Ghana Space Science and Technology Institute

(GSSTI)

GHANA SPACE
SCIENCE AND TECHNOLOGY
INSTITUTE

Annual report

2013/2014

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Executive Summary

The Ghana Space Science and Technology Institute (GSSTI) is committed to use space technology for national development. The application of space science and technology is seen in many sectors of the economy of Ghana. The year 2014 saw a number of research activities geared towards human development and other activities for infrastructure building. The Institute recorded ten publications and some technical reports to its credit.

1.0 INTRODUCTION

The Ghana Space Science and Technology Institute (GSSTI) was first established as a Centre under the School of Nuclear and Allied Sciences (SNAS) in January 2011 and launched in May 2012. It was later upgraded to an Institute in August 2013, to exploit space science and technology for socio-economic development of the country. This report gives the structure of GSSTI and details of work done at the Ghana Space Science and Technology Institute (GSSTI) from January to December 2014. The work done involves projects, research, seminars, workshops and training, etc. The report also highlights some of the challenges and points to some expectation for the next year.

2.0 MANAGEMENT BOARD MEMBERS

- Prof. F. K. Allotey (Institute of Mathematical Sciences) - Chairman
- Prof. Dickson Adomako (Ag. Director, GSSTI/GAEC) - Member
- Prof. E. H. K. Akaho (SNAS/GAEC) - Member
- Mrs. Margaret Ahiadeke (Head, Office of Legal Affairs, GAEC) - Member
- Mr. Daniel Acquah (Ghana Civil Aviation Authority) - Member
- Mr. Takie Yaboi (Ministry of Defence) - Member
- Mr. Yaw Nkasah (Ghana Meteorological Agency - Member
- Ms. Diana Djirackor (Administrator, GSSTI/GAEC) - Secretary

The Management Board has had one meeting (i.e. maiden meeting) since its inauguration in August 2013.

3.0 RESEARCH AND TECHNICAL COMMITTEE

The Institute's inability to hold a Management Board Meeting has delayed the decision on the adoption of the nominees for the GSSTI Research and Technical Committee. The recommended nominees are:

- Prof. E. H. K. Akaho (SNAS/GAEC) - Chairman
- Prof. Dickson Adomako (Ag. Director, GSSTI/GAEC) - Member
- Dr. P. K. Ashilevi (Deputy Director, GSSTI/GAEC) - Member
- Dr. G. Ofosu (Deputy Director, NNRI/GAEC) - Member
- Mr. Foster Mensah (Executive Director, CERSGIS, UG) - Member
- Dr. Mrs. Nana Ama Browne Klutse (Manager, RSGSCC, GSSTI/GAEC) - Member
- Mr. Christopher Nyakey (Manager, IESC, GSSTI/GAEC) - Manager
- Mr. Frederick Agyemang (Manager, SCDC, GSSTI/GAEC) - Member
- Mr. Eric Aggrey (Manager, RAAC, GSSTI/GAEC) - Secretary

4.0 ADMINISTRATIVE COMMITTEE

The Institute's Administrative Committee comprises the following staff members:

- Prof. Dickson Adomako (Ag. Director, GSSTI/GAEC) - Chairman
- Dr. P. K. Ashilevi (Ag. Deputy Director, GSSTI/GAEC) - Member
- Dr. Mrs. Nana A. B. Klutse (Manager, RSGCC, GSSTI/GAEC) - Manager
- Mr. Eric Aggrey (Manager, RAAC, GSSTI/GAEC) - Member
- Mr. Fredrick Agyemang (Manager, SCDC, GSSTI/GAEC) - Member
- Mr. Christopher Nyakey (Manager, IESC, GSSTI/GAEC) - Member
- Ms. Diana Djirackor (Administrator, GSSTI/GAEC) - Secretary

5.0 APPOINTMENTS AND TRANSFERS

5.1 Director

Professor Dickson Adomako assumed duty as the first Acting Director of the Ghana Space Science and Technology Institute (GSSTI) in August 2013 to date.

5.2 Acting Deputy Director

The Acting Deputy Director of the GSSTI is Dr. Prosper K. Ashilevi and he assumed duty in the current position in August 2013 to date.

5.3 Head of Administration

Ms. Diana Djirackor has been the Administrator of GSSTI since February 2014 after serving as a relief to the then Administrator, Mrs. Gifty Sika Nattey from 27th October, 2013 to 19th February 2014.

