SPACE TECHNOLOGY AS BINOCULARS FOR LIFE ON EARTH IN THE 21ST CENTURY

Vincent O.S. Olunloyo FAS
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INTRODUCTION

Man's romance with Space remains one of the wonders of all ages. In material terms, it has inspired quantum leaps in the technology of flight and transportation; on the metaphysical or spiritual plane our imagery of heaven and hell are both conjured and inspired by space and the myriad balls of fire and dark holes that define and decorate its spacescape. Biblical account of the divine act of creation merely confirms its pre-eminence in man's thoughts when it says:

> *"And God said, Let there be light in the firmament of the heaven to divide the day from the night: and let them be for signs, and for seasons, and for days, and years;*
>
> *And let them be for lights in the firmament of the heaven to give light upon the earth: and it was so.*
>
> *And God made two great lights; the greater light to rule the day; and the lesser light to rule the night: he made the stars also.*
>
> *And God set them in the firmament of the heaven to give light upon the earth,*
>
> *And to rule over the day and over the night, and to divide the light from the darkness: and God saw that it was good".*
> (Genesis 1:14-18)

For it was against the forboding vastness of space and the warmth, and mystery of the beckoning stars that man discovered both his identity and consciousness. Homo Sapien's early confrontation with nature must, most probably, have been so traumatic and intimidating as to make him seek refuge in the caves to contemplate his frailty and helplessness and in the process fashion out a survival kit. Such a survival kit evolved over just a few millions of years to transform him, not only into a master of his planet, but also in recent times, into a space adventurer. His survival kit was built around two central themes viz:-

(a) the need to know himself and everything about anything around him .

(b) the use of what he knows to improve and manage his present condition of life on the one hand and predict and plan for the future on the other.

After all, physical and scientific or metaphysical explorations and discoveries are predicated in the need to know, whereas innovation and technology merely reflect the ends and use to which man has put what he knows.

Within the context of man's intellectual evolution, the 20th century would stand out as an epoch of startling discoveries and stunning feats for it was during this century that man looked deep into the atom and reached out into space. By unlocking certain secrets of nature, man has unleashed the possibilities of new technologies in such areas as: bio-engineering and medicine, energy production, space technology, cybernetics and information technology.

For a start, he took a trip to the moon to see things for himself as it were; he also established manned observation posts in space and sent both probing and landing spacecrafts to sister planets like Mars and Jupiter. It was only natural that, intoxicated by such success, man dared to think that he could go wherever he wishes in space provided he could harness the energy required for such an undertaking. Also, having unraveled the chemistry of life, he is beginning to enjoy the luxury of thinking that, should he be displeased with the way God has created him, he now has the option and ability to remake himself as he wishes.

Although science made a lot of fundamental progress in the 20th century, the world was not ruled by scientists neither did they have much say as to what use. their results were put in the conduct of human affairs.

In this respect, the 20th century was not different from its predecessors as the dominant issue remained the contest and conflict for access to and use, of the world's resources and surplus. This was the origin of warfare. In such conflicts, each society deploys all its technical and human resources to achieve its objectives and it is not unexpected that any advances in science and technology (S & T) would be enlisted in such an effort, after all the military engineer was the predecessor of his civilian/municipal counterpart.

What was unusual about the 20th century however was that the advances in S & T were so rapidly deployed and with such startling success as to radically transform the nature and character of warfare.

Prior to the 17th century, religious wars were held in reverence, in the hierarchy of warfare, because of their scope, intensity, and the widespread devastation that accompanied them. Following their era, wars were mostly fought over specific interests of individual sovereigns and were therefore limited in both scope and objectives. This was to change with the French Revolution which broadened the objectives of warfare to the ideals of the revolution and made its scope total as it involved the mobilization of entire populations. There were two such major coalition wars in this century. The first world war (1914 - 1918) resulted in the loss of some 8.5 million lives but by the second world war (1939 - 1945) the casualty rose to a staggering figure of an estimated 40 to 50 million casualties.

With the evolution of nuclear weapons of mass destruction, war could no longer be regarded as an ordinary instrument of foreign policy and diplomacy as it now came with dire consequences for the survival of mankind.

In fact starting from the late 30's the world could be said to be mostly preoccupied with the business of war. This was to hold sway for the next 50 years. The era began with the Second World War but this was followed by a long drawn ideological battle between capitalism and socialism. Thus, for the next four decades, the main political project was the resolution of the ideological conflict and the primary item on the economic agenda was no other than the preparation for war; this was the major assignment of not just armies but entire economies. Under such a geo-political climate, defence drove the entire world economy and reconversion to civilian economy was soon to become a major problem of global concern.

Driven by such ideological differences, the world, by the middle of the century, was officially in a permanent state of war; the only difference was that hostilities were covert, not overt i.e. cold, not active, war.

Having realized the use to which scientists and their work could be put during the two world wars, governments made deliberate efforts to court and enlist their services in the national war efforts. In this regard, research funding was used as an effective tool for targeting strategic areas into which scientific effort and development would be focused. Thus, application of scientific results was progressively channeled into those areas that would support national interests of the leading economies in support and propagation of their ideological maxims.

It was within such an ideological conflict that the door to space was unhinged and the Yuri Gagarin's maiden flight into space was interpreted by politicians more as a challenge for ideological dominance than as a scientific breakthrough. In the context of such circumstances, space was projected as a new theatre of ideological warfare.

