Title: A Global Water Pollution Monitoring Satellite System (WAMS)

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Need

Covering 70% of the Earth surface, water is undoubtedly one of the most important natural resources that guarantee the existence of living things on the planet. However, we gradually pollute our water resources by many types of wastes, such as industrial, agricultural, domestic, etc. These wastes lead to the increase of nitrates, phosphates, heavy metals and even radioactive substances in the water. In order to monitor the change of the water resources quality all over the world, it is proposed to build a Global Water Pollution Monitoring Satellite System (WAMS) that collects data from rivers, lakes, oceans, and other water bodies; so that the pollution levels will be recorded and the responsible agencies can react in a timely manner.

Mission Objectives

The mission of the satellite constellation is to build a global system for monitoring changes in water quality. In this project, field ground stations will be built near the heavily polluted areas such as water bodies close to industrial zones and overpopulated urban areas, in order to collect data on water pollution worldwide. The data from the WAMS system will be provided freely on the Internet for researchers, environmentalists, students, and others to use. Because of the public nature of the database, anyone interested can get the necessary data for their study. This will help encourage researches on the water pollution and improve people's awareness on the issue. The information can be used by governmental agencies as well to locate areas that need closely monitoring, to implement suitable solutions. Another possible application of the system is to build a global water pollution map.

Concept of Operation

We propose a satellite constellation to collect data from field ground stations built near the water resources and send the acquired data to a central database which is accessible on the Internet by any agencies and individuals. See Figure 1.

Field ground stations

The first part of the system is the network of field ground stations located in places throughout the world to collect data on quality of water bodies. Field sensors will be used to measure concentrations of substances such as nitrates, phosphates, heavy metal compounds, etc.; as well as other factors like pH. The water levels and the temperature are also recorded. The data will be then sent as telemetry data to the satellites. AX.25 protocol, which is widely used in small satellite community, will be employed so that volunteer amateur ground stations or other satellites can get the data from or contribute to the system. See Figure 2.

