AFRICAN REGIONAL CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION – ENGLISH (ARCSSTE-E)

(Affiliated to the United Nations)

Obafemi Awolowo University Campus,

PMB 019 OAU Post Office, Ile-Ife, Osun State, Nigeria

Postgraduate Diploma (PGD) in Space Science and Technology Applications

STUDENT HANDBOOK

Contents

Welcome Message

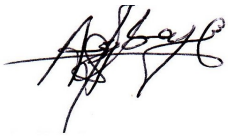
On behalf of the management and staff of the African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E), I welcome you to the ARCSSTEE. Located within the Obafemi Awolowo University, Ile-Ife, Nigeria, the Centre was formally inaugurated on the 24th of November 1998. The Centre is affiliated to the United Nations and also serves as an activity Centre for the National Space Research and Development Agency (NASRDA) – an Agency under the aegis of the Federal Ministry of Science and Technology (FMST), Nigeria. ARCSSTEE aims to build a critical mass of high quality indigenous capacity in Space Science and Technology (SST) for English-speaking African countries. This is with a view to support application in SST for sustainable national, regional and continental development.

As part of her educational programmes, the Centre offers 9 months Postgraduate Diploma (PGD) Programme in the following areas: Remote Sensing/Geographic Information System, Satellite Meteorology and Global Climate, Satellite Communications, Basic Space and Atmospheric

Science, Global Navigation Satellite Systems, Space Law, and Space Engineering (under development). Since inception, over 450 participants have graduated from the programme.

This handbook contains some practical information and hints on making the best use of the resources available in the Centre, and guidelines for award of the PGD degree. Therefore, it is my pleasure to recommend it to all course participants.

Best wishes as you embark on the programme.



Ganiy I. Agbaje, PhD, fnis
Executive Director

1.0 Preamble

This handbook is intended to serve as a guide to all participants of ARCSSTEE's Postgraduate Diploma programme. It contains information on educational facilities that are available to participants. It provides information about the lecture rooms, profile of lecturers, and management staff on the programme.

In order to keep participants abreast of activities in the Centre on a routine basis and for smooth running of the programme, this hand book narrows the communication gap between the Centre and course participants. The Centre hopes that at the end of the programme, the expectations of the participants would be met.

2.0 Teaching Facilities

(a) Lecture Rooms: To facilitate teaching and all academic presentations, the Centre has three functional modern lecture rooms fully equipped with multimedia projectors, digital board and internet facilities.

(b) Library: The Centre has a reference library situated within the office complex and it is continuously updated with books, journals, educational materials, etc. Course participants have free access to the library for short-term loan of books, Journals, research materials, newspapers, etc. In addition, course participants have access to the main (OAU) University library.

(c) Other Facilities:

i. Digital Camera
ii. Ao Smart Scanner
iii. Ao Plotter
iv. Handheld GPS
v. Supporting Materials
vi. Lecture Materials
vii. Timetable
viii. Course Calendar

3.0 Administrative/Secretarial Support

(a) **Identity Cards**: All the participants are issued with students' identity cards for security reasons. This is to facilitate their access to certain areas of the Centre and the University.

(b) **Health Services**: All course participants are expected to be registered at the University's Health Centre. Foreign students also expected to submit a copy of their medical insurance certification during registration.

(c) **Accounts**: Students will not be registered without full payment of tuition. Clearance will be required from the Accounts Division.

(d) **Traveling**: Prior to embarking on any trip, all participants are expected to obtain travel approval from the Executive Director upon recommendation by the Head of the Postgraduate Programmes.

(e) **Security**

The Centre places high premium on security and as such has a 24/7 CCTV.

The Centre will not allow course participants to use the Lecture rooms to entertain or receive guests. All visitors should be met at the security desk which is by the main entrance of the Centre.

4.0 Profiles of the PGD Programme facilitators

Dr. G. I. Agbaje: Executive Director, ARCSSTE-E.
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Tel: 08028327453
Email: director@arcsstee.org.ng or
gagbaje@gmail.com

Mrs. Lami Ali-Fadiora: Deputy Director (Administration and Finance).
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Samam Obaguo: Secretary,
Postgraduate Programmes.
Contact info:
Tel: 07035269373
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Abubakar Bunmi: Student's Welfare Officer.
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Email: abubakar11bunmi@gmail.com

5.0 Guidelines for Graduation and Award of PGD Degree

Registration

Each participant is expected to register for all the courses listed under the main module options being pursued and the General Module courses to be taken by all participants.

1. **Carry over courses**
   All failed courses shall be carried over to the next academic year. Such courses would be registered, and passed before certificates can be issued. Student shall pay for registration at a fee approved by the Centre's management.

