

ARCSSTE-E: 20 Years of Capacity Building in Space Science and Technology Applications

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Presentation at the 13th Meeting of the International Committee on GNSS
(ICG-13)

Xian, China

4-9 November, 2018



ARCSSTE-E

African Regional Centre for Space Science and Technology Education in English
Obafemi Awolowo University, Ile-Ife, Nigeria

Presentation Outline

- ❖ **Background**
- ❖ **Core Activities**
 - **Education - Diploma (PGD), Master' s (M-Tech)**
 - Curriculum on GNSS
 - Sample student projects
 - **Research**
 - **Training**
- ❖ **Other activities**
 - **Space Education and Outreach Programme**
 - **Workshops, Conferences and Public Lectures**
 - **International collaborations**
- ❖ **Future Direction of ARCSSTE-E**
- ❖ **Accessible national facilities**
- ❖ **Possible areas of collaboration**



Background of ARCSSTE-E

United Nations General Assembly Resolutions

- **37/90 of 10th December 1982 – UNISPACE '82**

'That the United Nations Office for Outer Space Affairs (UNOOSA), through its Programme on Space Applications should focus its attention, inter alia, on building of indigenous capacities for the development and utilization of Space Science and Technology, particularly at the local level'

- **45/72 of 11 December, 1990 – UN-COPUOS**

'That the UN should lead, with the active support of its specialized agencies and other international organisations, an international effort to establish Centres for Space Science and Technology Education at the regional level in existing national/regional educational institutions in the developing countries'



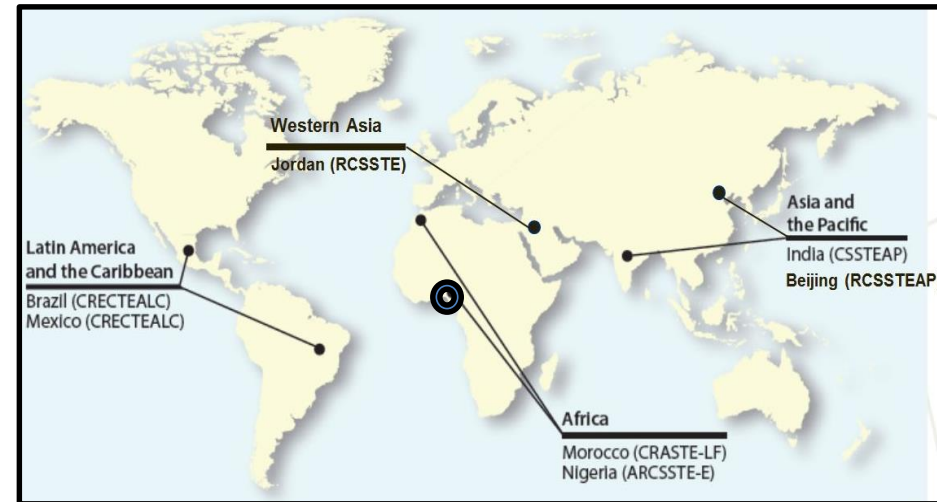
Background of ARCSSTE-E (contd)

- **African Centres**

- ARCSSTE-E (Anglophone – NIGERIA)
- CRASTE-LF (Francophone - MOROCCO)

- **Other Centres**

- India (inaugurated 1995)
- Mexico/Brazil (inaugurated 2003)
- Jordan (inaugurated 2012)
- China (inaugurated 2014)



- **Mandate:** “Develop, through in-depth education, indigenous capability in the core areas of SST”

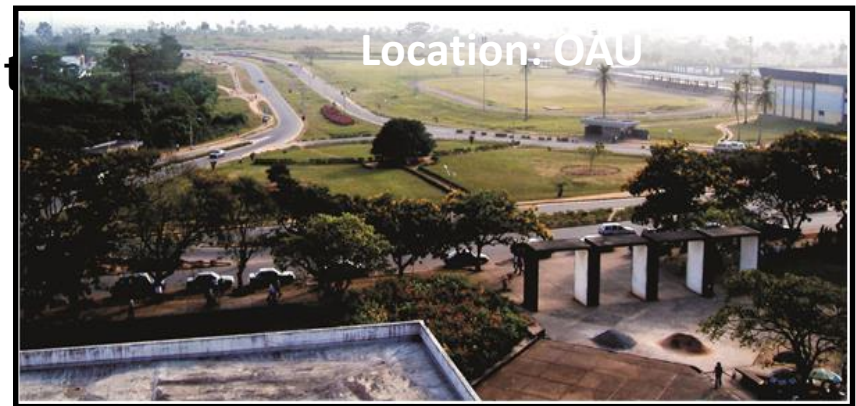


Background of ARCSSTE-E (contd)