5.4 Head of Accounts Section

Ms. Evelyn Oppong is the current Accounting Officer of the Institute. She assumed duties as such when Mrs. Ruby Katah had changed jobs and ceased to be an Accounting Officer of the GSSTI in July 2014.

6.0 CENTRES AND MANAGERS OF GSSTI

6.1 Manager of Radio Astronomy and Astrophysics Centre:

The Radio Astronomy and Astrophysics Centre is being managed by Mr. Eric Aggrey, effective February 2014.

6.2 Manager of Remote Sensing, GIS and Climate Centre:

The Remote Sensing Centre is being headed by Dr. Mrs. Nana Ama Browne Klutse, effective February 2014.

6.3 Manager of Instrumentation and Engineering Services Centre:

Mr. Christopher Nyakey took office as the Manager of the Instrumentation and Engineering Services Centre effective February 2014.

6.4 Manager of Satellite Communication and Development Centre:

The Satellite Communication and Development Centre is being managed by Mr. Frederick Agyemang with effect from February 2014.

7.0 PROMOTION

So far, the staff members of the Institute have not enjoyed any promotions since its inception in August 2013. However, the four (4) Centre Managers listed above have gained their promotions by virtue of being made Managers from their basic status of Research Scientists and Technologist respectively.

8.0 HUMAN RESOURCES AND STAFF STRENGTH

The Institute is seriously understaffed. The current staff strength is twenty-four (23). Currently, the office building for the Institute is underway. As a result, the Institute's human resources are currently occupying three (3) offices and one (1) Lecture Theatre of the Faculty Block of the School of Nuclear and Allied Sciences (SNAS).

9.0 INTRODUCTION OF BIOMETRIC REGISTRATION TO GAEC/GSSTI

The biometric attendance clogging system was introduced to the Commission and GSSTI was no exception. The GSSTI staff were therefore encouraged to clog in and out of work on each working day. However, a Biometric Attendance Register was later introduced for the use of those staff who normally work outside the office location.

10.0 PROJECTS

1. SKA SA – GSSTI Ghana Radio Astronomy Programme Conversion of 32m-diameter antenna at Kutunse
2. Unmanned Aerial Vehicles (UAVs) Research and Development
3. Outreach programmes on Space Education and Awareness Programmes
4. University of Leeds – GSSTI collaboration on Training on Radio Astronomy with funding from the Royal Society UK
5. TWAS Individual Research Grant - Climate effect on food security: Space technology for precision agriculture
6. MENASAT Gulf Group PLC – GSSTI collaboration on Satellite Data Centre

11.0 RESEARCH

11.1 Astronomy and Astrophysics Center

A. Assessment of the state of fire safety at Kutunse Earth Station

The baseline for fire satefy at Nkutunse station needed to be established. An inspection has been carried out in this regard. This will allow the Ghana Radio Astronomy Project to factor in the need for additional fire safety measures based on new equipment and other sensitive facilities to be introduced. All the rooms at the Kutunse Earth Station was assessed for locations and working conditions of smoke detectors, fire hose, break glass, fire alarms and fire extinguishers. All the smoke detectors were tested to determine if they could trigger the fire alarm when exposed to excessive smoke, which is an indication of fire. All the smoke detectors and fire extinguishers as well as the emergency break glasses were mapped. Emergency exits were also mapped as well as fire hydrant.

B. Planning for the Conversion of the Kuntunse 32-m Telecommunication Antenna into a Very Long Baseline Interferometry-Capable Radio Telescope

African astronomers are building new telescope array of VLBI-capable radio astronomy stations by converting redundant satellite communication dishes for use in radio astronomy. It is in this regard that the 32m-telecommunication antenna at Kuntunse is being converted to a radio telescope. For a project of this magnitude, one needs to strategically plan before commencing such a project. The objective of this paper is to describe the preliminary steps taken towards the planning of this conversion as well as create guidelines for future conversions.

C. Centering of the 32-m Telecommunication Antenna at Kuntunse

The aim of this project is to give a step-by-step account of the centering of the telecommunication antenna at Kuntunse, Ghana, which has been marked for conversion into a radio astronomy telescope. It will also serve as user manual for future centering either as part of routine maintenance or future conversions.

D. Qualification of Telecommunication Antenna for Conversion to Radio Telescope: Assessment of Antenna Motion Control System.