2. THE PUSH FOR SPACE

Whilst the cold war might have been an essential catalyst for the space race, three other factors influenced and promoted man's drive into the firmament viz:

- the spirit of exploration
- the search for knowledge/science

- the promise of commerce

All these factors were subsumed within the geopolitics of the period. With lime it became clear that Sputnik was merely an expression of man's spirit of adventure and exploration. This was soon to be followed by series of manned and unmanned trips to the Moon, and well as nearly to planets such as Mars and Jupiter. The recent successful landing of Pathfinder on Mars on July 4, 1996 has shown that the question is not whether but when will man extend his physical exploration of the Moon to Mars.

Another aspect of man's exploration of space has been to find out whether he could make his abode in the firmament and, if that is possible, to what extent can he make his living by exploring the resources of those planets to augment those on earth that are fast depleting.

With the breathtaking developments in wireless telecommunications, point to point microwave energy transmission, information technology, and materials science, to mention a few, came the progressive and irreversible qualification of space as a theatre of highly profitable commercial activity. It is also becoming increasingly apparent that the scramble for national presence in space is gathering momentum, but like the scramble for Africa, and indeed before that Asia, has shown, such moves are hinged on a credible force projection by the nations involved. For example, we know that since 1957, a total of over 22,000 satellites have been launched into space and as of today, over 7,000 of them are still in orbit. Following Yuri Gagarin's 90 minute epic (night of 12th April 1961), some other 700 men and women have escaped gravity and lived in space for periods varying from mere minutes to over 436 days' (Vallerani, 1997). In fact, cosmonauts and astronauts have altogether accumulated some 20,000 days orbiting over our planet.

In the US, several private companies have unveiled plans to launch constellations of satellites over the next few years (Spacerews, 1997). Boeing of Seattle, for example, plans to launch 16 MEO satellites to offer navigational information to commercial airplanes while Globalstar LP of San Jose, California, plans on launching 64 LEO and 4 GEO satellites for voice, data, and fax communications. Iridium LLC of Washington wants a 96 satellite-constellation to supplement the current 66 Iridium constellation.

At least some 30 other US companies have either announced their intent or are considering proposals to fly constellations of satellites. The rush is so much that the FCC is complaining of being overflooded with licence requests. Within the African region we have two entrants in the space race. South Africa (Sweeting, 1997) has two microsatellites Sunsat (Vallerani 1997, Space news 1997) whilst Israel also flies a mini satellite for military reconnaissance purposes. Egypt, in the meantime, now runs a fully automatic laser tracking station at Helwan near Cairo which is the first of its type in Africa and, with technical assistance from Czech Technical University (CTU), can now track satellites like Lageos-2, Ajisai, Etalm, Topex and ERS-2 to an accuracy of 10-25mm RMS. In nearby Cote de Voire, on the West African Coast, a Rascom-1 satellite is being proposed to be launched in 2001 as a regional African satellite communications and broadcasting service for some 1.2 billion US Dollars (ISIR, 1997).

Another way to look at this is to estimate what proportion of worldwide revenue is currently allocated to the space industry and what are the projections for the near future.

TABLE 1: PROJECTED GROWTH OF THE WORLD-WIDE SPACEINDUSTRY

1996 Worldwide Revenues	$76.9 billion
Anticipated Growth thru year 2000 (57%)	$120 billion
Employment by year 2000	840,000

Source: Compiled **from the US** (1997/98); European (1997); and Russian **Space Industry** (1996/97) Space Directories; Space Publications; **Reston; 1997.**

From the work of Einstein and others, man has found that the basic elements of life emanate and are circumscribed by the interplay of four basic forces viz: weak short range nuclear forces, strong short range nuclear forces, electromagnetism, and gravity and, whilst he has learnt to exploit the first three here on earth, he has come to realise that by using space as his platform, he might be able to exploit his release from the earth's gravity to evolve new commercial products and processes that would enhance the quality of life here on earth. New materials, new alloys, new drugs, and enzymes; new proteins and other substances are destined to evolve under such a microgravity environment (10^{-3} to 10^{-4} g).

Furthermore, using the vantage platform of space, he has also realised that many of the activities carried out on earth can be viewed from a clearer and better perspective and consequently tackled from a more holistic framework. This gave birth to earth observation satellites for monitoring its weather, animal, vegetable, and mineral resources. The Russian space Station MIR has helped to answer some of the questions in this area and we now talk of an International Space Station (ISS) that is supposed to be progressively assembled in space starting from 1999.

These achievements have progressively pushed the development of space science into public consciousness and to such an extent that distinct areas of application have emerged to radically change our way of life. Such technologies include:

(a) Remote sensing: These are earth observation satellites that have many applications varying from military to civilian such as reconnaissance, agriculture, disaster management, pollution, etc.;

(b) Solar energy power generation;

(c) Satellite communication;

(d) Meteorological satellite applications;

(e) Space and atmospheric sciences (such studies are important since space craft operate in space and have to move through space and the atmosphere as well as receive and transmit electromagnetic radiation signals, through these media).

3. A NEW WORLD ORDER

Given the demise of the cold war what future can we expect in the next century? If we are to believe what the scientists promise us, strange things are expected to happen in the next century. The world is destined to be a completely different place within the next thirty to fifty years. For very soon physicists expect to know more about the origin of the universe; what dark matter occupies the interstellar space and make up the COSMOS.

