



## **4<sup>th</sup> IAA African Regional Conference**

***Equatorial Plane: Attributes and Characteristics***

**30<sup>TH</sup> NOV – 2<sup>nd</sup> Dec., 2010**

**Sheraton Hotel Abuja, Nigeria**

**NASRDA/IAA**

**Report on Various Sessions**



**Day 1: Tuesday November 24, 2010**

**Session 01: Welcome and Opening**

**Session type: PLENARY**

**Chairperson: Femi Olayisade (Representative Hon. Minister of Science & Technology)**

**Rapporteur: Babatunde Rabiun and Bola R. Abdulrahim**

**Attendance: 145**

The session kicked off at exactly 9:50 am with the Nigerian National Anthem. The Moderator introduced the guests who were already seated on the high table and welcomed all participants to the Conference

**Welcome Address:** The Director General of NASRDA, Dr. S. O. Mohammed took over the podium at exactly 10:14 am to deliver a welcome speech. He recounted the success of the 3<sup>rd</sup> African Regional conference of IAA hosted exactly this time last year where burning issues concerning space development were discussed. He stressed the theme of this year's conference as another giant step by NASRDA to achieve her mandate and at the same time set pace for space development in our region.

**Welcome Address:** The Secretary General of IAA, Dr. Jean Michel Contant, gave the second welcome address on behalf of IAA. The presentation gave excellent review and analysis of 50 years of IAA activities in space for the past. In his presentation, he narrated the beginning of space activities, and highlighted major contributions to space development and missions that have taken place since the beginning of space age. The Journal of IAA, Acta Astronautica, first issued in 1955 was introduced to the public. IAA was established in 1960. His address highlighted the early pioneers of space research/exploration with affiliation to IAA and their notable achievements. The presentation gave excellent review of activities of IAA. It was a good exposition on IAA and offers a listener an invitation to join IAA

## **Keynote Address**

Professor E. E. Balogun presented the keynote address. In his address, he gave the analysis of the symposium's aim stressing that international cooperation should go beyond international trade, not even one-sided, but should be exchange of knowledge and ideas. He appealed to the government to encourage participation of local talents. He submitted that technology cannot be easily transferred but can be acquired.

## **Ministerial Address and Official Opening of Conference/Exhibition**

The ministerial address was delivered by Mr. Femi Olayisade, Permanent Secretary, Federal ministry of science and Technology who represented the Hon. Minister of the FMST, Professor Abubakar Ka'oje. The Honourable Minister outlined the huge gains and advantages from space exploration including its spin-offs benefits which have so much deeply integrated space technology into everyday life. He reinstated the fact that Nigerian Government has made it a matter of policy to make space technology a vital ingredient of her national development agenda and has been committing a substantial portion of national resources as a result of which two satellites namely: Nigeriasat-2 and Nigeriasat-X will be launched into space in the first quarter of 2011. He expressed his satisfaction with aptness of the theme of the symposium which is intended to further strengthen and also create a dynamic space industry in Africa. In conclusion, he reaffirmed his confidence in the symposium's choice of sub-themes which he believed will generate high level discourse that would lead to recommendations that will enable countries along the equatorial strip to identify the niche areas on which we could leverage our strengths and maximize derivable benefits for the development of Africa and the global space community. On this note he declared the conference open at exactly 11:07 am.

## **Goodwill Message**

Professor Ibidapo Obe, the President of the Nigerian Academy of Science, gave a goodwill message where he expressed his pleasure to be part of the symposium. He acknowledged all the works done so far in the development of space technology development and while congratulating Nigerians and IAA for the success recorded so far.

## **Closing Remark**

Dr Adigun Ade Abiodun gave a brief 'closing remark'. In his address, he gave reasons why the theme of this Symposium is timely. He emphasized that the needs for the nations around equatorial belt to engage in development of satellite technology around the equatorial plane as against traditional preference of polar orbits. He also encouraged that negotiation with international community should be a give and take affair, not buying technologies from abroad.

**Day 1:****Session type: plenary****Chairperson: Dr. Jean Michel Contant, Secretary General IIA****Rapporteur: Dr. Olakunle Oladosu (Nigeria)****Attendance: 88**

The session which focused mainly on learning from the experience of other countries and space-related entities kicked off at exactly 12:05 pm. Together for this session only three papers were presented although four was slated for presentation. One of the presenters was not available. The under listed were the papers taken for the plenary session.