Mechanical performance is one of the most important aspects of an antenna to perform as radio telescope. It is therefore intuitively obvious that the mechanics of a telecommunication antenna is one of the first things to check before embarking on conversion to a radio telescope. This work aims to present the mechanical assessment of the 32m-telecommunication antenna at Kuntunse to a radio telescope and will serve as guideline for future conversions.

E. Qualification of Telecommunication Antenna for Conversion to Radio Telescope: Assessment of rust.

It is obvious that the strength of the antenna structure is affected by rust. However, the extent of damage to the antenna structure is dependent on the rusted locations and the extent of rusting. Consequently, in conversion of redundant telecommunication antenna to radio telescope; it is almost intuitively obvious to first and foremost examine rusted parts of the structure and the extent of rusting. In this work, we present the assessment of rusting of the 32m Ghana antenna and its subsequent qualification as a possible candidate for conversion to a radio telescope. It is our hope that this research work will serve as a guide for future similar conversions.

F. FEA Model of the Ghana 32-m Antenna Structure: Alidade Structure and Elevation Assembly.

The Ghanaian 32m antenna structure situated at Kuntunse is being converted from a satellite tracking station to a radio astronomy telescope by SKA- South Africa. Performing successful Very Long Baseline Interferometry (VLBI) in radio astronomy requires very good antenna pointing accuracy. This part of the project investigates the flexural deformation of the 32m antenna structures due to its own weight and also obtains the translational displacements of a set of data points located on the main reflector panel surface as an output file. The output data from the finite element model (displaced data points) shall be further post processed and will indicate the pointing accuracy and RMS errors of the Ghana 32m antenna due to flexural deformation under 1g load.

11.2 Remote Sensing, GIS and Climate

A. Management of Coastal River Basins in Ghana: Hydrochemistry, Isotope Hydrology and Remote Sensing Approach.

The role nutrients play in the sustenance of both the hydrosphere and soil ecosystems are of great importance. Nutrient abundance may cause ecological problems such as eutrophication and hypoxia whiles its deficiency could affect productivity to a high extent leading to infertility,

stunted growth and possibly death of living organisms within the ecosystem. Nutrient fluctuations as a result of anthropogenic changes do influence the growth of algal blooms and species succession. Runoff and erosion from fertilized agricultural areas; river banks/beds, land clearing and sewage effluent are the major sources of phosphorus and nitrogen; which are the main contributors to eutrophication. This project therefore seeks to use remote sensing, hydro-chemical and isotope techniques to define and assess the magnitude and distribution of nutrient loads/losses and growth of algae bloom.

B. Climate modeling over Africa (West Africa and Southern Africa)

This project studies the climate dynamics of Africa. It specifically seeks to understand the key physical, chemical and biological processes that govern the climate over Africa using both global circulation models and regional climate models.

C. Climate impact assessment on health (Malaria and Diarrhoea) and gender

In this project, the extent of impact of climate on health and gender is assessed. The relationship between climate variability and malaria caseloads in Ghana has been reported by a few studies. Cerebrospinal Meningitis is a disease linked with humidity, rainfall, dry harmattan winds and dusty conditions. Diarrhoea is linked with rainfall and temperature. Dry weather condition increases dust in the atmosphere which may cause flus, sore throats, coughs; cold temperatures may cause rheumatism; floods or droughts may lead to increased spread of cholera, malaria, and diarrhoea; and low temperature, high humidity or high precipitation are strongly linked to eclampsia. Women face a lot of barriers culturally, educationally, politically, economically which limit their ability to cope with impact of climate change. In the advent of an extreme climatic condition, the mobility of women is greatly affected; vulnerability to short-term effect of climate change like floods, landslides, fires, etc. Men get drowned due to risk taken during floods and others. This project deals with the extent of the impact of climate on health and gender sensitivity in planning and implementation of climate strategies.

D. Urban Sprawl Analysis of Greater Accra Region

Urban sprawl has become one of the major threats to sustainable development of our time. This notwithstanding is not given the needed attention by authorities to curb this menace. It is against this backdrop that this project was carried out. The project considered the changes in the land cover that has happened between the period of 1985 and 2014 in the Greater Accra Region; and, how the urban lands, particularly, changed during that period, using the techniques of Remote Sensing and Geographical Information System (GIS).