- Established 15 September 1998
- Tripartite Agreement
 - United Nations (UNOOSA)
 - FGN (NASRDA)
 - OAU



- Hosted by Obafemi Awolowo University (OAU), Ile-Ife



- Also serves as NASRDA' s Center for Space Science and Technology Education (CSSTE)



Core Activities I

Education



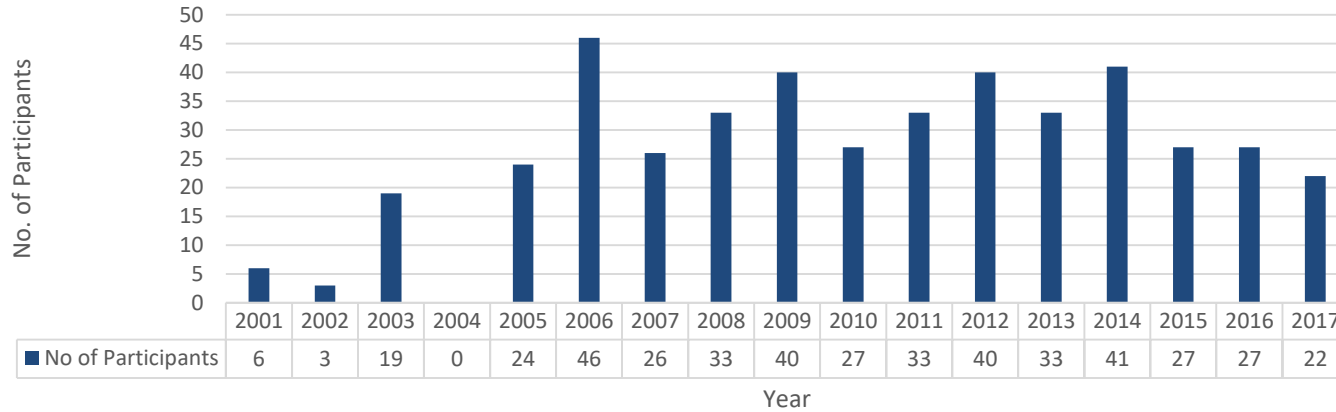
Postgraduate Diploma (PGD) programme

- 9-month Post-graduate Diploma Programme
- 6 thematic areas of Space Science and Technology
 - Remote Sensing/Geographic Information Systems (GIS)
 - Satellite Communication
 - Satellite Meteorology/Global Climate
 - Basic Space Science/Atmospheric Physics
 - **Global Navigation Satellite Systems (GNSS)**
 - Space Law

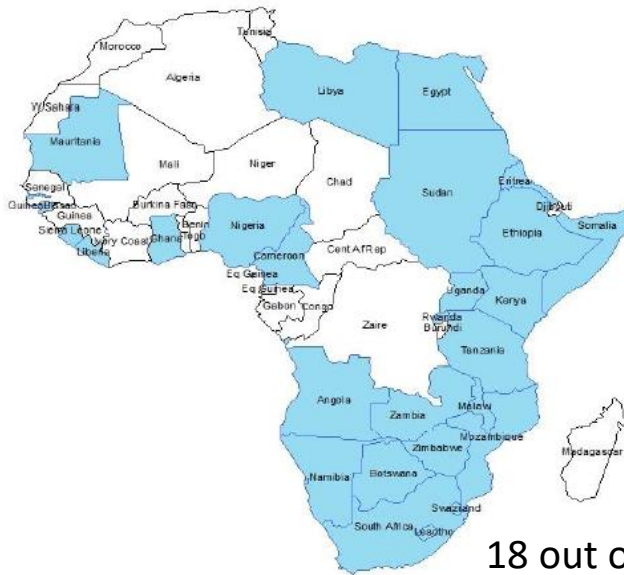


Postgraduate Diploma (PGD) programme (contd)

No of Participants



Botswana	2
Cameroon	33
Congo DR	1
Ethiopia	4
Gambia	1
Ghana	9
Kenya	15
Liberia	12
Malawi	7
Nigeria	334
Sierra Leone	1
Sudan	15
South Africa	1
Tanzania	5
Uganda	11
Zambia	3
Zimbabwe	7
Total	473