In the coming times, people should be able to work less, shop at home, work freely for clients in several continents whilst retaining their freedom as to where they live and operate from. Many commercial and service organizations will be virtual companies existing only in what we now know as the global electronic super highway. For those wishing to travel a lot, short interplanetary holiday trips will be possible to the moon and if you have the time, perhaps to mars. There will be little fear of getting lost in the vastness of space because existing Global Positioning Systems (GPS) are capable of being developed to take care of such eventualities. A lot of these feats will be made possible by the new developments in space technology.

That is not all; our health should be much better. Parents should be able to prepare and lodge specifications with their doctors for the type of offspring they desire and with the announcement, late in 1997, by a British scientist that they might have isolated the intelligence gene, the day is not far when almost every child can be a genius!

4 MESSAGE OF TODAY'S GEOPOLITICS

If indeed geopolitics is the driving engine of our world view and our development projections what then are the lessons from the present scenario? As stated elsewhere (National War College, 1998), the message of today's geopolitics can be summarised as follows:

(a) The balance of power doctrine of the cold war era was an ill wind that did no one any good; at best it was a burden to the strong and lured the weak into a false sense of insurance or security.

(b) There is now an emerging paradigm shift from an East-West to a North-South dichotomy. This:-

i promises an era of bliss and dominance for the strong

ii earmarks technology to be the metaphor for the era and R & D shall remain the primary dialectics

iii space to be the amphitheatre as:

- it provides strong linkage and symbiosis between the defence and civilian economies and promises a less disruptive and painful process of conversion from a defence to a peace economy;
- assures the super-powers a position of relative advantage

iv The strategy for developing and sustaining space technology shall mainly be one of col laboration:

- between a government and its private sector
- between governments on bilateral basis
- between government agencies on regional basis
- through the International Space Station (ISS) based on global participation

(c) The U.S. has emerged as the undisputed main actor in the new order and whilst its main political objective appears to be the enthronement of the doctrine of western de mocracy it also includes preservation of the western domination in world order.

The so cio-economic game plan calls for the entrenchment of laissez-faire entrepreneurship and western value system within the context of a global division of labour.

The main actor's strategy for achieving these objectives includes securing authority through:

- forging American hegemony and nursing northern alliances such as in G7 group etc;
- control of multilateral organisations such as the UN, IBRD, World Bank, ITU and similar agencies
- maintenance of technological and military superiority

The main-actor is prepared to enforce compliance by deviants through:

- economic sanctions
- socio-political isolation
- direct group intervention

(d) The challenges for the weaker nations include:

i the ability to craft more flexible, imaginative, and resourceful development and technology procurement policies.

ii the pursuit of self-reliance at an enhanced threshold than was possible under bi-polar ideological geopolitics.
iii the fashioning of regional economic and security arrangements based on the joint effort of the regional actors.

5. CHARACTERISTICS OF SPACE TECHNOLOGY

The question then is what are the characteristics of space technology that make it a suitable binoculars through which we can preview and project terrestrial activities and life style for the next few decades? Some of the more salient characteristics of space technology include the following:

- it is highly capital intensive
- it is global in reach and perspective. More than any technology, space technology hardly recognises geographical or political boundary. It is therefore hard to control or manipu late for exclusive use. In fact, its scale of operation is so large as to, for the meantime, intimidate man and overwhelm/contain his greed and acquisitive instinct.
- it cannot stand on its own; instead, it is tied to major infrastructure such as communications, informatics, robotics etc. the dual nature of [he technology and the industrial infrastructure that support it is a major asset.

- in particular space technology:
  – has both military and civilian applications

  – lends itself to easy conversion from military to civilian technology and applications; same applies to the industrial infrastructure that supports it

  – is dramatic in speed and scale of penetration/ proliferation. Evidence of such effects abound in the fields of communications, information gathering, environmental monitoring, and resource development

  –facilitates transparency and can therefore serve as cornerstone for promotion of international peace, security, and stability on the political, military, economic and environmental fronts.

- must remain rugged under fatigue in very harsh environmental conditions. For example although the ambient temperature in outer space is around - 270°C the surface temperature of a space module goes from a high temperature of 135oC while the sun is illuminating the surface to an extremely cold temperature of - 90°C when it is in shadow, all within a time frame of under an hour.

6. UNRESOLVED PROBLEM AREAS

This is not to say that all is rosy with space technology or that it is destined to be the panacea of man's problems in the near future; in fact, with increasing use and better understanding of the requirements of the technology, areas of unresolved problems are multiplying with time. Some of such basic problems include:

(a) Definition of outer space and its delimitation from air space.
(b) . Equitable use of geostationary orbits (GEO).
(c) Use of nuclear powered satellites.
(d) International direct television broadcasting.
(c) Remote sensing.
(f) Military use of outer space.

Nonetheless it is customary these days to discuss space technology activities in the context of three segments and a supporting infrastructural system viz:

* Space Segment
* Transport Segment
* Ground Segment
* Infrastructure System

However before we embark on a general description of the activities and challenges associated with any of the itemised segments it is appropriate to discuss the general framework within which space activities operate.

7. SPACE LAW AND TREATIES

Early in the space race majority of nations recognised the need to evolve and agree on a set of rules, principles, and guidelines that would regulate and govern the exploration and use of outer space, its resources, and the celestial bodies contained therein. The United Nations provided the forum and umbrella for such an exercise. As a result, a committee on the peaceful uses of outer space (COPUOS) was created and an office for outer space affairs was established under the leadership of the UN Expert on Space Applications. The thrust of COPUOS activities derives from the basic principle that space and all its resources belong to all mankind and should not be used for military activities. For example the Moon Treaty of 1979 bars military activities of any sort on the moon whilst the outer space treaty of 1967 prohibits nuclear weapons or weapons of mass destruction from being orbited around the earth.