11.3 Electronics and Instrumentation

A. Effective 2.4 Design and Construction of a Cost GHz Omnidirectional Wi-Fi Compatible Antenna

Antennas are devices for sending and receiving radio waves. In other words, they are metallic pieces of equipment of variable shape, used in sending and receiving radio signals. They come in different type of sizes and design techniques, based on the purpose for which they were designed to operate, either omnidirectional or directional. Changing trends in telecommunication technology such as Wireless Fidelity (Wi-Fi) has brought in its wake various designs and construction of antennas for the purpose of transmitting and receiving electromagnetic signals. Though these antennas are very useful or play vital roles in this field, most of the designs we have on commercial basis, such as the omnidirectional types come with complex design technique and are very expensive. It became relevant therefore to design a cost effective model with simple materials found in our locality to be compatible with the Wi-Fi 2.4 GHz (IEEE 802.11) technology, the type available on School of Nuclear and Allied Sciences (SNAS) Campus. Our omnidirectional antenna will be primarily designed to practically detect and extend the signal range of the 2.4 GHz Wi-Fi (IEEE 802.11g) for Wireless Local Area Network (WLAN) technology of the HOTSPOT Access Point (AP) of AFRANEST on SNAS campus which has limited range of about 30 m and also stationary.

11.4 The Satellite Communication and Development Centre

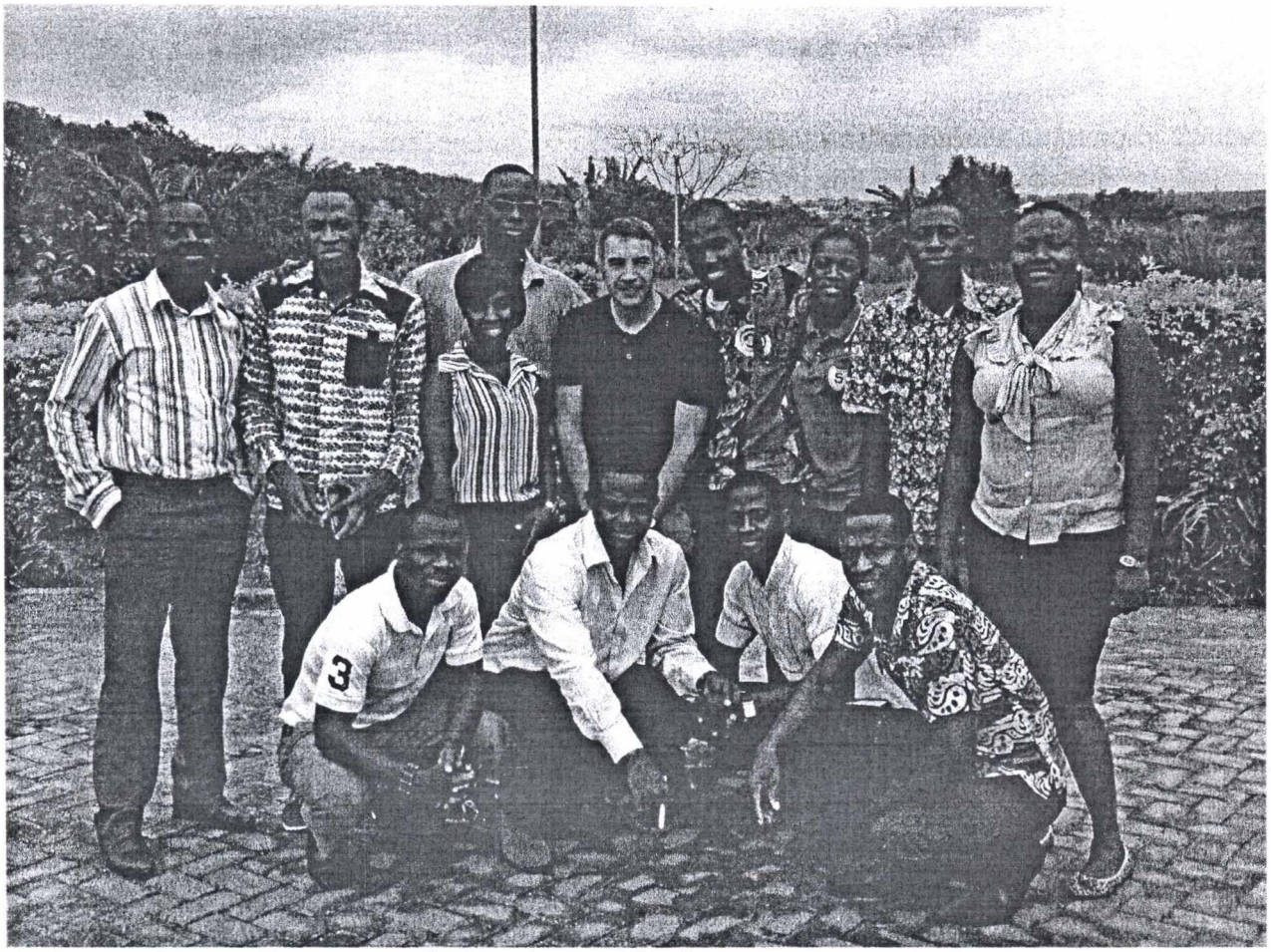
A. UAV design, construction, systems control, training and application