2. **Withdrawal from the Programme**
   A student who is unable to pass the examination at the second sitting would be advised to withdraw from the programme.

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Continuous Assessment

Assessment of student's achievement shall be carried out in form of assignments, quizzes, tests and reports. A minimum and maximum of 20 and 40 marks respectively would be considered for the continuous assessment of student.

Final Examination

Final examination for a course shall not normally exceed three (3) hours duration and shall be given only at the times, places established for that purpose by the Centre or its designated committee. The final examination for each course shall normally be at the end of each course module.

Project

Each student is expected to carry out a project that would be defended, graded and passed by the Board of Examiners.

Table 1: Table of Courses

GENERAL MODULE (FOR ALL PARTICIPANTS)			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	BSA 707	Space Biology	2
2	SST 800	Fundamentals and Principles of Remote Sensing and GIS	3
3	SST 700	Introduction to Space Law	1
4	SST 701	Research Methodology	1
MAIN MODULES (OPTIONS) **Remote Sensing & Geographical Information System**			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	RSG 701	Remote Sensing platforms, sensors and ground	2

		systems	
2	RSG 702	Image processing systems and interpretation	2
3	RSG 703	Digital image processing	3
4	RSG 704	Geographical information system	4
5	RSG 705	Remote Sensing and GIS applications	2
6	RSG 706	Natural Disasters and Management	1
7	RSG 709	Urban Planning	1
8	RSG 707	Sustainable development and Carrying capacity	2
9	RSG 708	Cost-Benefit analysis	1
10	RSG 799	Pilot Project	4

Satellite Communications Main Module			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	SCM 701	Communication System	2
2	SCM 702	Digital signal processing	2
3	SCM 703	Satellite Communication Systems	2
4	SCM 704	Earth Station Technology	2
5	SCM 705	Transmission, multiplexing and multiple access	2
6	SCM 706	Broadcasting using communication satellites	2
7	SCM 707	Applications and trends in satellite communication	2
8	SCM 708	Operational communication satellite systems	2

9	SCM 709	Network planning/ management/operation issues of satellite communication systems	1
10	SCM 710	Satellite Communication for development, education and training	2
11	SCM 799	Pilot Project	4
Global Navigation Satellite Systems			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	GNS 701	Fundamentals of GNSS	2
2	GNS 702	Position Determination Techniques	2
3	GNS 703	Technologies: Augmented Systems	3
4	GNS 704	Sensors and Embedded Systems Design	3

5	GNS 705	Receivers	2
6	GNS 706	GNSS/INS Integrated Navigation	3
7	GNS 707	GNSS Applications	1
8	GNS 799	Pilot Project	4
Satellite Meteorology & Global Climate			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	SMT 701	Basic Concepts I	2
2	SMT 702	Basic Concepts II	2
3	SMT 703	Applications (Image Processing and GIS)	3
4	SMT 704	Satellite data retrieval and applications	4
5	SMT 705	Numerical models and Satellite data assimilation	3
6	SMT 706	Global Climate	2

7	SMT 707	Environmental issues	2
8	SMT 799	Pilot Project	4
Basic Space And Atmospheric Science			
S/No	**Course Codes**	**Course Title**	**No of Units**
1	BSA 701	Mathematics for space scientists and engineers	4
2	BSA 702	Structure, Composition, dynamics and evolution of planetary atmospheres	2
3	BSA 703	Ionospheric Physics	2
4	BSA 704	Space Weather	2
5	BSA 705	Astronomy and Astrophysics	2
6	BSA 706	Basics of Spacecraft design, construction and launch	2
7	BSA 708	Space Geodesy	2

8	BSA 799	Pilot Project	4

Grading System

As contained in the Table above, each course has an assigned unit load. At the end, Examination scores / Grades are awarded points as follows:

Score Range	Grade	Point (P)
70 – 100	A	5
60 – 69	B	4
50 – 59	C	3
45 – 49	D	2
40 – 44	E	1
0 – 39	F	0

Each participant is expected to pass all the registered courses as contained in the Table of courses above.

Award of Class Degree

4.5 - 5.00	Distinction
3.5 - 4.49	Upper Credit
2.5 - 3.49	Lower Credit
1.5 - 2.49	Pass
< 1.5	Certificate of Attendance

COMPUTATION OF RESULTS

The following terminologies and abbreviations are commonly used in the computation of Grade Point Average (GPA).

1. **Total Load Units (TLU):** This is the total number of course units carried by a student. It is the summation of the load units on all courses carried during the programme. For example, a student taking 6 courses of 3 units each has a TLU of 18.

