Space Policy 28 (2012) 283–290

Contents lists available at SciVerse ScienceDirect

Space Policy

journal homepage: www.elsevier.com/locate/spacepol

Trends in the global space arena – Impact on Africa and Africa's response☆

Adigun Ade Abiodun [1]

539 Rockland Street, Westbury, NY 11590-3407, USA

ARTICLE INFO

Article history:
Received 23 February 2012
Received in revised form
23 July 2012
Accepted 26 July 2012
Available online 12 October 2012

ABSTRACT

Since the establishment of the United Nations Committee on the Peaceful Exploration and Uses of Outer Space (COPUOS) in 1959, many actions that affect the advancement of the space frontier have been taken, within and outside COPUOS, in the interest of the global community, but without much input from Africa. Yet a number of African countries have joined those with assets in space, albeit without the necessary infrastructure on the ground. These actions vary in scope, in importance and in participation; however, they affect us all. Examples include the legal instruments that are in operation today for the exploration and peaceful uses of outer space, sustainability of the outer space environment and the Global Exploration Strategy– Framework for Coordination (GES–FC), conceived by 14 spacefaring nations; this laid out the details needed for an active global space exploration programme. This paper reflects on existing space-related regional cooperation arrangements at the inter-governmental level, including the African Leadership Conference on Space Science and Technology for Sustainable Development (ALC). Noting that, despite UN General Assembly endorsement of the need for developing countries to have access to the International Space Station (ISS), almost all in Africa have not, it asks what Africa might gain from such an experience. The paper concludes with an examination of where and why Africa needs to focus its immediate space-related efforts – on the ground here on Earth or in outer space?

1. Introduction

Today there are numerous on-going activities within the global space arena. They range from national and regional initiatives to bilateral and multilateral programmes in specific areas that impact the welfare of all. In Africa, the focus is on the application opportunities that are inherent in such space efforts. This is probably understandable, given the overall state of development in the continent. Nevertheless, Africa should invest in scientific research, just as Brasil and South Korea are doing, in order to establish a sound platform that can advance its development agenda. Five of the key space-steps the global community has taken are: regional cooperation, microsatellites, sustainability of the outer space environment, human space flight, and participation in the space enterprise. This paper highlights these five areas and reflects, in each case, on the individual impact these steps have had on Africa, including Africa's response. Such a response should inspire Africa's citizens to be the initiators and developers of the tools and assets that can fulfil its space aspirations as well as power its economy and related developments.

2. Regional cooperation

At the dawn of the 21st century, it became apparent that the global community has fully embraced the concept of cooperation, at both the regional and international levels, in the exploration and peaceful uses of outer space. Proof includes the establishment and productive activities of such regional organisations as the European Space Agency (ESA), the Asia-Pacific Regional Space Agency Forum (APRSAF) and the Space Conference of the Americas. To enable developing countries to be partners in the exploration and use of outer space, the United Nations, through its Space Applications Programme, has established Regional Centres for Space Science and Technology Education in Africa, Asia, Latin America and Middle East.

For Africa, November 1996 is a good reference point. It was an active month for regional and international cooperation on space-related activities. In the first two weeks of that month, four different conferences, each of which focused on different aspects of space science and technology, took place across the globe. These

☆ This is a modified version of the paper invited for presentation, under the same title, at the Fourth African Leadership Conference on Space Science and Technology for Sustainable Development (ALC 2011), Mombasa, Kenya, September 26–28, 2011.

E-mail address: aaabiodun@optonline.net.

[1] The author retired from the services of the United Nations in 1999 as the United Nations Expert on Space Applications. Thereafter, he served as Chairman of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), from 2004 to 2006. He is Adviser to the Nigerian Delegation to COPUOS and he is the Founder of the African Space Foundation. The views expressed in this paper are strictly those of the author.

0265-9646/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.spacepol.2012.09.001

included the Second United Nations Conference on Space Science and Technology for Sustainable Development, held in Pretoria; the Third Space Conference of the Americas, Uruguay; The Third Asia-Pacific Satellite Communications Council (APSCC) in Seoul; and the 10th Plenary Meeting of the Committee on Earth Observation (CEOS), Canberra. All these assemblies were sponsored by both member states and entities within the private sector in each of these regions, except the one held in Africa. As the title of the conference in Africa implied, it was sponsored and funded by the United Nations with South Africa as the host.

Organisations, such as the ones identified above are providing region-wide professional advice and are driving cross-regional cooperation. Within ESA, intra-regional collaborations have matured into a variety of operational programmes including the development, design and launch of such space assets as METOP, Envisat, Meteosat and Galileo. In Asia, APRSAF partners are equally contributing to the APRSAF satellite project. Inputs to the latter include joint study on the concept of the satellite in order to meet the requirements of the Asia-Pacific region in disaster management. The joint development of the technology, design and fabrication of the satellite should provide opportunities for joint capacity building in the region.