The Unmanned Aerial Vehicle (UAV) acquired by the GSSTI is to undertake a number of commercial and research activities. Areas of interest include monitoring Illegal gold mining activities; vegetation monitoring; emergency response for disaster management specifically search and rescue, and hot spot identification; environmental monitoring including riparian assessment, hydrocarbon (oil) spills; utility monitoring including pipeline and electrical transmission line inspection; and many other applications.

12.0 EDUCATIONAL EVENTS AND TRAINING

A. Radio Astronomy postgraduate training programme – with support from Royal Society UK

The Radio Astronomy training programme was carried out in conjunction with the University of Leeds under the kind support of the Royal Society, UK. The course is an MSc level programme and is a part of a three year capacity building programme to train 10 students in 2014, 20 students in 2015 and 30 students in 2016 in radio astronomy focusing on both the science and engineering. Currently, 12 students are enrolled on the programme with one PhD student who is also registered at the University of Ghana.



A picture of the maiden group of 12 students with a lecturer

B. The Network for Astronomy School Education-International Astronomical Union's (NASE- IAU) Astronomy Course

The 52nd Network for Astronomy School Education-International Astronomical Union's (NASE- IAU) Astronomy Course was organized at the Graduate School of Nuclear and Allied Sciences, University of Ghana, Accra from the 28th to 31st July 2014 for some selected members of the Ghana Association of Science Teachers (GAST). It was hosted by the Ghana Space Science and Technology Institute (GSSTI) with support from the Ghana Atomic Energy Commission and the International Astronomical Union. The resource persons included Mirjana Mpovic and Ederlinda Viñuales both from Spain, and Dr. Nana Ama Browne Klutse, Proven-Adzri Emmanuel, Savanna Nyarko, Yaa Asenso, Bismark Kuhiator, Prosper Nyassor, Solomon Lomotey all from Ghana. The workshop attracted 21 participants.

In the wake of a successful 52nd astronomy course, a NASE group has been formed in Ghana to continue the teaching of astronomy in schools and also to train other science teachers all over Ghana. The NASE group is a focal point for promoting teaching and learning of astronomy in primary and secondary schools. The workshop provided scientific training for the science

teachers to promote astronomy in schools. The course consists of many activity-based workshop and lectures that made it interesting. Some of the highlights of the workshops included.

History of Astronomy

This workshop gave a schematic overview of the history of astronomy in different areas throughout the world, in order to show that astronomy has always been of interest to all the people.

Cosmology

This workshop accorded the participants understanding of the Universe and how it has evolved since the Big bang to today, galaxies, how matter and energy are organized in the Universe, analyze how astronomers can learn about the history of the Universe, and address concepts related to the possible existence of multiple universes.

Solar System

This workshop brings home the correct definition of what constitute our solar system according the IAU resolution of 24th August, 2006. These include 8 planets, 162 natural satellites of the planets, three dwarf planets, other smaller bodies like; asteroids, meteorites, comets, dust, Kuiper belts objects, etc.

Local horizon and Sundials

The study of the horizon is crucial to facilitate the students' first observations in an educational center. A simple model that was made allows us to make the study and the comprehension of the first astronomical rudiments easier. The model is simply an equatorial clock and from it, we can make other models (horizontal and vertical).

Stellar, solar and lunar demonstrations

This workshop presented a simple method to explain how the apparent motions of stars, the Sun, and the Moon are observed from different places on Earth, the procedure consists of building a simple model that allowed the demonstration of how these movements are observed from different latitudes.

