Title: Nile River Quality Monitoring
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(✓) We apply for Student Prize.
( ) Please keep our idea confidential if we are not selected as finalist/semi-finalist.

Need

According to statistics, 85% of diseases infecting African children are caused due to contaminated water. These diseases are one of the main causes of deaths in Africa, where 650 people die daily with a total of 2.2 Million deaths yearly because of unclean drinking water. Over 358 million people lack drinkable water in Africa which is almost equal to the number of people lacking good water in the rest of the world due to severe water stresses throughout the continent which affects all facilities not just drinking as 42% of hospitals in Africa don't have access to clean water which make it almost impossible to help and cure people; it's even possible that hospitals may cause more diseases than curing. After digging into these statistics about Africa, the mission target was set to save African population by providing them with data that help them monitor and control water pollution and contamination.

Mission Objectives

The mission will target one of the main sources of water in Africa, river Nile. The Nile passes through 11 countries; Egypt, Sudan, South Sudan, Ethiopia, Uganda, Kenya, Rwanda, Burundi, Tanzania, Democratic Republic of Congo and Eritrea.

It's considered the longest river in the world and the main source of water for all the countries it passes through with a total population of 501.075 million people living in these countries and depending on its water for all water needs.

The mission should monitor water levels along with water pollution and quality in the river Nile and sending these data to national authorities in those countries. The data can be processed in Ground stations to get information about water pollution causes and where exactly the pollution is localized to help control the pollution and fix water problems facing these countries.

Fig.1 Sustainable Development Goals

This mission targets 7 of the sustainable development goals introduced by the UN to be met by 2030 to guarantee that “Nobody is left behind”

The mission will definitely increase contributions between Nile basin countries to help save their common water resources by forming a community of sharing data and processed information to avoid any future disasters.

Concept of Operations

Mission consists of four main components:

1. Ground sensors
2. Satellite bus system
3. Ground stations
4. Users

Ground sensors will be deployed in water along river Nile to measure Water acidity, conductivity, temperature, turbidity and dissolved oxygen and water level. There will be almost 200 sensors along the length of the river, around one every 35 Kms. Data will be saved on a memory card. Sensors shall be fully autonomous as they should gain power using solar cells and internal batteries.

They would also have a communication system to send the data to sense the satellite and send the data to it. The structure of the system must be water resistant so that it can be maintained in water.

Satellite will receive data from ground sensors and it will be stored and forwarded to ground stations later. Bus system shall be equipped to handle harsh environment in the space and orbit is designed to maximize access to Nile Basin area. Satellite has a camera payload as well to take pictures of Nile river to be analyzed in ground stations and by users to get data about erosions and floods in river Nile. Sun Synchronous orbit is used to avoid the effect of shadow in pictures.

Fig.2 Concept Of Operation

There are four ground stations; two in Kenya and two in Egypt that will receive all the data to be analyzed and processed to get required information and complete integrated pictures of the Nile. The data will be forwarded to users by demand or if the data showed any dangerous levels of any of the parameters.

Users are local associations and institutes in the eleven Nile Basin countries or anyone who needs this information. All information is free and open to anyone to download from main servers.

Key Performance Parameters

In this mission, some key performance parameters have been identified to characterize the important aspects of the system:

- The camera resolution should be able at least 10 m, to detect the rise and fall of the river bank (Topsat, 2.5m GSD (ground sampling distance) and 3-colour imaging at 5m resolution).
- Sensors should be calibrated once every 2 weeks to ensure smooth operation and accurate readings.
- A representative sample of river water should be taken of the river water as a function of the depth to set a particular standard to measure against.
- The variable river flow rate should be kept in mind when inspecting the pollution data, as the higher flow rate during the flood season might mistakenly indicate more dilute pollutants but not less pollution.
- An effective transmission rate is to be maintained to ensure timely communication between the space segment and the ground stations.
- A sufficient power system should be ensured, with extra energy capacity supplied by batteries.
- low power consumption sensors: sensors will operate almost 12 hours a day so we should use components that consume low power.
- low cost sensors: along the Nile River, there will be a sensor every 35 Km so we need to reduce the cost of the components to be able to implement sensors as more as we could.
- modes of operation: we set three modes in the space segment and the ground segment. transmitting mode, charging mode, and receiving data mode. at every mode, at every mode, just the subsystem responsible for the process works and the other subsystem shuts down.

