Sustaining the Vision from GHANASAT-1 into GHANASAT-2

United Nation-South Africa Symposium on

Basic Space Science Technology

13th December 2017

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Content

- Introduction
- About All Nations University Space Activities
- Ghanasat-1 Project
- Ghanasat-2
- Future Plans

Ghana's Space Program Status

- In 2009: The establishment of Ghana Space Agency was conceived by the then minister of science and technology **[Hon. Ms. Sherry Ayittey]**

Imitating A Three Phase Program

- **Phase 1 : Year 2011**
  - Establish Space Technology Center
- **Phase 2 : Year 2013**
  - Establish Space Technology Institute (2013)
- **Phase 3 : Year 2016**
  - Establish Space Agency

Phase 1 and Phase 2 has been achieved

http://www.spacesafetymagazine.com/space-on-earth/national-space-programs/three-phase-development-plan-emerging-ghana-space-program/

Ghana Radio Astronomy Observatory Project

- Singed-up for the South African Square kilometer spearheaded by South Africa
- Becoming a partner of the African Very Long Baseline Interferometer Network
- By converting a 32-metre Intelsat Telecommunications Satellite Earth Station at Kuntunse into a functioning radio telescope.
- To build human capacity in radio astronomy in Ghana

Milestones for Science Operations Readiness

- **Milestone 1**: Science Commissioning Phase 1 after successful Engineering Release 1 (November 2016 – June 2017)
- **Milestone 2**: Science Commissioning Phase 2 after successful Engineering Release 2 to complete the conversion process (January 2018 – March 2018)
- **Milestone 3:** Preliminary Science operations in VLBI and non-VLBI modes (April 2018 – September 2018)
- **Milestone 4**: Successful Science operations in VLBI and Single dish modes at this stage signifies quality science readiness of the radio telescope (October 2018 – June 2019)

Officially Launched in August 24 ,2017

32M Telecom Parabolic Dish Antenna converted to Radio Telescope located at Kuntunse in the Eastern Region of Ghana

http://presidency.gov.gh/index.php/2017/08/24/president-akufo-addo-launches-ghana-radio-astronomy-observatory/

Ghana's Space Activity & Status

- Ghana is a member of UN-COPOUS since 2013

UNITED NATIONS
Office for Outer Space Affairs

About Us | Our Work | Benefits of Space | Information for... | Events | Space Object Register | Docum

Our Work > Secretariat of COPUOS > Member States and Observer Organizations > Membership Evolution

Committee on the Peaceful Uses of Outer Space: Membership Evolution

2013	76	GA resolution 68/75	Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Belgium, **Belarus**, Benin, Bolivia, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Chad, Chile, China, Colombia, Costa Rica, Cuba, Czech Republic, Ecuador, Egypt, France, Hungary, Germany, **Ghana**, Greece, India, Indonesia, Iran, Iraq, Italy, Japan, Jordan, Kazakhstan, Kenya, Lebanon, Libya, Malaysia, Mexico, Mongolia, Morocco, Netherlands, Nicaragua, Niger, Nigeria, Pakistan, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, the Saudi Arabia, Senegal, Sierra Leone, Slovakia, South Africa, Spain,

State, area or organization	(1)	(2)	(3)	(4)	(5)
	1967	1968	1972	1975	1979
Ghana	OST	ARRA	LIAB	REG	MOON
	S	S	S		

R: ratification, S: signature only

OST (Outer Space Treaty)	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies
ARRA(Rescue Agreement)	Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into OuterSpace
LIAB (Liability Convention)	Convention on International Liability for Damage Caused by Space Objects
REG (Registration Convention)	Convention on Registration of Objects Launched into Outer Space
MOON (Moon Agreement)	Agreement Governing the Activities of States on the Moon and Other Celestial Bodies

http://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html

All Nations University (ANU) Space Activities

The first Private Institution contribution to the sustainable Space Activities in Ghana

History of ANU

Dr Samuel Donkor , Founder and President

- Founded in April 1996
  - 3000 Undergraduate students
  - 160 Academic Staffs
- Vision
  - Provide higher education, pursued in a environment of truth and integrity.
- Mission
  - Provide quality higher education that promotes development and to raise leaders with values and ethics to serve society.

School of Engineering

School of Business and Nursing

http://anuc.edu.gh/home/aboutus/5/aboutus.html

All Nations University Laboratory Space Systems Laboratory [ANU-SSTL]

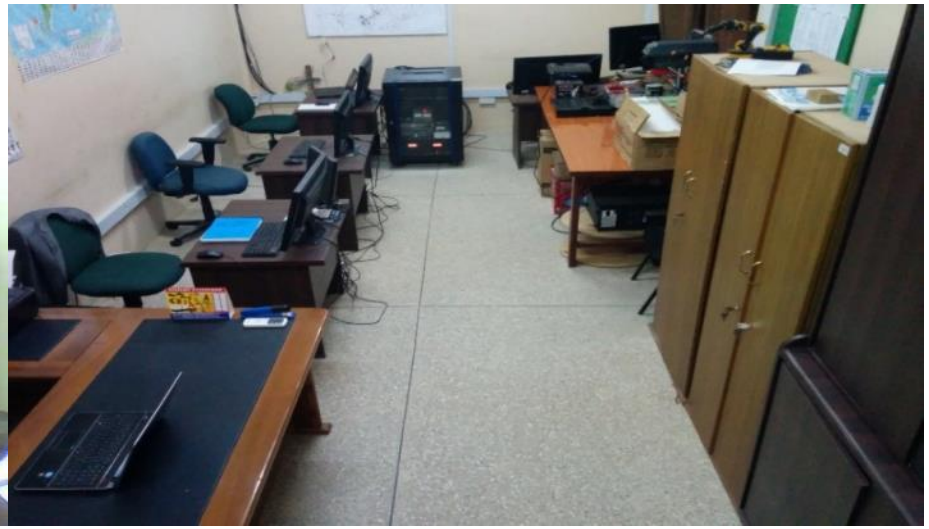
- Established in February 2012 _Under the Electronics & Communication Eng. Dept.
- Staffs: 6

Mission

To *promote and build human capacity* in the area of Space Science and Satellite Technology *through innovative research and development of educative projects* to impact our society and Africa as a whole.

ANU School of Engineering

ANU-SSTL Lab



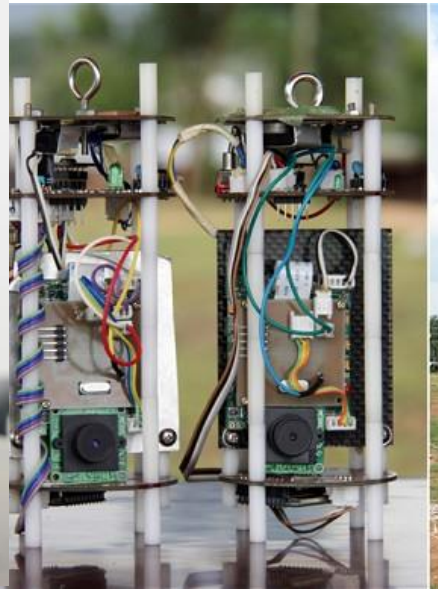
ANU-SSTL Milestones

The journey so far..