2. **Total Credit Point (TCP):** This is the sum of the products of course units and rating in each course. For example, consider a student who took 5 courses of 3 units each. Suppose the grades he obtained in the four courses were A, B, C, D and E respectively. The TCP of this student is obtained as:- (3 x 5.0) + (3 x 4.0) + (3 x 3.0) + (3 x 2.0) + (3 x 1.0) = 15.0 + 12.0 + 9.0 +6.0 + 3.0 = 45.0

3. **Grade Point Average (GPA):** This is the Total Credit Points (TCP) divided by the total Load Units (TLU). For example, consider the student's scores referred to in number above. The TCP is 45.0 and the TLU is 15. The GPA is therefore 45/15 = 3.0. The

possible GPA that can be earned is 5.0 and that is when a student has earned a grade of ‘A’ in every course during the semester. The lowest GPA obtainable is 0.0.

6.0 PGD Course Synopsis

A. General Module to all participants

SST 700 (1week): Introduction to Space Law: United Nations Treaties and Principles on Outer Space.

SST 800 (3 weeks): Fundamentals and Principles of Remote Sensing and GIS

- Overview of Remote Sensing Technology: History and Evolution

- Electromagnetic Radiation and its interaction with matter: Laws of radiation, Electromagnetic Spectrum and its characteristics, Sources of Electromagnetic Radiation; Propagation of Electromagnetic Energy: dispersion, scattering, absorption, refraction and reflection; Interactions between Electromagnetic Radiation and matter in the atmosphere and on the Earth's surface (emission of radiation): emissivity, black body radiation, Stefan's law, Kirchhoff's law, Wien's law, Plank's law; Physical processes in the interaction of

radiation and matter: properties of the atmosphere, constituents, contaminants, lapse rate, clouds, atmospheric sounding, scattering mechanisms, temporal variations; albedo, reflection, Snell's law, absorption, spectral signatures, photo electric effect, insulation. Spectral characteristics of crops/vegetation, soils, water etc.

BSA 707: Space Biology (2 weeks)

- Introduction to Space Biology; overall physiological response to space flight; Radiation and radiobiology; Medical hazards in space operations; Living in space.

SST 799: Research Methodology (1 week)

B. Main Module

I. Satellite Communications Module

This course consists of eleven modules (including an orientation module), each covering specific areas of Satellite Communications (theory, technology and applications).

Courses:

SCM 701 - Communication Systems (2 weeks)

- Principles of communications and networking (telecommunications overview; Principles of information theory; Principles of modulation and coding; Sampling principles, Theorems and techniques, pulse modulation (PAN, PWM & PCM. Delta modulation and compounders; Microwave theory and techniques; Optical communications; Principles of networking and protocols)

SCM 702 - Digital Signal Processing (2 weeks)

- Discrete time signals and Systems; sampling of continuous time signals; Z-transform; Discrete Fourier transform; Computation of discrete Fourier transform; Structure of discrete time systems; Filter design techniques; Examples of Digital Signal Processing (DSP)-based subsystems for Satellite Communications)

- Laboratory exercises/tutorial (MATLAB-based exercises)

SCM 703 - Satellite Communication Systems (3 weeks)

- Introduction to Satellite Communications: Satellite orbits (Parking orbits); Satellite configurations; Launch vehicle and launching of satellites; Space environment; Reliability; Satellite Bus subsystems; Communication payload [transparent and On-Board Processing – OBP]; Satellite Communications links; Frequency bands for Satellite Communications; Electromagnetic Interference [EMI], Electromagnetic Compatibility [EMC], Radio Frequency Interference [RFI]; Propagation effects on Satellite Communication links). Digital Satellite Communications, Maritime Satellite Communications.
- Experiments and demonstrations: Link parameter calculations, including real propagation models; orbit and footprint simulator; orbit and footprint simulations.

- Visits to Laboratories

SCM 704 - Earth Station Technology (2weeks)

- Satellite Communications Earth station- an overview; Technology of Earth Station Subsystems; Earth station design and fabrication considerations; Earth Station standards; check out of Earth Stations; reliability of Earth Stations; Operations and maintenance. Rockets launch Technology, Parking orbits.

- Experiments and demonstrations: using transmit/receive (TX/RX) satellite terminals.

- Visits to Laboratories

SCM 705 - Transmission, multiplexing and multiple accesses (2 weeks)

- Analog and digital modulation techniques; forward-error correction coding; multiplexing/de-multiplexing; spread-spectrum techniques; multiple access techniques.

