

DRAFT

UNESCO REPORT

ON

THE NEEDS FOR AN AFRICAN UNION/NEPAD STRATEGY FOR SATELLITE REMOTE SENSING APPLICATIONS FOR AFRICA'S SUSTAINABLE DEVELOPMENT

A Executive Summary

1. Our world today embodies the following: Major commercial fishing companies of the world have become permanent fixtures off-the shores of African coastlines with active up-welling systems. France and the United States alerted the world of the 1986 Chernobyl nuclear disaster and thus brought into motion actions that averted international catastrophe. Development and deployment of weapons of mass destruction can no longer take place in secret because, today, the means exist to keep the global community informed of such developments, including the unmasking of the nuclear detonation that took place off the coast of Southern Africa on September 22, 1979. The world's agriculturally-based commodity markets are constantly influenced by a large array of information collected globally, on a continuous basis, on key commodity indexes. Daily and long-term weather forecasts are now the rule rather than the exception. The global community had advance warning of the 1991 Mount Pinatubo volcanic eruption and adequate briefing on its post-eruption impact on global health and climate, and copious information on the devastation wrought by the Sahelian drought on the affected African population and the continent's land and water such as Lake Chad. The same is true of the annual havoc brought upon Mozambique by tropical cyclones from the Indian Ocean.

2. The fore-going are some examples of how the application of remote sensing - the science and technology of observing, collecting and analysing the data of planet Earth and its immediate environment from air and space altitudes - have enriched human knowledge of our globe and enhanced our survival therein. Today, operational Earth observation systems constitute human response to the challenge

credited to Socrates¹ and have confirmed the 1948 predictions of Fred Hoyle.² Remote sensing continues to be gainfully employed as major tool of international cooperation, as a critical component of the information economy and for sustainable developmental by most societies of the world. The latter are taking these steps because such societies have recognised that quality data collection, organization and management and the development of accurate maps and geo-spatial data are part of a nation's indispensable infrastructure, just as a network of transportation, healthcare, education, telecommunications and water supply systems are. Remote sensing can do the same for Africa and its people. However, today, because of poor data collection, organization and management practices - which cannot serve as a basis for any meaningful plan of action - the impact of remote sensing on the African landscape and its development efforts remains insignificant.

3. NEPAD, as Africa's collaborative vehicle for addressing the twin challenges of poverty eradication on the continent and Africa's effective participation in the technology-dominated economy of today and tomorrow, is in a unique position to redress the present situation. Specifically, NEPAD should develop a mechanism that would ensure Africa's effective participation in and engagement with remote sensing and its related sciences within its space science and technology programme, one of its priority S&T fields. The key elements of such a remote sensing participatory mechanism would, *inter-alia*, include,

- (i) Public Education and Policy formulation at national, sub-regional and regional levels,
- (ii) Capacity Building,
- (iii) Recognition and utilization of Africa's indigenous RS-GIS talents and capabilities, including those of the private sector,
- (iv) (iv) Investment, not only in the application opportunities provided by remote sensing, equally important is Africa's contribution to the development of technologies that are driving the information economy,

¹ Man must rise above the Earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives.

² Once a photograph of the Earth, taken from the outside is available - once the sheer isolation of the Earth becomes plain - a new idea as powerful as any in history would be let loose

- (v) (v) The coordination and integration of local, regional and international remote sensing efforts in Africa, and
- (vi) The identification of key areas of regional interest, exemplified by the Recommendations of UNISPACE III and the Millennium Development Goals, where collaboration can be assured.

4. In developing and implementing the above strategy, NEPAD would need to take cognisance of the following:

- (i) Areas of Africa's sustainable development needs where remote sensing can make a meaningful impact;
- (ii) Collaboration on on-going and future national and regional programmes on RS&GIS,
- (iii) Enhancement of Africa's research and development capabilities;
- (iv) The contributions of international remote sensing initiatives in Africa, such as those of UNESCO as well as ESA and Canada, through the TIGER Initiative;
- (v) Contributions of Africa's
 - (a) Regional Capacity Building institutions in Nairobi, Rabat and Ile-Ife in SST; and
 - (b) Capabilities and contributions of professional RS&GIS institutions (AARSE and Africa-GIS);
- (vi) Opportunities that can accrue to Africa's RS&GIS development through its contribution to and participation in the programmes of Group on Earth Observation (GEO); and
- (vii) Africa's effective participation in COPUOS.

B. Introduction

5. Africa is striving to survive in a digital world whose daily activities are almost totally dependent on space acquired and space transmitted information. And by being part of the international community, African countries are required to open their economies to the unfettered market “globalisation” rules of the World Trade Organization (WTO). But how developed and strong are the individual African economies? Can they withstand those of the industrialised countries? If Africa is to compete successfully in the global market of the future, what tools of development must its people apply? That is Africa’s challenge for the 21st century. And the strategies it adopts in the process would need to meet its developmental obligations and goals at home as well as its effective participation in the technology-dominated global economy of today and tomorrow.

6. Guiding the choice of its strategy is Africa’s realisation, today that from space altitude, we humans are using space-acquired information to improve, daily, our understanding of planet Earth and its environment, just as Socrates has predicted³ and have also discovered and are exploring the other planets in our Solar System. In the process, human knowledge of the birth and death of stars has been enriched; we have also gained some knowledge of the most distant galaxies and new theories about the origin of the Universe and life have emerged. But this is just the beginning. Africa and its people already know that human exploration of outer space has brought to a sharper focus the inter-connectedness of planet Earth and the interdependence of its inhabitants. That realization initially manifested itself in a global space race which has since metamorphosed into a global pursuit of *space enterprise*.

7. To call attention to the need for a universal effort in this and in similar human undertakings, in 1990, the United Nations South Commission published a report titled, *The Challenge to the South*. The latter, prepared under the leadership of the late **Hon. Julius Nyerere**, the late President of Tanzania, issued the following challenge to the South, and in particular to Africa, the cradle of human civilization:

³ Man must rise above the Earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives. (Socrates, about 500 BC)

Unlike the standard industrial technologies....., mastery over new sciences and technologies requires high expertise in the relevant basic sciences. Experience has shown that high technologies cannot simply be transferred; the notion that it would be possible for the South [including all of Africa] to obtain them from abroad without the development of an indigenous broad-based scientific and technological infrastructure is mistaken.

8. This report addresses what should be one of Africa's responses to these challenges, that is, its appreciation, understanding, mastery and contributions to the development and use of space technology in its development process. The justification for such an approach is that information is knowledge, and depending on its type, currency, accuracy and completeness, knowledge can result in safety, security and economic empowerment including the reduction of poverty.

9. According to former President Bill Clinton of the United States⁴,

We are in an era of unparalleled possibilities.....and the pursuit of knowledge would underpin the strength of the economy, the health of the environment and the length and quality of peoples' lives.

10. Accordingly, this report examines the many remote sensing initiatives, programmes and efforts that have been embarked upon, both internally in Africa and globally, in support of Africa's march forward and proposes a number of strategies that can advance these efforts. The corner stone of this set of strategies is NEPAD.