To date there are five main Treaties/Agreements and a set of basic principles that regulate the outer space activities of all space faring nations as itemised below;

7.1 Space Treaties

1. 1967 Treaty on Principles Governing the Activities of States in the Exploration and use of Outer Space.
2. 1968 Agreement on the Rescue of Astronauts, the Return of Objects launched into Outer Space.
3. 1972 Convention on International Liability for Damage caused by Space Objects.

4. 1975 Convention on Registration of Objects launched into Outer Space.
5 1979 Agreement Governing the Activities of States on the Moon and other Celestial Bodies. Most important are treaties on Principles and Liability.

Under COPUOS Treaty (1967), nations cannot claim sovereignty over the moon or other celestial bodies.

Nations are fully responsible for their activities in space, are liable for any damage caused by objects launched into space from their territories and are bound to assist astronauts in distress. Their space installations and vehicles shall be open, on a reciprocal basis; to conduct outer space activities openly and in accordance with international law.

7.2 What Basic Principles?

a) Outer space, including the moon and other celestial bodies, are not subject to national appropriation.
b) The state of registry of space object retains jurisdiction and control over such object and over any personnel thereof while in outer space or on a celestial body.
c) States bear responsibility for national activities in space and must subject such activities, either by officials or private individuals, to authorization and control.
d) States that launch or procure the launching of a space object or from whose territory or facility a space object is launched are internationally liable for damage caused to another state or its nationals by such object.

8. PROBLEMS OF SPACE LAW

Since states are forbidden from making claim to space territories, for instance, there is need to establish regulations governing the apportionment of usable resources that space may provide.

Another area of interest is the use of the upper atmosphere and geostationary orbits for purpose of communications. Satellite technology has, for example, expanded the range and lowered the cost of international communications.

8.1 Problem Areas

Although the article IV of 1967 Treaty prohibits the stationing of nuclear or other weapons of mass destruction in outer space or on celestial bodies it went on further to prescribe that the moon and other celestial bodies (without mentioning 'outer space') shall be used exclusively for peaceful purposes. The issues here are:-

(a) From evidence to date we are not sure that this provision is generally accepted or adhered to.
(b) What does 'peaceful purpose' mean? Is it 'non-military' or 'non-aggressive? The latter interpretation which is the position of the super-powers appears to be gaining currency.

Other than the UN, one of its agencies, the International Telecommunications Union (ITU), has been active in regulating the use of radio frequencies for telecommunications and direct television broadcasting by artificial satellites.

9. WHAT CAN SPACE TECHNOLOGY DO FOR MAN?

If space technology is to occupy a central position or engage the ingenuity and attention of mankind for a prolonged period", it must hold promise for solving some of the major problems, that threaten or compromise man's progress and survival in the near future. Prominent on the list of such problems are the following:

* Food and quality life for an exploding population
* Adequate and safe energy supply
* Managing the environment . .

The issue would then be to consider to what extent space technology could be deployed to either solve or contain and manage these problems within the next few decades.

9.1 Food and Population Explosion

The exponential population growth and the progressive and irreversible urban drift pose serious problems to man's quality of life in the near future. The world population which was put at 5.4 billion some 8 years ago in 1990 is expected to almost double by the year 2025 with a projection of 9.2 billion. Of this number, majority are expected to be urban dwellers since it is expected that, by the year 2000, not less than 55% of the world's population will be city dwellers and roughly two dozen of those cities will be classified as megacities with populations in excess of 10 million (Rao, 1996). An immediate consequence of such growth rate is the shrinking of the per capita arable land. Unless science and technology can find new ways of food production, poverty and malnutrition pose serious threats. The crowding of populations into cities also accentuates problems of proper land management, management of the local environment, integrated approach to urban planning and development of water supply, open spaces, transportation, housing and other infrastructure. Such megacities, which will be mostly located in developing countries, will require sound organisation, financial, and legislative framework for management and monitoring purposes. Remote sensing has been sufficiently developed to differentiate between different classes of urban zones such as residential, industrial, green belts, and their growth over time can be easily monitored to enable authorities plan for the physical growth of the city and the necessary infrastructural facilities.

The sea is increasingly becoming the other viable source of meeting the food demand of the globe's inhabitants during the next century. Most of the catch is located in the proximity of the continental shelf in the coastal regions of the world. Unfortunately this region also contains a high percentage of the world's inhabitants and is therefore prone to waste pollution emanating from the domestic, industrial, and agricultural activities of the dwellers.

Some of the relatively important basic facts about the coastal zone include the following. The coastal zone:

- * occupies 18% of the surface of the globe
- * contains less than 0.5% of the ocean volume
- * is the region where roughly 25% or the primary productivity on the globe takes place
- * is the region where around 60% of the world population resides
- * serves as home for two-thirds of world cities with population in excess of 1.6 million
- * supplies approximately 90% of the world fish catch

In view of the various activities which coastal waters are, subjected to (e.g. natural fish stocks, recreation, effluent discharges, aquaculture etc) the water quality can be used as a barometer for gauging the productivity or suitability of the zone for any of the itemised activities. One way of doing this is to correlate the quality with the colour of the water as remotely sensed.

