namely (i) Earth observation, (ii) navigation and positioning, (iii) satellite communications, and (iv) space science and astronomy. In so doing we aim to highlight the value and benefits of space science and technology in addressing our manifold socio-economic challenges.

2.1 Earth Observations

In countries where the failure of a harvest may mean the difference between bounty and starvation, satellites have helped planners manage scarce resources and head off potential disasters before insects or other blights could wipe out an entire crop. For example, in agricultural regions near the fringes of the Sahara desert, scientists used satellite images to predict where locust swarms were breeding and were able to prevent the locusts from swarming, thus saving large areas of cropland.

Remote sensing data can also help us manage scarce resources by showing us the best places to drill for water or oil. From space, astronauts can easily see fires burning in the rain forests of South America as trees are cleared for farms and roads. Remote sensing satellites have become a formidable weapon against the destruction of the environment because they can systematically monitor large areas to assess the spread of pollution and other damages. Such monitoring capabilities are critical for the long-term sustainable use of our scarce resources.

Remote sensing technology has also helped mapmakers. With satellite imagery, they can produce maps in a fraction of the time it would take using laborious ground surveys. The use of synthetic aperture radars or stereoscopic imaging provides topographic maps of the landscape. This capability enables city planners to keep up with urban sprawl and gives deployed troops the latest maps of unfamiliar terrain. The latter is vitally important for peacekeeping missions in Africa.

Because remote sensing satellites cover the whole globe, they are important for the study of large-scale phenomena like ocean circulations, climate change, desertification and deforestation. Satellites make it possible to monitor environmental change caused by human activity and natural processes. Because data is collected in a consistent manner, satellites can reveal subtle changes that might otherwise remain undetected. For example, the well known "ozone hole" over Antarctica and the phenomena of atmospheric ozone depletion was discovered using satellites.

2.2 Navigation and Positioning Applications

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), navigation and positioning applications 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 accurate localised weather newscasts. In addition, timely satellite imagery and communications links in hard-to-reach places can help stem catastrophic economic and human losses.

Navigation and positioning is the main element of the international air traffic management system providing worldwide navigation coverage to support all phases of flight. With appropriate augmentation systems, navigation and positioning satellites will enable gate-to-gate navigation and all weather capabilities for suitably equipped aircraft. With more precise navigation tools and accurate landing systems flying do not only become safer, but also more efficient by reducing delays, diversions and cancellation of flights. These interventions also assist in CO_2 emissions reduction in the aviation sector.

In general, mariners use the Global Positioning System (GPS) for either navigation or positioning. GPS has also recently been applied to the surveillance of illegal shipping activities, such as fisheries. The latter has also been extended to monitor oil spills and the ensuing environmental damages. Used together with remote sensing imagery, accurate maps of the ocean colour, temperature, currents, salinity and wind direction have been produced.

Such rich information is vital for protecting and extracting economic value from our Economic Exclusion Zones and providing a better understanding of the climate change models.

Many automotive navigation and positioning applications fit within the description of intelligent transportation systems (ITS). ITS programmes are intended to improve traveller safety; improve travel efficiency by reducing congestion; save energy through reduction of fuel requirements; and lessen the environmental impact of travel. Automobile navigation applications also help the driver to make the most efficient routing decisions – this application is also valuable for fleet vehicle management and the tracking of valuable assets, especially across national borders.

2.3 Satellite Communication Applications

The Internet in Africa is limited by a lower penetration rate when compared to the rest of the world, and overall available bandwidth indicates that Africa is way behind the "digital divide". According to 2011 estimates, about 13.5% of the African population has Internet access. While Africa accounts for 15.0% of the world's population, only 6.2% of the World's Internet subscribers are Africans. Africans who have access to broadband connections are estimated to be 1% or lower. In September 2007, African broadband subscribers were 1,097,200, with a major part of these subscriptions from large companies or institutions. Satellite communications can fill the gap and increase broadband access, particularly in land locked countries and rural areas where cable penetration is non-existent.