THE CANSAT (15th May, 2013)

A Partnership Program With Miyazaki Laboratory-Nihon University, Japan

Flight Model



Ground Testing

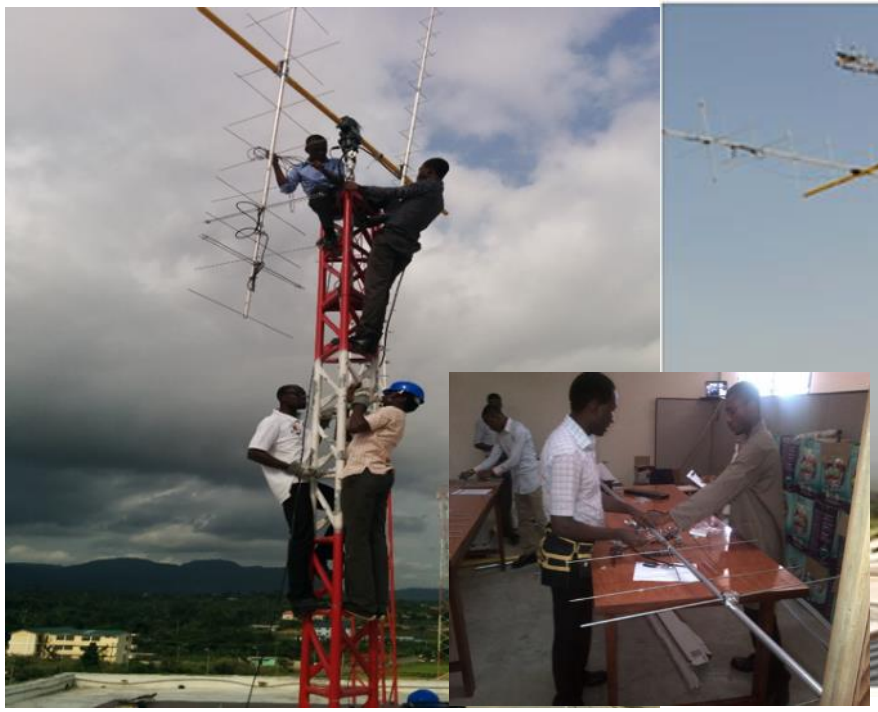
Launch Day

Flight

- An educational and deployable satellite.
- A 500ml can-sized structure housing components and sub-systems applicable to a real satellite.
- A tool for practical training in Satellite Technology.

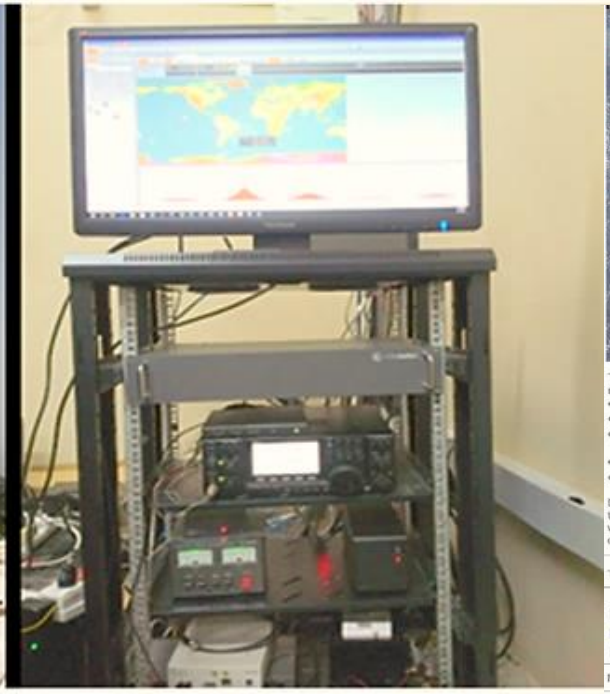
AMATEUR GROUND STATION (June , 2014)

Integration stage

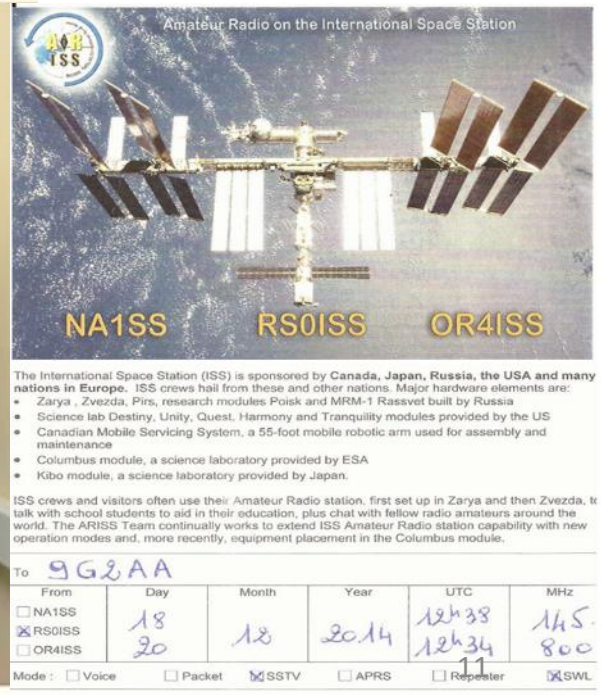


Outdoor Unit

Indoor Unit



QSL card from the ISS



Made a Historic contact with the International Space Station (ISS)

- Registered with NCA with callsign **9G2-AA.**
- Operates in UHF/VHF frequencies.
- QTH : LAT $6^{O}\ 6^{1}\ 33.87$ N , LONG $0^{O}\ 18^{1}\ 7.41$ W.
- Successful communication with amateur satellites and also with the ISS.
- **Its is part of the Birds Ground Station Network**

AEROSOL ROBOTIC NETWORK (November , 2015)

Integration stage

Outdoor Unit

Facilitator

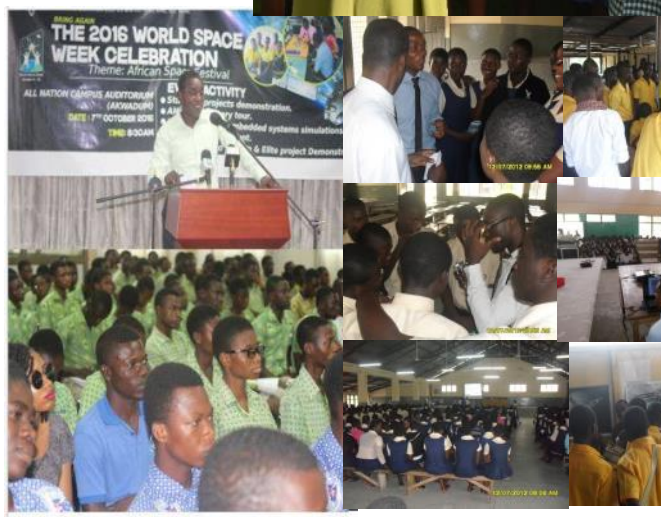
Dr. Richard Damoah,
Goddard Space Center.
Director,
ANU-SSTL.

- Sun photometer installed by Engineers from NASA and ANU-SSTL.
- The station operates as part of the NASA Aerosol Robotic Network.
- The system measures the atmospheric aerosol column over the region.

Conferences and Outreach Activities

2017 World Space Week Celebration

Annual Conferences(SSSTA-2015)



Conferences and Outreach Activities

Annual Conferences / Workshop (SSSTA-2016)

- Theme:

Importance of Small Satellite Technology Application To Enhance The Development of Developing Nation