Table 2: High-Resolution Sensors for ocean colour

Sensor	TM	HRV	MOMS	AVNIR
Agency	NASA	Spot Image	DARA	NASDA
Country	USA	France	Germany	Japan
Satellite	Land sat	Spot	Priroda - MIR	ADEOS
Operation Dates	07/82 -Date	1990 -Date	23/04 '96 - Non - Operational	17/08/96 - 21/06/97
Swath (Km)	185	60-80	95 - 105	80
Resolution	30	20	16 - 18	16
Spectual Coverage (nm)	450 - 900	500 - 890	443 - 670	420 - 890
Number of Bands	4	3	4	4

Source: Space Applications **Institute** (SAI); Commission Joint **Research Centre** (1997)

Such schemes have been successfully used by SAI in the past to monitor toxic algal blooms in the Baltic and provide early warning ‘white - tide’ signals in the Northern Adriatic sea. Several new sensors are planned to be flown within the next few months.

9.2 Energy Supply

The per capita energy consumption is generally used as an index of development. If the rest of the world were to develop along the lines of the North, then the energy demand will far outstrip supply. Recent studies have however shown that while other renewable or non-renewable conventional energy sources being studied might, ultimately, be viable as commercial ventures, the cumulative ultimate production capacity merely reduces but cannot close the shortfall in the projected energy supply requirements. On the contrary, what is called for are bold new initiatives that can meet projected requirements (Mankins, 1997). Thermonuclear power plants could at the appropriate scale provide such an alternative but in view of public opposition arising from their adverse environmental impact, the possibility of harnessing the sun's energy in space holds considerable promise. The original idea of the Solar Power Satellite (SPS) dates back to 1968 when it was first suggested by Peter Glaser but it has taken almost three decades of development work to bring us to the point of flying a technology demonstration satellite by NASA. Basically the plan is to configure solar satellites and associated systems that could deliver energy into terrestrial electrical power grids at prices equal to or below ground alternatives in a variety of markets and to do so without major environmental drawbacks. Following the initial concept, at least 4 SPS symposia have been held in Paris (1986 and 1991), Rio de Janeiro (1992), and Montreal (1997) and several modifications introduced. There is now some level of optimism that by deploying relatively small SPS in lower orbits such as the LEO-SS and MEO Sun Tower Systems, it might be possible to commence space solar power generation early in the 21st century. The moon has also featured as a possible base in the generation of solar power from space under three different scenarios viz:

i construction of solar power satellites from the moon.
ii construction of power stations on the moon's surface.
iii tapping of lunar helium 3 for terrestrial energy production in fusion reactors.

9.3 The Global Environment

Three of the major sources of threat to the global environment that have been identified are global warming, toxic and nuclear waste disposal, as well as natural disasters. Global warming could lead to partial melting of the polar glaciers; this would subsequently raise the water level in the oceans leading to massive flooding of the coastal lands and cities where, as stated earlier, 60% of the human population lives. Space provides a vantage platform for observing phenomena that occur on global scale such as, for example, meteorological phenomena. Whilst some of these phenomena derive from natural forces that cannot be easily manipulated by man, as of now, the acquisition of prior knowledge of their existence and provision of early warning to the public can, sometimes, reduce the level of damage, especially in cases involving natural disasters.

On the other hand, sensors have been developed that are capable of detecting presence of toxic and nuclear waste in ocean waters and on the global surface in general. It is well known, for instance, that the amount of oil illegally dumped from ships every week is equivalent to a disastrous spill from a supertanker. The scale of the problem underscores the need for effective monitoring and adequate legislation to protect the environment especially in coastal areas which are particularly at risk from such practices (ERS 1997). Forest fires can also be detected using remote sensing so that preservation of the green belts of the world would be facilitated.

Thus, we can observe that space offers a good platform for tackling two out of the three listed problems on a holistic basis. Whilst the problem of the environment and energy can be satisfactorily handled by deployment of space technologies, the level of involvement, in respect of the food problem, will have to be limited to areas like precision farming, as well as the management and monitoring of food resources.

This is not to say that there are no foreseeable problems with respect to the energy and the environment sectors. On the contrary, there are several, but the overall assessment is that such problems can, and will be solved, in the near future. For the energy requirement, such problem areas involve the development and availability of enabling technologies in such areas as robotics and artificial intelligence. Tethers, inflatable structures and superconducting materials. We will also need to develop and build modest energy storage systems at the ground site to service the inherent periodic shading of the SPS either by the earth or by its own arrays.

The use of space for conducting any technical or production activity carries risks of its own as it may have negative impact on the environment. Such risks will have to be managed with respect to their biological effects, and their possible effect on the upper atmosphere and the communications and electronics systems.

There is also the separate, but important, problem of keeping space projects within affordable limits. Even for the richest nations, the cost of transportation (launch systems) is prohibitive. The current rate of US 510,000 per kg is programmed to fall to as low as $2000 per kg within the next 5-10 years but the target is to be able (o keep this figure within the range $200 - $1000 per kg and it is hoped that this can be achieved within 10 to 20 years from now (Boudreoult et al, 1997).

The legal regime needs to address how to deal with the issue of making nations accountable for their use of not only space but also our terrestrial environment. In the final analysis, we cannot run away from the issue of how to meet the needs of all nations even when they do not all have equal access to or use of space resources. There is also the need to define the extent to which space technology can be allowed to compromise the sovereignty or security of a nation.