11. It is an axiom that Africa spent over half of the 20th Century serving the needs of the colonial masters, and the last 40 years of that same century looking for appropriate bearings that could guide its people to a promising future. Conscious of the many opportunities that could accrue to each African country through a collaborative approach, the African political leaders reorganised the Organisation of African Unity and renamed it African Union (AU). The first act of the AU was the establishment of the New Partnership for Africa's Development (NEPAD), a bold initiative that would unite Africa in collectively addressing its many common

⁴ Vanessa Houlder (1998), *America's pursuit of Knowledge*, reporting on the address of President Bill Clinton at the 1998 annual meeting of the American Association for the Advancement of Science, held in Philadelphia, PA, USA

problems while working together to foster accelerated development and sustained growth.

12. At the Meeting of Africa's Minister of Science and Technology held in Johannesburg, South Africa in November, 2003. The meeting adopted the following as the S&T goals of NEPAD [1]:

- Harness and apply science and technology to fight poverty, improve health status, achieve environmental sustainability and industrialize; and
- Contribute to global science and innovation.

13. It also identified a number of priority S&T fields⁵ that NEPAD would focus on. Amongst these are environmental sciences, geosciences, space science and technology, poor harvest technologies, desertification research, water sciences and technology, energy technologies and biodiversity – today, all these sub-set of NEPAD priorities are highly dependent on and will particularly benefit from Africa's full appreciation, understanding and use of remote sensing data in carrying out its development goals.

14. To accomplish the above, this report examines the roles of information in the development process, and identifies remote sensing as an indispensable component and tool that is critical for attaining sustainable development goals. Through a number of donor-driven initiatives, remote sensing was introduced in Africa without a corresponding appreciation, understanding and mastery of the technology at the local level. For the decision-makers who are still unsure of the roles of science and technology in the development process, going to space to look for solutions to earth-bound problems, was simply unreal. Thus the professionals and the academics worked with remote sensing in their respective countries, within the limitations of the authority and resources at their disposal. Now, the climate is changing. At the political level, African countries are now members of space-related institutions and African scientists have and are holding leadership positions in a number of these inter-governmental organisations. At recent Summit Meetings, African leaders have also unambiguously committed themselves to adopt national plans for achieving the Millennium Development Goals (MDGs) by

⁵ ICTs/Bridging the digital divide; Materials science; Biotechnology/Genomics

- Environmental sciences ; Geosciences ; Indigenous Technologies ; Laser technology
- Space science and technology ; Poor Harvest technologies; Desertification research;
- Water sciences and technology; Energy technologies;
- Biodiversity; Indigenous Knowledge and Technologies

2006, as well as achieve the Millennium Development Goals by 2015⁶. In Africa, NEPAD has agreed on a number of science and technology (S&T) priorities which include space science and technology (SST) and several development areas, where remote sensing is an indispensable tool. Thus this report proposes a number of remote sensing strategies that NEPAD can adopt and subsequently apply to achieve, in part, Africa's sustainable development goals as well as its Millennium Development Goals.

C. Role of information in the development process

15. Because the translation of any development goal, idea or vision into reality depends on accurate information, it follows that NEPAD should reinforce the following among its member States:

- The collection, analysis and use of information, particularly geo-referenced information, is a starting point on the path towards sustainable development.
- Why? Because the inability of many societies, including those in Africa, to undertake development efforts that are sustainable is rooted in poor quality data collection, organization and management - practices which cannot serve as a basis for any meaningful plan of action.
- Specifically, Africa's decision makers must recognize that maps and geo-spatial data are part of a nation's infrastructure, just as a network of transportation, healthcare, education, telecommunications and water supply systems are.
- Failure to recognise the indispensable roles and use of accurate maps in the development process has and continues to result in the wrong location of roads, housing estates and agricultural plantations - in swamps, flood plains and Earthquake zones - with their attendant casualties.
- Use of the computer and a base map has made it possible to geographically reference a large array of data, including those from Earth observation and geo-positioning satellites, and, in the process, capture, store, check, integrate, manipulate, analyse, display and deliver accurate information to

⁶ The Report of the Special GA Meeting in New York, Sept 14-16, 2005

consumers, such as programme managers, farmers, foresters, transportation authorities.

D. Remote sensing – An indispensable component of today’s information sciences

16. For the purpose of this report, remote sensing shall be defined, in part, as the observation of the Earth and its environment from air and space altitude with the aid of a variety of survey instruments, such as cameras, electronic sensors/scanners, radiometers, Charge Coupled Device (CCD)-based detectors and radar, that are mounted on board balloons, helicopters, aircraft, satellites and manned-space vehicles. From such an altitude, satellites, which serve as platforms for most of today’s remote sensing activities, are able to orbit the Earth, in a repetitive manner, and acquire, with the aid of the on-board sensors, a variety of information of a large area of the Earth’s surface during each orbit. Thus, Earth observation data can be acquired through single looks by geo-stationary satellites or in mosaics constructed from numerous individual scenes acquired by Earth orbiting satellites. Most remote sensing data consists of receiving and measuring reflected and/or emitted radiation from different features on the Earth’s surface (water, vegetation, soil, cultivated fields, roads, buildings etc.) Here on Earth, we can also use ground-based telescopes, photographic cameras, and our eyes as remote sensors to collect additional information that can complement satellite acquired data. Through this process, Earth observing systems have demonstrated the power and versatility of multi-spectral imagery for managing our planet's "health" and human utilization of its resources.

17. Space know-how and resources are affecting our daily lives here on Earth in more ways than most people realise. Examples include national and global security, communications, environmental management, food security, energy development and transmission, transportation, housing, disaster management, commerce and health-care. Through space exploration and utilisation, we are developing new technologies and finding new solutions for many problems here on Earth. Indeed, in 1961, the United Nations General Assembly, in its recognition of the oneness of our world, made more manifest by orbiting satellites, called for a study on measures to advance the state of atmospheric sciences and technology in

order to improve weather forecasting capabilities and to further the study of the basic physical processes that affect climate⁷.