**PRESENTATION 1*****Title: “Razaksat: Malaysia’s Journey to the Near Equatorial Orbit and Beyond”*****Presenter: Ahmed Sabirin Arshad (Malaysia)**

**Summary:** The presentation focused more on the experience, activities and future projection of Malaysia space activities. He narrated the experience of Malaysia in the launch of Equatorial orbit satellites which dated back from 1995 to date. Apart from focus on the design of satellite, he emphasized the need to addressing the usefulness of satellites to human such as, disaster management, security etc. He further talked on the future projection of Malaysia to include the launch of RasahSAT-2; COMSAT which are due for launch at the equatorial orbit. The presenter did not fail to show some imageries of RasahSAT – a near equatorial orbit satellite that was launch on 14 July 2009. Apart from the success stories highlighted by the presenter, he made mention of some of the challenges of near equatorial orbit satellite to include launch delay for years, the status quo polar orbit satellite problem and non participation of local vendor. He mentioned the need for the establishment of off-spin programmes and mission control centre for space programme sustainability. The experience of Malaysia regarding the rival between politics and technology which has resulted in the lack of a unified space policy was also emphasized.

**PRESENTATION 2****Title: Low Earth Equatorial Orbits as an Emerging Low Altitude Earth Observation Solution****Presenter: Stephen Wokes (SSTL, UK)**

**Summary:** The second presentation by Stephen of SSTL, UK started by introduction of SSTL as a satellite based company in the United Kingdom. He gave a good account of the company to

have in orbit at present 34 satellites and by 2011 the company plans to have about 35-40 satellites. The satellites were low earth orbit satellites at an altitude of 680 km and orbits the earth every 1hr 45 mins. The presenter listed the services offered by the company to include amongst other things to include pipeline monitoring; Deforestation; earth quake prediction; natural disaster management and assessment; maritime services and security. He mentioned the need to take into cognizance radiation, power generation, altitude determination and control in satellite design systems. He concluded by stating that the low earth equatorial orbit offers unique opportunities to both countries near the equator and the wider scientific/earth observation community.

### **PRESENTATION 3**

**Title: Comparison of Ground Station Networks from an Equatorial View Angle**

**Presenter: Martin Krynitz (Sweden)**

**Summary:** The presenter talked about PrioraNET, the world's largest commercial network of Ground stations that combines equatorial and polar ground stations. The presentation explained that the equator does not have a big advantage other than being close and that the latency time is better.. He mentioned that launching satellite at 20 degree inclination is ideal but that at 40 degree is good but not ideal. He further stressed some of the requirements needed for a ground station to be located in West Africa. He identified the necessity for improved funding for space development and more importantly pointed out the need for space programme to be run as business venture other than sole reliance on government funding.

#### **Conclusion**

The session plenary was concluded at about 1:30 pm with two questions by the participant and the questions were responded to by the presenters to the satisfaction of the delegates.

**Question 1 (Dr. Adigun Abiodun, Nigeria):** Where was the LEO Concept at the time Nigeria was launching the NigSat-1 and NigSat-2 due for launch at time from now?

**Response:** The question was responded to by saying the issue of NigSat-1 and NigSat-2 has to be looked into absolutely from a "Business concept" angle.

**Question 2 (Dr. Jared Ndeda, Kenya):** The delegates asked the presenter to shed more light on the "Innovative selection of near orbit satellite"

**Response:** The responder said the reference to innovation in this context dated back to about 10 year ago.

**Day 1: Tuesday November 30, 2010**

**Session 03**

**Session Type: Plenary**

**Focus: Learning from the experience of other countries and space-related entities**

**Chairperson: Dr. G.Agbaje**

**Rapporteur: Abdulrahim R.Bola**

**Attendance: 67**

### **Presentation 1**

**Title: Capability building, partnership and development: analysis of the space activities of equatorial countries**

**Presenter: Danielle Wood (USA)**

The paper offers three analyses that provide perspective on the space activities of equatorial countries as follows:

1. Consideration of all equatorial countries to understand their involvement in space related activities. Here an original frame work to observe equatorial space activity using quantitative measurement was used and this analysis provides broad perspective on the contributions of equatorial countries to international space activities.
2. The analysis focuses on equatorial countries in Africa considering many examples of satellite enabled activities in which equatorial African countries have participated
3. The third analysis considers issues faced by equatorial countries that are investing in local technical capability for satellite technology.

### **Presentation 3**

**Title: Systematic approach to Design Small Satellite for Specific Earth Observation Tasks**

**Presenter: Rainer Sandau**

The paper gave an insight to some facts about small satellites and the importance giving a systematic approach to designing a small satellite for a specific earth observation tasks using a micro satellite (BIRD BI-spectral infra Red Detection) as a specialized payload used to describe a possible approach for detection and quantitative characterization of high temperature events as example.