10. THE STAKE HOLDERS

If space technology is here to stay, it stands to reason that all stakeholders in society be put on notice and alerted as to their proper role in the deployment of this technology. In the present circumstances the stakeholders fall under four main categories viz:

Government

Multilateral organisations

Professiona bodies and non-governmental organisations (NGOs)

Private sector.

We next examine the posture of these stake holders towards participation in space activities.

<u>Government:</u> The position and activities of governments in the advanced countries mostly mirror the geo-political world order. Led by the U.S space agency, NASA, the emphasis appears to be to:-

- underwrite infrastructure;
- underwrite development and scientific explorations;
- exploit military applications;
- encourage private sector's involvement, by way of commercialisation either in an independent capacity or in conjunction with government in some hybrid arrangement, as was, for example, done on the Lewis Project.

Multilateral Organs: The UN and its agencies emphasize and encourage international cooperation and peaceful and scientific exploration and use of space.

Regional Space Agencies: involved in collaboration and concerned about issue relating to standardisation of equipment and environment.

Professional Bodies and NGQs:
Emphasis is on collaborative scientific exploration, need for standards for protection of space and terrestrial environment.

Private Sector: Emphasis is on development and application of space technologies. It wants to play a major role in the commercialisa tion of space (transportation: communications, manufacturing etc). Also, it wants to undertake these ventures within the context of globalisation and liberalisation.

11. THE DILEMMA OF DEVELOPING COUNTRIES

We are all familiar with the debate as to what should be the correct posture of developing nations towards the allure of space technology. Whilst it is agreed by all, on the one hand, that space technology is a capital intensive business, on the other hand, the field is relatively new and open to innovative and forward looking developmental strategies. Each enterprising nation still has the chance to partake in this venture especially in the downstream areas through Value Added Products. Thus, can we really say it is a distraction for them? Even if it is not, can they truly afford to commit their meagre resources to Space Technology, given their serious developmental problems?

Is it true that the issue of infrastructural development and utility services can be done cheaply by deploying some aspects of space technology?. The experience from China seems to give support to this point of view where space technology has been used in the areas of mass education broadcasting, cartography surveying, and mapping.

In fact, in 1997, the UN/IAF organised a workshop in Turin to sensitise the developing countries on the cost-effectiveness of space technology as a tool for improving infrastructures in developing countries.

Luckily, certain aspects of space technology can be acquired and developed on a small scale by focusing on the use of micro-satellites. This can also allow the richer countries to focus on the power and launch sectors of the industry whilst poorer nations focus on pay loads and application of the technologies. Having decided to develop an indigenous capability to build and operate space-borne remote sensing hardware, several newly industrialising countries (NIC) have adopted this strategy and they appear to have scored some success to date.

12. NATIONAL POSTURE

If indeed space technology is beneficial for developing countries, what has been the effort of our local scientists? Where are we in Nigeria? Where do we want to be and how do we get there?

The first thing is to consciously establish major principles, objectives, and guidelines for the Nigerian space activities. One of the most effective ways of doing this is to prepare a national policy statement or document for the development of space activities and there is the need to establish an organ for the realisation of the policy objectives. In simple terms, we need both a national policy document and a space agency. Whilst work has been virtually completed on the former there is to my knowledge no concrete plan afoot to establish a Nigerian Space Agency. Such an agency will be responsible for the establishment and support of programs in major areas like:

* Space application; (mostly RS activities)
* Satellites and payloads
* Satellite launching vehicles and sounding rockets
* Space infrastructure
* Space sciences
* Research and development on space technologies
* Training and development of human resources
* Development support for a national space industry

Such a space agency should not be expected to directly execute all these programs. Instead its role should be mainly that of a midwife using ail the human and material resources available within the country at its disposal. It is, for example, conceivable that such an organ will be more effective if it uses as much as possible, the facilities and resources within the higher institutions to execute its training and human resources program, whereas, in matters of space infrastructure, it might have to collaborate with both the private sector and multilateral organisations.

Even for the relatively ambitious program on satellites and payloads there are models of collaboration with foreign countries or institutions for the acquisition and internalisation of the skills that allow for indigenous participation in the space industry.

One of such models is the SSTL Technology Transfer Scheme of the University of Surrey, England that provides an affordable access to space for developing countries. The scheme involves the selection and training of client staff to enable participate in the design, construction, launch, and operation of a first microsatellite over a two year period whilst such trainees can in the next phase build another model of the same microsatellite by themselves in their own country. They receive both academic and technical training in the course of their programme and are able to operate ground stations and manage the orbital operation of the miccrosatellite once it is spaceborne. The initial set of engineers trained under sad) a programme can be expected to now form the nucleus of an indegeneous space industry. If properly executed such a scheme can:

(a) build indigeneous industrial and academic strengths.
(b) develop a nucleus of trained space scientists and engineers.
(c) launch and operate its first satellite and thereby
(d) demonstrate and explore small satellite applications
(e) progressively develop national capability and confidence by starting with microsatellites and gradually advancing to mini and large satellites.
(f) stimulate young people into science and technology and space.
(g) do all of the above at affordable cost and low risk.