E. Remote sensing information as a tool for international cooperation

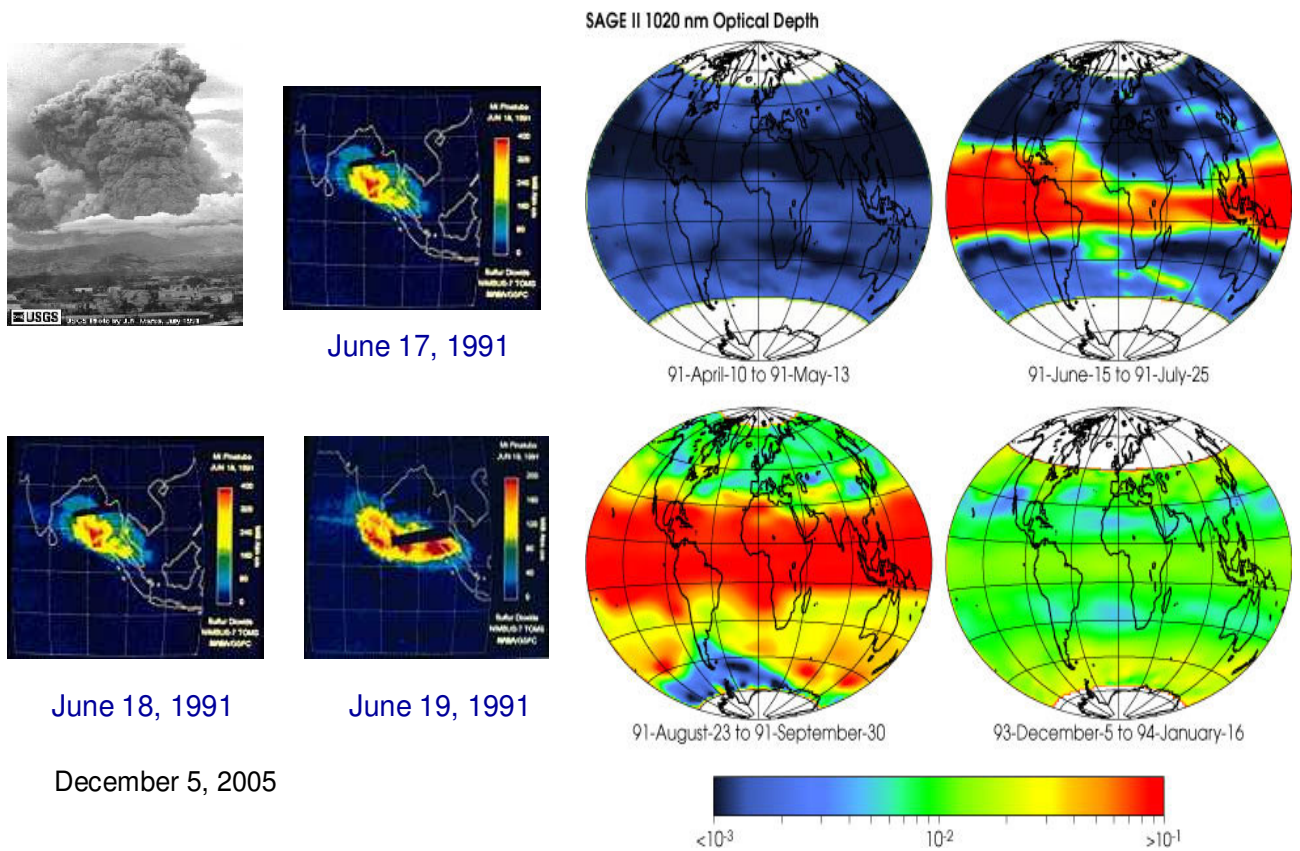
18. It is now universally accepted that our planet Earth is a unified system, and that events such as a volcanic eruption in one geographical location, such as that of Mt. Pinatubo in the Philippines in 1991, or the recurring El-Nino phenomenon, can create repercussions in other parts of the world. Remote Sensing Principles X and XI⁸ established the rules on how remote sensing technology can serve humanity as a whole, under such circumstances, by calling on the use of the technology to protect the Earth's natural environment and mankind from natural disasters.

⁷ United Nations General Assembly Resolution A/RES/1721(XVI) of December 20, 1961

⁸ *United Nations Treaties and Principles on Outer Space*, UN Doc. No. A/AC.105/572/Rev.2, United Nations, New York, 1997

Figure 1: Impact of the June 9-15, 1991 Mt. Pinatubo Volcanic Eruption on the Global Community

The Oneness of our world



19. ***Environmental applications:*** Remote Sensing Principle X provides a basis for the practical implementation of GA Resolution A/RES/1721(XVI) of December 20, 1961 which called for a study on measures to advance the state of atmospheric sciences and technology in order to improve weather forecasting capabilities and to further the study of the basic physical processes that affect climate. An example of how this has been put into practice is the agreement, by the international community, on the *1987 Montreal Protocol* on ozone destroying pollutants. Results of research on stratospheric ozone layer conducted under the auspices of the United Nations Environment Programme (UNEP) and the World

Meteorological Organization (WMO) provided the scientific guidance for formulating this Protocol and its Amendments.

20. ***Monitoring adherence to treaties and for peace keeping:*** In the last three decades, the role of surveillance satellites has been extended to include the monitoring of the adherence of signatories to treaties associated with tactical and strategic military developments. Today, onboard processing of space acquired information is possible, and a single satellite, with its high resolution and close-look capabilities can provide surveillance over a large area. Given the global political history, it should surprise no one that most parts of the world have repeatedly been subjected to such surveillance operations. These same capabilities have been used to ensure adherence to the articles of the 1963 Partial Nuclear Test Ban Treaty, the 1966 Space Treaty and the 1972 First Strategic Arms Limitations Talks (SALT I). In recent years, remote sensing has come in handily for monitoring the internal conflicts in such areas as Bosnia, Republic of Congo (Former Zaire), Rwanda, Sudan and Yugoslavia.

21. ***As an Emergency system:*** Remote Sensing Principle XI entreated member States participating in remote sensing activities to share any natural disaster processed data and analysed information in their possession that may be useful to the affected member State(s). Nuclear explosions are cases in point, and such explosions could be detected with the aid of nuclear explosion detection sensors (NUDETS). With such a sensor system, the *Vela* satellite of the United States was able to alert



Figure 2: Vela Satellite (USA)

the world of the various nuclear explosions that were taking place around the world, including the September 22, 1979 incident in South Africa, which the government of the Republic of South Africa neither confirmed nor denied⁹. Similarly, in 1986, *Spot* and *Landsat* satellites were credited for first alerting the

⁹ United Nations Document A/35/402 (1981). *South Africa's Plan and Capability in the Nuclear Field*, United Nations, New York.

whole world of and for providing significant and irrevocable information on the Chernobyl nuclear disaster in the then USSR.



Figure 3: Chernobyl Nuclear Accident, 1986 (Spot Satellite of France)

Such a system is also being employed to provide an alert operation for monitoring the cultivation of illicit drug-based plants, such as opium poppy, in different geographical regions of the world.

22. ***The Security Council:*** From the above, it is apparent that when the Security Council of the United Nations invokes an economic, political or other untoward action against a member State of the Organization, it is doing so as an *informed-decision making body* based on an array of information of which remote sensing-based information that is timely and reliable is a significant part.

F. Remote Sensing as a tool of Information Economy

23. Today, many people base their hopes for education, profit, and competitiveness in the abilities of information technologies; remote sensing is one of these technologies. Specifically, the remote sensing information market, particularly in the sales of satellite imagery alone, is expected to reach US\$2 billion in a few years. There are also the technology transfer and value-added companies, software developers, image processing work stations to be developed and built, image analysts and map makers whose contributions to the growth of the economy depends solely on what they are able to do with the imagery, i.e. translate these into useful information for the consumer, for the weather forecasting community, for settlement of flood insurance claims, for use by those responsible for guaranteeing food sufficiency in a given society, and for the millions of other end-users whose livelihood depend on such information.