- Hosted participants from about **15 countries, including JAXA delegates**

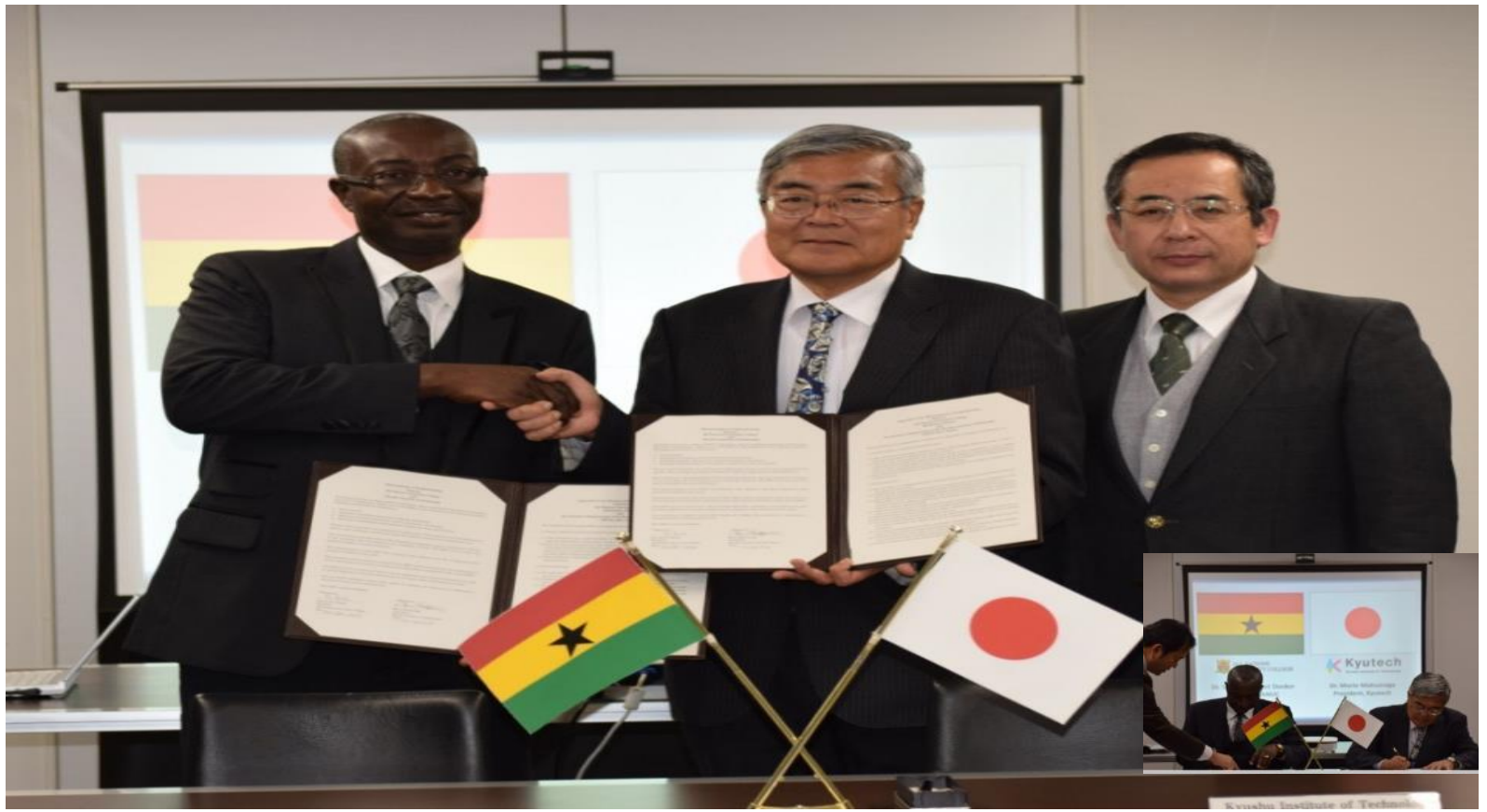
Facilitated by ANU & Kyutech

Ghanasat-1 Project

First Ghana Satellite into Orbit

Memorandum of Understanding (MOU) Between All Nations University(ANU) and Kyushu Institute of Technology (Kyutech)

ANU management visited Prof Cho , Director of Laboratory of Spacecraft Environment and Interaction Engineering (LaSEINE) to discuss the future of ANU Space Research and Education in **May 2015**



- Official signing ceremony : January 6 ,2016
- To train ANU sponsored students studying at Kyutech to build capacity in satellite technology and build the first Ghana satellite to contribute to the sustainable space activities in Ghana

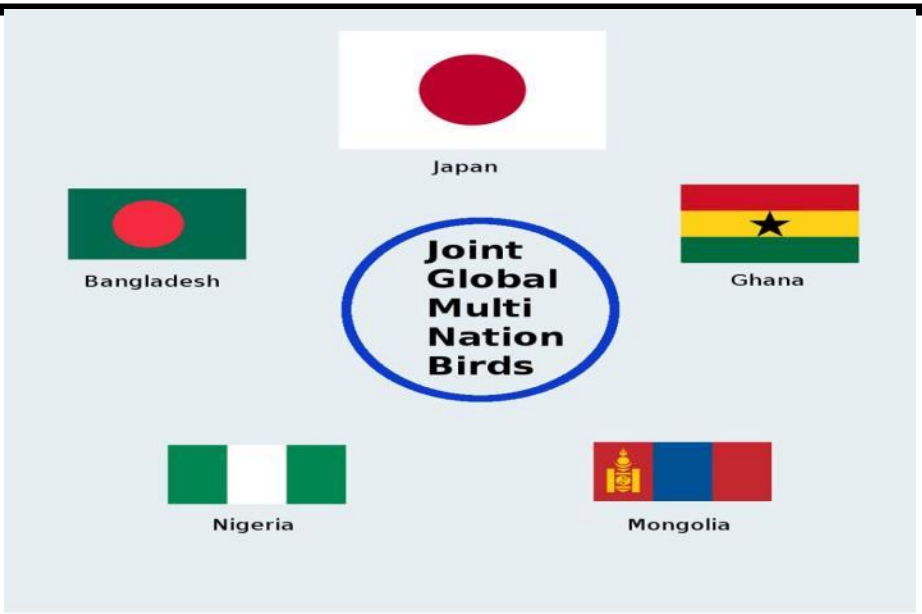
BIRDS Project

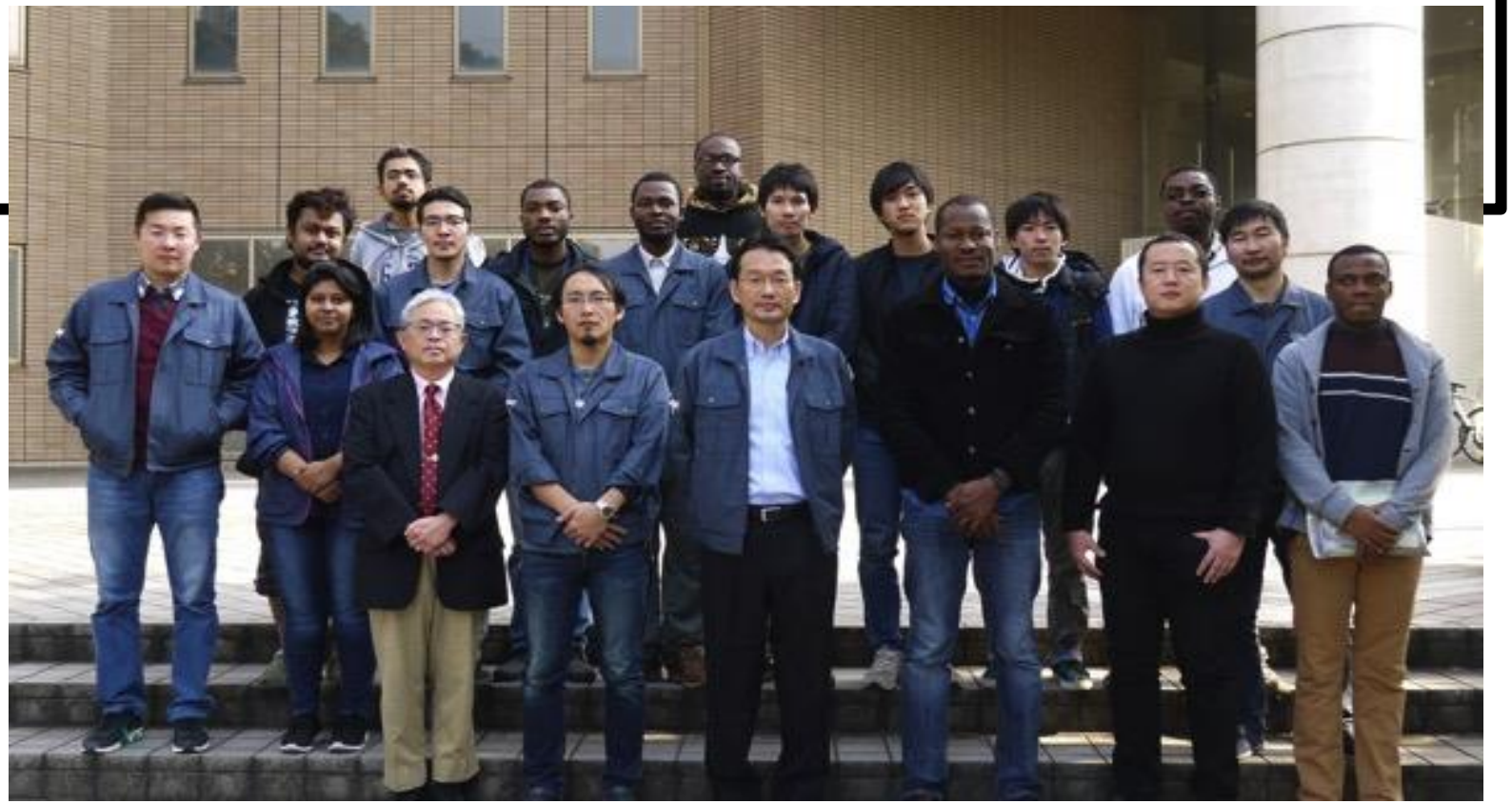
Joint **G**lobal **M**ulti-**N**ation **B**irds (JGMNB): Satellite program for non-space faring countries. *Shortly called as "BIRDS Project"*