- Laboratory experiments (MATLAB simulations; Hardware experiments)

SCM 706 - Broadcasting using Communication Satellites (2 week)

- Analog and digital broadcasting system standards; Digital television; Satellite TV and access systems; Internet Protocol (IP) broadcasting; selected applications, for example: Satellite News Gathering (SNG) for radio and TV, Radio networking, digital audio broadcasting, outdoor broadcasting van, TV studio and its operations, TV coverage of sports, Multicasting, Video Conferencing via satellite, Multimedia [video presentation]

- Laboratory experiments and demonstration (Practical experiments with TV and IP terminals)

SCM 707- Applications and trends in Satellite Communications (2 weeks)

- Satellite Communications services; Selection from Satellite Communications applications, for example: VSAT networks, Meteorological data reception system, News

and meteorological data dissemination system, Data collection system, Disaster management using Satellite Communications; Search and rescue system: International, Regional, Warning dissemination system, Telemedicine, Time and frequency transmission system, Mobile and Personal communication services, Strategic Satellite communication systems, Satellite Navigation system, Satellite-based Internet system, Multimedia broadband satellite system). Future of Satellite Systems.

- Laboratory experiments and demonstrations (Selected hardware experiments using existing facilities and end-user equipment and system demonstrations).

SCM 708 - Operational Communication Satellite Systems (2 weeks)

- Overview of Operational Communications Satellite Systems; Fixed Satellite Service [FSS], Mobile Satellite Service [MSS], Broadcast Satellite Service [BSS], Multimedia Broadcast Service [MBS]; Selection from operational communications satellite systems: International Telecommunication Union [ITU] and other standardization organizations, International Organization for Standardization [ISO], Asia Pacific Tele-community [APT], European Telecommunications Standards Institute [ETSI], NCC standards.

- International regulations

SCM 709 - Network planning/ management/ operational issues of satellite communications systems (1 week)

- Technical considerations for network planning; Planning for space segment; Planning for ground segment; Network operations and control; Management of Communication Satellite operations; Intra-system/inter-system interference

coordination; Space law; Financial aspects of satellite communication). Summary of satellite evolution and costs.

SCM 710 - Satellite Communications for development, education and training (2 weeks)

- Satellite Communications for development, education and training – an overview; Regional experiment with: Hardware, Software, Social research; Local broadcasting (TV, radio, cable network); Planning for Satellite Communications for development; Satellite Technology for development, education and training; Operational, technological and legal issues in trans-border channels for development; Teleconferencing experiences of users for rural development; Disaster management)

- Demonstrations with existing systems

SCM 799 - Research Project (12 weeks)

- Project definition: Needs of the participant's country, Topic of interest to the participant, the work leading towards the one-year project.

- Suggested topics for the project: Earth Station Subsystems, Systems Analysis for Communications Satellites, Spacecraft footprint design, Antenna footprint design, Communication Systems design, Network planning and relevant software development, Applications of TV and radio for development communications, Economics of Satellite Communications, Domestic system definition, Policy research.

II. Remote Sensing and Geographic Information System (GIS) Module

RSG 701 - Remote Sensing platforms, Sensors and Ground systems (2 weeks).

- Platforms - General overview of airborne Remote Sensing: photography, imaging; advantages and applications. Satellite Remote Sensing: classification by orbit, applications, advantages and disadvantages, type of observation, orbital dynamics. Types of satellites: Overview of Earth observation satellites; Overview of optical infrared (IR) remote sensing sun-synchronous satellites; overview of polar platforms and meteorological satellites. High-resolution

satellites; radar satellites; other missions: hyperspectral etc, future satellite systems.

- Sensors - Fundamentals of imaging technology: imaging/non-imaging, active/ passive, advantages and disadvantages. Concept of resolution: spatial, spectral, radiometric and temporal. Aerial photography systems: photographic, historical, camera systems, film types, multispectral photography, Airborne Laser Terrain Mapper (ALTM). Scanners/imagers: frame camera systems, scanning systems, pushroom scanners, spectrometers, charge-coupled devise (CCD), thermal imagers. Microwave sensors: Principles of side-looking airborne radar (SLAR), synthetic aperture radar (SAR) and its characteristics. Non-imaging sensors/systems: infrared radiometer, microwave radiometer, scatterometer, altimeter etc. Other sensors: hyperspectral, laser imaging etc.
- Ground systems - Data reception and pre-processing systems and their configurations. Principles of data reception systems, data transmission and receive chains; recording; archival; pre-processing: radiometric and geometric corrections; types of satellite data

products; value-added products. Ground data collection and truthing; errors in image data and their correction.