24. In the next ten years, it has been predicted that the market value of commercial remote sensing and spatial information industry has the potential to

grow from US\$1 billion today to over US\$10 billion.¹⁰ Who are these consumers? We all are, particularly through many well known civil applications as analysed above, and most of which are being aided by a variety of information technologies. In the commercial market, the end-consumers of remote sensing information and related technologies are many and varied; indeed, it is impossible to identify them all, since new uses are being found, continuously, for remote sensing-based information and associated technologies. For example, Fisheries and Ocean Canada¹¹ have implemented a workstation for operational processing of *ERS* and *RADARSAT* SAR data into vessel detection information used for monitoring fishing and transportation vessel operations in the Canadian Exclusive Economic Zone. In the transportation industry, sensors developed to help a military aircraft detect and jam enemy sensors are being adapted to alert drivers of obstacles on the road, including automatic collision avoidance. In this category of emerging products is the Intelligent Vehicle Highway System (IVHS) which is being installed in some car models. Computer algorithms developed for military target (e.g. incoming missile) recognition are being applied, medically, to three dimensional imaging of moving systems, such as cell movement or embryonic development in the human body¹². This is now finding wide adaptation, particularly in early detection and diagnosis of breast cancer in women. High resolution images of the Earth, used in conjunction with GPS, are crucial to the monitoring of crop conditions (e.g. diseases, water/irrigation conditions and need for fertilizer), and have thus become an effective tool in the precision agriculture industry. Property developers are also beginning to integrate high resolution imagery into their business. For example, a property located thousands of miles/km away from the customer's location, can now be examined, through three-dimensional modelling, from the database of the realtor, locally, without incurring the expense of time and money to travel to the physical location of the property.

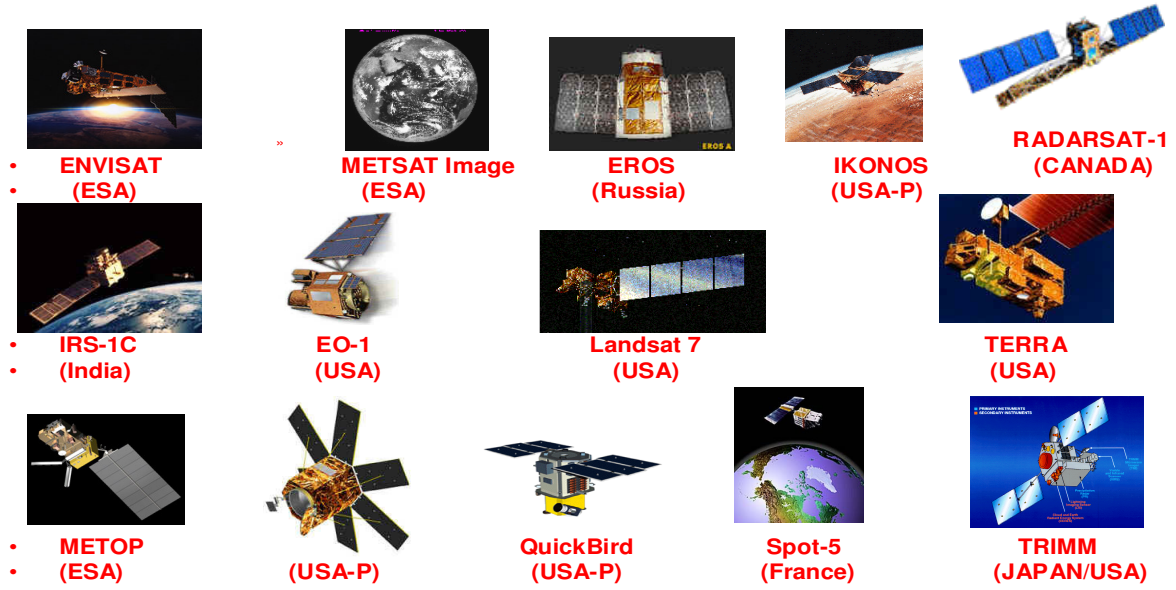
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¹⁰ <http://www.crsp.ssc.nasa.gov/CRS/WORKFORC.HTM>

¹¹ *Canadian Significant Events/Achievements*, Report to XI CEOS Plenary, Toulouse, France, November 1997

¹² Flam, Faye (1994). *Ex- defence scientists come in from the cold (in Science After the Cold War)*, Science, 263, 4 February, 1994.

Figure 4: Some of the current satellites in the service of humankind for understanding the Earth and its life support systems



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<u>Country</u>	<u>Launch Date</u>	<u>Satellite(s)</u>
Pakistan	1985-89	BADR-1
South Africa	1989-91	UoSAT-3/4/5
Rep.Korea	1990-94	KITSat-1/2
Portugal	1993-94	PoSAT-1
Chile	1995-97	FASat-Alfa/Bravo
Thailand	1995-98	TMSAT-1
Singapore	1995-99	Merlion payload
Malaysia	1996-98	TiungSAT-1
China	1998-99	Tsinghua-1
Brazil/China	1999-2003	CBERS-1&-2
Algeria	2003	ALSAT
Nigeria	2003	NigeriaSat-1

Table 1: Additional sources of satellite-derived data for sustainable development

25. Figure 4 above shows the operational Earth observing satellites of the major space fairing nations of the world. Table 1 is a list of those countries who, at one time, belonged to the category of states being sensed by the remote sensing tools of member States with satellites depicted in Figure 1, but have now developed/acquired their own tools of membership as sensing states.

[Footnote - Government of France, by the Centre National d'Etude Spaciales (CNES) in August- September 1973.]

History of EOS Development (1)

Generations of Earth Observation Satellites					
\	Name of Satellite	Sensor Type	Spatial Resolution	Other Characteristics	
1 st Generation 1960 -1962	Corona, Argon, Lanyard	KH- Camera	140 metres	1. Less systematic; 2. Basically aerial photogrammetry; 3. 556x556 km Swath	P
2 nd Generation 1972 -1986	Landsat-1, July 23, 1972	Multi- spectral Scanner	80 metres (4 bands);	1. Synoptic; 2. Repetitive (18 days); 2. 185 km Swath	
	Landsats-3 &-4	Multi- spectral Scanner	Added 30 metre res. of 7 TM spec. bands		4

History of EOS Development (2)

Generations of Earth Observation Satellites				
	Name of Satellite(s)	Sensor Type	Spatial Resolution	Other Characteristics
2 nd (Contd.) Generation 1972 -1986	SPOT-1	Multi-spectral Scanner & 2 HRV Sensors	30 m. in 3 spec. bands and 10 m HRV panchromatic	
3 rd Generation Early 1990s	ERS -1 & JERS -1	Synthetic Aperture Radar	30 metre	Active Microwave L-Band Added (JERS-1)

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History of EOS Development (3)

Generations of Earth Observation Satellites				
	Name of Satellite(s)	Sensor Type	Spatial Resolution	Other Characteristics
4 th Generation (1997-2010)	IKONOS, Quick Bird etc., etc.	Hyper-spectral (0.4 to 2.5 micron)	0.6 to 3 metres	<ol style="list-style-type: none"> 1. 4 to 40 km Swath; 2. 1 to 3 day revisit
<p>Owners would include: Argentina, Brazil, Canada, China, France, India, Israel, Japan, Korea (South), Portugal, Russia, South Africa, Ukraine and USA</p>				