2.1. Impact on Africa

At the time of the 1996 Pretoria Conference cited above, a space-related regional cooperation entity was not in place in Africa. That vacuum provided opportunities for many voices, both outside and inside the continent, to speak on space-related issues for Africa without any consensus input from informed Africans. The proposed GEO-Africa satellite, with a ground resolution of 25 m at nadir, and estimated to cost €455 million is a case in point.

Furthermore, 80% of the GEO-Africa satellite project cost (€364 million) was supposed to come from the European Union, with the balance of 20% (€91 million) funded by Africa. Irrespective of the merits of this initiative, subsequent related discussions in Accra, Pretoria and Abuja showed that the proponents of the project might have overlooked and did not take cognizance of Africa's budding knowledge of space science and technology. Furthermore, the project's proponents did not consider which country(ies) in Africa would provide the needed African contribution for this project. Would it be those countries that have operational Earth observations satellites of their own or those that have none?

Similarly, in 2010, at the invitation of the European Union, a select group of African leaders went to Brussels for a one-day meeting to discuss "*Space for the African citizen*". For many reasons the outcome of that meeting was inconclusive.

Also, on 6 August 2010, in Abuja, Nigeria, at the close of the Third African Union (AU) Conference of Ministers of Communications and Information Technologies, the ministers agreed to set up an African space agency.[2] Justification for establishing such an agency included '*the need to help ensure that the continent becomes an important player in the global space programme*'. The feasibility study on establishing the agency would also draft a common space policy, with both the United Nations Economic Commission for Africa (ECA) and the International Telecommunication Union (ITU) as advisers. This decision was reached after Algeria had presented the report of the 2009 African Leadership Conference on Space Science Technology for Sustainable Development (ALC) and the Regional African Satellite Communication Organization (RASCOM) had had its replacement satellite, Rascom-QAF 1R, jointly built by Thales Alenia Space of France and Italy, and successfully launched from Kourou on 4 August 2010.

A South African policy analyst, Jonathan Mahlangu, subsequently thought the space agency—space policy proposal by the African Union was long overdue. "Think of the contributions of NASA and ESA to the development of America and Europe", he said. "A well coordinated space agency for Africa will assist in solving most of the challenges before her".[3] According to Mahlangu, the critical mass already exists to start an agency. "All African Union needs to do is to put up a call to her citizens in NASA and Europe to come and contribute with their knowledge". Dr. Peter Martinez, the coordinator of South Africa's National Working Group on Space Science and Technology and Head of the Space Science and Technology Division at the South African Astronomical Observatory was more cautious and noted that the idea was premature: "A number of African countries should first develop their own capabilities and these [countries] could then take the lead in perhaps forming a continental space agency".[4]

The circumstances described above are, in part, responsible for the very limited gains in Africa's overall development efforts. First is the non-utilisation, under-utilisation or mis-utilisation of Africa's talents to arrive at informed decisions at the national and regional levels within the continent as well as at the international level. The net effect of these practices has been a continuous brain-drain not only in the field of space science and technology but also in practically all fields of human endeavour. Irrespective of the impact of such an exodus on Africa's development, what is not in doubt is that skilled labour is an internationally mobile commodity which responds only to appropriate economic and other suitable incentives. B.N. Bhattasali, the former Executive Director, National Productivity Council of India, observed that:

> The quality and the character of a man's perceptions as well as his subsequent responses are determined in part by limitations imposed by, or opportunities available in his environment. If he is to manifest any real growth and reach his higher potentials, his creativity would need nourishment from his environment.[5]

Among all the developing countries that are now in transition, India leads the way in recognising and complying with Bhattasali's views. It did so in its Scientific Policy Resolution of 1958 that proclaimed *inter-alia*:

> The Government of India has decided to pursue and accomplish these aims by offering good conditions of service to scientists and according them an honoured position, and by associating indigenous scientists with the formulation of (national) policies.[6]

The African Union and the African governments should carefully examine the merits, at the practical level, of this aspect of India's S&T policy and apply them locally, as appropriate.

2.2. Africa's response

On 8 November 1996 the African participants at the Second United Nations Conference on Space Science and Technology for

[2] Abutu, Alex Augustine (2010). Africa considers a continent-wide space agency, SciDev.Net, August 20, 2010.

[3] See Footnote 3.

[4] For further discussion of this question, see P. Martinez, 'Is there a need for an African space agency?', *Space Policy*, 28 (3), 2012, pp.

[5] Bhattasali, B.N. (1972). *Transfer of Technology among the Developing Countries*, Asian Productivity Organization, Tokyo.

[6] Government of India Doc. No. 131/cf/57 of 4th March 1958, Phalguna, 1879 — Scientific Policy Resolution.