RSG 702 –Image processing systems and interpretation (2 weeks)

- Introduction to Photogrammetry: Aerial Photography, photo interpretation, analogue photogrammetry, digital photogrammetry. Principles of accuracy assessment and error analysis

- Configuration, choice and selection. Integrated image analysis and GIS

- Principles of image interpretation of optical, thermal and microwave satellite data

RSG 703 - Digital Image Processing (3 weeks)

- Overview of programming languages: C++ (an object-oriented programming language), Visual Basic (VB), macro languages. Statistical concepts: average, median, mode, standard deviation, covariance matrix, eigenvalues, eigenvector, principal component analysis etc. Ground data for digital image processing. Elements of digital image processing and pre-processing: radiometric, geometric and atmospheric corrections. Image enhancement techniques: histograms, contrast, stretching, transfer functions, histogram equalization, histogram specifications. Filtering: low- and high-pass filters, ideal filter, Butterworth filter, exponential filter, trapezoidal filter etc., smoothing. Classification techniques: spectral distances, probabilities, error analysis, clustering, training areas, sampling methods, extrapolation; per-pixel classifier, Maximum likelihood (MXL)/ Bayesian/ parallelepiped etc., classifiers, object-oriented classifier, Neural Networks (NN), textural, fractals. Accuracy assessment and error analysis. Image fusion techniques. Image segmentation and feature extraction

techniques: knowledge-based techniques, artificial intelligence, fuzzy image concepts. Image transforms and wavelets. Stereo image processing techniques. High-resolution image analysis techniques. Principles of analysis of SAR data, SAR interferometry and differential-interferometric synthetic aperture radar (INSAR) techniques. Processing hyper-spectral, polarimetric, ALTM and other types of data

RSG 704 - Geographic Information System (4 weeks)

- Characteristics and types of GIS data: types of data; concept of information. Maps and projections: principles of cartography, ellipsoids, cartographic projections, coordinate systems, types and scales; accuracy of maps. GPS concepts, techniques, systems, applications. GIS principles: concepts and principles of GIS: GIS models, GIS components, inputs to GIS; GIS database design and organization; integration in GIS, querying in GIS, GIS outputs and visualization, accuracy of data in GIS, GIS integration errors. 3-dimensional GIS: representing 3rd

dimension in GIS, 3-dimensional analysis and derivatives. Concepts of temporal GIS, decision support systems, GIS modeling, visualization techniques, virtual reality, mobile mapping, World Wide Web-GIS. Illustrations and overview of GIS applications. Spatial data infrastructures: metadata, search/access, data warehousing, data mining, standards, specific programmes of countries (United Nations Environment Programme (UNEP)/Global Resource Information Database (GRID), digital Earth, global spatial data infrastructure (GSDI), global mapping etc.); common standards: open GIS, ISO-TC211

Remote Sensing and GIS applications

- RSG 705 (2 weeks): Remote sensing and GIS applications for water resources; agriculture; urban; coastal and oceans; environment; forestry; ecology; geology; mapping and others
- RSG 706 (1 week): Natural disasters
- RSG 707 (2weeks): Sustainable development and carrying capacity
- RSG 708 (1 week): Cost-benefit analysis
- RSG 709 (1week): Urban Planning

RSG 799 – Research Project (12 weeks)

Review for project planning and execution for pilot project

- Pilot project (3 months): pilot projects to be executed at the regional Centre; the topics are chosen by the student, in consultation with his/her sponsoring organization and approved by the Centre.

III. Satellite Meteorology and Global Climate Module

SMT 701: Basic Concept I (2 weeks)

- Meteorology (Atmospheric dynamics; General circulation of the atmosphere; Tropical and extra- tropical weather systems),
- Climatology (Components of the Earth's climate Annual and semi-annual cycles; Climate variability; Overview of world climate)
- Oceanography (Role of oceans in weather and climate; Oceanographic parameters; Ocean circulation; Air-sea interactions)
- Overview of meteorological satellites/orbits (Orbital dynamics; Polar and geostationary

satellite; Operational meteorological satellite)

SMT 702: Basic Concept II (2 weeks)

- Mathematics (Matrices; Partial and total differential equations; Integrals and derivatives)
- Statistics (Data Analysis; Supervised and unsupervised classification)
- Computer techniques (Different computational environments; Computer language; Meteorological software; Graphic tools; Multimedia)

SMT 703: Image processing and GIS (2 weeks)

- Instrumentation and meteorological sensors (Passive and active sensors; Sensor technology: optical/infrared/water vapour; Sensor technology: microwave; Concept of resolution: spatial, temporal; Spectrometers; Imagers versus sounders)
- Image interpretation and application (Synoptic and meso-scale systems; Tropical and extra-tropical weather systems; Atmospheric pollutants (dust, haze, smoke, forest fires etc.); Ocean monitoring)

- Image processing techniques (Projection software; Image registration/navigation, radiometric and geometric correction; Atmospheric correction; Image classification, clustering etc.).
- Basic GIS (Basic concepts; Data management; Data manipulation; Implementation of GIS; Multi-layer map production; Applications for meteorology and climatology).