Birds Project is initiated by Kyushu Institute of Technology (Kyutech), Japan, through its Laboratory of Spacecraft Environment Interaction Engineering (LASIENE).

Proposed Date : July 17 July , 2015

Kick Off: 22 October ,2015





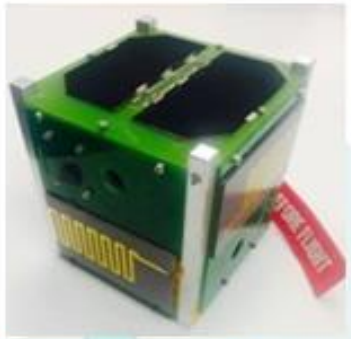
Mission Statement

Successfully building and operating the first national Cubesat and making the foremost step toward indigenous space program at each nation.

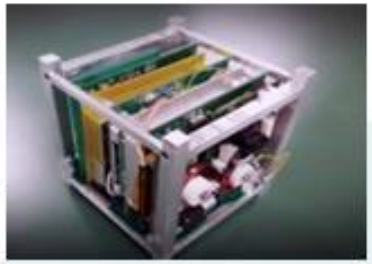
GhanaSat-1 Life Cycle and Timeline

Launch

FDR; Flight Readiness Review



Flight Model Fabrication



Engineering Model Fabrication

CDR; Critical Design Review

Bread Board Model Fabrication

PDR; Preliminary Design Review

Research and Discussion to define CubeSat System

SDR; System Design Review

Research and Discussion to define CubeSat Mission

MDR; Mission Definition Review

Mission of GhanaSat-1

- **Take monitor the coastal belts of Ghana and other neighboring countries**
  - -Employed 2 Cameras (High and Low Resolution)

- **Digi-singer Mission (SNG)**
  - -Exchange of voice data from satellites to Ham Radio receivers (UHF band)
  - -An initiative aimed at stimulating interest in science, technology, engineering and mathematics (STEM) education in high schools and tertiary institutions.

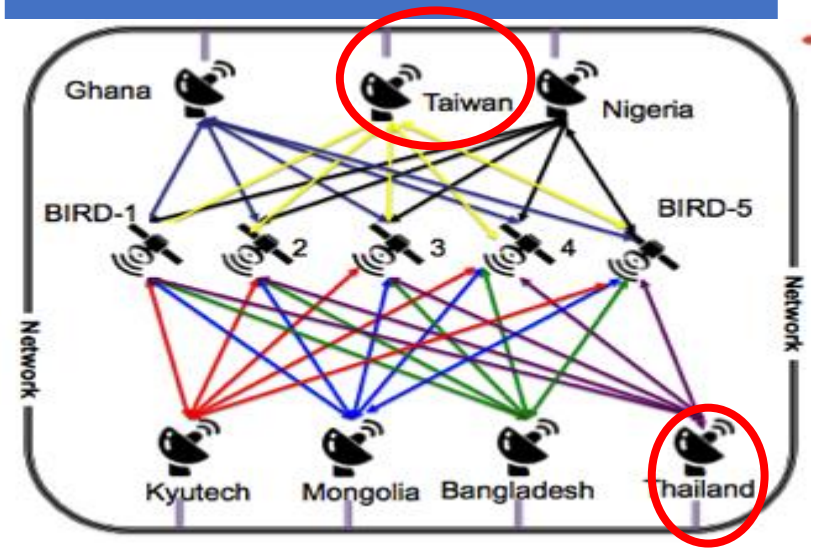
- **Measure Single Event Latch-up in orbit (SEL)**
  - -By taking log of microcontroller reset events over period of time.

Mission of GhanaSat-1 and other Birds Satellite

- **Determination of Satellite Precise Location (POS) without GPS**
  -Using analysis of Time Of Arrival (TOA) from time lag among multiple ground stations

- **Atmospheric Density Measurement (ATM)**
  -Using Orbital analysis from precise satellite tracking information (POS).

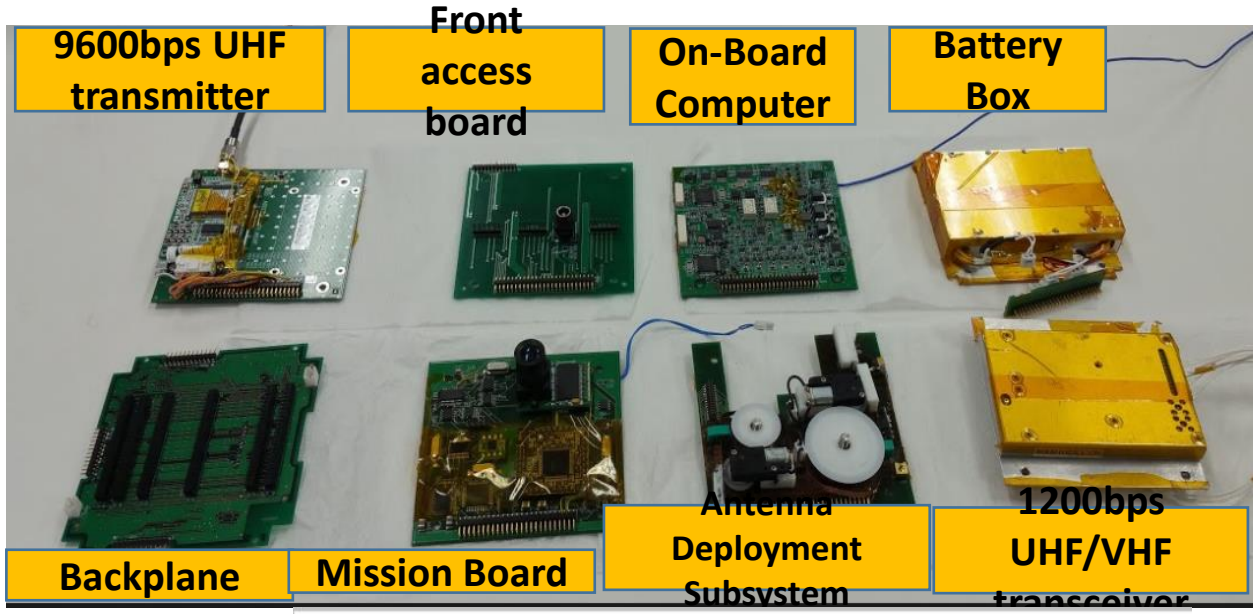
- **Demonstrate Ground Station Network for CubeSat Constellation (NET)**