Sustainable Development, reflected on these Africa's concerns and unanimously declared that:

> There is now a very urgent need for national and regional leadership in Africa to adopt space technology as a tool for meeting national and continent-wide development needs, particularly in the following areas: resource management and the environment, information and communications, food, health and capacity-building

This was the call that eventually led to the birth of the ALC at its maiden conference in Abuja, 23–25 November 2005. That conference paved the way for subsequent ALC conferences in South Africa in 2007, in Algeria in 2009 and in Kenya in 2011. Ghana has offered to host the 2013 ALC biennial conclave.

The goals and vision of ALC are contained in the ALC Booklet now available on ALC 2011 website.[7] The Mombasa Communiqué, which was adopted by the participants on 28 September 2011 at the end of the concluding session of ALC 2011, contains a wealth of action-oriented steps which should set Africa and its space journey on the right course.[8] It reflects the commitment of the ALC and its members to harness space science and technology for the betterment of the human condition in Africa. A complementary regional initiative to develop space technology in Africa is the African Resources Management Satellite (ARMS) constellation, a concept that is open to other African countries that wish to join the venture in the future. It is noteworthy that the four ALC host countries to-date are also the same entities that are in the forefront of the ARMS constellation. The goals of ARMS include, *inter-alia*, the following:

- generating indigenous knowledge to develop and transfer satellite technology;
- developing African human resources by means of joint participation and knowledge sharing activities;
- providing Africa with rapid, unrestricted and affordable access to satellite data thereby ensuring effective indigenous resource management in Africa by Africa.[9]

Through such a partnership, space acquired data could be used to benefit partner countries in such application areas as climate monitoring, land-use, water resources and agriculture.

Accomplishing all of the above goals will require robust private sector participation, not only in South Africa as it is currently the case, but also in a significant number of other African countries, particularly those with space aspirations.

3. Microsatellites

While the ALC was still at the conception stage, a portion of the global space community was dancing to the 'small is beautiful' tune. This was the time when satellite manufacturers began to tout the advantages of microsatellites over larger ones and developing country participants, including those from Africa, were exposed to microsatellite capabilities. At various conferences African representatives rubbed shoulders and established a variety of contacts with the companies that were marketing microsatellites. The resounding message from these companies was unambiguous - microsatellites are indispensable tools of development and they offer the cheapest way for developing countries to get into space.

3.1. Impact on Africa

A number of the African countries present at these events were among those who did not want to be left behind, so they were willingly and successfully persuaded. In the end, they swallowed the bait.

3.2. Africa's response

The first action in some of these countries was the emergence of national space-related organisations just before Unispace III. Such a step provided the leverage needed to enter into negotiations, at Unispace III, with the satellite manufacturers. Before long, contracts were signed to buy and purchase Earth observation satellites, most of which have now been launched into low Earth orbit (LEO). In some cases, these decisions were taken without a national space policy in place.

Today, a few African countries are now proud owners of orbiting microsatellites. However, the essential prerequisites and the science and technology readiness required, at the local level, for getting into space by each purchasing nation, did not feature in the plan(s) of the purchasing countries nor in the marketing strategies presented by the companies.

For many of those countries that bought and are still buying microsatellites on the open market, it is now becoming apparent that the route to indigenous capability development in space may demand a different approach. First, you assess your current capabilities and thereafter build upon it by investing in knowledge generation in the enabling technologies. An initial mastery of these technologies is an indispensable first part of successful space aspiration. Building up such capacities begins with the acquisition of fundamental scientific knowledge and the evolution of the technologies needed to initiate, develop, design, fabricate, build and test, locally, a variety of hardware and software components, some of which may end up in a variety of products including space-related ones.

What has become apparent is that a nation does not need to have a satellite in space to be space capable. Ghana came to that understanding in January 2011 when it established and outlined the immediate focus of the Ghana Space Science and Technology Centre (GSSTC).[10] Also, by the April 2011 cancellation of the planned launch of EgyptSat-2, and the announcement that "60 percent of the components and software of its new satellite [new EgyptSat-2] will be Egyptian-made", the Egyptian authorities informed the world that they had already gotten the same message.[11] By engaging Nigerian engineers to be fully involved in the building of NigeriaSat-X, successfully launched on 17 August 2011, Nigeria demonstrated that it has also, in part, understood the message. For other African countries that are nurturing a space ambition, the

[7] http.www.ncst.go.ke.

[8] Martinez, Peter (2012). The African Leadership Conference on Space Science and Technology for Sustainable Development, Space Policy 28 (2012) 33e37, January 2012.

[9] Abiodun, Adigun Ade (2009). Background, Scope and Objectives of the African Leadership Conference on Space Science and technology for Sustainable Development (ALC), Invited paper presented at the 3rd African Leadership Conference on Space Science and Technology (ALC 2009), Algiers, Algeria, December 7–9, 2009.

[10] Official Statement of the Republic of Ghana at the 54th Session of the United Nations Committee on the Peaceful Uses of Outer Space (Vienna, Austria), on June 2, 2011 contained the following information on the focus of GSSTC: The centre has a series of projects and activities ear-marked in its Official Working Document, ranging from short through medium, to long-term. But the most immediate and current ones are: (1) Operating/hosting a Space Astronomical Observatory (Ghana Astronomical Project); (2) Building a mega Planetarium and Space Science and Technology Museum; and (3) Running Postgraduate Study Programmes in Space science and Technology.

