Title: Underground and surface water detection and monitoring using a microsatellite.

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1. Key Concept and Business Impact on Society and Environment

According to studies by the United Nations Environment Program (UNEP), Africa's urban areas are dealing with enormous challenges regarding the availability of water supply and sanitation services. This is because African urban areas are growing at a significantly faster rate than the rest of the world; today 240 million Africans live in urban areas where the water supply is insufficient. The UNEP also stated that the number of people living with insufficient water has risen from 30 million in 1990 to 55 million in 2008 [1].

With this in mind, we propose a satellite mission to detect and monitor freshwater resources. Freshwater refers to water found in water bodies under the earth's surface as well as above it. Apart from drinking, it may be used for various purposes such as agriculture and sanitation services. The main focus of the proposed mission will be Africa.

One cannot underestimate the importance of freshwater in our daily lives because it affects the following:

- **Health** – the water project organisation [2] notes that poor health, hunger, and lack of education are associated with a lack of clean water which in turn, leads to poverty. In developing countries, about 80% of illnesses are linked to poor water and sanitation conditions, thus clean and safe water is essential to healthy living [2].
- **Agriculture** – water is one of the main drivers of agriculture, be it crop or animal farming. Easy access to fresh water will create a positive impact on agricultural activities therefore, making it sustainable. Having a sustainable agriculture will help alleviate hunger and poverty amongst the masses. Africa consists of developing countries whose major exports are from agriculture, thus improved access to water is imperative.
- **Electricity generation and industry** – One of the ways to generate electricity is by extracting energy from the water. In addition, most industries also use water in processing their products. As a result, water shortages can negatively affect the productivity of industry thus; an improved access to water can assist the industrial sector.

- **Economic growth** – one of the drawbacks of economic growth in Africa is as a result of inadequate fresh water resources [1]. This is because communities spend more time trying to locate sources of fresh water. Therefore, improving access to fresh water can indirectly lead to economic growth as people will now have time to do other activities for economy upliftment.

The proposed mission will lead to the availability of vast amounts of water data that can be used for various application fields. The benefits obtained from the fresh water resources will help to alleviate poverty and also improve the economic growth of the countries in Africa. Our aim is therefore to detect and monitor levels of the underground water sources from space as well as to collect data from sensors placed in surface water sources. The proposed mission falls into the remote sensing and data collection type missions.

2. Business Model Structure

Our assumed and expected target market includes governmental and non-governmental bodies, farmers, and companies dealing with water management. Because underground water levels change slowly, the proposed mission will provide weekly updated data. This data will be available on a website (updated weekly) from where the various customers can access the information. This information may also be requested and provided as per request. Information containing water levels and mapping of sources will be provided as well. The water sources will be categorised according to the surface and underground levels. A microsatellite with sensors necessary to detect and monitor level of underground water will be launched into a polar orbit and information will be obtained via ground stations spread across the African continent. Figure 1 depicts the flow chart of the business model structure of the proposed mission.