The presenter advocated for more use of small satellite giving the following as their advantages.

- More frequent mission opportunities and therefore faster return of science for application data

- Larger variety of missions and therefore also greater diversification of potential users
  - More rapid expansion of the technical/scientific knowledge base
  - Greater involvement of local and small industries
  - Several contemporary trends all supported small satellite missions were given as
    - I. Advances in electronic miniaturization and associated performance capability but also improvement in such diverse fields of technology as optics, mechanics, signal processing, communication navigation, etc
    - II. The recent appearance and market of new small launchers through the use of modified military missiles to launch small satellites
    - III. Transition from large science missions equipped and synergistically working multi instrument payloads to operational missions focusing on specific tasks.
    - IV. Ongoing reduction in mission complexity as well as in those cost associated with management with meeting safety regulations.
    - V. The development of small groundstation network connected with rapidity regulations.
    - VI. The development of small groundstation network connected with rapid and cost effective data distributed method
    - VII. Operational responsive space : a new paradigm in space flight missions to enable quick response on actual events like disasters
  - The paper also stressed the fact that small satellites provide unique opportunities for affordable constellation while both spatial and spectral resolutions are increasing
- conclusion.
- The presenter concluded there is need to pursue small can satellites because the smaller the satellite the smaller the cost and this can be achieved through difference approaches.

#### **Presentation 4**

**Title: Comparative design of attitude stabilization and control schemes for space vehicle in equatorial orbit**

**Presenter: Adetoro M.A. Lanre**

The paper presented various wheels configurations for three axes active attitude control systems as well as their attitude control strategies used nominally for controlling the orientation of various telecommunication satellites in Geo and active control strategy using frequency domain approach was implemented.

A study of the spacecraft dynamics and behavior based on the Euler linearized equations of motion was done and the implementation of the pitch and roll/yaw control architectures using their respective mathematical models was also done. It was shown in the study that via tuning the control gain values, the pointing errors can be minimized for all the wheels configurations,

comprising of the type a, type b, c and d. the responses of the attitude control obtained from the feedback systems on different wheel configurations show that good pointing accuracies can be accomplished with dedicated attitude controllers, however with varying performances. For the control synthesis, the presenter used the mass properties, payload requirements, configurations and control system parameters similar to Nigeria communication satellite (NigComSat).

1. From the comparative study done on the different types of wheel configurations, it is shown that type c can withstand much lower structural frequencies than type a and type b. the time response for type c and type d are found to be nearly the same. The stability margin of type d was however found to be different from type c because of the added stiffness due to momentum wheel. The stability of type a was found to be very sensitive to structural resonance due to thruster activities.
2. It was concluded that a good pointing accuracy can be achieved with configuration of NigComSat I where the mass properties principle axis has the relation  $I_x > I_z > I_y$ . The roll attitudinal with the yaw control (type b) has the least pointing accuracy especially in yaw axis and this indicates that yaw attitude has poor pointing accuracy with the existing of the solar radiation disturbance.

Recommendation:

It was recommended that a more complex filtering design technique as implemented on NigComSat should be done to estimate yaw error if the external disturbances need to be rejected.

## **Presentation 5**

**Title: Analysis of common causes of satellite failure in orbit**

**Presenter: Odimayomi P.K**

The paper presented an analysis of common trends in satellite failure, classifying the failure based on the particular subsystem from which the failure is originated. The study was done for failures over a period of sixteen years and the result shows that the satellite failure picked in 2006 which coincides with the solar minimum. The paper also provides the analysis of some top level checks on the satellite subsystem which are:

- I. Determination of failure mode
- II. Determination of propagation of faults that might lead to a single point failure
- III. Evaluation of system level redundancy to determine if the design is adequate to tolerate a credible single point failure
- IV. An overall impact of the failure on the mission was also verified i.e what will be the state of the mission after the failure.

Major causes of satellite failure were analyzed according to each subsystem of the satellite and it was observed more failures were from the power A&OC and payload subsystems respectively.

### Recommendation

The presenter recommended that satellite designers should pay critical attention to the subsystem responsible for the highest number of failures in the period under review to increase system reliability.

### Presentation 6

**Title: Validating the Auroral zone lower ionosphere model**

Presenter: Michael Afful

This paper is a project aimed at validating a recently developed empirical model for the lower ionosphere in the auroral zone to predict electron densities in the D-region and at the same time compare other existing models that are designed for the same purpose. The presenter gave a general overview of the ionosphere with different layers existing models like the international reference ionosphere (IRI) model only provides mean values whereas actual values deviate due to larger day to day variation and it does not take into account any irregularities in the ionosphere.