[11] EgyptSat-2 Launch Excised (Satellite), Satnews Daily, April 24, 2011.

African space landscape today offers many instructive lessons and templates to learn from.

4. Sustainability of the outer space environment

Other lessons include how African countries with space assets can ensure or contribute to the safety of their space assets within the outer space environment. The international community has been grappling with the hazards of the outer space environment for sometime. This concern is predicated on the fact that active and inactive space-based objects (spacecraft, asteroids and space debris) pose potential hazards to humans and infrastructure both in space and on the ground. These hazards originate from three possible sources, namely, possible collisions in space between man-made objects, the impact of natural objects from space, such as asteroids that cross the Earth's orbit, on the Earth's surface as well as on other objects in space, and the harmful effects of space weather as a result of solar flares or solar storms. How to mitigate the dangers posed to life and property on Earth by asteroids, meteorites, space debris and space weather is today, in each case, a permanent agenda item at the annual sessions of COPUOS and its two sub-committees (Scientific &Technical and Legal). For, even if few African countries are yet active in space, they are equally at risk from asteroid and space weather hazards, and also need to feel that, once they are in a position to build and launch their own satellites, these will still find room in crowded orbits.

4.1. Impact on Africa

Natural objects falling on African soil: Africa has not been spared the fall-out from space. Unlike the surface of the moon, where scars of impact craters are clearly visible, soil erosion and earthquakes have scrubbed clean or covered up many of the asteroid and meteorite impact craters on the surface of the Earth, including those on African soil. But clearly visible are such impact craters as the Bosuntwi impact crater − 10.5 km in diameter, a result of an asteroid impact over one million years ago - (now a lake) in Bosuntwi, Ghana and the Vredefort impact crater in South Africa, the oldest known crater on Earth, 140–300 km in diameter and formed by the impact of an asteroid 2000 million years ago. Natural rocks from space have also created impact craters in other parts of Africa, *inter-alia*, in Algeria (Ouakizz), Botswana (Kgagodi), Egypt (Nakhla), Namibia (Roter Kamm & Hoba meteorite, 80,000 years ago[12]), Libya (Arkemu), South Africa (Tswaing) and Tanzania (Mbozi). In October 1962, a meteorite landed near the Village of Zagami, in the then Katsina Province of Nigeria, about 10 feet away from a farmer who was trying to chase crows from his corn field. The rock, known as the Zagami meteorite, with a weight of 18,000 g (40 pounds), is the largest single individual Mars meteorite ever found.[13]

Man-made objects falling on African soil: Most countries, including those in Africa, have no mechanisms specifically designed to protect their space assets from potential collision with space junk or other satellites and space vehicles in the over-crowded outer space environment. In 1998 satellite insurance companies paid $1.8 billion in claims, of which half was for satellite failures in orbit. This is a major challenge to the success and sustainability of all human space efforts. Nigeria experienced such a challenge twice in the first quarter of 2010. That was when the US Joint Space Operations Command (JOSC) assisted it in steering its first Earth Observation satellite, NigeriaSat-1, away from a collision path with space object 28955 on 3 January and again with space object 01716 on 8 March.[14] Table 1 provides a partial list of some of the space debris that have landed on African soil between 1962 and 2011.

4.2. Africa's needed response

Because a number of African countries already have assets in space, Africa must become more knowledgeable about the current status of the space environment and should be party to the determination of the best steps forward in tackling the variety of dangers faced by humans and by its own space assets in that environment. Specifically, Africa should effectively utilise the abundant talents at its disposal and its financial resources to ensure that the continent becomes an active partner in both space debris and NEO tracking and mitigation efforts. To accomplish that goal, African countries would need to invest, collectively, in a world-class astronomy programme including the joint ownership of a robust optical telescope. In order to gain some knowledge and needed experience, African countries should also seek active participation in the international mission science team that has been established to analyse the data from Canada's NEOSat and Germany's Asteroid Finder satellite programme.

Human scientific understanding of how the Sun affects both the Earth and the space environment is still limited, in part, because of recent reductions in research funding. That notwithstanding, the "The Sky's the Limit: In the 21st century, satellites will connect the globe"[15] mentality is driving unprecedented investment in space technology. In 2005, the ITU predicted that the high demand for voice and data transmission services would increase to US$1.2 trillion, with satellites accounting for US$80 billion. But as electronic technologies have become more sophisticated and more embedded into everyday life, they have also become more vulnerable to solar activity.[16] Indeed, many new commercial satellites may be more susceptible to solar storm damage than their less sophisticated predecessors, only a decade older, because they lack adequate shielding and radiation-hardened circuitry. How much shielding should a satellite have? How much shielding do the solar panels, electronic circuitries, sensor systems, among others, in the orbiting satellites built for African countries have? How can Africa ensure that its space assets are adequately protected from the effects of space weather? The answers can be found in requisite knowledge generation and development.