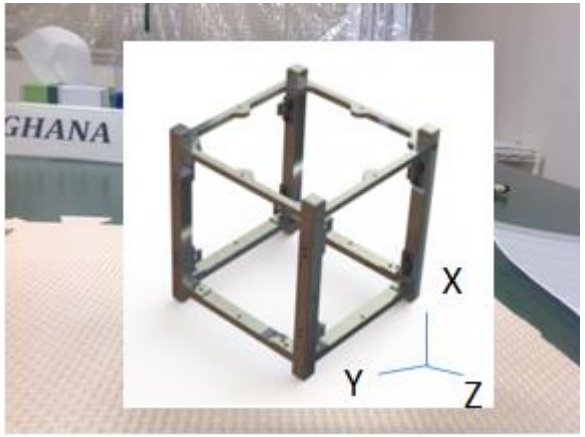


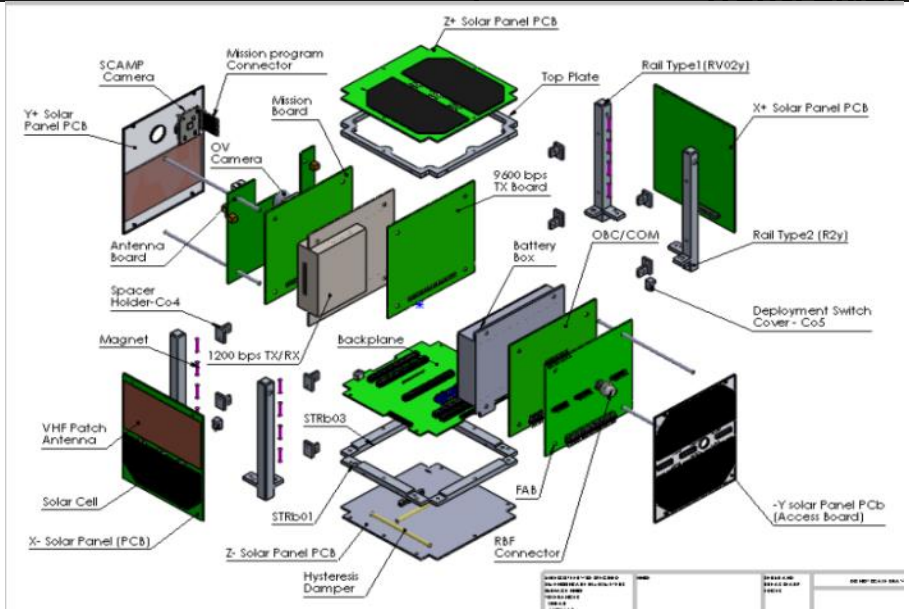
Ghanasat-1 Development Phases

Ghanasat-1 Parameters

- Ghanasat-1 is an educational satellite
- Ghanasat-1 is a 1U Cubesat
- Mass : 1.11kg
- Size: 10cm x 10cm x 10cm
- Operating Frequency: VHF /UHF
  - VHF: 145MHz-146MHz (Uplink)
  - UHF:435MHz – 438MHz (Downlink)
- Modulation Scheme
  - AFSK
  - GMSK
- Data Throughput
  - 1200bps
  - 9600bps
- RF Transmit Power
  - Modulation:27dBm (0.5W)
  - Unmodulated: 30dBm (1W)

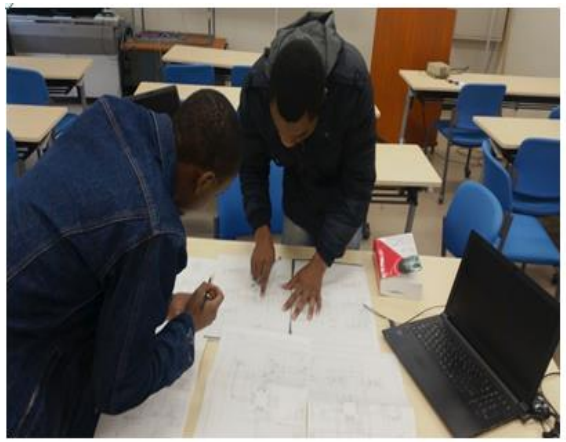
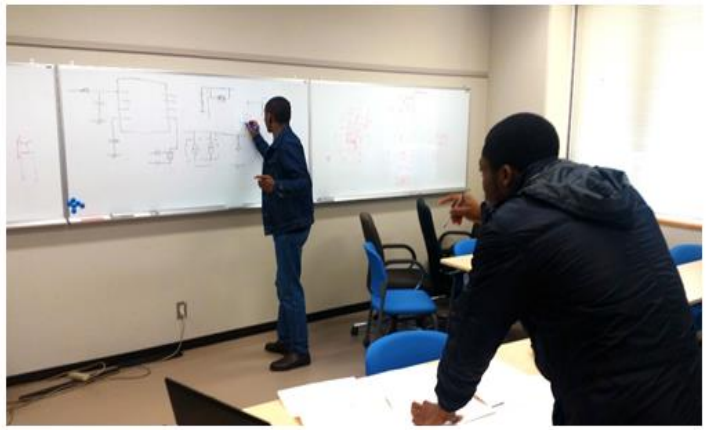




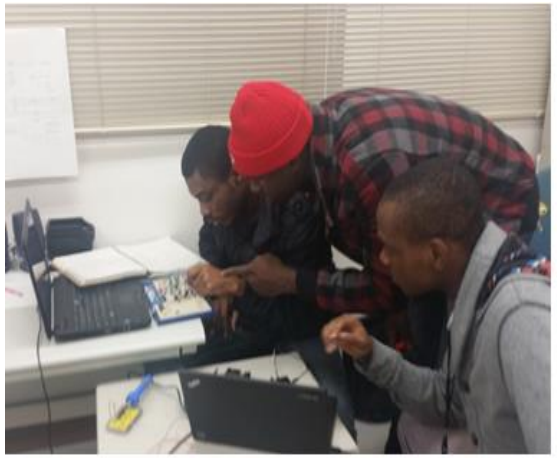


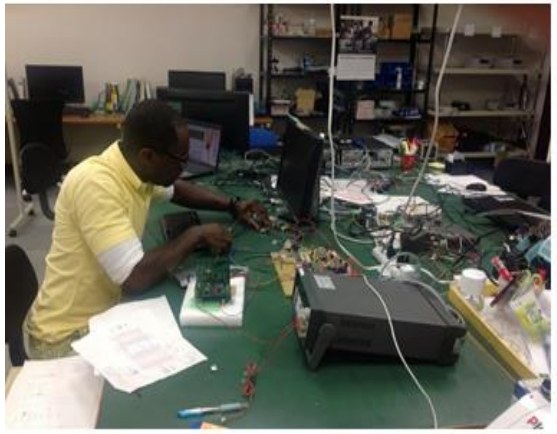
Bread Board Model (BBM) Development Phase (Activities)

Brainstorm session

Design , Development and Functionality Test






Results are been presented during the Birds Meetings and the team should be ready to face questions , criticism and comments .

Flight Model Development Phase (Activities)

Assembly , Integration and Functional Test

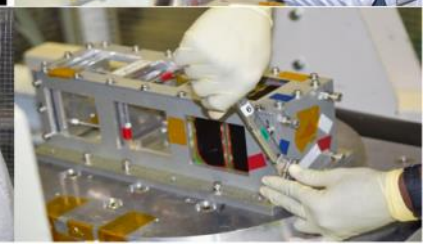


Solar Simulation Test




Vibration Test



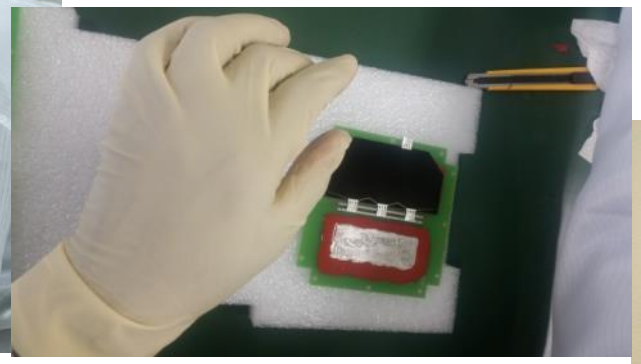


Antenna Deployment Test

Fit check and Safety Review by JAXA Officials



Problem Encountered and Lesson Learned



Solar Panel Attachment , three solar panel was broken in the FM development phase