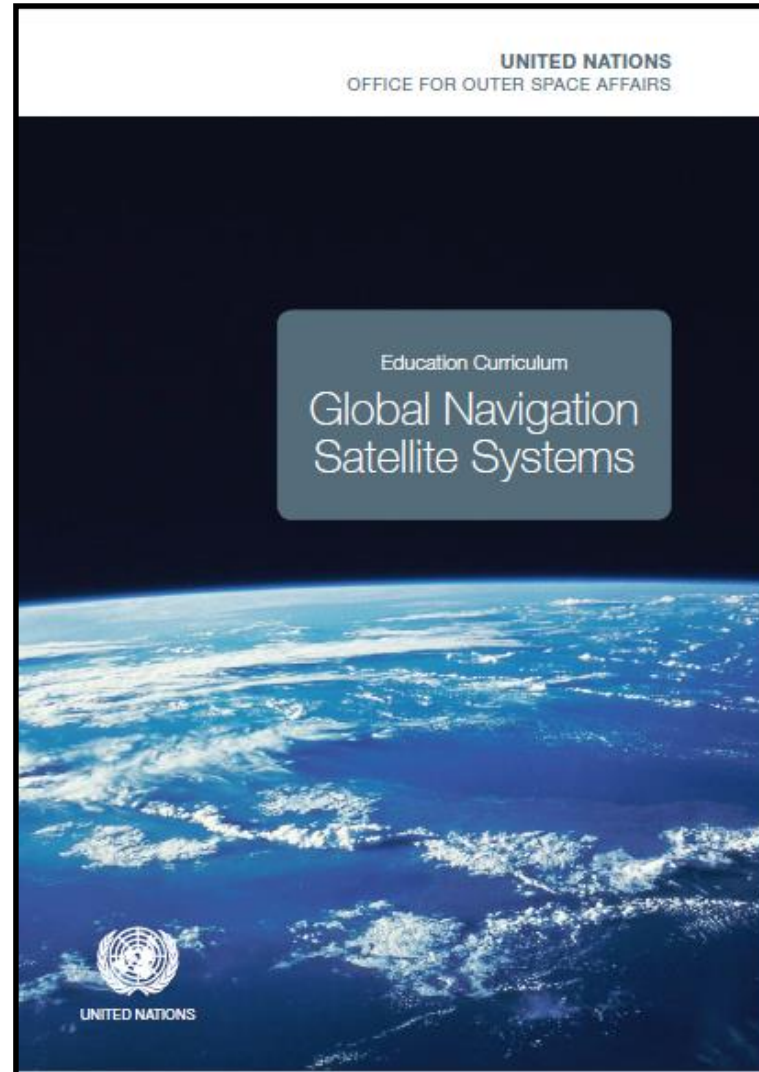
18 out of the 24 Anglophone African countries have participated



Curriculum of GNSS Course

Three parts

- Common Module
- Core Module
- Project



Curriculum of GNSS Course (*contd*)

Common Module

- **Introduction to Space Law**
 - ✓ United Nations Treaties and Principles on Outer Space
- **Fundamentals of Remote Sensing/GIS**
 - ✓ Overview of Remote Sensing Technology: *History and Evolution*
 - ✓ Electromagnetic radiation and its interaction with matter
 - ✓ Spectral characteristics of crops/vegetation, soils, water, etc.
- **Space Biology**
 - ✓ Introduction to Space Biology
 - ✓ Overall physiological response to spaceflight
 - ✓ Radiation and Radiobiology
 - ✓ Medical hazards in space operations
 - ✓ Living in Space
- **Research Methodology**



Curriculum of GNSS Course (*contd*)

Core Module

<i>Module</i>	<i>Topic</i>	<i>Duration in hours</i>
	Lectures	540
I:	Fundamentals	60
II:	Position determination techniques	60
III:	Technologies: augmented systems	80
IV:	Sensors and embedded system design	60
V:	Receivers	80
VI:	GNSS/INS integrated navigation	80
VII:	GNSS applications	80
VIII:	Space weather and GNSS	40
	Practical exercises and thesis	
IX:	Laboratory experiments, field visits, project work	540



Core Module (contd)

• Module 1: Fundamentals

- ✓ Introduction to GNSS: *Background, concepts, Evolution of GNSS*
- ✓ Reference Systems
- ✓ Satellite Orbits
- ✓ Basic techniques of communication: *Antennas, signal processing*

• Module 2: Position Determination Techniques

- ✓ GNSS measurements: *pseudoranges, carrier phase, doppler*
- ✓ Position determination techniques
- ✓ Single point position technique: *models and estimation methods*
- ✓ Satellite constellation and Dilution of Precision (DOP)