Earth-moon-sun systems: phases and eclipses

This workshop exposes the participants to understand why the moon has phases, causes of lunar eclipses, why solar eclipses occur, determine distances and diameters of the Earth-Moon-Sun system, to understand the origin of the tides.

Young Astronomer briefcase

To further observe, it is necessary that students have a set of simple tools. It is proposed that they construct some of them and then use them in observing the sky from the school itself. Students should understand in a basic way how various instruments have been introduced over the

centuries, how they have developed, and have become necessary. The briefcase included a ruler for measuring angles, a simplified quadrant, a horizontal goniometer, a planisphere, a map of the moon, an equatorial clock, and a spectroscope.

Solar spectrum and sun spots

This workshop includes a theoretical approach to the spectrum of sunlight that can be used in a high school. The goals included the sun's spectrum and the spectrum of light, sunspots and the historical significance of sunspots and Galileo's work on the rotation of the sun.

Life of Stars

To understand the life of the stars it is necessary to understand what they are, how we can find out how far away they are, how they evolve and what differences exist between them. Through simple experiments, it is possible to explain to students the work done by scientists to study the composition of the stars, and also build some simple models.

Astronomy beyond the invisible

Celestial objects radiate in many wavelengths of the electromagnetic spectrum, but the human eye only distinguishes a very small part: the visible region. There are ways to demonstrate the existence of these forms of electromagnetic radiation that we do not see through simple experiments. In this workshop, the participants were introduced to observations beyond what is observable with a telescope that can be used in a primary or secondary school.

Expansion of the universe

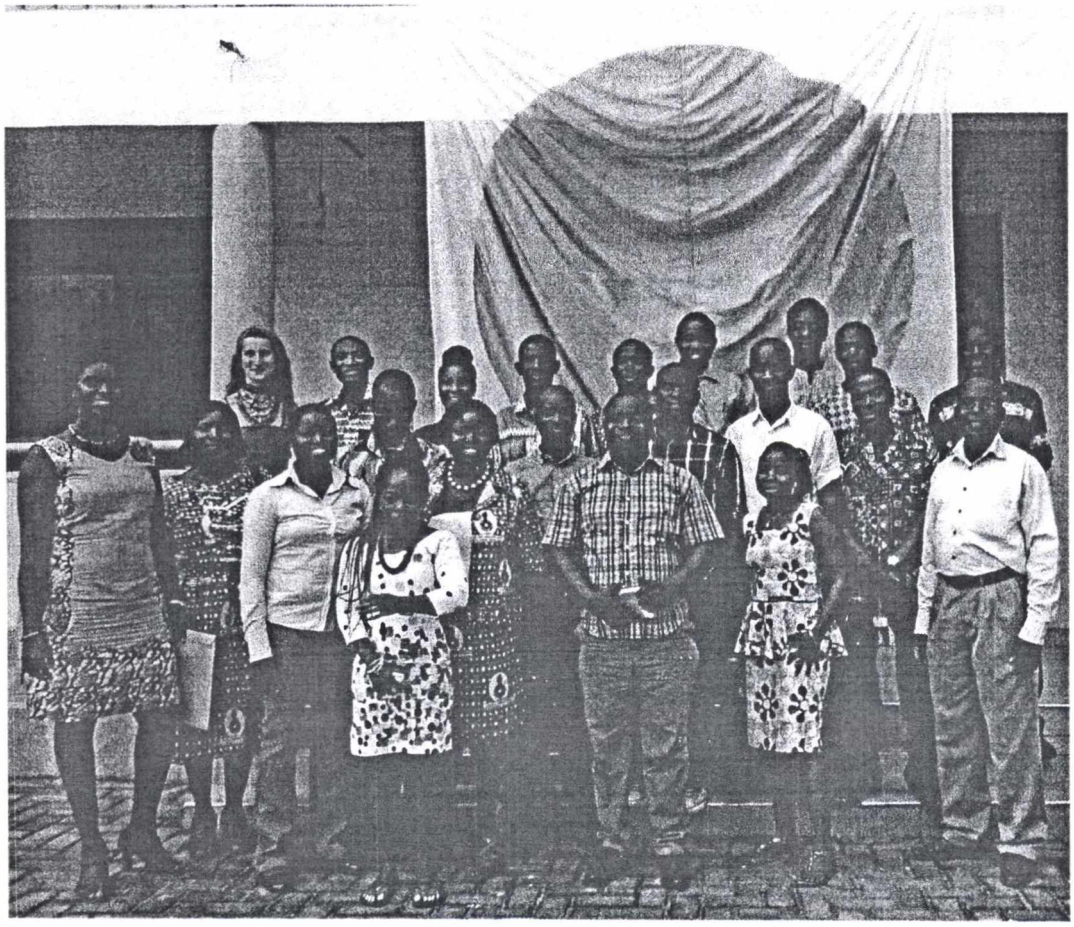
This workshop contains six simple activities to do in which to work with the key concepts of the expanding universe. In the first activity we build a spectroscope to observe spectra of gases. In the second, third, and fourth we experiment qualitatively with the expansion of a rubber band, a balloon, and a surface of points, respectively. In the fifth activity we work quantitatively with the expansion of a surface and even calculate the Hubble constant for this case. In the sixth activity we detect the microwave background radiation.