African governments and universities need to understand that a significant number of the space-bound payloads including those that are contributing to space debris and NEO mitigation efforts are contributed by other universities and research institutions around the world, albeit, with the support of their respective governments. For example, the Extreme Ultraviolet Variability Experiment (EVE) on board the USA's Solar Dynamic Observatory is a product of the University of Colorado. EVE is contributing to a better understanding of the violent effects of the sun on near-Earth space weather that can affect satellites, power grids, ground

[12] Estimated at over 60 tons, the Hoba meteorite (also known as Hoba West meteorite) is the largest known meteoriteand the most massive naturally-occurring piece of ironknown on the Earth's surface. It was named after the place where it was found, the Hoba West Farm, near Grootfontein, Namibia. It has been uncovered but, because of its large mass, it has never been moved from where it fell. The Hoba meteorite is thought to have landed over 80,000 years ago.

[13] ABIODUN, Adigun Ade (2003). *Re-entry of space objects into Nigerian territory*, The Presidency, Abuja, Nigeria.

[14] The United States Space Command keeps a constant, round-the-clock watch over erring and disabled space objects (natural objects called asteroids or meteors/meteorites and man-made satellites and space vehicles).

[15] Credited to Investor Magazine of May 2005.

[16] http://science.nasa.gov/science-news/science-at-nasa/2008/06may_carringtonflare/.

Table 1
A partial list of space debris landings in Africa.

Date of impact	Country of impact	Origin of spacecraft or vehicle	Name of Launcher/Spacecraft	Date of launch
Oct. 1962	Cote d'Ivoire & Burkina Faso	USA	Atlas Booster for Mercury MA-8	Oct. 3, 1962
July 1966 and in Aug. & Nov. 1966	Zambia Swaziland (5.4 kg metal cone)	USA	Debris from S-IVB Stage of Apollo-Saturn	July 5, 1966
July 1970	Chad (near Lai) – a spherical pressure vessel	USSR	Spherical Pressure Vessel	Unknown date
April 2000	Cape Town, South Africa-70 kg tank	USA	Debris from Delta II booster	March 28, 1996
March 2002	Kasambaya, Uganda –pressure sphere hit a home	ESA	Debris from Ariane 3 booster	March 21, 2002
August 2002	Near the Village of Manzau, Angola	ESA	Debris from Ariane 4 booster	August 11, 2002
Mid-November 2011	Namibia, about 480 miles from the capital, Windhoek	Possibly USA	Debris similar to a Delta II solid rocket motor casing found in South Africa in 2000 from a March 28, 1996 launch and in Australia in 2008 from a June 12, 1990 launch.	Unknown for now[26]

[26] http://www.examiner.com/article/mystery-space-junk-baffles-african-authorities.

communications systems and even astronauts and aircraft crews. Similarly, the University of Surrey served as the launching pad for the microsatellites that a number of African countries have purchased in the past decade from Surrey Satellite Technology Ltd (SSTL). In Latin America, the Sergio Arboleda University in Colombia developed, designed and built *Libertad 1*, a CubeSat and Colombia's first satellite; it was launched on 17 April 2007 from the Baikonur Cosmodrome, Kazakhstan. With the support of their governments, many African universities could accomplish comparable goals, particularly through regional and international cooperative efforts.

5. Human space flight

The International Space Station (ISS) is the most ambitious experiment in peacetime international scientific and technological cooperation ever attempted. It is now being used to undertake fundamental, industrial and pre-competitive research and development in science, education, industrial products and commercial projects. The building of the ISS, which started eleven years ago, was accomplished because its partners placed much emphasis on cooperation through knowledge sharing, that is, the contributions of the research and development efforts of each partner to the current architecture of ISS.

Justifications for participation in ISS: The aforementioned research efforts are expected to improve the efficiency of the production process as well as the quality of goods produced on Earth. In addition, the attendant economic impact could be very significant and far-reaching. Presently, potential industrial opportunities from space-related activities are being projected into billions, if not trillions of US dollars. These opportunities are already attracting the private sector in each of the ISS-partner countries and other countries to begin modest investment in space-based industrialization.

Because of its potential as a platform for a wide range of cutting-edge industrial products in the immediate future, space industrialization is receiving the attention of many nations. Advances in ISS-based research and production can be expected in such areas as bio-medicine (new antibiotics and antibodies and other treatments for cancer, malaria, HIV-AIDS and other diseases), the growth of collagen fibres to be used in the repair and replacement of human connective tissues, organic and polymer chemistry compositions for use in such areas as advanced data processing, and new materials. The latter include new alloys, the growth of crystals for semiconductor devices, the development of iron with high carbon content and lubricants – all in their purest forms because of the micro-gravity environment of outer space. The use of these new materials in combustion engineering is expected to yield new stress-resistant and higher strength materials for Earth-based vehicles and machines as well as substitutes for non-renewable resources. Material processing in space is also expected to influence the development and production of alternative sources of energy on Earth.