Integrating information and communication technologies (ICTs) into governance processes can greatly enhance the delivery of public services to all citizens. ICT integration will not only improve the performance of governance systems, it will also transform relationships amongst stakeholders, thereby influencing policymaking processes and regulatory frameworks. In the developing world, however, the potential of ICTs for effective governance remains largely unexplored and unexploited. Such services can be delivered through connectivity via satellite links in areas with minimal access to Internet. Satellite connectivity involving post offices may be used for access to such services for those who have no access to Internet.

Technologies for education and training, in particular distant education and multimedia, may be instrumental in meeting the needs of countries that have to train and integrate a large number of workers in widely dispersed and under-equipped areas. This allows for a constant renewal of skills without being limited by Information Technology (IT) infrastructure. The use of VSAT terminals coupled with communication satellites makes education more accessible, especially in rural areas.

Many countries have to cope with large-scale disease outbreaks and telemedicine may help to meet these challenges by improving the organisation and management of health care. Databases may be linked through networks to monitor the development of diseases, provide access to medical expertise through tele-consultation and support remote medical assistance. In this regard, satellite communications can contribute to preparing and implementing health policies. Telemedicine is a cost-effective solution for providing affordable health care in rural areas.

National weather forecasts begin with a current satellite view of Earth. At a glance one can tell which parts of the country are clear or cloudy. When satellite maps are put in motion we easily see the direction of clouds and storms. An untold number of lives are saved every year by this simple ability to track the paths of hurricanes and other deadly storms. By providing farmers valuable climatic data and agricultural planners with information, this technology has improved food production and crop management. Weather satellites are integrated in the Global Telecommunications System, as an essential element of global, regional and national coverage.

2.4 Space Science and Astronomy

The runaway greenhouse effect on Venus, caused by an excess of carbon dioxide in its atmosphere, has led to an understanding of the dangers of carbon dioxide build-up on Earth and the resulting global climate change. In addition, finding aerosols in the atmosphere of Venus and observing how they interact with the molecules has led to knowledge about what happens when aerosols are introduced into the Earth's atmosphere. Observing and analysing the dust storms on Mars have provided scientists with models of what happens to a planet's climate if massive amounts of dust were blown into the atmosphere, as would happen on Earth from a volcano or from a large impact of an extra-terrestrial object.

Astronomy is a science that reaches from planets to stars to galaxies and the universe as a whole, from the first light up to the present, 14 billion years later. It embraces all of physics in an endeavour to understand the origin and evolution of the universe and its constituents. Astronomy is a way of advancing science that, until recently, has been the preserve of the industrialised world. Increasing public interest in astronomy and improving scientific education helps develop a more skilled workforce and which skills, both conceptual and practical, are easily transferred to applied fields such as meteorology, computer science and information technologies.

Space geodesy uses astronomical techniques to define an International Celestial Reference Frame (ICRF) that in turn is used to define an International Terrestrial Reference Frame. This terrestrial reference frame is used to provide precise geographic coordinates that are used in many practical applications such as ocean and ice level measurements, continental drift, and the orbits of artificial satellites. These reference frames, for example the African Reference Frame, are also used for modern map making and location based applications, such as the mapping of vegetation growth and the demarcation of borders. Space science and astronomy therefore provides basic knowledge that has practical use in daily location-based applications.

The earth's magnetic field protects us from charged particles and electromagnetic radiation. However, variations in the earth's magnetic field, due mainly to space weather related perturbations, could cause many adverse effects on technical systems in space and on earth. For example electrical discharges inside of satellites render these satellites inoperable, induced currents in long power and telecommunication lines result in power outages and communication blackouts, and disruptions in geomagnetic surveys negatively effect the commercial exploration of precious minerals and oil. Space weather monitoring provides an effective tool for mitigation against these disruptions to both space and ground-based operational systems.