Planets and exoplanets

This workshop provided a series of activities to compare the many observed properties (such as size, distances, orbital speeds and escape velocities) of the planets in our Solar System. As a final activity, some properties of extrasolar planetary systems are explored and compared to the Solar system. At present, several methods are used to find exoplanets, more or less indirectly. It has been possible to detect almost 100 multiple plan.

Preparing for observation

In this module, participants learnt how to choose the correct place, date, what equipment you will take and how to plan an observation. The use of the program Stellarium was also taught.



A group of teachers, resource persons and instructors for the 52nd NASE workshop

C. School outreach Programmes:
   i. Visits to schools
   ii. GSSTI hosts school children
D. Advocacy on Satellite data usage in Ghana:
   i. Ministry of Food and Agriculture
   ii. Ministry of Environment, Science, Technology and Innovation
   iii. Ministry of Roads and Highways
   iv. Ministry of Defence

E. Emmanuel Osei Frimpong was sent for a Post Graduate Diploma training in remote sensing and geographic information system at the Obafemi Awolowo University, Nigeria to acquire the requisite knowledge for the Centre's operations from January 5 to October 3, 2014.

13.0 SEMINARS AND CONFERENCES

i. Stakeholders' Meeting on Satellite Usage in Ghana held on 17th December 2014 at the SNAS Conference Room, GAEC.

ii. Training programme for Middle Level Management – Administrators, Centre Managers of GAEC

iii. SKA – Africa partner countries ministerial meeting, Pretoria, South Africa, 25 – 27th March 2014.

iv. 3rd Space and satellite technology workshop – All Nations University College – 7&8th April 2014.

v. National Physics Conference 2014, School of Nuclear and Allied Science Conference Room, 26 – 28th November 2014.

vi. Technical training on the RADAR data processing and interpretation. To prepare for an anticipated data centre. December 15 – 17, 2014.

vii. Ghana Association of Science Teachers Biennial Conference, Cape Coast on *26 August, 2014:* The GSSTI and the SKA

viii. IOP Physics/ AIMS Entrepreneurship Workshop for Scientist and Engineers, AIMS, Biriwa, 14- 18 July, 2014

ix. SKA training in Radio astronomy, Cape Town, South Africa, 14 October 2013 to 31 May 2014

x. Third VALUE training workshop on Spatial and Temporal Variability in Statistical and Dynamical Downscaling. 3-8 November 2014

xi. 7th ICTP workshop on the Theory and Use of Regional Climate Models. 12-23 May 2014

xii. 2nd TOSCA Training School on Solar Variability and Climate Response 13-17 October 2014

xiii. 50 Years of Science for the Future – Anniversary Celebration. October 2014

xiv. Training on climate modelling and tools, Department of Physics, University of Cape Coast, Cape Coast on 16 -18 July 2014.

xv. African VLBI Network Training Program, SKA-SA, Cape Town and Pretoria on October – May 2014 .

xvi. INCOSE-South Africa First Meeting for 2014, CSIR, Stellenbosh, Cape Town,South Africa on February 27 , 2014

xvii. Africa Scientific Renaissance Day Celebration, GAEC, Accra on June 30, 2014.

xviii. SKA African Partner Countries Meeting, Sheraton Hotel, Pretoria, South Africa on 25-27 March 2014

xix. High-performance Signal and Data Processing: Challenges in Astro- and Particle Physics and Radio Astronomy Instrumentation, Witwatersrand University, Johannesburg, South Africa on 27 -31 January 2014

xx. ComTIA Linux+, Observatory Road, Cape Town, South Africa on 5- 9 May 2014.

xxi. One day workshop covering Presentation skills and challenges in Communicating astronomy, SAAO, Observatory Road, Cape Town, South Africa on April 11, 2014.