The FIRI model developed for IRI using electron density data based on Faraday rotation experiment. Here the data used for its establishment are restricted to result from rocket –Bourne sounding with onboard radio waves propagation experiment.

The work introduced and substantiates the new auroral zone lower ionosphere model compare with other existing models and real data while providing some guidance on its performance and the need for improvements. The model integrated successfully an approach to NNs for the development an empirical lower auroral ionospheric model and the result existing models and hence absorption levels could be predicted using IMAZ .The paper conclude that IMAZ has the capability to predict electron density profiles that reproduced the absorption they are meant to represent however, the electron density is not allowed to decreased with increasing.

### **Recommendation:**

Although the results as presented in the paper show that IMAZ predict accurately the lower ionosphere and further improvement has been reported for the extend IMAZ , the model would benefit from the significant upgrade that could be achieved through the investigation of additional high quality data.

### Questions and Answers



At the end of the presentations, questions were raised on some of the topics presented and they are as follows.

Question 1:

Considering meteoroids, what do you think is the ideal inclination of a satellite in the equatorial plane?

Response:( Adetoro Lanre; Nigeria): What usually drive the inclination of a satellite is the satellite mission and that is why series of test is done before launch.

Question 2:

Is there room for correcting the mistakes done in the past as presented by Danielle Wood ?

Response:(Dr. Adigun Ade Abiodun; Nigeria):Anybody that has work should try as much as possible to check for mistakes and get necessary correction done

Comment :Prof. J. O. Adeniyi commented that participation of the local people should be looked into instead of focusing on the mistakes alone.

Question 3:

- i. Are the failures recorded in satellite operations over the years in geostationary Orbit or Low Earth Orbit?
- ii. Why did Nigcomsat 1 Failed?

Response; (Odimayomi P.K):

- i. The failures recorded were not particular to a particular orbit.
- ii. Expected temperature appendage is about  $60^{\circ}\text{c}$  but unfortunately rose to  $2000^{\circ}\text{c}$  which could be as a result of solar activities and there is a probability that the satellite was hit by solar debris.

Question 4:

Is there any statistical performance to describe the IMAZ model?

Response: absorption method was used and 75% accuracy was gotten which makes the IMAZ model better.

**Day 2: 1<sup>st</sup> December 2, 2010**

**Session 04:**

**Session Type: Plenary**

**Focus: Space exploration and utilization – Overcoming the challenges within the equatorial plane and along each of its orbits**

**Chairperson: Dr J. O. Akinyede**

**Rapporteur: Abdulrahim Bola**

**Attendance: 81**

### **Presentation 1**

**Title: Studies Involving Attributes and characteristics of the Equatorial Plane Over Nigeria.**

**Presenter: Okeke F.N**

The paper presented explicitly past works relating to the attributes and characteristics of the equatorial plane over Nigeria. In this study, the presenter outlined the previous works carried out the geomagnetic storms, solar flares, electron density, solar coronal mass ejections and equatorial electrojet that have contributed to changes in the outer space environment most especially in the equatorial plane. It was latter shown that all these characteristics has different effects at different latitudes which spew large plasma densities into the equatorial plane more than any latitude, thereby creating a new space environment.

Recommendation:

More Future work is suggested in order to throw more light on simplifying the complexity and effects on space weather.

### **Presentation 2**

**Title: Comparative Study of the Responses of Equatorial and Auroral Ionospheres to the Geomagnetic Storm of April 5<sup>th</sup> -7<sup>th</sup> 2010 Using GPS Measurement.**

**Presenter: Fasunwon Olusola**

The paper investigated the response of the equatorial and Aurora ionosphere for the first storm of this solar cycle making use of the GPS measurements obtained from a number of IGS equatorial stations. The variability of the total electron content TEC with time as storm occurs were critically analyzed to deduce the response of the ionosphere to the storm event and the behavior of the equatorial ionosphere which was later compared with that of the ionosphere at mid and high latitudes. The result of the work shows that there is TEC enhancement at the storm onset

which was on the 5<sup>th</sup> of April; the main storm was experienced on the 6<sup>th</sup> while the recovery phase was on the 7<sup>th</sup> of April 2010 respectively. From the results, conclusions were drawn as follows

- There are more electron content over equatorial latitudes than auroral latitudes
- There is enhancement at the storm onset which could probably be due to additional injection of charged particles into the ionosphere which accompany the commencement of the storm
- Also there is redistribution of electron content during geomagnetic storms which depends on latitudes and there is latitudinal gradient on ionospheric response to magnetic storms.