Some of the emerging space nations that have benefited from such a scheme within the last

Table 3 List of Emerging Space Nations under the SSTL Scheme

Country	Period	Microsatellite
Malaysia	1996 - 98	TuingSat - 1
Singapore	1995 - 97	UoSAT - 12
Thailand	1995 - 97	TMSAT
Chile	1994 - 95	FA Sat - A & B
Portugal	1992 - 94	PoSAT - 1
South Korea	1989 - 93	KITSAT - 1 & 2
South Africa	1989 - 92	UoSAT - 3/4/5 (SUNSAT)
Pakistan	1984 - 88	BADR - 1 (BADR - B)

decade are listed below:

A second model for Transfer of Technology in space technology is provided by the China-Brazil Earth Resources Satellites (CBERS) programme featuring South-South collaboration. The programme, which started in 1988, involves the collaboration of China and Brazil in the development of two remote sensing (AEB, 1997) satellites designed for global coverage using optical cameras similar in characteristics to those of landsat and spot, flying on a polar sun-synchronous orbit and earring DCP Transponders. The first satellite CBERS 1 is due for launch in 1998 but both countries are already studying the possibility of extending the program to include two more satellites. Brazil is also considering flying an environmental data collection system to operate in Africa based on the Brazilian data collecting satellites (INPE, 1997). For this purpose it plans to fly the satellite SCO 3 on a circular equatorial orbit.

A third model, based on regional cooperation, is provided by NASDA (Saito, 1997). This provides tor cooperation between Japan and individual countries in the Asia-Pacific zone either on bilateral basis or under multilateral cooperation. The satellites belong to Japan but under bilateral cooperation, recipient countries are offered direct data reception, data analysis research cooperation, and, sometimes, they even jointly undertake pilot projects. In respect to the African Region, only South Africa and perhaps Egypt would be in a position to offer Nigeria such collaborative support.

Payload and Instrumentation

Choice of Payload and instrumentation are strongly influenced by mission objectives and application requirements, as illustrated in the table below:

Payload	Applications
High Resolution Camera	*Disaster managemernt. damage assessment *Urban planning * Agriculture and forestry * Coastal erosion
Hyperspectrial Images	* Sea and coastal pollution * Clorophyll monitory * Suspended sediment * Vegetation health sums
Infrared Radiometer (IR)	* Temperature mapping * Geology * Vegetation stress * Thermal imaging
Synthetic Aperture Radar (SAR)	* Surface movemeo: phrnomma; oil spill, earthquakes, volcanoes, landslides glacier surgessubsidence due to water or oil removal.

These payloads are, at the high performance and generally characterised by

- high spatial resolution
- high spectral resolution
- night and day operation
- short revisit time
- high flexibility in pointing and
- short time availability of data

There are however tradeoffs between resolution, grond coverage, data rate, and data storage volume. As pointed out by Glackin (Glackin 1997), there are developments under way to seriously downsize from large, complex, and expensive systems to focused missions on small satellites with multi-use systems and lower costs.

Local Research Effort in Transport and Ground Segments

Within the field of space technology, our effort at the University of Lagos was initially in the transport segment as we were interested in the flight performance characteristics of the launcher be it in the context of a rocket or a reusable aircraft. In particular, we tackled the problem of ascertaining and ordering the relative magnitude and effects of flow characteristics such as the skin friction or drag and the lift or pressure distribution over wings at supersonic speed or blunt bodies at hypersonic speed.

This was done in a series of publications (Ludford and Olunloyo, 1972a and b; Kapila, Ludford and Olunloyo, 1973; Olunloyo, 1973; Olunloyo, 1979a and b), over the period 1972 - 1981, and put to rest a lot of controversy that was needlessly retarding progress in this field at that time. The work was partly done in collaboration with my mentor and late Professor GSS Ludford of Cornell University contributed to the subsequent design, construction, and deployment of such vehicles.

Subsequently we moved into the allied area of data processing and informatics, starting with the establishment of the Nigeria Water Data Bank over the period 1977 - 1984. The Data Bank which was subsequently relocated to NIWR Kaduna was at that time the first attempt to establish a data bank of its type in Nigeria and perhaps in this sub-region as reflected in the references. Our work in this area led us into AI and robotics. This was a natural progression because if we study the development and ascent of the expert system as illustrated in the connotative view representation below:

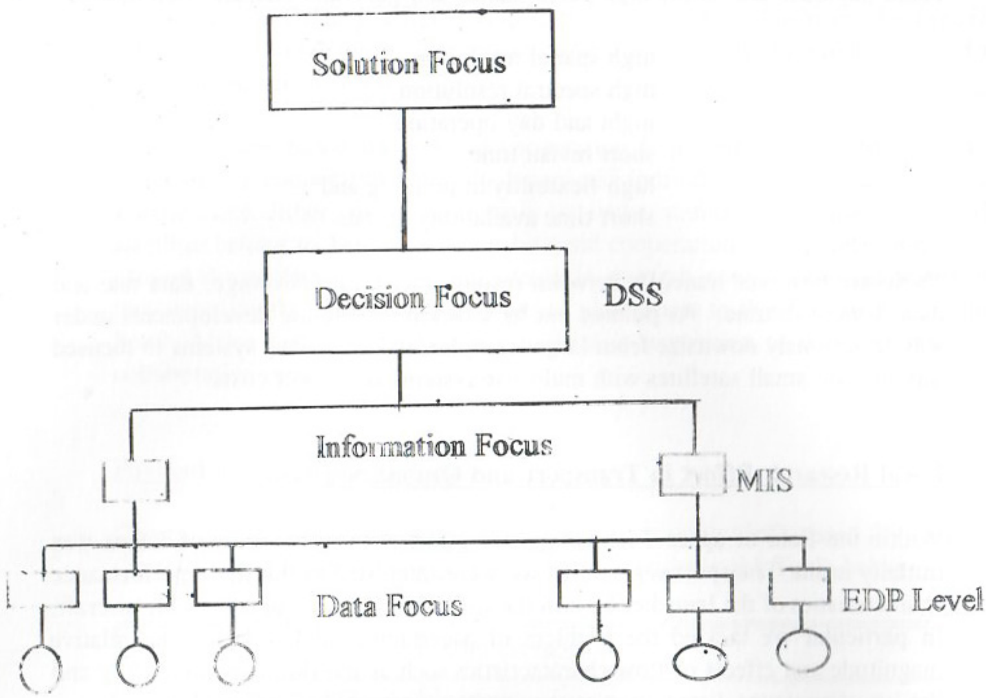

Fig 1: The Connotational View of IT

We will find an easy explanation for the evolution of the work and research interest at the EAU of the University of Lagos. Subsequently, Prof. Oye Ibidapo-Obe and one of his students, A. Alonge, veered into robotics and the design of bided mechanical (Ibidapo-Obey, Alonge and Badiru, 1995). In recent times he and his students have been responsive to the mood of the nation and are studying the design of decision support systems in strategic management environments. Some of our other students are interested in designing expert systems for managing essential services and utilities in a crisis environment such as what is now our traditional fuel crisis. We have also looked at neural computing in. the context of pattern recognition and interpretation of remotely sensed data (INPE 1997a and b). There is a strong remote sensing applications group in our Geography Department led by Prof Peter Adeniyi. He and his colleagues have been-responsible for generating a host of thematic maps that are so essential for our national socio-economic development programmes The Surveying Department of the Faculty of Engineering also fields a few experts in applied areas of geomatics and remote sensing applications. The work in "space, related technology is not limited to University of Lagos alone. In fact, there is a strong team at University of Ife spearheaded by Prof. Balogun of physics and Prof. Lere Ajayi of the Department of Electrical Engineering. Whilst Prof. Balogun is interested in the atmospheric physics aspects and meteorological applications of space-based systems, Prof. Ajayi is looking at radio signals and data transmission protocols. The same can be said of some of the space related research going on in some of our other institutions but the problem has been the inability to find an effective forum for peer interaction and the focusing of effort towards some clearly defined objectives.

Apart from the research effort at the universities, there is a National Centre for Remote sensing (NCRS) in Jos that is currently being operated as one of the development centres under the aegis of NASEM and the Federal Ministry of Science & Technology

NCRS is mandated among other things, to undertake research, development and production into:

(a) satellite remote sensing payload systems.
(b) satellite data ground receiving systems.

There are plans to establish and operate a satellite ground receiving station at NCRS capable of receiving data from a range of satellites. If such a facility can be fully established and equipped, then the centre will be in a position to meaningfully contribute to the development of the country.

The UN has selected University of Ife for the siting of the African Regional Centre for Space Science and Technology Education for capacity building for local expertise to build competence in the use of space systems and technologies. Whilst this is a beneficial thing, the lime has come when we need to put more emphasis on utilisation rather than the building of local expertise. As food for thought I discovered some three months ago that the UN office of Outer Space Activities has the names of over 40 Nigerian experts on its mailing list but the impact of such an expert manpower base is still to be felt around here.

I believe that one area where early success can be scored would be in the ground segment and especially in the context of value added products.

Whilst we are at this, the scientific community and professional engineers, in particular, should make the effort to popularise space studies and promote the formation of space clubs at the secondary and tertiary institutions. The Association of Consulting Engineers of Nigeria (ACEN), at its last annual general meeting, deliberated on this issue and is currently spearheading some initiatives to bring the importance of space technology into our national consciousness.(ACEN, 1997) It is surprising that one of the factors retarding the penetration of space technology is the lack of awareness among decision makers about space technology and its usefulness in the development of infrastructure and the achievement of sustainable development.

The planetarium can always be a veritable tool in the public enlightenment and popularisation drive. Prof. Emovon of Sheda Science and Technology Complex (SHESTCO), I am told, is working hard on making one such planetarium available in the science museum before the new millennium arrives. There is need to have such facilities in our major universities. We also need to review the curriculum at such institutions to reflect the fact that space technology is here to stay for some time. Space studies should, therefore, be adequately reflected in the Physical Science, Engineering and Law degree programmes.

13 CONCLUSION

In conclusion, we have reviewed the dramatic ascent of space technology in the 20th century. We found that it was initially propelled by the East-West ideological conflict but, given its dual nature, it did not suffer significant setback at the end of the cold war but metamorphosed into the mechanism for conversion from a defence to a peace economy. Driven by advances in telecommunications, material science, and artificial intelligence, space technology appears destined to remain with us for some time and would marginalise those who would not give ii its due.

Given such a scenario, suggestions are made as to how the country could enter the space race at an affordable cost and with minimal risk. In this regard the ground segment and the value added products offer a safe starting points whilst the space segment can be progressively attacked in a calculated and affordable fashion. For this to happen, the educational curriculum will have to be received to reflect the new realities of our times, the professional bodies will need to be more aggressive in educating the public as to the importance of the emerging technology, and the decision makers must be made to understand and appreciate the promise this technology has for our dreams of sustainable development.

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