SMT 704: Satellite data retrieval and applications (4 weeks)

- Geophysical parameter retrieval (Statistical and inversion methods; Weighting functions)

- Atmospheric parameters (Winds; Atmospheric profiles; Precipitation; Outgoing long wave radiation (OLR); Aerosol concentration; Cloud information; Radiation budget)

- Land and ocean parameters (Sea-surface temperature, Sea-surface winds; Vegetation index; Land-surface parameters)

- Applications of derived parameters (Intra-seasonal variability; Tropical/extra-tropical systems; Drought monitoring; Rainfall variability; Air-sea interaction; Regional/local weather systems)

SMT 705: Numerical models and satellite data assimilation (3 weeks)

- Regional and global models (Simple models and zero-, one-, two- and three-dimensional (0-D, 1-D, 2-D, 3-D) models; Basic model structure; Role of satellite data for parameterization

- Concept of data assimilation (Basic of data assimilation; Observing systems; Subjective, objective analysis; Assimilation cycle; Model output)

- Satellite data assimilation (Humidity, wind, temperature; Rainfall; Impact

SMT 706: Global Climate (2 weeks)

- Climate change (Basics of climate monitoring; Greenhouse effect and global warming; Short- and long-term variability; Radiation budget and feedback mechanisms; Anthropogenic effects)

- Impact of climate change (El Nino-type impacts; Upwelling; Icecap; Sea level and coastal inundations; Future climate projections)

- Climatology based upon satellite data (Cloud climatology [International Satellite Cloud Climatology Project – ISCCP]; Land surface climatology [International satellite Land Surface Climatology Project – ISLSCP]; Global precipitation [Global Precipitation Climatology Project-GPCP])

SMT 707: Environmental issues (2 weeks)

- Atmospheric chemistry (Ozone; Other trace gases; Role of pollutants; Satellite observation programmes)
- Environmental protocols (Global climate change and policy implications; Agenda 21: integrated sustainable development; Kyoto Protocol to the United Nations Framework Convention on Climate Change)
- Disaster management (Monitoring techniques; Dissemination of information; Satellite-based warning systems)

SMT 799: Research Project (12 weeks)

IV. Basic Space and Atmospheric Science Module

BSA 701: Mathematics for Space Scientists and Engineers (4 weeks)

As an introduction to the topic of Mathematics for Space Scientists and Engineers, a refresher course could cover the following topics: algebra, geometry, trigonometry, linear algebra, calculus, ordinary differential equations, probability and statistics (Poisson and Gaussian distributions), introduction to numerical analysis, simple computer programming, and basic knowledge of vector analysis. It may be desirable to make extensive use of examples taken from areas of space physics such as motion in a gravitational field, satellite orbits etc. Following the refresher course, the following courses could be held.

- Statistics and data analysis: error analysis, time-series analysis, trends, Fourier analysis, effects of noise on data, fitting techniques, least squares, maximum likelihood, linear filtering methods, and statistical tests of significance.
- Methods of numerical analysis: interpolation and extrapolation, finite difference methods, integration.

- Modeling: numerical solution of partial differential equations, development of a simple numerical model, practical use of numerical model.

BSA 702: Structure, composition, dynamics and evolution of planetary atmospheres (4 weeks)

- Atmospheres (including Earth's atmosphere)
- Energy budget of planet Earth
- Structure composition and dynamics of Earth's atmosphere
- Solar radiation and effects of variability in Earth's atmosphere
- Comparison with atmospheres of other planets
- Long- and short-term evolution of the atmosphere
- Regional climatology

BSA 703: Ionospheric Physics (2 weeks)

- Structure and variability of Earth's ionosphere; Ionospheric techniques, especially space techniques; Ionospheric plasma dynamics; Optical emissions from the ionosphere; Ionospheres of the planets and their satellites; Ionosphere-atmosphere

interactions; Radio communication through the ionosphere.

BSA 704: Solar wind, Magnetosphere and Space Weather (2 weeks)

- Solar activity and its effects; Magnetic fields of Earth and other planets; Magnetosphere of Earth and other planets; Interplanetary medium and space weather

BSA 705: Astronomy and Astrophysics (2 weeks)

- Introduction to Astronomy; Structure and evolution of stars and galaxies; Astronomical observations at all wavelengths; Cosmic rays; Basic cosmology

BSA 706: Basics of spacecraft design, construction and launch (2 weeks)

- Orbital dynamics and launch vehicles; Altitude measurement and control; Power generation and storage; Telemetry and command, data management; Mechanical design and testing. Thermal design and control; Payload design considerations; Materials for use in space systems.