International Cooperation: On-board efforts on the ISS are also expected to deliver a variety of benefits to humanity on Earth while preparing the way for future exploration activities beyond the LEO. The integrated international operations and research on board the station should also pave the way for enhanced collaboration on future international missions. Only a limited number of countries has successfully participated directly in the utilisation of the facilities on board the ISS to carry out experiments in their own interest. How other countries might secure the same opportunity received attention at the 1999 Unispace III conference. The conference recommended to the GA a possible approach for other interested countries when it recognised that global challenges can best be met by global dialogues, and that the conception and execution of joint projects between spacefaring and developing countries should be encouraged and facilitated, particularly within the framework of ISS.[17]

5.1. Impact on Africa

The ISS initiatives of a number of countries, particularly those countries in transition, such as Brasil, Malaysia and South Korea, are being showcased for others to emulate. Brasil, for example, flew a number of experiments in space, which focused on the growth of proteins, on hybrid seeds and on miniature Wire Heat Transfer Tubes. Such protein crystals can be used for X-ray analysis, for structure-based drug design, and as time-released protein pharmaceuticals. In 2007 a Malaysian ISS astronaut performed his experiments on the characteristics and growth of liver cancer and leukaemia cells, and on the crystallisation of various proteins (lipases) and microbes in space. Lipase is a type of protein enzyme used in the manufacturing of a diverse range of products, from textiles, detergents, food, pharmaceuticals including cosmetics to biodiesel. By being able to grow these elements in space, Malaysian

[17] The programmes adopted within the "Space Millennium of UNISPACE III included the use of space applications for human security, protecting the outer space environment, increasing developing countries' access to space science and its related benefits, raising public awareness of the importance of the peaceful use of outer space, strengthening the UN's space activities, and promoting international cooperation. Among the recommendations of UNISPACE III were the encouragement of improved access by states to the International Space Station and provision of support to the UN-Affiliated regional centres for space science and technology education.

scientists could take a crack at an industry worth some US$2.2 billion worldwide by producing these elements locally. In order for all the non-ISS partners, including African countries, to benefit from these future industrial opportunities, they will need to be active partners in the challenges that will yield these rewards.

5.2. *Africa's response*

However, the prospects for direct access to the ISS by non-ISS partners may be rare and limited in the immediate future following the USA's phasing out of the Space Shuttle programme. Thus, access to the ISS in the immediate future will be available only through Russian spacecraft and that of Space X, the latter a USA-based commercial developer of space transportation systems. Nevertheless, one could hope that there will still be opportunities for African countries to conduct experiments not only on board the ISS, but also on board future space stations, such as the Chinese space station currently being developed, with the expectation of a 2020 launch date.

One possibility is an initiative developed by the Office of Outer Space Affairs (OOSA): the Human Space Technology Initiative (HSTI). This is an innovative approach that offers all interested developing countries the prospect of involvement in the utilisation of the ISS and similar facilities.

Among the objectives of HSTI are:

- expanding the use of a space station as a platform for space science and technology development;
- expanding the use of a space station as a platform for education and outreach programmes; and
- discovering and utilising human space technology applications (spin-offs).[18]

To accomplish these goals, those who own laboratory modules on a space station will be asked to provide resources in the form of space station-experiment-instruments for use in, and astronaut/cosmonaut time to support the experiments commissioned by developing countries. They will also be asked to contribute to HSTI activities by ensuring a wider use of all space stations. Through this arrangement, HSTI will work with space station owners, serve as an advocate for their use by developing countries and, in the process, help brings the benefits of this unique facility to more people in the world.

5.3. *Suggestions on how African countries could participate in space station activities*

The focus of Africa's participation in space station activities would need to be guided by the key focus areas of each space station. The focus of the Chinese Space Station will evolve in the coming years. In the case of the ISS, the focus includes: Scientific, Engineering, Utilisation and Education potential. Within the framework of HSTI, experiments from interested African countries may be focused on the following:

- healthcare;
- more efficient processes in industry;
- advanced high-performance materials for automotive, medical and industrial applications;
- agricultural experiments on hybrid seeds;
- variety of experiments focusing on astronomy, biology, meteorology (climate change) and physics;
- education outreach.