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Table 2 -1, -2, & -3 above show the history of Earth Observation Satellites' Development:

G. FUTURE Intelligent Systems

26. The characteristics of future Earth observation systems, now referred to as future intelligent systems, will include the following:

- 🌐 Until now, space system design ignores user requirements, focusing instead on defining and specifying the satellite systems, resulting in placing numerous scientific instruments on relatively large and expensive space platforms. In the future, the principle of design for intelligent satellite systems would dictate that users and their needs form the starting point. This is because more and more users want providers to deliver the value-added content they need, without having to be concerned about the technical complexities of image processing requirements presented by users above.
- 🌐 Accordingly, the next generation of satellites will be ones of dedicated intelligent systems, configured for dynamic and comprehensive on-board integration of sensors, data processors and communication systems;
- 🌐 Because users' demands in the GIS, mapping, natural resources, environmental science, Earth monitoring, and applications communities have migrated from basic imagery to temporal, site specific, update mapping products and image-derived information, satellites of the future will enable simultaneous, global measurement and timely analysis of the Earth's environment for real-time, mobile, professional and common users;
- 🌐 Data and information revisions will be requested more frequently; that is, in many ways analogous to today's weather updates. In addition, common consumers will be less concerned with the technical complexities of image processing, requiring imagery providers to use different strategies to provide users directly with value-added images (e.g., ortho-rectification, feature enhancement, radiometric intensification, etc.) and value-added products (e.g., ortho-image mosaics) in order to meet real-time, mobile needs.
- 🌐 The design of future intelligent systems will use multi-layered satellite web with high-speed data communication (cross-link, up-link, and down-link), and multiple satellites with on-board data processing capability.





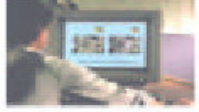
Various Users		Illustration
Mobile user	A real-time user, e.g., a mobile GIS user, requires a real-time downlink for geo-referenced satellite imagery with a portable receiver, small antenna and laptop computer.	
Real-time user	A mobile user, e.g., a search-and-rescue pilot, requires a real-time downlink for geo-referenced panchromatic or multispectral imagery in a helicopter.	
Lay user	A lay user, e.g., a farmer, requires geo-referenced, multispectral imagery at a frequency of 1-3 days for investigation of his harvest.	
Professional user	A professional user, e.g., a mineralogist, requires hyperspectral imagery for distinguishing different minerals.	
Professional user	A topographic cartographer, e.g., a photogrammetrist, requires panchromatic images for stereo mapping.	

Figure 5: Future Intelligent Systems

27. Justifications for Africa’s effective participation in and contributions to remote sensing and other space related technologies:

- (i) The aforementioned array of Earth observation satellite systems are providing copious environmental and natural resources information for the benefit of the global community. The need for Africa’s participation in the application of such information for the social and economic development and upliftment of its people resulted in Resolution 280(XII) of February 1975 by ECA’s Council of Ministers. This resolution also resulted in the

establishment of the regional remote sensing centres in Africa¹³, including those in Nairobi, (Kenya), Ouagadougou (Burkina Faso) and Ile-Ife (Nigeria)

- (ii) For a long time to come, space borne sensor systems may be the main source of reliable data on the environment and natural resources of many African countries. The availability of such data sets can assist these countries to better understand and safeguard their environment as well as ensure a more efficient management and productive harnessing of their natural resources.
- (iii) In a 1990 report of the World Bank on Africa¹⁴, a report that is still current in 2005, given the prevailing conditions, the World Bank concluded that:

If Africa is to benefit from advances in information systems and other sciences and technologies, including remote sensing and its environmental application potentials, it must improve its science and technology training and aim at the highest standards for at least a minimum core of specialists.

The report further noted that foreign aid should go towards building excellence and relevance in science and technology and helping to link (*African*) institutions to others outside the continent. Such institutions, the report concluded, should match science and technology with economic and social development by establishing effective relationship between teaching, research and delivery of services.

- (iv) Globally, and on each passing day, the inter-relationships between the state of the Earth's atmosphere and the welfare of humankind here on Earth is causing grave concern. Global warming is now a fact of life as a result of both nature's and human contributions of greenhouses gases to the Earth's atmosphere. Sea-level rise as a result of the melting of ice-caps is resulting in beach and coastal erosion globally, and air pollution is creating a variety of health-hazards. African countries now belong to COPUOS, WMO, FAO, UNESCO (IOC) and GEOSS without a requisite knowledge of the science and technology that shape the activities of these entities including the evolution of the space-related legal treaties that

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govern human activities in outer space and to which most of them have committed themselves.

H. Areas of immediate needs of remote sensing in Africa

28. An examination of NEPAD S&T priority areas shows that remote sensing can significantly aid NEPAD's activities in the following fields:

Water and Sanitation Agriculture Energy Environment; and Disaster Mitigation

(See Agriculture: [Comprehensive Africa Agriculture Development Programme](http://www.nepad.org/2005/files/documents/caadp.pdf) lien

<http://www.nepad.org/2005/files/documents/caadp.pdf>

Transport : lien <http://www.nepad.org/2005/files/documents/31.pdf>

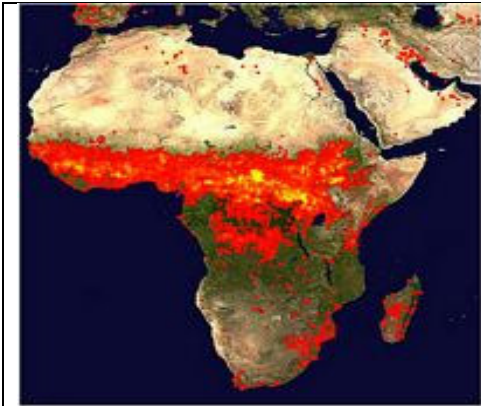
Energie : lien : <http://www.nepad.org/2005/files/documents/28.pdf>

Water : lien <http://www.nepad.org/2005/files/documents/29.pdf>

All infrastructures : lien

<http://www.nepad.org/2005/files/documents/27.pdf>

29. Figure 6 below reflects the practical applications of Earth observation systems for sustainable development in Africa. **(Elaborate as shown below)**

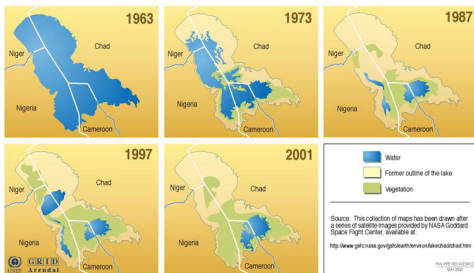


Details to be added



Details to be added

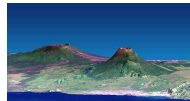
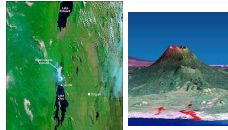
The Disappearance of Lake Chad in Africa



Details to be added

Applications of satellite data
(Examples of other types of applications)

Charter on Space and Major Disasters
(Landsat-7, Terra and Space Shuttle)
Goma Volcanic Eruption, January and July, 2002