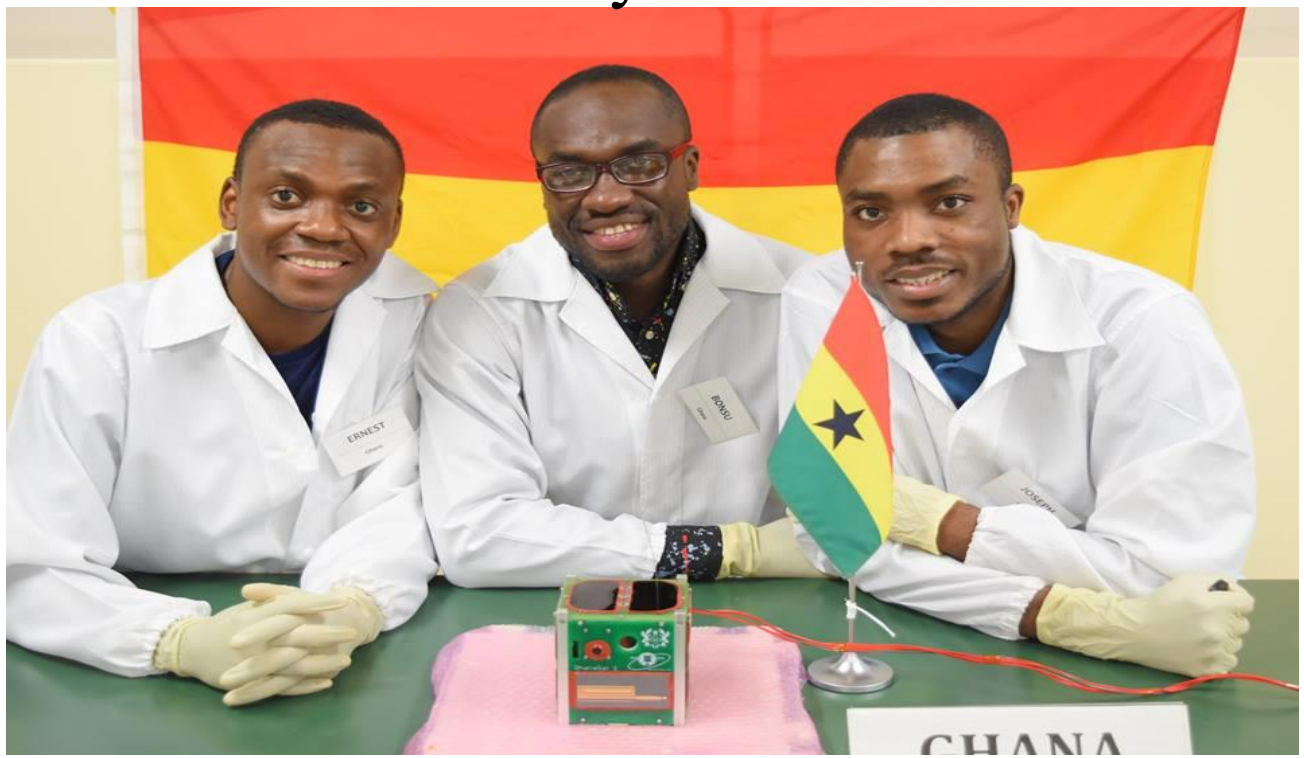
Structure Assembly and Fit check Acceptance

❖**Lesson Learned**

1. Don't use broken components for FM development
2. Time and schedule is very critical in satellite development

GhanaSat-1 Team and BIRDS Project Team Members before satellites delivery to JAXA

- Date : 8th February 2017



Ernest Matey (Left), **Benjamin Bonsu** (Middle), **Joseph Quansah** (Right)

Birds Project Team Members

Birds Satellites Delivery at JAXA

- Date of Delivery : 9th February 2017

© JAXA

Birds Team Members | JAXA Team

© JAXA

Launch to International Space Station

- **Launch : June 3, 2017 @ 5:07pm GMT**
- **Launch Vehicle: SpaceX Falcon-9 CRS 11**
- **Launch Site: Kennedy Space Center LC-39A**

SpaceX CRS -11 Dragon docked to ISS on June 5 , 2017

Deployment of GhanaSat-1 into Orbit

- **Deployment**
  - **Date: July 7 , 2017**
  - **Time: 9:05 am UTC**

Dr Donkor , Founder of ANU delivers speech during JAXA press conference after Ghansat-1 Deployment into Orbit

Deployment of GhanaSat-1 into Orbit via ISS /Japan Kibo Deployment System

Ghana Ambassodor, H.E Allotey Parker (in white) with JAXA president and other dignitaries at JAXA VVIP control room

Hon. Ursula Owusu , Ghana Minister of Communication congratulated the Ghanasat-1 team , Kyutech and JAXA for making Ghana recognize in the global space community

Ghanasat-1 Operational Status

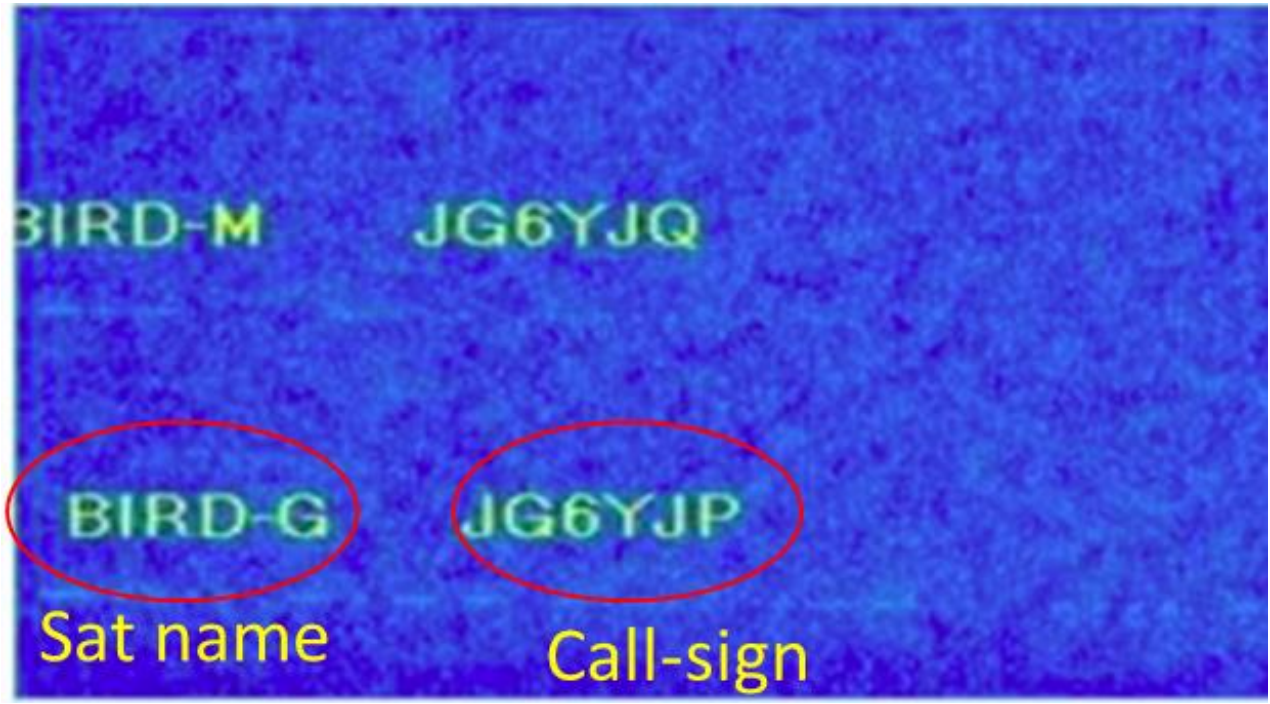
- GhanaSat-1 Signal Reception

(Health Status Data Monitoring)

- In the Operational Phases

(Main Mission not started yet)

GhanaSat-1 signal QSL (Contact Verification card)



GhanaSat-1 signal reception decoded by Software Define Radio Interface

Publications of Ghanasat-1

More than 70 articles has been published about Ghanasat-1 in both local and international media

Ghanasat-2 Mission Concept

Developing a homebased CubeSat

PROBLEM STATEMENT

- Ghana is rich in Gold [One of our major natural resources]
- There is therefore a lot of illegal gold mining activities at the gold resourced mining arears
- Most water bodies are polluted by the illegal mining activities in this gold resourced arears
- The Environmental Protection Agency [EPA] responsible for stopping these activities face the challenge of automatically monitoring the illegal mining activities

The “Galamsey” A National Concern

The illegal mining “Galamsey” has become a major concern for the country and much money is channeled to reducing its effect to the society

Current Proposals and Implementations

The use of Drones for monitoring

Gov't to deploy drones worth $3m for anti-galamsey campaign

Source: Ghana | Myjoyonline.com

Date: 14-09-2017 Time: 11:09:00:pm

Disadvantages

- Physical attack to flying drones
- Miners are armed.