3 Situational Analysis

3.1 SWOT Analysis

Strengths	Weaknesses
• Political support for the growth and development of high-tech sectors, including the space sector. • Significant Government support for the establishment of national and regional space programmes. • Critical mass of space professionals committed to leveraging space for socio- economic development • Intra-continental partnerships fostering space science collaboration. • Africa's strategic and geographic location that is suitable for astronomical and space physics facilities. • Existing nodes of space expertise and in-situ capabilities. • Established satellite assembly, integration and testing facilities • Existing knowledge base and expertise in space engineering. • Experience in the manufacture and/or operation of small satellites. • Space physics capability that leverages its proximity to the southern ocean islands and the South Atlantic Magnetic Anomaly. • Existing and established centres focused on exploitation of geo spatial data	• Disparities in space expertise and capabilities across the continent. • African user needs are not well quantified and documented. • Lack of governance structure to coordinate and manage continental level space activities. • A lack of a critical mass of core skills for space • Limited number of space initiatives leading to a poor retention of skills. • Duplication of efforts and suboptimal coordination • Uneven distribution of core capabilities. • Suboptimal investment in space sector. • Disjointed continental efforts due to the lack of data management and sharing policies • Limited access to libraries, journals, and scientific and technical databases. • Uncoordinated regulatory environments on issues of immigration, and cross border taxes and tariffs
Opportunities	**Threats**
• Large rural communities whose needs can be supported by space products and services. • A young population that could be trained to serve the requirements of an indigenous space sector. • Maturing public awareness and knowledge of the societal benefits of space science and technology. • Servicing the sustainable development needs of a population of 900 million people spread over 30.3 million km^2. • Natural resources endowment that provides a significant socio-economic growth potential. • Contribution of space products and services to Global change challenge. • Leveraging the skills and expertise of the African Diaspora. • International partnerships for the co-development of space platforms, products and services. • Potential to share infrastructure and other capacities among various African countries. • Learning from existing indigenous satellite programmes to strength continental capacity	• Lack of a coordinated approach to international treaties and conventions. • Political will for continental level space initiatives not universally shared, amidst other pressing national socio-economic priorities. • Over reliance on financial and technical support from outside of the continent. • Political instability • A weak financial base. • A brain drain. • Competition for radio frequencies allocated to Africa that could limit the future usage of such resources. • A space programme not able to assimilate and adopt rapid technological advancements. • Lack of a focus on user needs and innovation in delivering relevant space services and products. • Limited collaboration and coordination due to an exclusive focus on National priorities. • Lack of a coordinated continental approach to multilateral space treaties and agreements.

3.2 Developing the Strengths and Addressing the Weaknesses

- Promote programmes and projects that fosters intra-continental partnerships by strengthening the existing nodes of space and in-situ capabilities; harmonising and standardising the suite of critical facilities and infrastructure; adopting appropriate data management and sharing policies to promote data access; and sharing the space experience to bolster the capacity of member states that wish to pursue national space programmes.
- Leverage Africa's strategic location to attract mega-science projects in astronomy and space physics studies that will enhance the scientific profile of the continent and support the building of critical scientific infrastructure, which will also be used to develop the cohort of skills and expertise required to service the various scientific disciplines.
- Establish human capacity development programmes that attract the young student population into a postgraduate pipeline that primarily serves the requirements of an indigenous space sector and the broader requirements for high-end skills within the changing socio-economic landscape.
- Institute an appropriate governance structure that is contextualised on an African space agenda and adequately resourced, both financially and human capacity wise, to ensure effective implementation of the African space programme, from a continental to sub-regional levels.
- Ensure a regulatory environment that is conducive to the promotion of the African space agenda, but yet is cognisant of the international obligations and responsibilities for ensuring the long-term sustainable use of outer space resources.
- Use the extensive rollout of optical fibre networks across Africa to secure broadband capacity that will be needed to operate scientific equipment and infrastructure and to ensure seamless connection that will be needed for data management and sharing.
- Pursue a common regulatory framework on the continent that will counter any limitations imposed on the African space agenda and ensure the long-term sustainable use of outer space resources.