Details to be added

Figure 6. Africa observed from space by satellites

I. Introduction of remote sensing in Africa

30. Given the implications of the developments demonstrated in Figure 1 above, Sierra-Leone, went into action, on behalf of Africa. As a member of the United Nations Committee on the Peaceful uses of outer Space (COPUOS) Sierra-Leone became the voice of Africa and the developing world, at the First United Nations Conference on the Exploration and Peaceful Uses of Outer Space, held in 1968 in Vienna, Austria. On that occasion, Sierra-Leone spearheaded the drive that subsequently resulted, in 1971, in the creation, by the United Nations General Assembly (UN-GA), of what is known today as the United Nations Programme on Space Applications (UN-PSA) in the Office for Outer Space Affairs (OOSA) in Vienna, Austria. This programme was established upon the recommendation of that 1968 conference to assist member States, particularly the developing countries, to further their knowledge, participation, experience, and application opportunities in space science and technology. The first major training course organized by the United Nations, under the auspices of the Programme, was attended by several African scientists and engineers. It focused on remote sensing technology and its related applications in human activities, and was hosted in Tarbes, France, on behalf of the

31. The aforementioned effort of the United Nations was immediately followed by a whirlwind of national activities - training courses, workshops and conferences - in a number of African countries between 1974 and 1979, albeit virtually all of them were donor driven by the United States, France and by the United Nations system (the United Nations Office for Outer Space Affairs, FAO and WMO). The limited level of knowledge and understanding of remote sensing as well as its unappreciated value and implications, particularly at the leadership level, did not provide an enabling environment, at that time, for a firm rooting for the technology in Africa. Indeed, the pre-occupation of most of the African countries was totally different. **As in other areas of science and technology, sub-Saharan Africa's participation in remote sensing began and still remains a technology transfer effort with 95 percent of the effort focusing on what the technology can do without a parallel/corresponding devotion to an understanding of why and how the technology works the way it does.**

32. At the regional level, a donor driven effort, with the support of the Economic Commission for Africa (ECA), to establish two Earth observation ground receiving stations in Ouagadougou and Kinshasa and five sub-regional remote sensing training centres in Upper Volta (now known as Burkina Faso), Egypt, Kenya, Nigeria and Zaire (now known as Congo), between 1975 and 1979, subsequently

resulted in the establishment of only two sub-regional training centres in Ile-Ife, Nigeria and Nairobi, Kenya. Today, these two ECA-Affiliated centres, the WMO-Affiliated African Centre of Meteorological Applications for Development (ACMAD) in Niamey, and the United Nations -Affiliated Regional Centres for Space Science and Technology Education in Rabat and Ile-Ife shoulder the bulk of capacity building in Earth observation sciences, particularly in sub-Saharan Africa. **(Add the roles of the non-governmental organisations, specifically, AARSE and Africa-GIS JUSTIN)**

33. Table 3 below shows the latest programmes of the inter-governmental organisations in the field of remote sensing and satellite meteorology on the continent. Unlike the earlier efforts, many of the programmes shown in this table have been developed through consultation and input by the beneficiaries, they are long-range in approach and most of them are tied to Africa's regional/national institutions. The main limitation of these programmes is funding, since all of them, without exception, receive the bulk of their financial support either from donors, from their respective host country or a combination of both. In addition, in support of Africa's sustainable development efforts, both the European Space Agency (ESA) and Canada, through its Canadian Space Agency (CSA) have embarked on the use of data of the continent acquired by their respective space craft, such as Envisat and Radarsat, to contribute to integrated water resource management in the continent. This effort, known as the TIGER initiative, aims at assessing the role of new technologies, such as space-based information technologies, in the understanding of the African water sector, its problems and its potentials. At this juncture, it is pertinent to have a closer look at one or two of these programmes, and the benefits that are accruing to Africa and its people through their implementation. **(Three of these programmes, Nos 1,6&7, and the activities of AARSE and Africa-GIS will be further elaborated upon to show elements of capacity building in and related applications of remote sensing technology in Africa and which should be tied to NEPAD's programmes).**

Table 3. Some of the contributions of United Nations Organisation to Earth observation programmes in Africa

	Organization	Projects/Programmes/Activities
1.	Economic Commission for Africa (ECA)	<ul style="list-style-type: none"> • African Information Society Initiative • Establishment of two RS regional training and user-assistance centres at Ile-Ife and Nairobi
2.	World Meteorological Organisation (WMO)	<ul style="list-style-type: none"> • African Centre of Meteorological Applications for Development (ACMAD)
3.	Food and Agricultural Organisation of the United Nations (FAO)	<ul style="list-style-type: none"> • Food security and early warning project • AFRICOVER Project – for the establishment of land-cover maps
4.	World Health Organisation (WHO)	<ul style="list-style-type: none"> • Health information systems
5.	UNEP	<ul style="list-style-type: none"> • GRID Programme
6.	UNEP, UNIDO and UNDP	<ul style="list-style-type: none"> • Assessment of the Gulf of Guinea Large Marine Ecosystem on the Atlantic coast of West Africa with Benin, Cameroon, Côte d’Ivoire, Ghana and Nigeria as beneficiaries. The objectives of the project include assessment and mitigation of ecosystem pollution, protection of human health, redressing loss of bio-diversity, and capacity-building for marine resource and environmental management.
7.	UNESCO	<ul style="list-style-type: none"> • GOOS-AFRICA (IOC) <p>Cross-cutting project in remote sensing</p>
8.	United Nations Office for Outer Space Affairs (UN-OOSA)	<ul style="list-style-type: none"> • Establishment of Regional Centres for Space Science and Technology Education in both Morocco (French) and Nigeria (English)

J. Africa's readiness, at the political and professional level, to embrace remote sensing in its development agenda

34. COPUOS with African membership - 15

African membership of CEOS

1992 Rio Conference and its focus

UNISPACE-82 and 1999 UNISPACE III

The Montreal and Kyoto Protocols

The Millenium Summit and the Millenium Development Goals

The 2002 World Summit on Sustainable Development

The 2005 WORLD SUMMIT - HIGH-LEVEL PLENARY MEETING

35. African membership of GEOSS - 14

Established national remote sensing centres – many

With Earth observation satellites in Orbit – Three countries, with one under development

Membership of WMO - Weather and climate

Indigenous private RS-GIS establishments – very few

NEPAD S&T priority areas

K. Mechanisms for full engagement of remote sensing in sustainable development in Africa.

Elaborate how each of the elements shown below will enhance **NEPAD priority S&T goals, particularly agriculture, water, environment and energy.**

- **Public education on the role of information, including remote sensing, in the development process**

36. Because most policies have environmental implications, it is only appropriate that the public in general, and the policy and decision makers in particular, should have a fundamental understanding of the relationship between the atmosphere, human survival as dictated by its interactions with the atmosphere and the ecological systems that provide the food and fibre that sustain life. After almost 50 years of mankind's first successful venture into outer space, Africa is obligated to develop the necessary knowledge and appreciation of how outer space and the natural processes taking place therein, including the contributions of mankind to these processes, affect the well-being and the future of Africa and its people. This would require appropriate education at all levels.