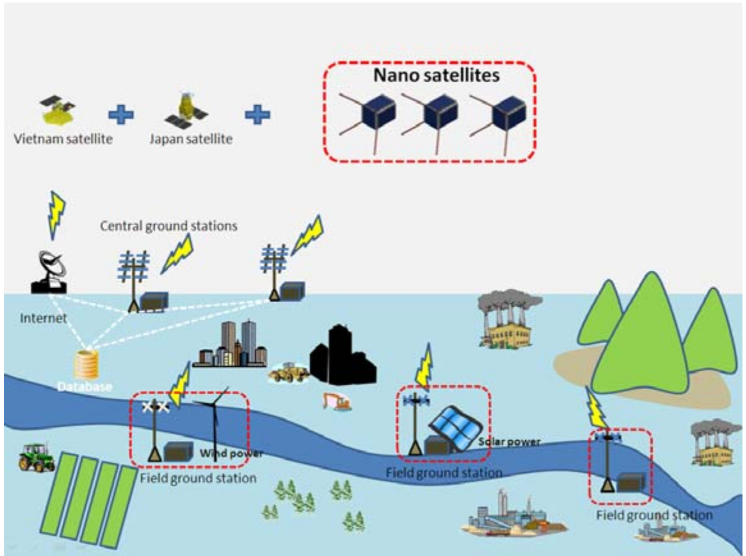

Figure 1: Global Water Pollution Monitoring Satellite System

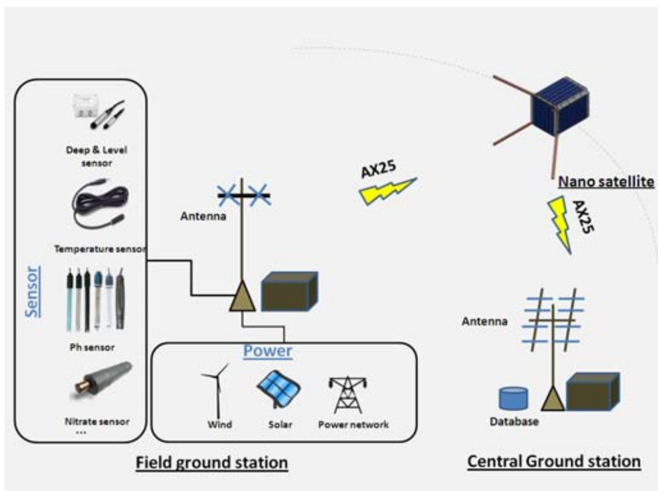

Figure 2: Major components of the system

Satellite constellation

The satellite constellation includes three nano satellites to acquire data from the field ground station and send the data to the central database through the central ground stations.

By computations, the minimum number of satellites in a constellation is five in order to cover the whole globe and to achieve daily data update. We propose two cases for the satellite constellation, normal and optimal cases.

1. *Normal case: **Three** nano satellites for updating data with low frequency.*
2. *Optimal case: **Five** satellites, amongst which **three** will be funded by this project; the additional two will be contributed by other countries. For example, **one** small satellite from Vietnam and **one** small satellite from Japan. By this way, the updating frequency will be increased largely.*

Central Ground Stations

The last part of the system is the *central ground stations*. These ground stations, which are located in several countries, communicate with the satellite constellation to obtain data from field ground stations, and send to a central database. Beside, these ground station will operate the satellite constellation by telemetry commands.

Key Performance Parameters

The most important aspect of this system is communication. It is necessary to create standard protocol for the field ground stations, satellite constellation, and central ground stations. In order to encourage contribution of the small satellite community, we plan to use the amateur frequency range and AX.25 protocol which is very popular in the amateur radio community.

The communication parameters are as follow.

- *Uplink frequency:* *145 MHz*
- *Downlink frequency:* *435 MHz*
- *Telemetry format:* *AX.25*

The second aspect should be considered is the field ground station configuration. In the field ground station, a number of sensors are necessary to assess the water quality. The following is the list of proposed sensors for water pollution measurement in the system.

- *Deep & level sensor*
- *Temperature*
- *pH sensor*
- *Nitrate sensor.*

Space Segment Description

Mass: ***<15 kg.***

Size: ***~20x20x20 cm.***

Communication Subsystem

- *Uplink:* *145 MHz*
- *Downlink:* *435 MHz*
- *Protocol:* *AX.25.*

Attitude Determination Subsystem

- *Sensors:* *Magnetic sensors, MEMS Gyro sensor.*
- *Control method:* *Spin stabilization.*

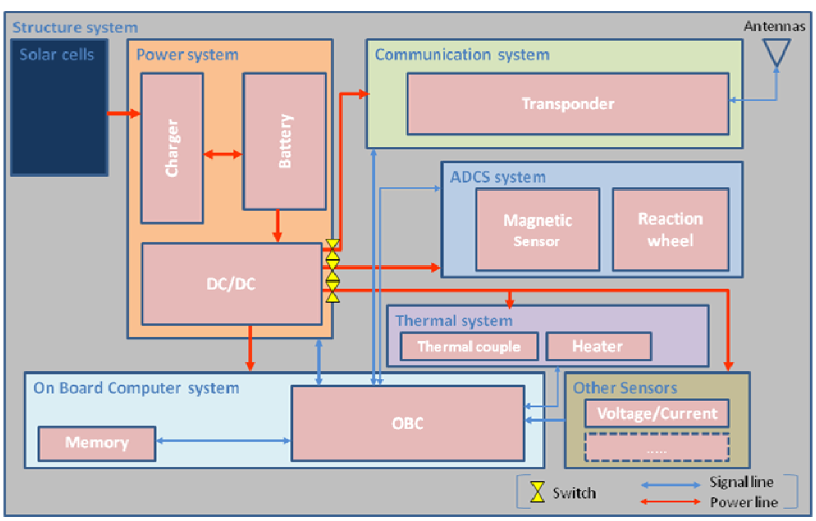

Figure 3: System function blocks

Orbit/Constellation Description

Orbit parameters

- *Type:* *Sun-synchronous*
- *Altitude:* *~1000 km*
- *Inclination:* *~98 degree.*

The orbit is chosen so that it is appropriate for a secondary launch. The ~1000km altitude is to avoid effect of atmospheric drag which would shorten the life time of the satellite, while the inclination of this orbit is to maximize its global coverage.