14.0 PUBLICATIONS

1. E. Proven Adzri, N. A. B. Klutse, D. Adomako, P. K. Ashilevi, and E. Aggrey, 2014. Ghana in the square kilometer array. Advance in Research, 2(12): p1040-1045.

2. Emmanuel Proven-Adzri, Theophilus Ansah –Narh, Felix Tetteh Madjitey, Joseph K. Nsor, Emmanuel Kodwo Monorh. LabVIEW model of the half- power beam width of the Kutunse antenna. Mathematical Theory and Modeling. 2014;4:2.

3. Alexander Akoto-Danso, Severin Azankpo, Emmanuel Proven-Adzri, Marcellin Atemkeng, Theophilus Ansah – Narh. 'Beam Pattern Simulation of Nkutunse Antenna', International Journal of Computer Science and Network, August 2014, Vol 3.

4. Alexander Akoto-Danso, Felix Tetteh Madjitey, Emmanuel Proven-Adzri , Theophilus Ansah-Narh Processing HDF to FITS Image: Python Pipeline Mode, International Journal of Computer Science and Network, August 2014, Vol 3.

5. Emmanuel Proven- Adzri, Kofi Korsah, Charles K. Nartey, A. Ayensu Gyeabour. 'Mathematical model of the point kinetic equations of a fast reactor in LabVIEW'. Mathematical Theory and Modeling, Vol.4, No.6, 2014.

6. Emmanuel Proven-Adzri, Theophilus Ansah –Narh, Felix Tetteh Madjitey, Joseph K. Nsor, Emmanuel KodwoMonoh. 'LabVIEW Model of the Half- Power Beam Width of the Kutunse antenna'. Mathematical Theory and Modeling, Vol.4, No.2, 2014.

7. Klutse, N.A.B., Aboagye-Antwi, F., Owusu, K. and Ntiamoa-Baidu, Y. 2014 Assessment of Patterns of Climate Variables and Malaria Cases in Two Ecological Zones of Ghana. *Open Journal of Ecology*, 4, 764-775.

8. Nkrumah F.; Klutse N.A.B.; Adukpo D.C.; Quagraine K.A.; Owusu K.; Owusu A,; Gutowski W.Jr. 2014. Rainfall variability over Ghana: Model versus rain gauge observation, *International Journal of Geosciences*, 5, 673-683. http://dx.doi.org/10.4236/ijg.2014.57060

9. Gbobaniyi, E., Sarr A., Sylla, M.B., Diallo, I., Lennard, C., Dosio, A., Dhiédiou, A., Kamga, A., Klutse, N.A.B., Hewitson, B., Nikulin, G., Lamptey, B., 2014. Climatology, annual cycle and interannual variability of precipitation and temperature in CORDEX simulations over West Africa. *International. Journal of Climatol.*, 34: 2241-2257. doi: 10.1002/joc.3834

10. T. Ansah – Narh, A. Akoto-Danso, F. T. Madjitey and E. Ofori. (2014). " Parallel Computing Approach to Determine the Multiplication Factor of One Dimensional Boltzmann Neutron Transport Equation Of Slab Geometry", Research Journal in Engineering and Applied Sciences, 2(5), 293-303, ISSN: 2276-8467

15.0 CHALLENGES

The GSSTI needs a budget (Government Subvention) and or financial support to enhance its growth. The Institute also needs additional Administrative Assistants at its four (4) Centres to take up administrative or secretarial activities of the Centres and the Institute at large. Additionally, Research Scientists and Technologies especially in the areas of Radio Astronomy and Astrophysics, Remote Sensing, GIS and Climate, Instrumentation & Engineering Services and Satellite Communication & Development. Above all, work on the building for the GSSTI, which seems stalled as a result of financial constraints on the part of the Contractor of the building project, should be looked at and action on getting the building completed should also be expedited. Descent offices are largely and urgently needed for the staff of the Institute for effective productivity.

16.0 CONCLUSION

The prospects of the Institute are enormous and if given the required financial support at its teething stage, it will be of great benefit to the Institute, the Commission and the nation (Ghana) as a whole. At the moment, the Institute is seriously understaffed.