Space Segment Description

Key specifications for cubesat are shown in Fig.3

	Satellite
Size	10 x 10 x 30 cm
Weight	About 5 Kg
Power	Power generation: 22W Power consumption: average 6W Bus voltage: 3.3V, 5V, 12V Battery: 5.2AH Nano power Bp4

Communication	UHF/VHF and S-band
Mission	Store & forward
	High resolution optical camera GSD: 10m

Fig.3 Specifications of Cubesat

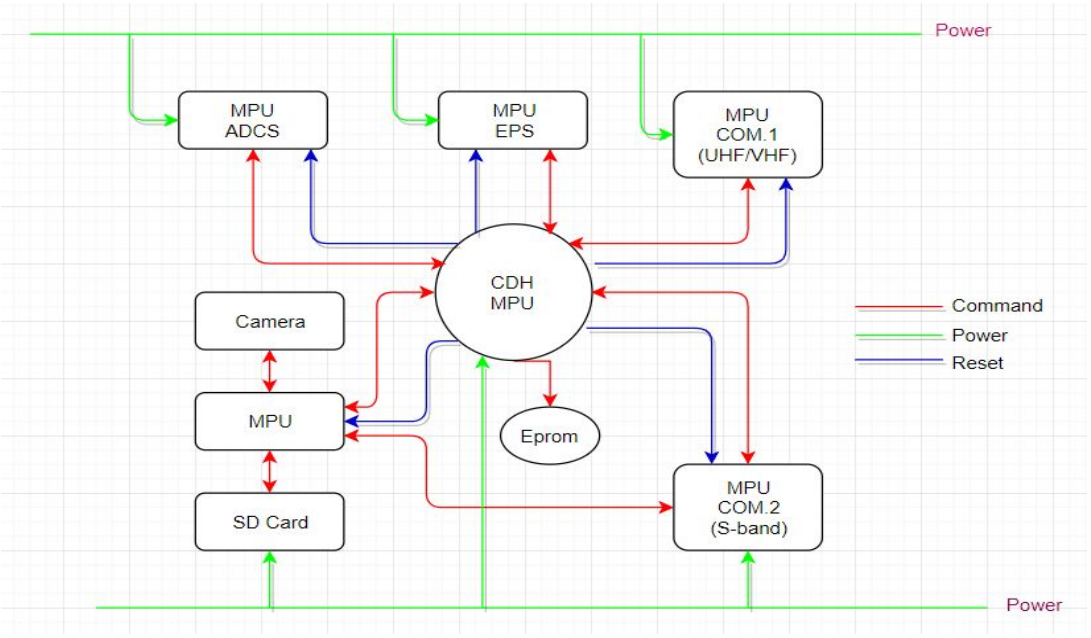


Fig.3 Cubesat subsystem

Orbit/Constellation Description

By analyzing the mission requirements, the main aim is

1. to have the highest access to Nile river countries
2. to obtain clear pictures of Nile river to compute data about floods

These requirements are satisfied by choosing a sun synchronous orbit to overcome shadow effect in the pictures.

To maintain highest rate of revisits to the required area, analysis that combined both sun synchronous orbits and also repeated Earth orbits functions was used.

For sun synchronous orbit:

$$\dot{\Omega} = \frac{2\pi}{T_{ES}} = -3\pi J_2 \left(\frac{R_e}{a(1-e^2)} \right)^2 \cos(i) \frac{1}{2\pi} \sqrt{\frac{\mu}{a^3}}$$

For Repeating Earth Orbit:

$$j \left| -2\pi \frac{2\pi\sqrt{a^3/\mu}}{T_E} - \frac{3\pi J_2 R_e{}^2 \cos(i)}{a^2(1-e^2)^2} \right| = k\,2\pi$$

where T_{ES} (Orbital period of Earth around the Sun) = 3.0781×10^7 sec.