• Module 3: Technologies Augmented Systems

- ✓ Errors in GNSS measurements
- ✓ Effects of errors: *error budget, User Equivalent Range Error (UERE)*
- ✓ Error mitigation techniques: *RTK, DGNSS*
- ✓ Augmented systems: *WAAS, EGNOS, SDCM, MSAS, GAGAN*
- ✓ GNSS networks: *GNSS permanent networks, geodetic infrastructure*
- ✓ GNSS impact factors and mitigation techniques

• Module 4: Sensors and Embedded System Design

- ✓ Sensors and transducers
- ✓ Embedded systems

Core Module (contd)

- **Module 5: GNSS Receivers**

- ✓ Receiver architecture
- ✓ Signal tracking
- ✓ Measurement algorithm

- **Module 6: GNSS/INS Integrated Navigation**

- ✓ Inertia navigation systems
- ✓ INS error dynamics
- ✓ GNSS/INS integration
- ✓ General sensor fusion concepts

- **Module 7: GNSS Applications**

- ✓ Geospatial databases
- ✓ GNSS navigation: *professional and personal, GIS/mapping, surveying, natural hazards management, natural resources, infrastructure*
- ✓ Navigation and communication: *integrated application*
- ✓ Communication, navigation and surveillance: *integrated application*
- ✓ GNSS applications for remote sensing of the atmosphere and space weather: *radio occultation for monitoring terrestrial weather and for monitoring ionospheric weather*
- ✓ Revenue model for value-added services

Core Module (contd)

• Module 8: Space Weather and GNSS

- ✓ Sources of space weather and related background physics
- ✓ Impacts of space weather events on GNSS
- ✓ Satellites, interference with solar radio emission, radio wave propagation
- ✓ Different view in precise (geodesy, DGPS) and safety of life (aviation) applications
- ✓ Ionospheric scintillations and their impact, monitoring and modelling
- ✓ GNSS-based monitoring of the ionosphere by ground and space based measurements
- ✓ Ionospheric correction and threat models

• Module 9: Laboratory experiments, field visits, project work

- ✓ GNSS/INS equipment
- ✓ GNSS data formats: RINEX, RTCM, NMEA
- ✓ Single point positioning solution
- ✓ High precision post-processed GNSS
- ✓ Experiment with DGPS
- ✓ Experiment with RTK receivers
- ✓ Experiment to demonstrate accuracy using SBAS
- ✓ Design aspects of software for integrating LBS with position eg. smartphone applications
- ✓ Design of application: *combining satellite navigation with satellite communication (fleet monitoring)*

Sample Student Project 1

- **Name**: Ponfa Bali
- **Academic Year**: 2018
- **Title**: An Evaluation of the Quality of Coverage of EGNOS over Africa using Systems Tool Kit (STK) software
- **Objectives**:
 - (i) To simulate the EGNOS system over Africa using STK
 - (ii) To compute and evaluate the coverage

GEO Name	PRN Number	Orbital Slot
ASTRA-3B	PRN 123	31.5 E
ASTRA SES-5	PRN 136	5 E
INMARSAT 4F2 EMEA	PRN 126	64 E
INMARSAT 3F2 AOR-E	PRN 120	13.5 W

Satellites used by EGNOS



Sample Student Project 2

- **Names**: Joshua Echoda, Yakub Onimago, Taiwo Olunuga
- **Year**: 2014
- **Title**: Design of a space-based augmentation system for Africa
- **Objectives**
 - (i) To explore the use of small satellites for satellite navigation
 - (ii) design and simulate, using STK, a new augmentation system with service targeted at African region, paying attention to choice of orbits and location of ground stations



MTech. Space Science & Technology

AFRICAN REGIONAL CENTRE FOR SPACE
SCIENCE AND TECHNOLOGY EDUCATION -
ENGLISH, OAU CAMPUS, ILE-IFE



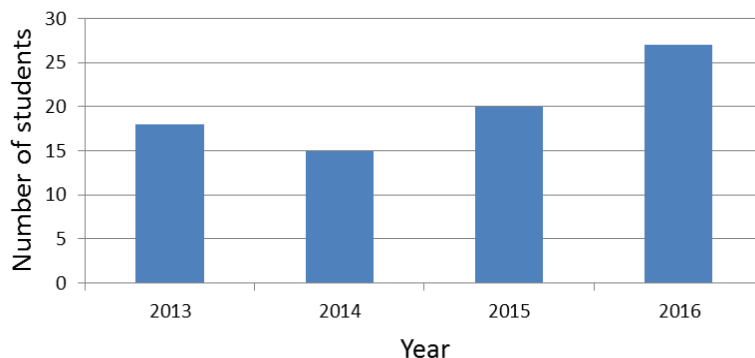
THE FEDERAL UNIVERSITY OF TECHNOLOGY
AKURE