- Introduction of information sciences, particularly geography, Earth observation sciences, and computer science in all levels of education at each national level;
- Atmospheric science as an educational discipline (see COSPAR's paper of July 1988)
- Knowledge generation in computer sciences, including the development and utilisation of relevant soft- and hardware systems (See Zurich Paper);
- Capacity building in the acquisition, processing and analysis of Earth observation data and their subsequent utilisation in the development process;

Human capacity building

Africa's requirements: Today, the understanding of the array of remote sensing data by the user community is also inadequate. Specifically, there is a major knowledge gap between the providers of raw remote sensing data and that of the user community, particularly those interested in the new high level information. In order for the segment of the information economy being driven by remote sensing to remain buoyant, an urgent and greater priority must be devoted to the development and transmission of the knowledge and skills needed to address the myriad of application requests for remote sensing information by the growing user-community. A number of efforts are being undertaken, globally, to address these issues as well as develop the needed capacities.

In this digital and space age, Africa's engagement with any component of space science and technology, including remote sensing, demands a thorough assimilation and understanding of computer science and its related technologies to be preceded by a full inculcation of mathematics in all tiers of African educational systems. Mathematics is a unifying field on which all other disciplines and human transactions depend. It is a prerequisite in the education of scientists and engineers, it is indispensable in government business and it is the cornerstone of all commercial and industrial operations. Simply stated, without mathematics, no society can advance. Above all, mathematics makes learning, through fundamental research and definitive scholarship across a wide range of fields, possible.

In addition to embracing the above challenges and those of the South Commission¹⁵, most African governments would need to implement the advice of the World Bank's Advisory Committee¹⁶ on its review of "Program on Environment Information Systems in Sub-Saharan Africa" which noted that :

Indeed, most cooperation programs are geared to short training sessions to fill short term objectives.."

On education and training, the Committee also noted that:

If a country is to have an effective environment information system. It must have policy makers and administrators capable of appreciating the applications and implications of the information, and scientists, engineers technicians and teachers capable of developing, adapting, applying and teaching the technology. Both education and training are required to build up these skills.

In its 1990 report on the Remote Sensing of the Sahelian Environment, the Commission of the European Communities (CEC) shared the views of the World Bank's Advisory Committee as reflected above, and noted that:

Conventional approaches to technology transfer, such as training courses and short-term, in-country demonstration projects are useful educational tools, but on their own, they will not result in effective and permanent integration of remotely sensed techniques into operational programmes: In identifying the several steps needed to arrive at practical applications of remote sensing for environmental monitoring and natural resources management, the CEC report opined that :

- (i) Research and development are needed to integrate remote sensing techniques into resource management systems; and that*
- (ii) Research and development of remote sensing data processing, analysis and interpretation provide the scientific basis for application of the techniques*

¹⁵

¹⁶

United States: In the United States, the Commercial Remote Sensing Program (CRSP) of NASA's John C. Stennis Space Center is focusing on identifying and responding to the needs of the *spatial information industry*. After analysing the remote sensing landscape including the many high resolution satellites to be launched now and in the future, the Center established a Commercial Remote Sensing (CRS) Workforce 2005¹⁷. The main goal of this programme is to stimulate the growth of a workforce to populate the remote sensing industry. The CRS Workforce 2005 will transfer industry requirements and needs to an educational/training environment. The educators in this environment will then design the programmes and products that meet the knowledge and skills specification being sought by employers. In order to prevent over- or under production, the industry itself has the responsibility to define the anticipated types and number of jobs, training specifications and levels of education ranging from community college and/or vocational technical schools to graduate and Ph.D. level positions that will be needed to manage future advances in the technology. This approach develops a working partnership between the remote sensing industry and the academic community.

United Nations: At the United Nations, it has been recognized for a long time that a level of knowledge and expertise higher than what exists today is needed by educators and research and application scientists, particularly in the developing countries of Africa, Asia, Latin America and the Caribbean and the Middle-East. Such a level of knowledge would enable them to significantly contribute to the solutions of global, regional and national environmental problems and become active partners in these global ventures. Specifically, educators and scientists from these communities should participate in the definition of remote sensing instruments, and in the investigation of the weaknesses and difficulties in current and future instrument designs including the definition of techniques for their improvement¹⁸. They should contribute to the development of calibration techniques for Earth-observation data including the development of software for image assessment, the establishment of assessment criteria and for the definition of calibration strategies with the aid of calibration targets and targets of opportunity. They should also contribute to the evaluation of Earth-observation data and to the assessment of their value in various Earth science disciplines. These capabilities

¹⁷ CRS WORKFORCE 2005, <http://www.crsp.ssc.nasa.gov/CRS/WORKFORC.HTM>

¹⁸ Abiodun, Adigun Ade (1993). *An international remote sensing system: A possibility*, *SPACE POLICY*, August 1993, pp 179-184, Butterworths, London, UK

can only be acquired through long-term intensive education, and related knowledge and skill development^{19, 20}.

The recognition by the United Nations General Assembly (GA), of the paramount need to develop the aforementioned indigenous capacity resulted in its resolution 45/72 of 11 December 1990, which endorsed the recommendation of its Committee on the Peaceful Uses of Outer Space (COPUOS) that: *the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing institutions in the developing countries.* The host countries for the Centres are: India (Asia and the Pacific - established), Brazil and Mexico (Latin America and the Caribbean), Morocco-Franco phone countries and Nigeria-Anglophone countries (Africa). Seven central, eastern and south-eastern European countries (Bulgaria, Greece, Hungary, Poland, Romania, Slovak Republic and Turkey) plan to establish a similar Centre that will operate in a network mode. These centres have been established under the auspices of the United Nations Space Applications Programme (UN-SAP), Office for Outer Space Affairs, United Nations, Vienna AUSTRIA.

The goals of these centres are to stimulate scientific cooperation among the member States of each region as well as build-up, in each participating country:

- A capacity that would enable each country to enhance its scientific and technical knowledge and experience particularly in those applications areas (air/land/water) that have the potential for a greater impact on each country's economic and social development including preservation of its environment;
- A capacity to utilize data from Earth observation systems for weather prediction and monitoring of hurricanes and other natural phenomena so that they could undertake appropriate disaster management and mitigation programmes;
- A capacity that would strengthen institutions of higher learning and national and regional institutions and will subsequently enable each country to support research and developmental efforts in its national institutions,

¹⁹ Abiodun, Adigun Ade (1993). *Centres for space science and technology education: A United Nations initiative*, INT. J. REMOTE SENSING, VOL. 14, No. 9, pp 1651-1658, Taylor & Francis Ltd

²⁰ Abiodun, Adigun Ade (1997). *SPACE EDUCATION, Advances in Space Research (COSPAR)*, Vol. 20, No. 7, pp. 1341-1349, Elsevier Sciences Ltd

especially those dealing with the understanding and application of environmental information systems;