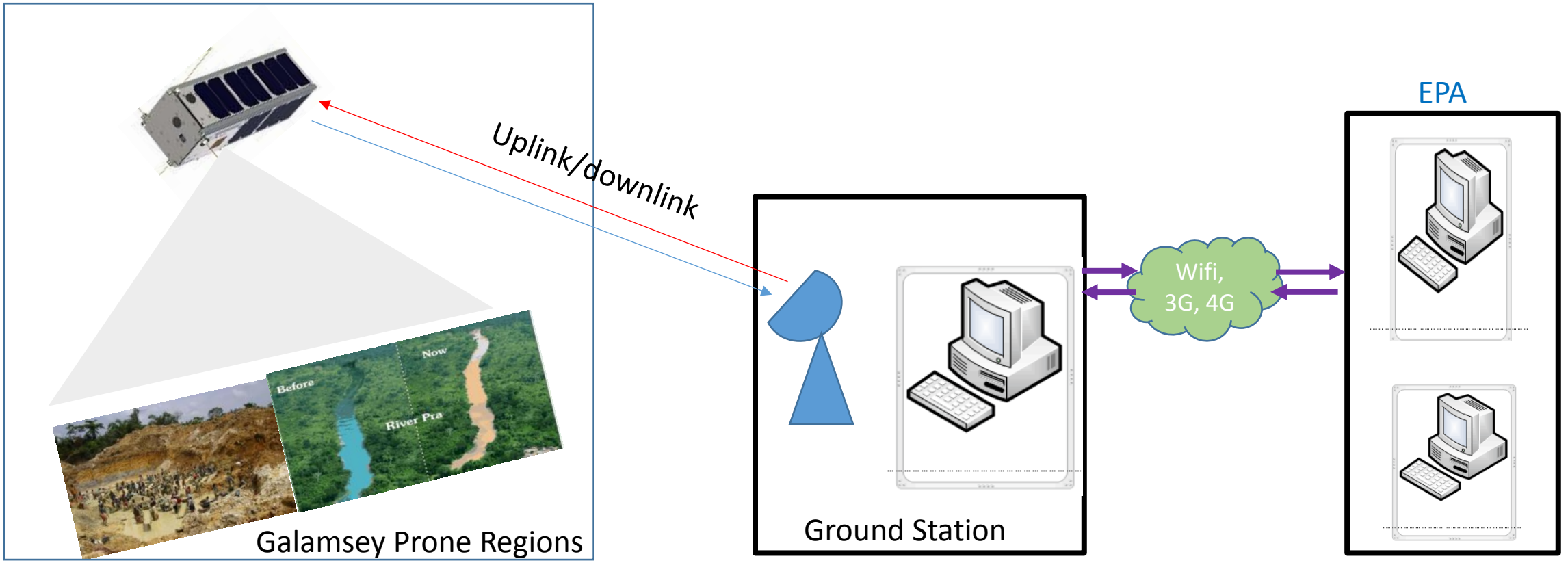
GhanaSat-2
MISSION STATEMENT

To help Ghana to stop illegal mining (galamsey) activities and hence the water pollution problem by providing useful data through satellite technology.

GhanaSat-2 Mission Definition Concept to solve the "Galamsey" activities

Concept-1: Earth observational CubeSat Mission- Ghanasat-2

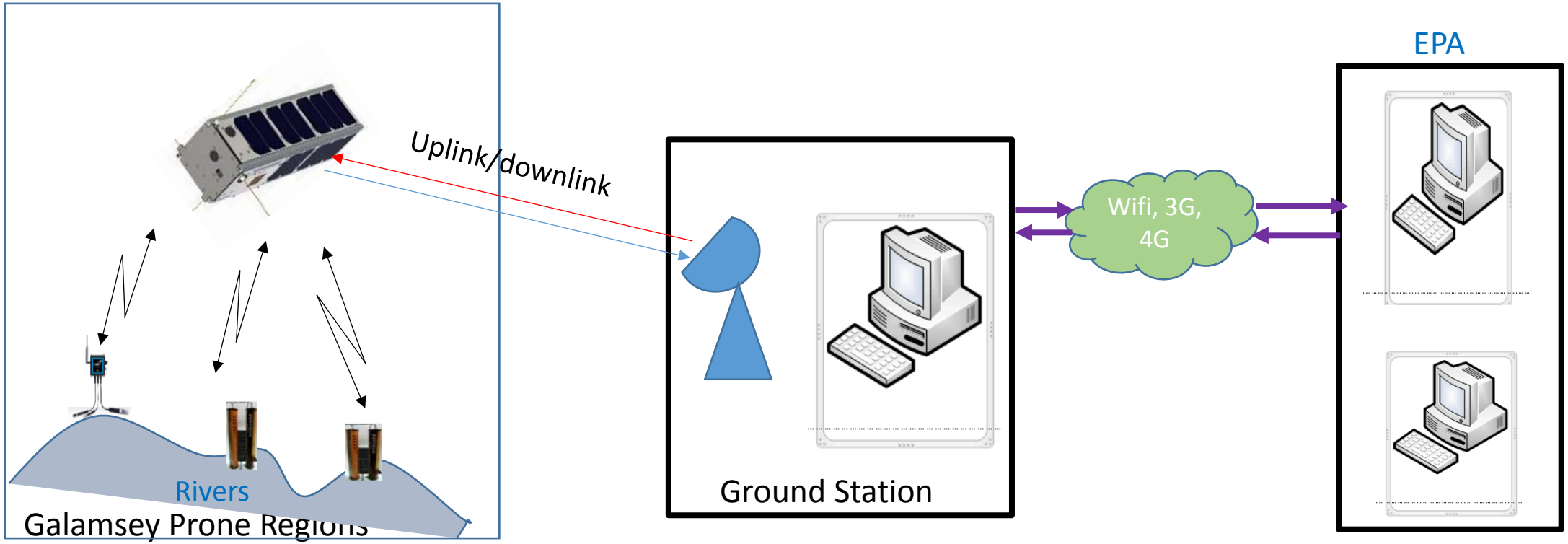
- Employing onboard camera with ground resolution less than **30 meters for spatial analysis and change detection of "glamsey" land sites and arears.**
- Employing **hyperspectral sensor for detecting the colour change of polluted water bodies** at the "galamsey" arears.