3.3 Responding to the Opportunities and Managing the Threats

- Develop a robust public awareness campaign that targets and solicits the support of all sectors of society about the manifold benefits of space science and technology and its potential to fuel economic growth and address social challenges, especially the needs of large rural communities.
- Link the spatial market needs and the management of the natural resources in a manner that takes into account global change, and the associated responses, and ensures the sustainable long-term socio-economic development and growth of the African continent.
- Use the international partnerships and the African Diaspora to build local skills and expertise, and to support the co-development of space platforms, products and services and in so doing provide the absorptive capacity that will limit brain drain and minimise over-reliance on foreign support.
- Leverage on the existing space initiatives, space experience, national space programmes and the collective capacity of African countries to build and expand the indigenous space capabilities and state of the art infrastructure, and to minimise duplication of effort.
- Pursue a common regulatory framework on the continent that will counter any limitations imposed on the African space agenda and ensure the long-term sustainable use of outer space resources.
- Adopt a collaborative plan on the allocation and use of frequencies so as to protect and maximise the usage of those frequencies allocated for Africa and in so doing maximise the opportunities for hosting and operating key space equipment and facilities.

4 Strategic Focus

4.1 Vision

An African Space Programme that is user-focused, competitive, efficient and innovative

4.2 Goals

1. Space-derived decision-making services and products used for addressing the economic, political, social and environmental challenges on the continent.
2. An indigenous space capability, both in the private and public sectors, that defines an independent, coordinated and effective space programme.

4.3 Strategic Actions

4.3.1 Leveraging space-derived benefits

The primary marker of success in an African Space Programme is how effectively the supported space initiatives respond to the user needs and the concomitant positive impacts it brings to the quality of life of the citizens on the continent and the improvement of Africa's global economic standing. The initiatives must resonate with and respond to the needs in a way that is relevant and ensures a reasonable financial and/or social return. The initiatives must also be globally competitive in order to be positioned in the global space market, where there is a significant need in many developing countries outside of Africa for such initiatives. The space derived-benefits must transcend all spheres of governance from continental level right down to municipal level. In addition, the benefits accruing to women and the youth must be factored into the outcomes of these initiatives.

Indicators

- Number of communities of practice
- Returns on investment

4.3.2 Facilitating R&D and innovation

An enabling factor in the development of indigenous capacity and capabilities is the level of research, development and innovation within an African space sector. Given that space science and technology is still a fledgling sector on the continent, research, development and innovation must play a key part in R&D led industrial development. Hence, knowledge production (R&D) and the exploitation thereof (innovation) will be central in ensuring a financial and/or social return. Research, development and innovation initiatives will also provide opportunities for the scientific and engineering space-workforce to internalise the current intellectual capital and excel in the development of next generation technology platforms, products and services.

Indicators

- Number of services and products using African capacities
- Number of publications
- Number of patents

4.3.3 Developing the human capital

Human capital development is the bedrock of a viable and sustainable African Space Programme. The requisite skills and expertise will be harnessed through robust training and human capital development programmes. Much effort and resources will be invested in ensuring that the Pan African University for Space Science is an effective vehicle for producing the cohort of next-generation scientists and engineers. Where such critical skills and expertise are lacking on the continent, we must draw on the intellectual capital of our strategic partners and also make effective use of the African diaspora. Knowledge production and transfer will, therefore, be a strategic focus for the dissemination and diffusion of critical skills and expertise.

Indicators

- Number of students graduates
- Number of space related-research centers

4.3.4 Institutionalising good governance

The contextualisation of a centralised governance framework must be embedded on current attempts to formalise African space initiatives. The current African Space Policy provides for the governing principles to be adopted in a programme for African space initiatives, whereas this Strategy articulates the space ambitions of the African continent. These instruments must be used as a reference frame for all indigenous and developmental assistance programmes to ascertain the relevance and the fit for purpose in relation to the needs of the African continent. Failure to do so will result in a proliferation of initiatives that will ultimately contradict the developmental focus and initiatives of the African continent. It is imperative that a proposed governance framework must efficiently and effectively provide for the management of all objectives, as a collective, by ensuring the guiding policy principles are adhered to.