### **Presentation 3**

**Title: Equatorial Launch Sites: Untapped Resources in Africa**

**Presenter: Oludare Mabogunje**

The paper described explicitly the potential and opportunities abound in the use of the equator by nations located and the earth equator in African or near it. The untapped resources will contribute immensely to the growth and development of Africa thereby leading to the creation of job and industries. One of the opportunities nations near or on the equator has is that the experience the quickest rate of the sunrise and sunset in the world and the potential sites in African were given to have Broad launch site angles north, west ,east and maximum earth speed.

The presenter analyzed the launch site specification at various latitudes and the conclusion was drawn that African with northern and southern poles enrichment could take advantage of any of the launch site options analyzed in the paper as a common African resource. Also applying all the numerical values of the launch parameters, a comparative analysis of equatorial launch site among nations on the equatorial plane shows the benefits of the equatorial launch site.

### **Presentation 4**

**Title: 2006 eclipse in West African: an opportunity for outreach programs in Ghana**

**Presenter: Nana Browne (Ghana)**

The presenter recalled the 2006 total solar eclipse which occurred on the 29 of March 2006 seen by Ghana, Togo, Benin, and Nigeria which gathered tourist and scientist at various part of the world, and at the same time raised various controversy, superstitions and debates especially in African.

The study used the opportunity of the reality of 2006 eclipse to organize an outreach program for school children in Ghana where they were encouraged to identify meaningful importance of the

sun to human in particular and life in general. The result of which has left challenging questions in the mind of the children making them to strive for more knowledge in the solar systems leading to the studies in astronomy and science in general.

Recommendation:

The presenter recommended the following:

- Science should be taught with interesting exercise and simple experiments
- International institutions should organize courses for trainers/teachers
- Outreach program should be carried out at basic level to build interest of girls early enough before the choice their field of interest.
- People in position should reach out to the young ones.

#### QUESTIONS AND ANSWERS

1. How do you answer all the questions listed in your outreach program  
Answer: Nana Browne – most of the answers were answered by performing simple experiment like scattering of lights because most of the question have to do with light and absorption.
2. Did you process the actual GPS data  
Answer: Olusola Fasunwon- the data were processed directly using developed software
3. Are there cases were a decrease in atmospheric TEC is observed during a geomagnetic storm.  
Answer: Olusola Fasunwon- there are reduced electron content in the aurora region.
4. Do you have limited computer resources and what can you do to mitigate against geomagnetic storm at the low altitude countries.  
Answer: Olusola Fasunwon- They are natural resources that is why the study of space weather is necessary and switch off your equipment whenever there is alert.

**Day 2: Wednesday 01-12-2010,**

**Session 05**

**Session Type: Plenary**

***Focus: Space Exploration and Utilization – Overcoming the Challenges within the Equatorial Plane and along each of its Orbit.***

***Chairperson: Martin Krynitz (Sweden)***

***Rapporteur: Olu Bolade C. (Nigeria)***

***Attendance: 78***

Papers presented are:

**1. Paper 1: April and August 2010 Magnetic Storm Effects on the Ionosphere over Ilorin, Nigeria. Prof. J. O. Adeniyi (Nigeria)**

The paper studied a typical Equatorial Station

Instrument used: transmitting antenna, receiving antennae and recording system.

Three receiving stations for movement of ionization discussed.

\*On the ionospheric parameters used, four (4) parameters were identified:

- NmF2: Peak electron density of the F2 layer
- hmF2: The height of the peak electron density
- BO: The thickness Parameter of the layer
- V: Ionization Drift Velocity

**2. Paper 2: *Impact of Space Weather and Solar Forcing on Climate Change in Low Latitude-C.F.Talabi and Rabiu A.B***

The paper examines and evaluates the degree of impact of Space Weather as well as Solar forcing on climate change using various climatic parameters measured in Equatorial Planes in Nigeria.

The amount of energy striking the earth from the sun is the main driver of weather and Climate.

Temperature differences from day to night and from season to season are consequences of the intensity of sunlight falling into the surface and into the earth's atmosphere.

The paper employed the monthly meteorological data of relative humidity, minimum and maximum temperature, average temperature, rainfall, solar radiation, wind speed and evaporation achieved at Nigerian Meteorological Agency between 1979 to 2005.

Correlation coefficients between the various metrological variables and Space variables of each of the synoptic stations were evaluated. Modeling of the meteorological variable using space weather variables was done using a Multivariate Linear Model, and Empirical coefficients determined by applying least square fittings.