GhanaSat-2 Mission Definition Concept to solve the "Galamsey" activities

Concept-2: Store and Forward CubeSat/Remote Monitoring Mission- Ghanasat-2

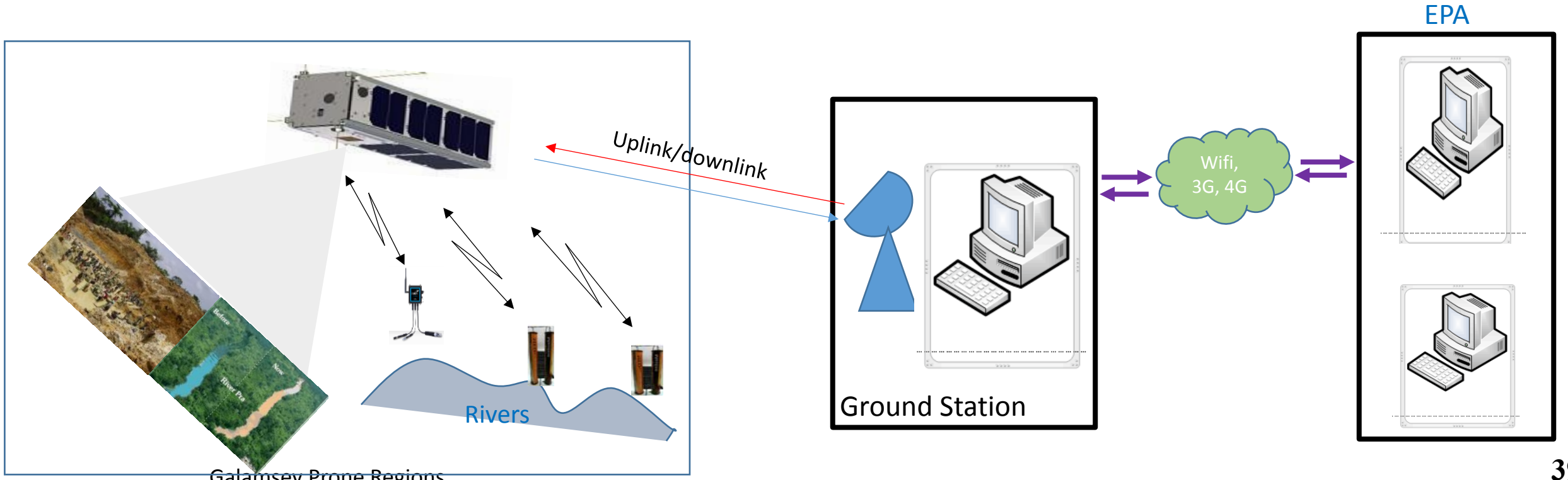
- **Mounting chemical sensors along the water bodies to measure the level of chemical pollutants** (mercury, arsenic, lead etc. and the water PH level).
- The **Satellite shall implement store and forward to receive telemetry from the ground sensors and relay data to the designated ground station**
- Alternatively sensor data shall be relayed to the nearby remote ground stations also.



GhanaSat-2 Mission Definition Concept to solve the "Galamsey" activities

Concept 3: Combined Alternative Mission Concepts

- Earth observational CubeSat Mission- Ghanasat-2
- Store and Forward CubeSat and Remote Monitoring Mission- Ghanasat-2



Ghanasat-2 Mission Requirement

Launch Orbit: ISS orbit 400km (for technology demonstration)

Structure/Size

- Mission Concept-1 : 3U
- Mission Concept-2 : 1U
- Mission Concept-3 : 3U

Communication

- Telemetry & House Keeping Data: UHF/VHF
- Data Downlink: S-band Transmitter (Mission Concept-1 & 3)
- Data Downlink: UHF/VHF (Mission Concept-2)

Attitude Control

- 3 Axis Attitude Control: Mission concept-1 & 3
- Passive attitude determination and control: Mission concept 2

Ghanasat-2 Development
SHORT – TERM GOALS

Mission Development Time: 2 to 3

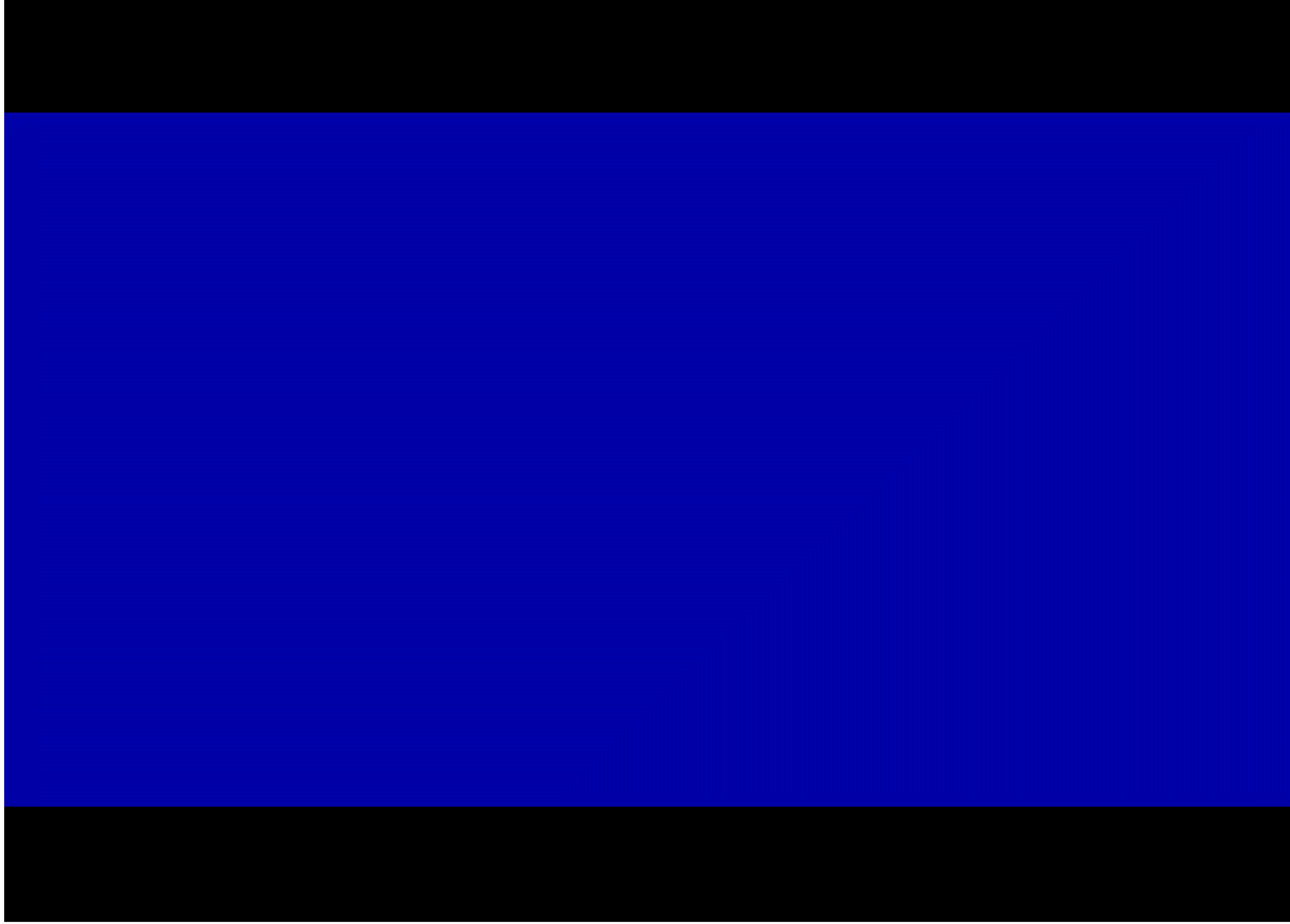
Schedule	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1. Detail Mission Definition								
2. Field Survey								
3. Detailed Payload and Subsystems Definition								
4. Bread Board Model								
5. Preliminary Design Review								

Future Plans

- To contribute to the establishment the Ghana Space Agency and Ghana Outer Space Act
- Sign and Ratify United Nations five Outer Space Treaties
- Run Accredited Bachelor Degree in Space Program
- To develop a home-based GhanaSat-2 to monitor Illegal Mining and Detect Water Pollution activities in Ghana
- Expand our capacity building activities through our outreach programs at senior high schools (cover all the 275 constituencies) in ghana
- Expand our Satellite Development Infrastructure

Future Building of All Nations University Space Science and Technology Laboratory (ANU-SSTL)

GhanaSat 1 Development & Launch Video



GhanaSat 1 Development & Launch Video

Thank you for your Attention