Indicators

- A centralised coordination office
- Number of sub-regional centers

4.3.5 Adhering to regulatory requirements

For Africa to compete effectively in the global space market, a regulatory framework that is supportive of its space activities and developmental efforts must be put in place. Such a framework must be compliant with international treaties and conventions and ensure Africa's commitment and response in preserving and maintaining the long-term sustainability of outer space resources. In addition, associated activities must promote and ensure Africa's access to space, including the assignment and use of orbital slots and the frequency spectrum, both for ground and space-based infrastructure. Such activities must include adequate representation on international multilateral bodies important for the coordination of space resources.

Indicators

- A regulatory framework that is supportive of space activities
- Participation in multilateral fora critical for the peaceful uses of outer space

4.3.6 Building critical infrastructure

The leveraging on existing facilities and strong regional and continental coordination in the development of new facilities should be regarded as a critical success factor. Despite the strong public sector driven approach, Public Private Sector Partnerships, particularly through the integration of space technology into other sectors of the economy would promote the development of the continents' space infrastructure. Hence, key success factor will be the creation of strong linkages between the space sector and other economic sectors, such as communication, agriculture, energy, transport, and peace and security. Also, regionally distributed but differentiated space infrastructure is a further critical success factor upon which regional space economies can be optimally stimulated.

Indicators

- Number of early warning systems on the continent
- Number of space mission infrastructure
- Number of space applications infrastructure

4.3.7 Fostering regional coordination

Strong regional coordination is critical for the success of space activities on the continent given the resources constraints and the need to minimise duplication. In light of the resources constraints, advantage must be taken to enhance joint technology development, knowledge sharing, technology transfer and the management of intellectual property. Duplication will be minimised through the optimal and complementary development and use of critical infrastructure. To garner public support for and participate in the formal space activities, space awareness campaigns will be increased in the region.

Indicators

- Number of joint collaborative programmes
- Number of space awareness campaigns

4.3.8 Promoting strategic partnerships

Strategic partnerships will be pursued to address inherent gaps in skills and capabilities. Where possible such gaps should be addressed through intra-continental partnership, public-private partnerships and partnering across different economic sectors. International partnerships should be encouraged to address any remaining gaps and pursue new learning opportunities through active participation in global space initiatives. All such partnerships will be underpinned by mutual benefits and participation as equal partners through research, development and innovation.

Indicators

- Number of international partnerships
- Number of public-private partnerships
- Number of institutional partnerships

4.3.9 Funding and Sustainability

It is crucial that adequate funding is committed to ensure the optimal development and long-term sustainability of space initiatives on the continent. It is critical that such funding be sourced from within the continent to allow for an independent African space agenda. Space technology is costly and it is, therefore, essential to exploit existing space resources on the continent and to build and optimise upon such resources. Monitoring and evaluation will be vital to ensure relevance and the long-term sustainability of space activities in Africa.

Indicators

- Level of long-term funding secured from the continent

5 Implementation Guidelines

5.1 Thematic Focus Areas

The thematic focus areas, namely earth observation, navigation and positioning, satellite communications, and/or space science and astronomy, provide the broad parameters within which the appropriate technology platforms and programmes, both new and current, should evolve to address the user needs. In this regard, the use of space to adequately respond to the most pressing socio-economic challenges on the continent is conveniently represented in Table 2, which identifies the primary user requirements mapped against the thematic focus areas. The various deliverables for each of the thematic focus areas are identified next.