The synoptic stations considered in this paper are Ibadan Calabar, Minna, Maiduguri and Yola. The models show the effect of solar forcing on the climatic parameters at different locations.

***\*Paper 3: On the Numerical Harmonic Analysis of selected Geomagnetic and Ionospheric Variables at Low Latitude K. S. Oluyo (Nigeria)***

The paper studied:

- Variability as a common feature of physical parameters
- Geomagnetic parameters as physical data
- Ionospheric parameters as physical data
- Numeric harmonic analysis as used to decompose data

Many researchers and experts showed a high degree of interest in variations of physical data.

Some fields that use Harmonic Analysis extensively are:

- Signal Processing
- Medical Imaging
- Quantum Mechanics and
- Acoustics

Harmonic Analysis key areas: Fourier analysis, Complex analysis, Number theory etc.

Harmonic Function:

- It is broadly understood as the study of decomposition of functions and operators into their basic constituents
- In Physics and Engineering, harmonic functions are called potential functions.

The Literature Review reveals the computation and study of Fourier Series as harmonic analysis and is extremely useful as a way to break up an arbitrary periodic function into a set of simple

terms that can be plugged in, solved individually, and recombine to obtain the solution to the original problem or an approximation to it, to whatever accuracy is desired or practical.

What the paper contribute to knowledge:

\*It shows that physical data (e.g. ionospheric and geomagnetic data) which show observed variation.

**Paper 4: Analytical Computation and Simulation of Perturbed Geostationary Orbits Initially Located at the Equatorial Plane of the Earth. Author: Ogundele D. A, Odimayomi P. K, Akoma Henry E. C. A, Ovie EseOgene.**

\*This paper analyses, in detail, the various *perturbation forces* that tend to shift a geostationary satellite initially located at the equatorial plane of the earth.

\*The effects of *three major perturbation forces* such as non-homogeneity of the earth, third body perturbation and solar radiation pressure on geostationary satellite were studied through the simulation.

\*The paper also studied the gravitational attraction of the earth as the principal force determining the orbits of Earth Satellites. This also applies to all earth satellites whether they are in low or high orbits, in circular or eccentric orbits and whatever their period of revolution.

The main characteristic of the geostationary orbit is its period of revolution, which is equal to the period of rotation of the earth, over an altitude of 35,786 km above the equator. Its inclinations are null or close to null and the eccentricity too is very small or zero.

The geostationary orbit characterizes a mission where it is important to keep the satellite fixed in apparent position relative to the earth. In practice, once the satellite is operational in the geostationary orbit it is affected by a variety of perturbations that must be compensated by frequent station-keeping maneuvers using onboard thrusters. Perturbation forces tend to change the position of geostationary satellite in orbit.

The paper established that the earth globe is not a perfect sphere, neither is its mass distribution homogeneous. These facts produce perturbing accelerations on the moving body. This is evident in the simulation of the effects of non-homogeneity of the earth where it was discovered that any small drift of satellite will affect its nominal position.

The simulation results show that the higher the effects of gravitational force of the sun and the moon the higher the inclination, and that solar radiation pressure changes the eccentricity of a GEO satellite initially positioned at a particular mean longitude.

## **Discussion Session**

**Question1:** Eze Chinedu (Centre for Remote Sensing, Jos) : “What is Orbital decay?”

**Response:** Ogundele D. A. – Orbital decay is the decrease in altitude of a satellite which might be caused by perturbation.

**Question2:** Dr. Charles U. (CSTP-Lagos) “.....if data obey conditions which qualify to be represented by Fourier series.....justify”

**Response:** Oluyo K.S. – The conditions in question is the Divichlet Conditions. Most data which exhibit spatiotemporal variation do obey this condition as they are characterized by points of discontinuity among others.

## **Day 2**

**Wednesday December 01, 2010**

**Session 06: space exploration and utilization – *Overcoming the challenges within the equatorial plane and along each of its orbits***

**Session type:** PLENARY

**Chairperson:** Ahmed Sabirin Arshad (Malaysia)

**Rapporteur:** Adia S.O (Nigeria)

**Attendance:** 63

The session kicked off at exactly 2:10 pm.