- **Duration:** 18-month MTech. (SSTA) in five key areas of Space Science and Technology (SST) Education
- **Collaborating University:** Federal University of Technology, Akure (FUTA)



Student enrolment of MTech programme



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Core Activities II

Research



Desertification Monitoring System over Sahelian Region of Nigeria

February 2017

- The establishment of a system of information is vital in order to accurately assess the processes that lead to desertification and droughts, and to build a framework for environmental accounting.

OBJECTIVES

- Continuously measure parameters (Pressure, temperature, humidity, wind - velocity and rain rate);
- Analyse data obtained and ascertain if desertification is occurring or not;
- Model possible rate, volume and direction of future encroachments; and generate a hazard map for affected regions.

GNSS was used in localisation and data gathering





GEONetCast Installation - 2017



On-going EUMetcast C-Band installation at ARCSSTE-E Space Museum, OAU, Ile-Ife.

GEONetCast is a global network of Satellite-based data dissemination systems providing environmental data to a world-wide user community

Data: MeteoSat, GOES East & West image data; EUMETSAT & NOAA-NESDIS metrological data; Sea surface temperature and Vegetation Data; etc.

Licence granted & Installation (95% completed)

On Completion of the Earth Station the Centre will be poised to provide real-time world class data to support the Postgraduate programmes and collaborative research.

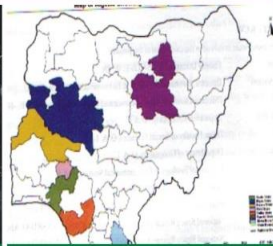
Useage within Centre



Satellite Communication



Satellite Meteorology



Remote Sensing

Core Activities III

Trainings and Workshops





GNSS Training Workshop (1)

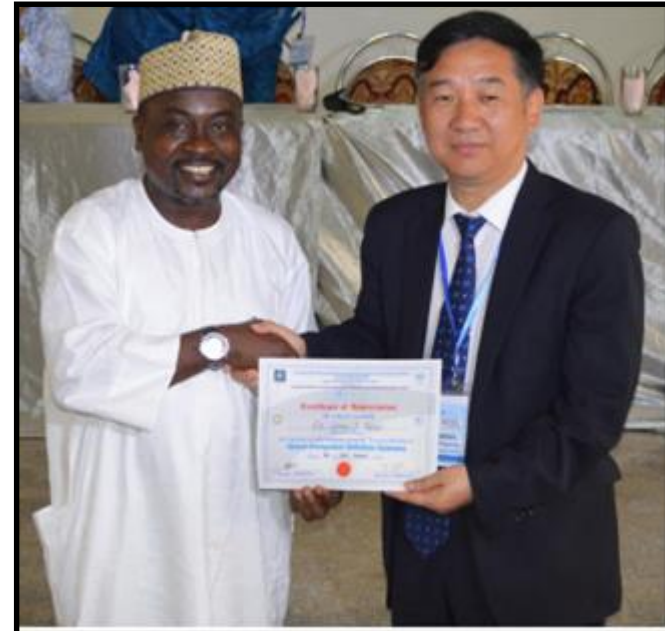
- Jointly sponsored and organised by UNOOSA, ARCSSTE-E, RECTAS (now called AFRIGIST), OAU, FUTA and NASRDA
- Held 4th – 29th October, 2010
- Course was designed to provide the basic principles and applications of GNSS
- 30 participants from 9 African countries
- The training involved classroom lectures, laboratory demonstration and practical sessions using different types of GNSS receivers, computer based simulations using MATLAB, and tutorials.





Joint Africa/Asia-Pacific UNOOSA-Regional Centres Collaborative Training Efforts on Global Navigation Satellite Systems [GNSS]

- UNOOSA recommended that developing countries should seek partnership with other developed/developing countries to implement and oversee common programmes in space-related science
- ICG's mandate: "...to promote the introduction and utilisation of [GNSS] services and their future enhancements, including in developing countries, if necessary, with integration into their infrastructure."
- ARCSSTE-E partnered with RCSSTEAP and Beihang University to organise a training on GNSS in August 2016.