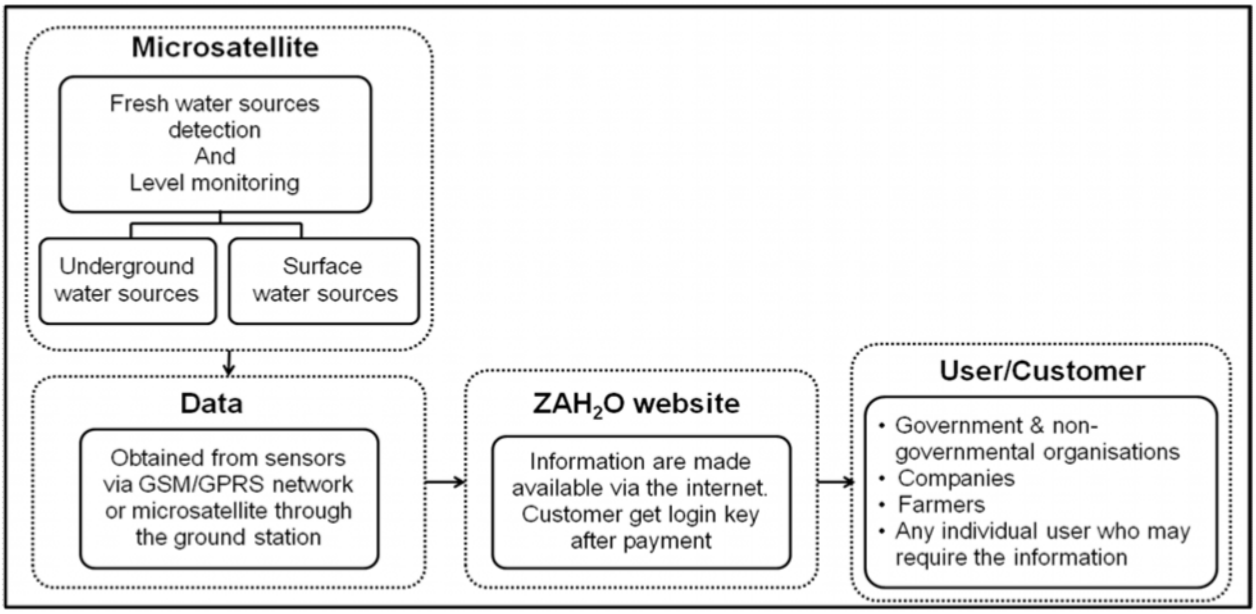

Figure 1: Business Model Structure

3. Business Feasibility

Table 1: Cost estimation

	Description	Specification	Cost (M$)
Microsatellite Specification	<50kg	Lifetime of 3-5yrs	
Bus cost (Downlink data rate)	Medium level speeds	1 Mb/s	2
Payload cost	Remote sensing	sensors	1
Satellite bus levels	Satellite co-ordination	subsystems	0.8
Ground Station expenditure (GSEX)	Per station, for one time	For 1 Mb/s DL	0.5
Operational expenditure (OPEX)	Per year per station	For 1 Mb/s DL	0.2
Data Analysis	Per mission per year	Remote sensing	1
Engineers and technicians	Satellite development		1.5
Launch	Piggyback		1
Total cost	Rounded off		8

The total cost of the proposed mission is projected to be $8,000,000 with profits at the end of the first year estimated to be $2,000,000. Summing the total cost, the operational expenditure, ground station expenditure and the assumed profit; the yearly income revenue will amount to $10,700,000 as shown in Table 2. In the first year, assuming that information (data) is provided to 20 African countries (clients), the amount of $535,000 would be generated per country in a year, which equates to a monthly amount of $44,583. It is hoped that further marketing would attract another 20 clients/countries in the second year. With this in mind, and also, so as to retain customers, our first year customer subscriptions/payments will be discounted in the second year whilst the new customers pay the full amount of $44,583. Summing up the total monthly income generated for all the countries in the second year, our estimated monthly income would be $1,337,500. The third year should also see an increase in the customer base as well as market competition as other organizations may start or have started offering such services. To compete, all our customers would have discounted rates. Table 2 gives a summary of total revenue and satellite cost estimation.

Table 2: Total revenue vs satellite cost estimation

Year (yrs)	Monthly income ($)	Yearly income ($)	GSEX & OPEX ($)	Satellite cost ($)	Yearly profit ($)
First	891,667	10,700,000	700,000	8,000,000	2,000,000
Second	1,337,500	16,050,000	800,000	0	15,250,000
Third	1,248,333	14,980,000	850,000	0	14,130,000
Accumulated total (3yrs)					31,380,000

4. Logistical Feasibility

The key elements in this mission include the payload and the bus level of the satellite, ground stations and launch.

- **Payload**

  Table 3 gives sensors used in satellite missions on water monitoring. These sensors will be further investigated to ascertain whether they can be modified for use in this mission.