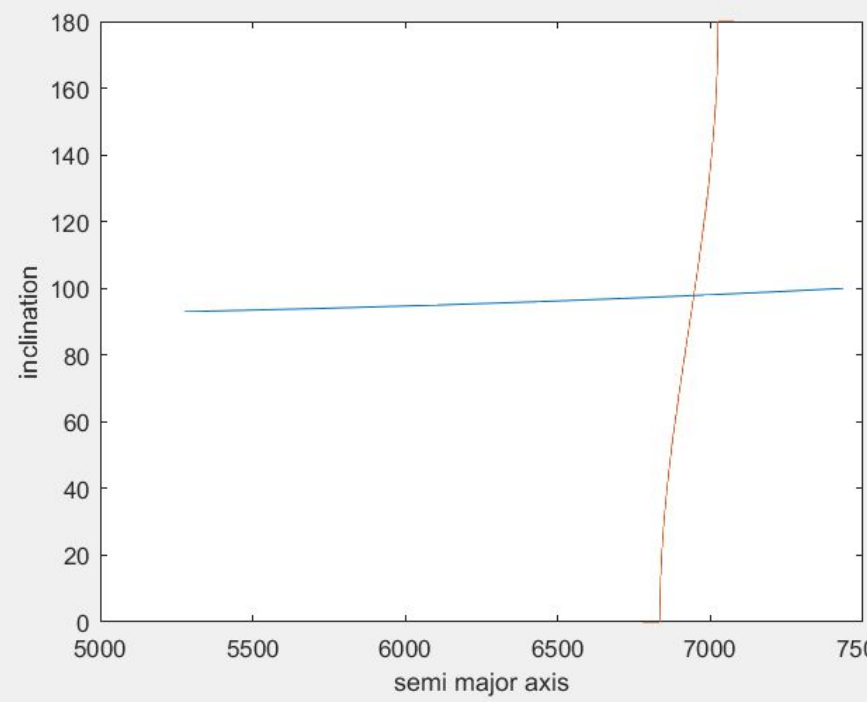
j_2 (coefficient of second zonal term of Earth oblateness) = 1082×10^{-6} km^5/s^2

R_e (Radius of the Earth) = 6378 km

a (orbital semimajor axis)

e (orbital eccentricity) assuming circular orbit for sun synchronous

i (inclination of the orbit)
j (number of revolutions till a nadir revisit)
k (number of days for a nadir revisit)
T_E (Period of Earth rotation around itself) = 86164 sec.
The equations were solved together and got the following data



Also by iterating for the highest access time for the required area, final orbital elements were obtained as follows

semimajor axis	6945.35747 km
inclination	97.8642 degrees
period	96 minutes
k	1 day
j	15 rotations

Access time data
Mean access time = 9.3 minutes per orbit
While the satellite will pass by 4 times each day for communication

Implementation Plan

Many organizations in Egypt and all around the world can play a vital roles in our project. some organization may help the users to get data like NARSS and Ministry of water resources and irrigation. UNISEC can afford to manufacture the space segment, also the ground sensors will be funded by the Nile basin countries as each country would choose how many modules would it need to cover its main monitoring points. Launching will be held by the KiboCube UN/ Japan cooperation project

Ground stations will be located in the Nile basin countries as they are the main users so no extra fund or logistical procedures needed to analyze satellite data. There are 4 ground stations in the target area; two in Egypt and another two in Kenya.
The top 5 project risks are:

- Political issues in Egypt and other Nile Basin countries
- Not succeed to develop low power consumption or stand-alone sensors
- lack of funding
- Problems in manufacturing and integrating the satellite