User Needs	Earth Observation											Navigation and Positioning	Satellite Communications	Space Science and Astronomy
	Spatial Resolution								Temporal Resolution					
	< 50cm	50cm-1m	1m-2.5m	2.5m-5m	5m-10m	10m-20m	20m-30m	>30m	Daily	Seasonal	Annual			
Disasters	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Health					✓	✓				✓		✓	✓	
Energy				✓	✓	✓					✓	✓	✓	✓
Climate					✓	✓			✓			✓		✓
Water		✓	✓	✓	✓	✓	✓	✓		✓		✓		
Weather		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Ecosystems				✓	✓	✓	✓	✓		✓		✓		
Agriculture				✓	✓	✓	✓	✓	✓			✓	✓	
Biodiversity				✓	✓	✓	✓	✓			✓	✓		
Peace, Safety and Security	✓	✓	✓		✓			✓	✓			✓	✓	✓
Human Migration and Settlements		✓	✓	✓							✓	✓	✓	
Education and Human Resources				✓	✓	✓	✓	✓			✓	✓	✓	✓
Communications												✓	✓	✓
Trade and Industry			✓	✓	✓	✓	✓	✓		✓		✓	✓	
Transport		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	
Infrastructure			✓	✓	✓	✓			✓			✓	✓	

Table 2: User needs mapped against the various space thematic areas

5.1.1 Earth Observation

Specific interventions relating to Earth observation must include:

- Developing the critical mass of skills and expertise in earth observation applications and usage.
- Develop and improve earth observation institutions in Africa.
- Foster knowledge sharing among African experts, users and stakeholders.
- Develop space based and in-situ infrastructure to help in responding to the user needs and societal benefits.
- Develop Earth observation services and products using web-based and appropriate technologies in order to meet user needs.
- Foster stakeholder engagement to ensure the generation of the relevant services and products that maximises the benefits of earth observation applications.
- Raising awareness among the public, users, policy and decision makers.

5.1.2 Navigation and Positioning

Specific interventions relating to navigation and positioning must include:

- Developing the critical mass of skills and expertise in navigation and positioning applications and usage.
- Ensuring seamless integration into existing global navigation satellite services.
- Build on existing infrastructure such as ASECNA, TRIGNET and AFREF.
- Promote an African array study for seismic applications using seismic reference receivers.
- Developing an indigenous continental level navigation augmentation system.
- Developing navigation and position application products and value added services to support user requirements.

5.1.3 Satellite Communications

Specific interventions relating to satellite communications must include:

- Developing technologies for communication applications in rural and remote areas.
- Developing technologies for e-applications.
- Providing flexible extensions for the terrestrial network expansion and backup.
- Developing platforms to support disaster management.

5.1.4 Space Science and Astronomy

Specific interventions relating to space science and astronomy must include:

- Developing robust and coordinated programmes in the various disciplines of space science and astronomy, such as space physics, space geodesy, aeronomy, and optical-, gamma- and radio-astronomy.
- Instituting capacity and capability building programmes to ensure sustainable space science and astronomy initiatives.
- Developing and maintaining the appropriate infrastructure and facilities for a vibrant space science and astronomy programmes.
- To ensure value addition to Africa's economy through the spinoff development of human capital and technologies in space science and astronomy.

5.2 Functional Platforms

Functional programmes represent the means to achieving the key deliverable and are primarily embedded in the underlying technology platforms. It represents the key elements for a space mission concept, which comprise of the collection of satellites, orbits, launch vehicles, operations networks, and all other elements that make a space mission possible. Functional programmes support each of the thematic areas, which seek to organise the scientific and engineering capacities into four large clusters, where each cluster carries out specific functions, which are summarised below.

5.2.1 Mission Requirements

The mission requirements can be summarised as follows:

- Low Earth orbiting satellites with multispectral and hyper-spectral optical payloads and navigation augmentation payload systems.
- Low Earth orbiting SAR radar satellites to complement the optical satellite missions.
- A geostationary orbiting communications satellite with multiple communication transponders and a navigation augmentation payload system.
- Ground based augmentation systems that complement the space based GNSS systems.