The satellite constellation can communicate with field ground stations and central ground stations around the world. This means that the data acquired by the Global Water Pollution Monitoring Satellite System is updated on a daily basis.

Ground coverage and user access (assuming the ground station located at Hanoi/Vietnam)

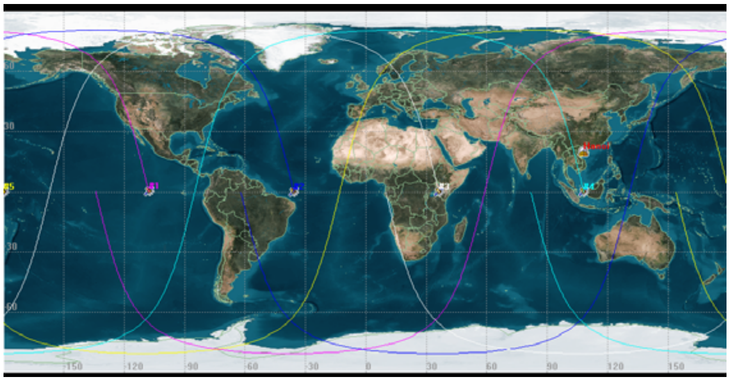

Figure 4: Ground coverage of five small satellites

Implementation Plan

Organization

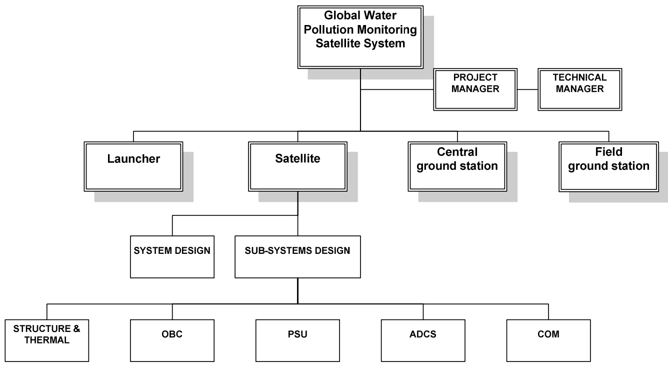

Figure 5: Project organization structure

List of facilities

- *Clean room.*
- *Thermal chamber.*
- *Vibration test system.*
- *Ground station.*
- *Assembly, integration and test facilities support.*

Top 5 project risks

- *Public the data on water pollution might not be accepted by some country.*
- *Sensors might need to calibrate in schedule to maintain their accuracy.*

Total life cycle cost

1	**Filed ground stations**	
	Single filed ground station	*$330*
	Number	*$30*
	Sub-total	*$15.000*
2	**Central Ground stations**	
	Single ground station for amateur radio	*$19.000*
	Number	*5*
	Sub-total	*$95.00*
3	**Satellites**	
	Single satellite	*<$1.500.000*
	Number	*3*
	Sub-total	*<$4.500.000*
	Margin	***$90.000***
Total cost		***<$4.700.000***

Table 1: Cost estimate of WAMS system.

Contribution from other countries

The contribution from space organizations around the world is necessary for this system to realize the its full potentials. The contribution from the organizations to the development of the five satellites will be welcome.

Vietnam

Vietnam is planning to build Vietnam Space Center to manufacture two Earth observation satellites with SAR technology by 2020. The data obtained by the satellites may possibly be considered to share to the common database of global WAMS for water pollution.

Other countries

It is recommended that other satellite systems to share their data to this system's database to maximize the potentials and to increase its global coverage.

References

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