On the whole, each prospective African country would need to determine, enhance and sustain its local capacities and capabilities to support its participation in space station activities; these would require the development and sharing of fundamental and applied knowledge. Of equal importance are the priority needs of each country and the areas where they would want to make their mark and make a difference. Details of how to participate in the HSTI, are available at the United Nations for Outer Space Affairs, Vienna.[19]

6. Africa's participation in the space enterprise

As one reflects on the variety of space activities addressed, one singular message needs to be emphasised, namely, that the value of any national space programme is its beneficial impact on the well-being of the country's citizens. Simply stated, it should address a significant amount of the basic needs of the people, including employment opportunities. Participation in the space enterprise also does not necessarily mean a physical presence in space with satellites and space vehicles, nor does it necessarily mean that a given country should be able to deploy payloads in space with its roaring rockets. Several countries are space capable, are avid users of Earth observation data, and do not yet have any specific space-based assets of their own, such as Earth observation satellites. In most cases, necessity dictated the course of action. Britain was such a country until it invested in TopSat. Canada also had to invest in developing and building its Radarsats-1 and -2 because most of its territory is under snow and ice for over 50% of the year. Many other countries concluded that duplication and cost implications, particularly in the case of Earth observation, do not justify such independent investments, hence they collaborated or are collaborating; ESA offers the world the most successful example of such a regional collaboration. That was how the SPOT satellites also came into being.

Africa also must not forget the decades'-long individual national attitude of its member states towards science and technology, the indisputable foundation of any space programme. Compliance or lack of it to the allocation of 1% of GDP in each African country to science and technology, as agreed to in the Lagos Plan of Action, is a case in point. In its 1990 report, the South Commission, under the chairmanship of former Tanzanian president, Julius Nyerere, reflected on this issue when it noted that:

> 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.[20]

Africa cannot jump over these fundamental steps. Its efforts over the years to do so have won it either a bench warmer status at international meetings or exclusion from international S&T meetings. At such meetings, where knowledge and skills in a specified S&T field are the prerequisites for participation, each country is expected to participate and share knowledge as well as contribute to the solution of global problems. This may explain why no African country is a member of the Inter-Agency Space Debris Coordination Committee (IADC). Similarly, no African country was invited to

[18] http://www.oosa.unvienna.org/oosa/en/SAP/hsti/index.html.

[19] HSTI Contact: Dr. Takao DOI, United Nations Expert on Space Applications, Office for Outer Space Affairs, United Nations Office at Vienna, Vienna, Austria., Phone: (43-1) 26060-5750; E-mail: Takao.DOI@unoosa.org.

[20] *The Challenge to the South (1990)*. The Report of the South Commission, Oxford University Press, New York.

contribute to the evolution of the Global Exploration Strategy, although the global community is expected to unite and contribute to its implementation.

Africa must prioritise the education and training of the scientists, technicians, engineers and mathematicians it needs for both national and collective regional space efforts and related social and economic development activities. With such knowledge, Africa would be in a better position to address its meaningful participation in the space enterprise. The following example serves to illustrate this point.

6.1. The Africa Regional Centres for Space Science and Technology Education in English (ARCSSTE-E in Nigeria) and French (ARCSSTE-F in Morocco)

From its inception in 1971 until 1982, the United Nations Space Applications Programme (UN-SAP) along with FAO and WMO organized a variety of one to two-week training courses, workshops and seminars, principally for the benefit of programme managers in the developing countries, including those in Africa. By 1982, it soon became apparent that an enhancement of the mandate of UN-SAP by COPUOS and the General Assembly was in order. Thus, among the recommendations of UNISPACE-82 was the COPUOS—inspired expansion of the mandate of UN-SAP *to enable it develop indigenous capability in space science and technology and its applications at the local level*. The subsequent translation of that recommendation led to the establishment of both the UN-Affiliated ARCSSTE-E and ARCSSTE-F, respectively in Nigeria and Morocco, in 1998. The initial programmes of each of these two centres focused on: remote sensing and geographic information systems; meteorological satellite applications; satellite communications and geo-positioning systems; and space and atmospheric sciences.[21]

The UN-SAP established each of the centres in partnership with an appropriate local university. The university connection was envisaged as a means to develop the skills and knowledge of university educators and research and applications scientists, through rigorous theory, research, applications, field exercises, and pilot projects in aspects of space science and technology that could contribute to sustainable development in each country. Today these programmes have produced a number of qualified educators and professionals that are gainfully employed, particularly in the fields of communication and in the application of Earth observation data, in African universities, in government establishments and within the private sector.

However, if the outcome of a 1979 UNESCO-sponsored workshop to establish a Giant Equatorial Radio Telescope (GERT) and its International Institute for Space Science and Electronics (INISSE) in Kenya had materialised, these regional centres might not have been necessary today. GERT was to be built near the equator in Kenya, at a cost of US$15 million, for the benefit of developing countries.[22] At that time, GERT/INISSE was the most comprehensive regional proposal ever developed for fundamental space science and technology research in Africa. But in the absence of any funding support, GERT remains an unfulfilled dream for Africa. However, Professor Govind Swarup of India, the convenor of the workshop, got the funding support of his own government and completed the establishment of a GERT-equivalent in India, known today as the Ooty Radio Telescope.[23] A similar absence of funding support is plaguing the two UN-affiliated centres in Morocco and Nigeria because, in both cases, the financial burden of keeping them afloat is shouldered mostly by the host country. One might expect that all the beneficiaries of the programmes and services of both centres would consider it noble to also contribute to the funding of these establishments. A robust funding of these centres and collaboration with relevant international institutions will enable them to advance beyond their initial mandate and capture for Africa what was envisaged in the 1979 GERT/INISSE initiative. In this regard, the partnership between South Africa and seven other African countries on the Square Kilometre Array (SKA) project is worthy of study by all the African countries.[24]