5.2.2 Enabling Technologies

The requirements for the future satellite missions, as per the payload and subsystem technology options, are as follows:

- Developing a fully indigenous capability for the medium to high-resolution payloads and subsystems.
- Developing the SAR payload and subsystem requirements.
- Developing a geostationary communications satellite with indigenous African participation on the technology and engineering front.
- All satellite subsystems must rely on a fully indigenous capability.

5.2.3 Mission Operations

The requirements for the space mission operations are as follows:

- Assembly, integration and testing facilities and design centres to support the satellite manufacturing facilities.
- Ground segments for telemetry, tracking and command to support the satellite operations and the retrieval of data.
- Space segments, such as mission control centres, for the effective housekeeping and health of the satellite.
- Securing appropriate orbital slots for use by indigenous satellites.

5.2.4 Space Applications

In order to ensure that the services and products developed in response to the user needs are indeed relevant, the following must be enabled:

- A data sharing policy that ensures affordable and equitable access to spatial data and information.
- Timely access to the right data sets at the procurement end.
- The provision of appropriate services and products that respond to all user needs.
- Robust processing capabilities to ensure that timely access to the requisite services and products are available to the end users.
- Ensure that all tiers of governments are able to access space and ground based data through a centralised portal.
- Provision of data for education, and research and development.
- Provision of data for commercial exploitation at a minimal cost.

5.3 Supporting Programmes

Supporting programmes are crosscutting elements that are critical for the realisation of the thematic focus areas and the functional platforms. The supporting programmes comprise of the following:

1. **Human capital** – the appropriate expertise and skills necessary for an African space programme will be an area that will receive priority attention, as without this all existing and envisaged programmes and infrastructure will be of limited value.
2. **Space Awareness** -for the African space programme to be meaningful to the broader public there is a need for creating public awareness relating to the benefits that space technology and its manifold application products and services can deliver.
3. **Infrastructure**– appropriate infrastructure is the cornerstone of an effective space programme, enabling technology transfer and human capacity development initiatives.
4. **International partnerships** – strategic partnerships with foreign partners are necessary for tangible and intangible technology transfer and a viable and sustainable space programme that is underpinned by mutual benefits.

5. **Industrial participation and development** – development of the continental space industry to participate in the various functional platforms is a key requirement for the sustainability of a formal space programme.

5.3.1 Human capital development and space awareness

The following are strategic interventions for human capital development and increasing space awareness:

- Developing coordinated, sustained and targeted public awareness and outreach programmes that:
    - Use classical and contemporary communication platforms.
    - Demystify space science through popularizing space science with high quality outreach material for all audiences.
    - Create opportunities to engage and attract the best minds towards careers in space science.
    - Promote gender parity in space science.
- Supporting Space Science teaching and research at universities through:
    - Building the Pan African Space University and linking existing research and training initiatives to it.
    - Enabling bi-directional linkages between continental research efforts and national and global research programmes.
    - Instituting continental researcher and student exchange programmes.
    - Creating an enabling research and technical pipeline for graduates to be employed.
    - Enabling the development of networks and dissemination of information using modern media platforms for drawing on the expertise of African Diaspora scientists and engineers.
    - Enabling easy access to open data and processing tools to facilitate capacity development in the use and dissemination of geospatial data and information.
    - Introducing space science and astrophysics at undergraduate levels with a focus on technical and academic requirements on the continent.
- Supporting space science and astronomy teaching at primary and secondary school level through:
    - Developing and introducing basic space science and astrophysics courses aimed at science students.
    - Developing in service training programmes for space science and technology for teachers to promote the discipline at school levels.
    - Developing specialized curriculum, material and teaching aids to create awareness in space science and technology.
    - Enabling the development of a student portal for the development of virtual space science clubs, access to information, open data, processing tools and advice.
    - Draw on the deep roots of indigenous civilizations of Africa to explore synergies with space science and astrophysics.