Directors of ARCSSTE-E and RCSSTEAP



Affiliated to
UNITED NATIONS
Office for Outer Space Affairs



Joint Africa/Asia-Pacific UNOOSA-Regional Centres Collaborative Training Efforts on Global Navigation Satellite Systems [GNSS]

2016 GNSS Workshop Participants

- 85 participants (15 females and 70 males) drawn from Seven countries including six African nations (Cameroon, Ghana, Kenya, Liberia, Nigeria and Sudan) and China.
- These participants were from the Federal, State and Local Government agencies and institutions; non-governmental organizations, and private industries; and Service Personnel (Air Force, Army and Navy).



ft to Right: Prof. Yang Dongkai; Dr. Ganiy Agbaje; Professor Weng Jingnong; The Representative onorable Minister of Science and Technology, Dr. Halilu Shaba; the Representative of the Ag. Vice or of Obafemi Awolowo University, Professor Segun Fatusi; Prof. Yin Ping, Prof. Jide Kufoniyi



Joint Africa/Asia-Pacific UNOOSA-Regional Centres Collaborative Training Efforts on Global Navigation Satellite Systems [GNSS]

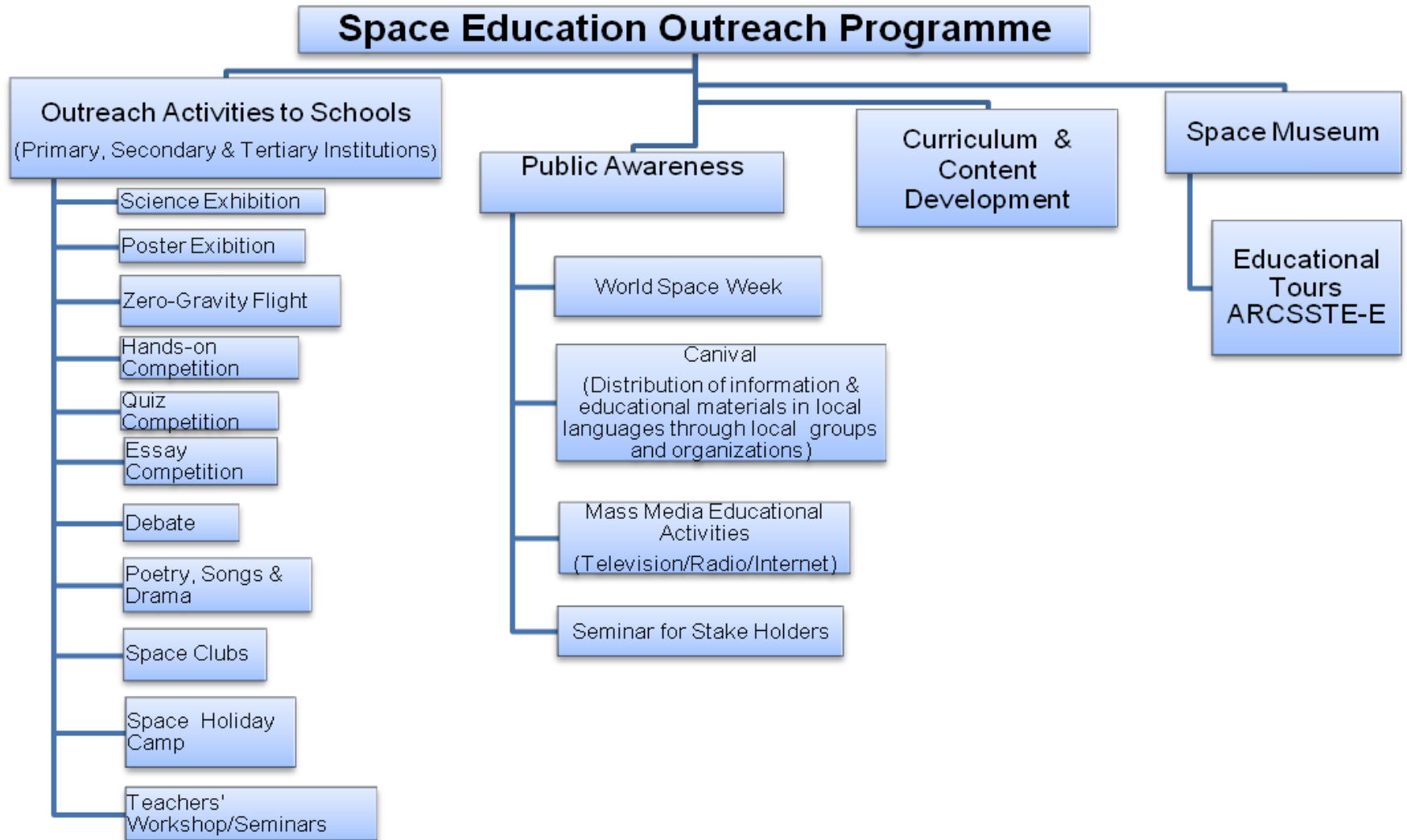
- The Collaborative Training Efforts between ARCSSTE-E and RCSSTEAP is dual fold:
 - Technical Staff training in GNSS
 - International Training workshop in GNSS
- 2 ARCSSTE-E staff offered scholarship in GNSS tenable at Beihang University, China, in 2014
- 2 ARCSSTE-E Staff offered PhD positions in the Programme of Space Technology Application at Beihang University, China
- One staff offered scholarship to study Space Law in 2016
- One staff offered scholarship to study Remote Sensing in 2017