BSA 707: Space Biology (2 weeks)

- Introduction to Space Biology; overall physiological response to space flight; Radiation and radiobiology; Medical hazards in space operations; Living in space.

BSA 708: Space Geodesy (2 weeks)

- Coordinate systems: Earth-based, global and regional; Establishing coordinate systems from space- based observations; Global Positioning System (GPS): theory and implementation; Geographic Information System (GIS): theory and implementation; Scientific applications of Space Geodesy: continental drift, Earth-Moon, separation etc.

BSA 799: Research Project (12 weeks)

V. Global Navigation Satellite System (GNSS) Module

GNS 701: Fundamentals (3 weeks)

- Introduction to GNSS: Conventional navigation, background, concepts and evolutions of Global Navigation Satellite Systems (GPS, GLONASS, Galileo, BeiDou/ COMPASS) and regional navigations

satellite systems (IRNSS, QZSS). Comparison of GNSS with other navigation systems;

- Reference systems: Terrestrial, celestial and orbit coordinate reference system. Height Systems. Geoid. Time systems, synchronization and data conversion. Transformations between coordinate reference systems. Contribution of the International GNSS Service (IGS) to providing access to the International Terrestrial Reference Frame (ITRF);

- Satellite orbits: Orbital parameters. Orbital motion, representation (Keplerian elements, etc) Determination of satellite position, visibility and ground tracks;

- Basic techniques of communications: Propagation of Electromagnetic Waves. Antennas and propagation channels. Signal modulation and multiple accesses. Signal processing.

GNS 702: Position determination techniques (2 weeks)

- GNSS measurements: pseudo-ranges, carrier phase and Doppler;
- Position determination techniques (general);
- Single point position technique: models and estimation methods;
- Satellite constellation and dilution of precision: satellite geometry, bounds and calculations on dilution of precision (DOP).

GNS 703: Technologies: augmented systems (3 weeks)

- Errors in GNSS measurements: functional model and fundamental error equation, effect of GDOP, classes of ranging errors and biases;
- Effects of errors: error budget, user equivalent range error, position accuracy with one sigma and three sigma errors;
- Error mitigation techniques: real time kinematic (RTK), differential GNSS (DGGNSS), local area DGNSS, wide area DGNSS;
- Augmented systems: Wide Area Augmentation System (WAAS), European Geostationary Navigation Overlay Service

(EGNOS), System of Differential Correction and Monitoring (SDCM), Multi-functional Transport Satellite (MTSAT) Satellite based Augmentation System (MSAS), GPS Aided Geo Augmented Navigation (GAGAN), etc.;

- GNSS networks: Global, regional and local GNSS Permanent Networks and geodetic infrastructure for real positioning services;
- GNSS impact factors and mitigation techniques: Orbit errors, clock errors, multipath, troposphere, ionosphere including higher order ionospheric refraction effects, vulnerability against space weather, jamming.

GNS 704: Sensors and embedded system design (3 weeks)

- Sensors and transducers: Introduction, Sensor classification, characteristics and compensation, classification of transducers. Transducer descriptions, parameters, definitions and terminology;
- Embedded systems: Cell phones, pagers, PDAs, answering machines, microwave ovens, televisions, VCRs, CD/DVD players, video game consoles, GNSS devices, network routers, fax machines, cameras, music synthesizers, planes, spacecraft,

boats, and cars all contain embedded processors.

GNS 705: GNSS receivers (3 weeks)

- Receiver architecture: Technology, radio-frequency front end, signal processing system hardware and software techniques, software defined radio;
- Signal tracking: Maximum likelihood estimate of delay and position, delay lock tracking of signal, coherent and non coherent delay lock tracking of pseudo noise sequences, mean square error estimation, vector delay lock loop, receiver noise performance, maximum likelihood estimate, early late gating;
- Navigation algorithm: Measurement of pseudo range, Doppler, decoding and using of navigation data, single point solution, precise point positioning, dynamics of user, Kalman filter, least-squares adjustment, and other alternatives.

GNS 706: GNSS/INS integrated navigation (3 weeks)

- Inertial navigation systems. Accelerometer, Gyroscopes, Inertial platforms, Navigation

equation, Integration of modeling equations in e-frame;
- INS error dynamics: Simplified analysis, Error dynamics equations in e-frame, INS initialization and alignment;
- GNSS/INS integration: Integration mode, Mathematical model of supported INS navigation, Observation procedures for inertial surveying;
- General sensor fusion concepts.