## **PRESENTATION 1**

**Title:** Longitudinal structure in the characteristics of Equatorial Electrojet along African sector

**Presenter:** Rabi, A.B and Yumoto K.

**Summary:** The presentation introduced the MAGDAS network across Africa; specifically data from four stations were used to study Equatorial Electro Jet along the equator. MAGDAS is the **Magnetic Data Acquisition System** and its principal investigation is Professor Kiyohumi Yumoto of the Space Environment Research Centre, Kyushu University, Japan. Stations used for the analysis were Ilorin, Lagos, Addis Abba and Nairobi. The presenter mentioned that the EEJ is an



intense current flowing eastward at within the strip  $\pm 3^\circ$  along the magnetic equator. Other current systems described are the aurora electrojet and the Sq (worldwide current) which is driven by solar radiation. MAGDAS instruments have been installed based on a chain network across the globe as we have the African meridian, Japanese meridian and the magnetic equator. The presenter made mention of a new MAGDAS station already installed in Abuja being hosted by the National Space Research and Development Agency. The results of the analysis showed that Sq value at Ilorin is greater than the Lagos station. The western EEJ appears to be weaker than eastern EEJ and the EEJ at the South American sector is stronger than the Indian sector which can be due to the thickness/width of the Jet. In recommendation the presenter proposed more establishment of ground based facilities before putting satellites in space.

### **Questions and Response**

**Prof. Adeniyi (Ilorin):** apart from latitudinal variation, is there a possibility of studying the longitudinal variation and are stations in Abuja, Ilorin and Lagos enough to study EEJ.

**Response:** The station in Lagos is off the electrojet, but there is a proposal for installation of more magnetometers across Africa and one to be installed in the country very soon.

## **PRESENTATION 2**

**Title:** Estimation of Ionospheric delay from GPS observables in the equatorial region

**Presenter:** Adia S.O, Rabi A. B. and Adeyewa Z. D

**Summary:** The paper tried to show the delay experienced by GPS signals propagated through the ionosphere. The presentation noted the various layers of the atmosphere, classifying the atmosphere into the upper and lower, mentioning that the GPS signals are delayed by the atmosphere. The ionosphere was considered as composing of charged particles that delay the signals from the satellites to ground based receivers. The delay experienced in the ionosphere depends on the total electron content along the path of the signal and the ionosphere is a dispersive medium with depends on the refractive index and the frequency of propagation. The presenter presented results from three IGS stations analyzed to estimate the ionospheric delay. Stations considered for the study are located at the equator (Cote d' Ivorie), high latitude (France) and low latitude (South Africa). Results presented from the study showed that the ionospheric delay is high at the equator relative to other geographical location low latitude and high latitude respectively. Also the maximum time delay is experienced at mid day within the hours of 1200 UT and 0300UT.

### **Comments and Response**

**Dr Dodo (Nigeria):** Processing of GPS data of the ionosphere can be done relative to the position of the GPS receiver i.e. taking in consideration receiver positioning parameters and also try to know the model used by most software that process GPS data to give TEC values.

**Response:** The software used to process the data to derive the vertical TEC data is valid for accurate values for TEC.

**Dr Adigun (Nigeria):** where is Nigeria effort in Space research?

**Response:** Nigeria is playing a critical role in space research. In terms of observational studies that we have functional facilities, but still South Africa has facilities more for space research studies. But Nigeria has human resources for space research and some serve as visiting professors to other universities in Africa, supervising masters and PhD programmes but there is need to encouragement. Nevertheless must facilities has come by donations and the space agency is making effort to solve the problem of setting up facilities, but the problems still faced is the power and internet access for help research.

### **PRESENTATION 3**

**Title:** Improving understanding of the African Equatorial ionosphere through focused space physics research supported by increased observations from ground-based instruments and equatorial space weather satellites.

**Presenter:** Ben Opperman (South Africa)

**Summary:** The presentation introduced the history of the South Africa space history since 1829 – 2010, where in 2010 the commencement of building a space weather satellite was initiated. South Africa has the policy of using geographical advantages for science research as mentioned by the presenter. The presenter tried to describe the geographical advantage of the equator making mention of the large population factor. The presenter further mention issues ascribed to equatorial anomaly and the equatorial electro jet. The ionosphere plume over USA in October 2003 was traced to Africa due to geomagnetic storm as mentioned by the presenter. Space physics research as stated by the presenter requires more ground based observational platforms such already available in South Africa are the GPS ionospheric scintillation monitor, GNSS antennas, and Total field magnetometer amongst others. The presenter made mention of the distribution of real time GPS receivers across Africa and magnetometers owned by the HMO. Also the presenter noted efforts of Africa collaboration with IGS, SCINDA and AFREF programmes. Also the installation of Africa array UNAVCO GNSS instruments was based on

short campaigns. Instruments such as Doppler radar for ground based space weather research can measure the sporadic E region of the ionosphere; imagingnometer images the D layer of the ionosphere other is the ionosonde. In conclusion the presenter established that satellite observations are good to compliment ground based instruments, noting some observations are only visible from space and concerns for this study are funding, internet access and political will amongst others.