Other Activities





Space Education Outreach Programme (1)





Space Education Outreach Programme (2)

2017 Space Generation Advisory Council (SGAC)/Centre for Atmospheric Research/ARCSSTE-E Outreach Programme:

'WHY SPACE?' - *Space Exploration: A Step into the New Frontier*

University of Benin, Nigeria; Date:16th of May, 2017

ARCSSTEE's Staff at Launch Site



Over 350 Participants



Drone Test Launched



Astronaut Soyoon Yi

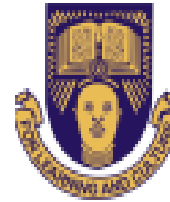


Drone Constructed by Space Club, OAU



National Collaborations

- Obafemi Awolowo University, Ile-Ife



**OBAFEMI AWOLOWO
UNIVERSITY**

- Federal University of Technology, Akure
 - Center for Space Research and Applications (CESRA)



- Kwara State University, Malete, Kwara State



International Collaborations of ARCSSTE-E

1. **GEO**, Geneva, Switzerland



- Participating Organisation (PO) status

2. **International Committee on GNSS**,
UN-OOSA, Vienna



3. **RCSSTEAP**, China



4. **EUMETSAT on GEONetCast**
- establishment of



5. **Samara State Aerospace University**, Russia



Planned Collaborations

- **China-Brazil Earth Resources Satellite (CBERS)**
- Ground Receiving Station (educational)
- **ESRI Educational licensed products** e.g. ArcGIS
- **ESA; Others welcome!**



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ARCSSTE-E contributions to UN GNSS activities

- Observer status at ICG
- Regular participant at the ICG annual meetings
- First to hold inter-regional center training
- Initiated formation of alliance of regional centers



Future Directions of ARCSSTE-E

- Specialised training
 - Location Based Services (LBS)
 - GeoSpatial data analytics
- Commencement of PhD programmes
- E-learning programmes
- Outreach programmes to other African countries
- Organisation of international conference on GNSS



Accessible national facilities

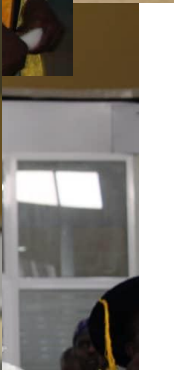
- NigComSat-1R
 - Has 2 navigation payloads (L1/L5 dual band) which can support augmentation, with PRN Code 147
- CORS Stations
 - Over 25 have been established in Nigeria, forming NigNet
- NASRDA Ground Receiving Station
- Facilities at CGG Toro
 - International GNSS Service (IGS) station
 - Global Geodetic Observing System Core Site
 - African GNSS Data Processing Centre



Staff Strength

- Full-time lecturers - 14
- Adjoint lecturers - 17
- Part-time lecturers - 5
- Administrative staff - 5







Announcement of the Postgraduate Course in Space Science and Technology Applications