5.3.2 Infrastructure

To this end, the following are strategic interventions for infrastructure:

- Building centers of excellence and competence within the five regions in Africa, whilst expanding and upgrading existing facilities.
- Building new and expanding existing Assembly, Integration and Testing (AIT) centers on the continent to service continental and regional needs.
- Building national and regional vicarious calibration facilities to support continental and global Earth observation efforts.

- Building national and regional data banks and high performance computing centers and/or use existing ones.
- Leveraging continental and global partnerships to build a space based industry for manufacturing space hardware and software that could serve as a center for hands-on training.
- Developing and expanding existing mission control to service the continental and regional needs.
- Developing and strengthening research and development centers so that these are accessible to researchers across the entire continent.
- Expanding existing observing infrastructure and ensuring data accessibility for research (for example, GPS receivers, magnetometers, ionosondes).
- Developing complementarities between space based and in situ based infrastructure.

5.3.4 International partnerships

Specific strategic interventions relating to international partnership include:

- Establishing a Pan African cooperation and partnership framework to enable coordination and networking for the effective implementation of continental level activities.
- Establishing cooperation agreements with governmental, intergovernmental and regional organizations and agencies focusing on the exchange of experiences and launching common programmes with the objective of reducing the space divide and technological gaps.
- Encouraging African academia to establish a partnership arrangement with international academic networks concerned with space activities.
- Establishing a framework for the development of an African space industry operating in close cooperation with the foreign space industry with the purpose of establishing synergies between them.
- Integrating the African space infrastructure and programs as a part of the global space infrastructure with a clear recognition of the African rights and access in this regard.

5.3.5 Industrial participation and development

In this regard, the strategic interventions include:

- Developing an industrial framework to unlock industrial opportunities and to enhance industrial development, strengthen manufacturing capabilities and provide support for industry and related services.
- Building an industrial base to support Africa's requirements for space technologies by ensuring maximum participation possible of the private sector in public sector space projects.
- Establishing a supportive regulatory framework to ensure compliance with regulatory provisions and applicable international obligations when competing in international space markets.
- Maximising the benefits of innovation and technology transfer into and out of the space sector thus promoting the broader industrial development on the African continent.
- Creating an enabling environment for small, micro and medium enterprises by supporting their effective participation in the development of the space industry and market.

5.4 Projected Outcomes

The projected outcomes over the next decade must ensure a long-term sustainable and viable continental space programme that always remains aligned with user requirements. In meeting user requirements, a concerted effort must be made to put in place adequate human and financial resources, strategic intercontinental and international partnerships, and appropriate technology platforms. Whilst these efforts are undertaken, the global relevance and positioning of the continental space programme must be kept in mind. The response within the implementation framework for this Strategy could be broken into immediate (1 year), intermediate (5 years) and long-term (10 years) outcomes that provide for rolling milestones, which are expressed below.

Projected 1-Year Outcomes

- Establishing the governance elements needed for a sustainable space programme, including regional centres of excellence;
- Approval and rollout of an intercontinental and international partnership plan;
- Approval and rollout of a human capital and infrastructure development plan; and
- On-going research and development, and technology programmes that will contribute to building the foundations for a continental space programme.

Projected 5-Year Outcomes

- A fully established continental space programme;
- Appropriate technology platforms in place to support the building blocks of a continental space programme;
- Advances in human capital development that supports the continental space programme;
- Strategic partnerships, both intercontinental and international, through projects that promote research and technology development; and
- Operational and on-going developments of space application services and products for the broader public good.

Projected 10-Year Outcomes

- A continental space programme that is globally positioned and ranked in the top 10;
- Independent Earth observation high-resolution satellite data available for all of Africa from a constellation of satellites designed and manufactured in Africa;
- Appropriate services and products relating to space applications;
- Resident space capacity both in terms of technology platforms and human capital;
- Spin-off enterprises emanating from space activities and programmes; and
- Strategic partnerships, both intercontinental and international, that are translated into viable space missions, applications, products and services.

6 Conclusion

[To be completed after consultation]