6.2. Lessons for Africa

Before the purchase of microsatellites for Earth observation by a number of African countries, observation of the Earth from space had become operational and a variety of satellites, such as the Landsat, Spot, ERS and RadarSat series had acquired a large amount of data of the global community including those of African countries. Indeed, a number of African countries entered into agreements with the USA for the acquisition of data on their respective territories from Landsat satellites. The countries concerned made these requests because they recognised that a nation does not have to have assets in space before it can gainfully use Earth observation data or communication transponders to power its socioeconomic development, as India did in its early spacefaring days by ‘borrowing, from 1 August, 1975 to 31 July, 1976, a spare ATS-6 satellite from the USA for its own social and economic needs. If a comparable practical approach had been taken in the case of Earth observation in Africa, it would have resulted in a greater understanding, processing, analysis, interpretation and subsequent use of the data acquired. Africa would also have proudly showcased how such efforts had improved different segments of its economy. Aspects of the economy that would have benefited the most would have included mapping, agriculture and food security, land use, forestry, water resources, fisheries, management of coastal and marine resources, environmental management, mining, transportation and civil works to name a few.

What is apparent from the above is that as Africa looks forward to its active participation in the space enterprise, it should begin with a dedicated use of space acquired data to genuinely solve its social and economic development problems. Such an approach should:

- enhance Africa’s ability to evaluate Earth-observation data and assess their value in various Earth science disciplines;
- contribute to the development of calibration techniques for Earth observation data including the development of software for image assessment[25];

[21] In addition to ARCSSTE-E in Nigeria and ARCSSTE-F in Morocco, other United Nations Affiliated Centres established by UN-SAP include those in India (for Asia and the Pacific), Brasil and Mexico (for South America and the Caribbean) and Jordan (for South West Asia).

[22] (a) SWARUP, G., T.R. Odhiambo and S.E. Okoye, INISSE and GERT, (unpublished), (1979). (b) GERT and INISSE — GERT was envisaged as a tool for fundamental research in the frontier areas of astrophysics, cosmology, space physics and extra-terrestrial phenomena. GERT and INISSE were to contribute to competence building in such areas as microwave systems, space science and technology including satellite systems, digital electronics including micro-processors and computers. The institute was envisaged as undertaking the building of scientists and technologists both for the needs of the institute and other establishments of the participating countries through an appropriate choice of scientific programmes in the field of electronics, radio and space sciences.

[23] RAY Jayawardhana (1994). Science, Vol. 24, 22 April, 1994, pp 501-502.

[24] The seven other African countries collaborating on SKA with South Africa include Botswana, Ghana, Tanzania, Kenya, Madagascar, Mauritius, Mozambique and Namibia.

[25] ABIODUN, Adigun Ade (1997). *SPACE EDUCATION*, Advances in Space Research (COSPAR), Vol. 20, No. 7, pp. 1341–1349, Elsevier Sciences Ltd.

- enrich the understanding of Africa's scientists and engineers, on the type of sensor parameters that can meet development requirements in the continent;
- enhance the productivity and food security of each country concerned and, in the process, contribute to its economic development.

By following the above route, Africa would become an intelligent partner and a meaningful contributor to technology innovation particularly in the definition, development, design and fabrication of Africa's scientific instruments, remote sensing and other satellites and their payloads and much more. In the process, Africa's inquiring minds, at home and abroad, will be there to give such a commitment all the necessary support; Africa's local content will become part of an African-designed and -built space hardware and software, including satellites and their payloads; and Africa's private sector will have the opportunity to grow and contribute significantly to Africa's future as well as experience the joy of laughing its way to the bank. In social and economic development terms, Africans will gain knowledge and experience; and jobs associated with Africa's strategic and dedicated participation in the space enterprise will be there for educated and skilled Africans.

7. Conclusion

For those African countries that are just entering the space arena, there is a need to learn from the experience of the forerunners. And it is encouraging that a number of those who have already started without taking such first steps as outlined in this article are beginning to reflect and take necessary corrective measures. Africa's space activities need to connect with the people because for many in society, the benefit of space to daily life is hard to see. The jobs, the gains and the benefits associated with any space programme are not in space; they are on the ground, here on Earth, where they affect people's lives. A space programme that is initially focused on ground-based applications accomplishes much more. It will be a bottom-up approach (instead of a top-down one) which can be better achieved through purposeful regional cooperation. From that vantage position, Africa will learn many things that will inspire its citizens to be the initiators, developers and builders of the tools and assets that can power its economy and related developments as well as fulfil its space aspirations. By that time Africa will have equipped itself to meaningfully contribute to the advancement of the space frontier.