### **Questions and Response**

**Dr Adigun (Nigeria):** what is the extent of collaboration within African continent particularly southern Africa with reference to space physics research?

**Response 1 by Ben Opperman:** there are already collaborations with HMO and institutions, particularly the training of students and after the students return to their institutions with space observing equipments. Two PhD Student one from Lagos, Nigeria and Zambia has returned to their countries with GPS receivers and with the SCINDA network HMO is linked with other research institutes.

**Response 2 by A. B. Rabi:** HMO has played a leading role in supporting the international cooperation within the African region with major attention on the south and eastern region sector of the continent, but also the western region of the continent still has benefited from these cooperation an example given is a graduate student who made a presentation during the symposium, presently studying at the HMO and other students from Nigeria.

### **Discussion session**

**Chairperson: Dr Adigun Abiodun (Nigeria)**

**Rapporteur: Adia S. O**

### **General comments**

**Dr Ben Opperman (South Africa):** the meeting was a great experience as the meeting provided a motivation to collaborate and partner.

### **Question**

**Dr Sias Mostert (South Africa):** How is pace weather activity in Nigeria been coordinated

### **Response**

**Dr Rabi A. B (Nigeria):** serve as the national coordinator of the international space weather initiative of UNOSA in Nigeria and on the international steering committee of ISWI. Various Nigerian scientists are involved in space research, as presently there are three functional magnetometers and an ionosonde at the university Ilorin and also 5 functional GPS receivers for

ionospheric studies over Nigeria in collaboration with Boston College USA. Data available from these equipments are used to study our atmosphere. NASRDA trying to consider the proposal for networking facilities across the nation and some of these data are made available to by permission from the donor institutions for use even as they are streamed through the internet to them, also permission has been received from some of these donors to establish a sun-network, which the space agency (NASRDA) is considering.

**Prof. Adeniyi (Nigeria):** Donors who give instruments from outside do have their plan. If we have a body that can encourage the coordination of these systems will be encouraged, having a backing from the space agency to at least take care of some of the cost on maintaining the equipments such as the power and internet access.

**Dr Agbaje (Nigeria):** the space agency (NASRDA) mandate is harness space related research in the country and the agency has assisted several universities in the country as regards to facilities in carry out projects and results of projects presented at international meetings. The agency will continue to make more effort in harness human resources from institution and facilitate projects.

### **Question**

**Dr Adigun Abiodun (Nigeria):** what should Nigeria, Africa learn from this meeting and recommendations for respective African Government.

### **Response**

**Dr Dodo (Nigeria):** 9 GPS stations have been established by the Office of the Surveyor General of the Federation, distributed across the country and these stations do stream data to Abuja, making use of solar panels to power them and using MTN internet facility for the internet access. But there is need for possible collaboration with the other five GPS stations meant for ionospheric studies. GPS data are raw and with these data more research can be carried out.

**Prof. Adeniyi (Nigeria):** the nine GPS stations are for geodetic purpose, but we are interested in the ionosphere, but how do we come together and coordinate is still the issue. Efforts should be made to ensure accessibility of the data and coordination of the facilities.

### **Question**

**Dr Adigun Abiodun (Nigeria):** what is the collaboration of the efforts of having these stations?

### **Response**

**Dr Agbaje (Nigeria):** NASRDA work is to facilitate and coordinate these activities and it has been operational. But if there are other places such related research is been carried out, approaching the space agency will help for collaboration. But data sharing is another issue, so there is the need for related research to be open if you what other people to be part and assist in the research. Nevertheless the space agency is the focal point for space research.

**Dr Agboola (Nigeria):** it's already noted that the office of the surveyor general has GPS stations, but there is the limitation for getting data. The office of the surveyor general has its objective for having those stations, but if the data can be stream to the space agency it will be good and useful for part of our objective. From this meeting, we are proposing that there should be the coordination of all equipments by one center. Also the issues of power and internet access are part of the issues to be resolved within the coordination.

### **Question**

**Dr Sias Mostert (South Africa):** How is the space weather mission we constructed in the Nigeria contest and who will be the driver?

### **Response**

**Mr Lawal Abdul (Nigeria):** like stated in last year's meeting (2009), still there is the need to come up with a short term, medium term and long term plan, to drive the road map for achieving our goals in space research.