- A capacity to develop an environmental and an atmospheric sciences curriculum that can easily be taught and demonstrated at the high school and university levels in each country and to prepare effectively the educators to teach classes and undertake research and applications programmes in these disciplines on their return to their institutions; and
- A capacity to participate in regional and international programmes such as the International Geosphere-Biosphere Programme (IGBP) and Mission to Planet Earth (MTPE), and to contribute to the understanding and support of international actions on such issues as global warming and climate change, ozone layer depletion, global deforestation, land degradation and management of the coastal marine environment.
 - Application of remote sensing in addressing Africa's needs through established national, sub-regional and regional networks and programmes. Amongst the tools to be employed are the establishment and operation of viable space-based communication networks among appropriate tertiary institutions and regional application centres;

Knowledge creation and knowledge sharing through NEPAD: It should be noted that the 1986 Remote Sensing Principles were based on the prevailing state of knowledge and expected developments in civil Earth observation from space. At that time, the prevailing spatial resolution for *Landsats* 1, 2 and 3 was 80-metre pixel. Declassification of military technologies was neither a factor in the formulation of RSP nor in the operation of earlier civil remote sensing satellites. *Landsat-1* satellite, which was launched in July 1972, and was the first in this series, set the stage for civil remote sensing information acquisition. At that time also, commercialisation of remote sensing was also not an issue. But contributing to the challenges and opportunities Africa faces today are that remote sensing has been fully commercialised and remote sensing sensor systems are in the hyper-band categories WITH VERY HIGH RESOLUTION.

Among the key S&T fields of NEPAD are biotechnology, energy technologies, materials science, space science and technologies and laser technology, fields that can be classified as belonging to frontline research that would contribute to knowledge creation, innovation, and subsequently result in technology development and associated economic spin-off benefits and assist Africa in meeting the aforementioned challenges. Several African countries have also accepted the challenge contained in *The Challenge to the South* and are already engaging their experts and are investing their funds, albeit, in a limited manner, in some of these disciplines; among these are Algeria, Egypt, Ghana, Kenya, Mauritius, Morocco, Namibia, Niger, Nigeria, Senegal, South Africa and Tunisia. NEPAD also proposed, in July 2004, the establishment of Centres of Excellence as a vehicle to link all these national efforts in the interest of the overall development of the continent. Of key interest to remote sensing development in Africa is also the establishment of the African Institute of Space Science (AISS)²¹ under NEPAD.

In order to accomplish their respective missions and share the knowledge so developed, through networking as envisaged by NEPAD, these Centres of Excellence would need a very capable and functional ICT infrastructure. It is heartening to note that the void created by the non-implementation of Africa ONE by AT&T has been mostly filled by the submarine cable known as South Atlantic Telecommunications Cable No.3 / West African Submarine Cable / South Africa-Far East Cable System, also known as SAT-3 / WASC / SAFE or SAT 3 for short. SAT 3 is owned by a number of incumbent national communication operators in the continent.

The above, notwithstanding, each African country would need to invest, internally, in broadband communication technology in order to be part of e-commerce and e-research of today and tomorrow. It is encouraging to note that a number of African countries have initiated modest steps in installing optical fibre cables to link their countries with SAT 3. But much effort in this field is critical to ensure that an effective network can be established among Africa's universities and research and development institutions, banks and other establishments of commerce and industry.

²¹ *NEPAD Boosts Science And Technology - Sets Up Centres of Excellence* by Remmy Nweke in Daily Champion Newspaper, Lagos, Nigeria, July 20, 2004

Information Exchange among Africa's professionals: It was the absence of such a communication infrastructure as described above that led African professionals to call for an urgent action that could improve the existing state of information exchange within Africa, at the United Nations Regional Conference on Space Technology for Sustainable Development in Africa, held in Dakar, Senegal in October 1993. The call subsequently led to the development of a space-based information network project known as COPINE²² which was designed to address immediately, the collection, transmission, distribution and exchange of information among a number of African and European universities in such areas as health-care, education, science and technology, agriculture, the management of natural resources, the environment and natural disasters. The System proposed for COPINE included the following capabilities:

- ***High-speed data file transfer*** for the near-real-time transfer of larger files,
- ***High Resolution Graphics*** transmissions for tele-engineering and full Internet access,
- ***Full text transmission*** of documents including illustrations,
- ***Audio transmission*** for audio conferencing and in the context of tele-education,
- ***Image transmission*** supporting distance learning, near-real-time transfer of images, and
- ***Video transmission*** for video conferencing in the context of expert group deliberations.

The original backers of COPINE included ten European countries²³ and UNDP²⁴. In addition to internally generated funds in Africa, and other sources of

²² <http://www.oosa.unvienna.org/> - The United Nations Office for Outer Space Affairs, Vienna, Austria has more detailed information on the COPINE Project.

²³ Finland, France, Germany, Ireland, Italy, The Netherlands, Spain, Sweden, Switzerland and The United Kingdom

²⁴ In his letter of 25 January 1994 to the United Nations Expert on Space Applications, UN Office for Outer Space Affairs (OOSA), the Director of the UNDP Special Unit for TCDC acknowledged receipt of the Report of the aforementioned Conference in Dakar and indicated possible cooperation with OOSA on the COPINE project as follows: "...We have reviewed the report and the activities that have taken place in this important area in Africa. In regards to your specific request for possible area of collaboration with the Special Unit for TCDC, we note with interest the recommendation for the various parties in space technology for sustainable development in Africa. *I am happy to indicate that one area of cooperation is identified under Continent-wide Linkages (point 6) 'the urgent need to establish an efficient communication network/linkage among African professionals and scientists at national and sub-regional/continental levels'. As you may know, an area of concentration of the Special Unit is to encourage networking among countries as a way to facilitate exchange of ideas, data and experiences which seems to coincide with the objectives of that recommendation. We look forward, therefore, at the appropriate stage, in the process to consider a request for cooperation in the area of networking among scientific and professional communities.*"

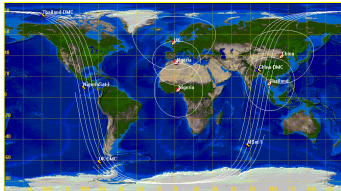
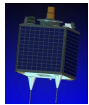
funds that may be available to NEPAD from the industrialised countries, the Africa Union (AU) should also request:

- The European Union (EU)²⁵ in cooperation with the UNDP to fund high-speed (broad-band) Internet connections, (similar to the ALICE Project in Latin America) that will allow African scientists and engineers to network among themselves in Africa and with European-based scientists. Through such a process, a time will come for the establishment of genuine scientific cooperation between Africa and Europe as is currently the case with the EU-ASEAN S&T Cooperation;

9. Africa's resource management constellation satellites

Disaster Monitoring Constellation – (DMC)
with Algeria and Nigeria as Partners

Aisat-1 (Algeria), NigeriaSat-1



Sunsat-1 (Republic of South Africa)

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10. The utilisation of Africa's human rich resources and the active participation of Africa's indigenous private sector

²⁵ See Footnote 29. The EU is also currently funding, to the tune of € 12.5 million, the ALICE Project (America Latina Interconectada Con Europa), set up in 2001, to provide high-speed connection to the pan-European research network (GEANT) for Latin American educational and research institutions for effective research collaboration *Europe boosts Latin America's high-speed research net* Luisa Massarani 13 June 2003, SciDev.Net, London, UK.

11. Conclusion