Table 3: Past and recent mission sensors

Sensors	Missions	Target description
Radar Altimeter	GEOSAT Altimeter (635 kg)	Used to measure sea level height and monitor world- wide water levels [3].
Circular Polarized-Synthetic Aperture Radar (CP-SAR)	Microsatellite (<100 kg)	Retrieving of the physical information of earth surface, vegetation height, surface water, soil and snow characteristics [4].
Laser Altimeter	UNISAT (40 kg)	Used over the land and water, laser altimeter to track land and topography [5].
Multi-Spectral imager	Beijing-1 (166 kg)	Used to undertake a study of surface water resources [6].
MIRAS	SMOS (350 kg)	Soil Moisture and Ocean Salinity [7]

Calculation of how many pictures can be downloaded daily from our ground station.

Downlink speed: 1 Mb/s (A moderate rate for an Earth sensing satellite)

Downlink period: 1020 s

Image size: 8 MB (worst case picture size): 8×1024 KB= $8\times1024\times1000$ Bits = 8192000 Bits

Images per day: $S \times 1020 \times G / (8 \times 8) = 1020 / 64 = \sim 16$ images per day at S =1, G=1.

Where S and G are the number of satellites and ground stations respectively.

The number of downloaded images will increase with the availability of more ground stations.

- **Bus level**

  The subsystems that will be included in this mission are the on-board computer (OBC) and data handling subsystem, attitude determination and control (ADCS) subsystem, power subsystem and communication subsystem.

- **Ground operation**

  The proposed mission will use a single ground station presently located at the Cape Peninsula University of Technology in Bellville (South Africa) and will be looking forward to partner with two other ground stations around Africa. The ground station will be situated in countries like Nigeria and Morocco.

- **Launch**

  The single microsatellite with necessary payloads will be launched into a polar orbit with an inclination near 90 degrees to the equator. The satellite will cover the entire southern hemisphere but focuses mainly on Africa. The satellite will orbit at an altitude of 650km.

5. Risk Analysis

Some risks were identified and are described below:

- The occurrence of natural disasters might damage ground station equipments and the distributed sensors network.
- Damage of the satellite subsystems may also shorten the in-orbit life.
- At the commencement of the proposed mission there could be possibility of not having enough customers.
- Possibility of delayed revenue due to customers taking time to take up the service.
- Political risks in some African countries and some governments may not want to take up services or even try to shut down the mission due to security reasons.
- Hackers might want to access the satellite or website to corrupt and or obtained information.

References

[1] 16th Africa water association international congress & exhibition. (2012). Challenges of the water sector in Africa. [Online]. Available: http://www.gwp.org/Global/Events/AAE%20VA-Congr%C3%A8s.pdf. [30 March 2012].

[2] The water project. (2011). Poverty and water in Africa. [Online]. Available: http://thewaterproject.org/, [30 March, 2012].

[3] Sandwell, D. T. (2011). Radar Altimetry. [Online]. Available: http://topex.ucsd.edu/rs/altimetry.pdf, [25 April 2012].

[4] Mattei, S., Santovito M, S., Moccia, A. “Microsatellite altimeter feasibility study.” *IEEE transactions on aerospace and electronic systems,* 2006, *42(4):* 1187-1197.

[5] Sumantyo, J. T. S. “Development of Circularly Polarized Synthetic Aperture Radar (CP-SAR) Onboard Small Satellite.” *PIERS Proceedings*, 2011, 334-341.

[6] H. Z. Zhou,Y. B. Chi, Z. Y. Wang, Q. Wu,Q. Ran, C. J. Wei, "A study on surface water resources in Chaobaihe Basin of Beijing based on Beijing-1 Microsatellite data." *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol XXXVII.Part B8* , Beijing 2008.

[7] CNES. (2012). *SMOS*. [Online]. Available: http://smsc.cnes.fr/SMOS/, [11 April 2012].