ABOUT THE PROGRAMMES

The vast and unlimited benefits of space technology, both direct and indirect, have introduced new dimensions into the study and understanding of the earth's resources and processes, with a view to applying the technology to improve the quality of life. All countries are expected to contribute to space science and technology development and to share the benefits. An essential pre-requisite to partaking in these opportunities is the building of various indigenous capacities for the development and utilization of space science and technology. In recognition of such a pre-requisite, a consensus has emerged within the international community that if effective assimilation and appropriate application of space science and technology are to succeed in the developing countries, devoted efforts must be made at the local level for the development of necessary human and infrastructural capacity in all space science and technology fields. Toward this end, the United Nations (UN) General Assembly initiated the establishment of Centers of Space Science and Technology Education at the regional level in developing countries (Brazil, India, Mexico, Jordan, China, Morocco and Nigeria). The African Regional Centre for Space Science and Technology Education in English Language (ARCSSTE-E) is established in Nigeria at the Obafemi Awolowo University Campus, Ile-Ife. Within the frame work of its mandate to build capacity in core areas of Remote sensing and GIS, Satellite communication, Satellite meteorology and Global climate and Basic space and Atmospheric sciences applications, the center trains participants mostly from English speaking African countries: Angola, Botswana, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mozambique, Namibia, Nigeria, Sierra Leone, South Africa, Sudan, Swaziland Tanzania, The Gambia, Uganda and Zimbabwe. The space education courses comprise a 9 months post graduate diploma programme that begins from January to September every year; and an optional 18 months Masters in Space Science and Technology degree programme in collaboration with the Federal University of Technology, Akure, Nigeria.

OBJECTIVES OF POST GRADUATE COURSE IN THE FIVE FOCAL AREAS OF SPACE SCIENCE AND TECHNOLOGY APPLICATIONS

- To develop the skills of university educators, researchers, telecommunications professionals, weather forecasters, applications scientists, government personnel, policy makers/planners and others in application of space science and technology to broadcasting, telecommunications, health care, education, disaster management, climate change etc.
- To provide assistance in preparing satellite-based communications project, defining policy and establishing communications systems;
- To develop expertise in the use of operational systems and integrate advances in communications technology in day-to-day activities;

Area / Discipline	(PGD certificate)
1. Remote Sensing and GIS	Core Module and Pilot Project
2. Satellite Communication	9-months
3. Satellite Meteorology Applications	9-months
4. Space Basic and Atmosphere Sciences	9-months
5. Global Navigation Satellite System	9-months

Area / Discipline	(MSST certificate)
1. Remote Sensing and GIS	Project (in Nigeria or candidate's home country)
2. Satellite Communication	18-months
3. Satellite Meteorology Applications	18-months
4. Space Basic and Atmosphere Sciences	18-months

ELIGIBILITY

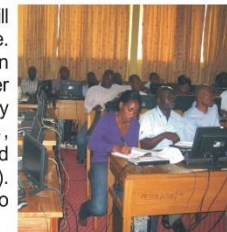
Master's/Bachelor's degree in Science or Engineering or equivalent qualification relevant to the field of study, in all aspects of Space Science and Technology Applications such as natural resources/environment, forestry, agriculture, land use, water resources, environmental analysis, oceanography, telecommunications, broadcasting, health care, disaster monitoring, and management, etc. (for candidates with higher qualification, the minimum experience may be relaxed.). Graduate level knowledge in mathematics and statistics is required. Candidates with qualifications in other fields with adequate administrative experience in Core Area of training may be given admission subject to demonstration of ability to cope with graduate level mathematics/statistics.

SELECTION OF CANDIDATES

The Center's Admission Committee will review all application forms and assess candidate's eligibility. Candidates satisfying all requirements for admission will be selected subject to the number of bench spaces available. Successful candidates will be notified of their admission.

TEACHING FACILITIES

Modern methods of teaching and instruction will be used for imparting training during the course. The course instructions will depend on classroom lectures, video lectures, computer based interactive packages, laboratory experiments, group discussions, demonstrations, seminar presentations and field work/case studies (as applicable). Computer based interactive packages will also be used for self learning.



EVALUATION PROCEDURE

The performance of the participants in the Centre's programmes will be assessed through oral, written and laboratory assessments at periodic intervals during each of the course.

EDUCATIONAL TOURS AND EXCURSIONS



As part of the course, the participants will have the opportunity to visit different facilities of the affiliated institutions and other organizations concerned with appropriate areas of concentration of the candidate. The Centre also organizes excursions to tourist and historical destinations within the country, to create opportunity for recreation and for the students to learn about the cultures of the people of Nigeria.

INFORMATION ON APPLICATION PROCEDURES

- Prospective candidate can visit ARCSSTE-E's website at www.arcsstee.org.ng, download application form, fill, scan, attach all credentials and send to masters@arcsstee.org.ng or pgd@arcsstee.org.ng as applicable.
- Programme commences on 15th January of each year.
- Application starts from June of each year.



For further information, please contact:

The Director/CEO

African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E)
Obafemi Awolowo University Campus, Ile-Ife, Nigeria.

e-mail: director@arcsstee.org.ng

Contact: Head of Postgraduate Programs: kunle.oladosu@arcsstee.org.ng, 08059642012

www.arcsstee.org.ng

*Thank
You*

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