GNS 707: GNSS applications (2 weeks)

- Geospatial databases: Geo extensions for Open Source Databases, POSTGRES, MySQL etc.;
- GNSS navigation: Professional and personal, GIS/mapping, Surveying, Natural Hazards management, Earth Sciences, 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 technique for monitoring

terrestrial weather (temperature and water vapor) and monitoring ionospheric weather (electron density and total electron content);
- Revenue model for value added services;
- Management, team work, intellectual property, business in GNSS.

GNS 708: Space Weather and GNSS (2 weeks)

- Sources of Space Weather and related background physics: Sun, Galactic cosmic rays, magnetosphere, thermosphere, ionosphere coupling;
- Impact 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 modeling;
- GNSS-based monitoring of the ionosphere by ground and space based measurements;
- Ionospheric correction and threat models.

GNS 799: Research Project (12 weeks)

Lecturers

S/N	Name	Qualifications	Area of Specialization
1	Dr. G.I Agbaje	Bsc.(Hons), Msc (Unilag), MPhil (Camb), PhD (Lancs), fnis	Geo-informatics
2	Dr. O.R. Oladosu	B.Sc.(Makurdi) M.Sc., Ph.D. (Ife)	Atmospheric & Space Physics
3	Prof. S. O. Fadare	B.Sc., MCP (Ewu), PhD (Sheffield), MURP, Ph.D.	Urban & Regional Planning/ Environment
4	Dr B.O. Balogun	B.Sc., PGD, M.Sc., Ph.D.	Environmental Control & Management
5	Prof J.D. Arotupin	B.Sc., M.Sc., Ph.D.	Space Biology

6	Dr. K. Adepoju	B.Sc., M.Sc. Ph.D. (Ife)	Environmental & Resource conservation
7	Dr. S. Ayanlade	B.Sc., M.Sc. (Ife) PhD (London)	Environmental Science
8	Dr. F.O Akinluyi	B.Sc., M.Sc., Ph.D.	Geo-informatics
9	Mr. Ogah O.	BSc., PGD, MSc. (GNSS)	GNSS
10	Dr. M. Fagbeja	B.Tech, M.Sc., Ph.D.	Environmental, Air Quality & Climate Change.
11	Dr. Bayo Ojo	M.Sc., Ph.D	Environmental & Resource conservation
12	Dr. Olawole, O	M.Sc., Ph.D	Transport Management
13	Dr. Baloye, D	B.Tech, M.Sc., Ph.D.	Environmental & Resource Conservation
14	Shonubi F.B.	BSc, MSc, PGD (Basic Space)	Space Physics

15	Dr. A.O Salau	B.Eng, M.Sc. PhD (Ife)	Telecommunication Traffic
16	Mr. J.A.K Adeniran	M.Sc.	Cost Management
17	Barr. J.O Nester	LL.B, B.L, LL.M, MIR, M.Phil.	Space Law & Policy
18	Barr. A.O Awotoye	B.Sc.(Babcock), LL.M(UK)	Int. Law, Cooperate Governance & Space Law
19	Mr. Felix Buba	B.Sc., PGD, M.Sc.	Environmental Geology
20	Mr. O. Aluko	B.Sc., PGD, M.Sc.	Environmental Geology
21	Mr. O. E. Ebeiyamba	B.Sc. (UNN), PGD (ARCSSTEE), M.Tech (Akure)	Environmental Management, Geo-Information Technology
22	Mr. A. Adegbite	B.Sc. (Ibadan), M.Sc. (Sheffield)	Environmental Management

23	Mr. Leye Salu	B.Sc., M.Tech, M.Phil.	Satellite Communication
24	Prof. A.B. Rabiu	B.Sc. (Ilorin), M.Sc, PhD (UNN)	Space Physics
25	Mr. O. Adebowale	B. Tech. (Ife)	Satellite Communication
26	Mr. T.P Owolabi	B.Tech (Minna), PGD, M.Tech (Akure)	Space Physics
27	Dr. O.O. Ajileye	B.Sc., M.Sc., Ph.D (Ife).	Atmospheric Physics
28	Dr. R.A Badru	B.Eng, M.Sc., Ph.D (Ife).	Electronics & Electrical Engineering
29	Dr A.O Atijosan	B.Eng, M.Sc., Ph.D.(Ife)	Electronics & Electrical Engineering
30	Dr. O. Oluwatope	B.Sc., M.Sc., Ph.D. (Ife)	Communication Systems
31	Dr. O. O. Alabi	B.Sc., M.Sc. (Ife), Ph.D.	GIS & Geosciences

		(USA)	