Title: NanoSatellites Monitoring for Human Health Control

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(X) We apply for Student Prize.

(   ) Please keep our idea confidential if we are not selected as finalist/semi-finalist.

Need

Growth, hypertension, diabetes, irregular heartbeat, COPD (Chronic Obstructive Pulmonary Disease) are examples of such common health problems which requires periodically and continue visits to medical centers for monitoring. The traditional method for analysis is costly for daily control. Therefore, the nanosatellites technology presents an interest solution for wireless health monitoring. It offers the possibility to integrate wireless health system with telemedicine systems which can alert the patients and medical person when they have a serious condition occur. Furthermore, this system can be used for monitoring the patient health in an ambulatory setting such as a diagnostic procedure, optimal chronic disease care and supervised recovery from acute event or surgical.

"A major challenge for telehealth is for it to reach the wider population of ambulatory care patients." «Theo Ahadone ». The fig.1 present the number of world telehealth patients by disease which is predicted until 2017. [1]

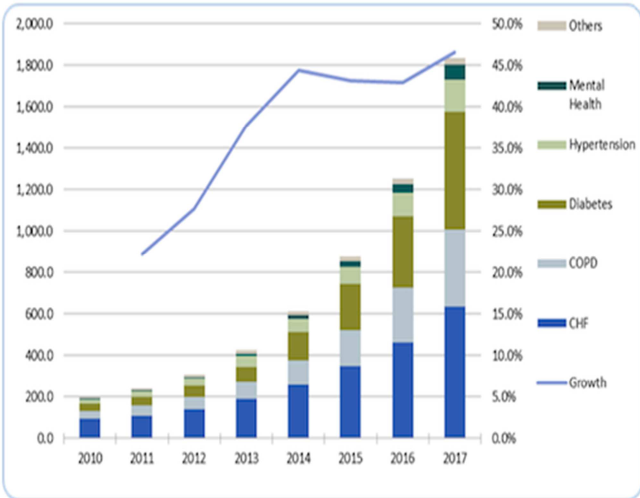

Fig.1 world telehealth patients by disease

Mission Objectives

The primary objective of this proposal would be the demonstration of integrating the space technology in human health monitoring routine. The complete mission objectives are as follows:

1. Increase the number of world telehealth monitoring through a reliable and autonomous system.
2. Change the way of health care services which are structured for reacting to crisis and managing illness rather than wellness.
3. Monitor changes in vital signs and provide information to help maintain optimal health.
4. Monitor the health of patients in an ambulatory setting :
    a. Optimal chronic disease care.
    b. Supervising recovery from an acute event or surgical.
5. Integrate the area without infrastructure from developing countries in telehealth routine.

Concept of Operations

The general multi-tier system architecture is shown in fig. 2. It consists in three segments:

<u>Space segment</u>:

Includes a constellation of 9 satellites which are conceived to use a standard 1 U cubesat structure that can be launched using a PPOD (Poly-Pico Satellites Deployed) launcher system. The satellite design is based on COTS components (see section space segment description).

<u>Ground segment</u>: consists of three ground stations, it encompasses a network of health care and related service (medical service, emergency and physician) based on internet.

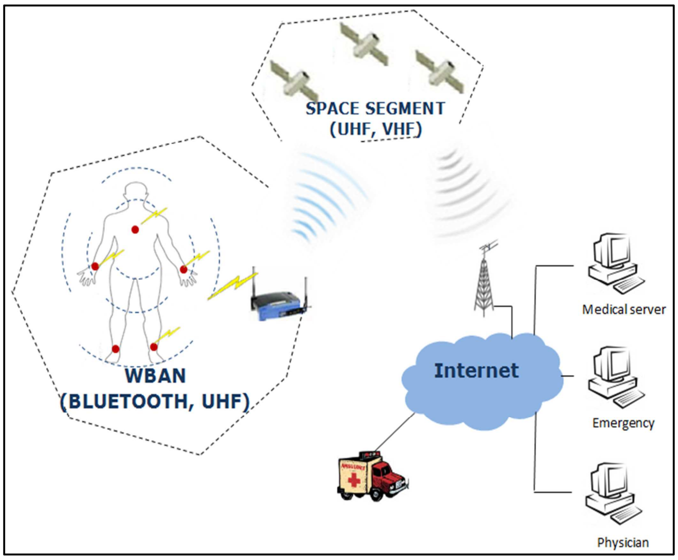

Fig.2. Wireless health system architecture

<u>Users segment</u>: Each user wears individual WBAN [2] (Wearable Body Area Network) node sensors which are strategically placed on her body. The primary functions of these sensor nodes are collecting vital signs (heart rate, blood pressure, activity…) and transferring the relevant data through Bluetooth technology to a bridge Bluetooth-UHF which is responsible on communication with the satellite constellation.

The segment interfaces are described below:

1. **User interface**: based on bluetooth technology. A piconet topology is proposed, the bluetooth-UHF bridge has a function of master and the sensor nodes are the slave devices in this topology.
2. **User-Space Interface**: based on amateur satellite band UHF. The bluetooth-UHF bridge adapts the signal received from the sensor nodes to the appropriate protocol of communication (AX.25), the modulation type AFSK and finally transfer it to satellite.
3. **Space-Ground interface**: based on VHF band. The satellite constellation uses the VHF band for downlink. After being received across the ground stations, the data are distributed through Internet.

Key Performance Parameters

Our mission idea belongs to the information collecting mission, the key system parameters are listed below:

- Number of sensors: depends of the number of patients. Each user wears four biosensor nodes. Among the role of the bridge bluetooth-UHF, reducing the number of sensors that communicates with the satellite constellation.
- The data transmission speed: for the downlink is 9.6 kbps.
- Revisit interval: the revisit interval of the satellite over the bridge-UHF is calculated as follows: $0.5/9 \approx 1.3$h.

– The average latency: for the initial version of our mission the average latency is 4h but based on the possible cooperation with other universities or medical centers, we can increase the number of ground stations then the average latency will decrease.

Space Segment Description

A 1-unit CubeSat envisaged with COTS components. We propose the following architecture (See Fig.3) which contains the main subsystems of the satellite: a GomSpace NanoMind A702 used to manage data as an On Board Data Handling, a ADCS subsystem to control the stabilization of the satellite and a transmitter/receiver to communicate with the ground station.

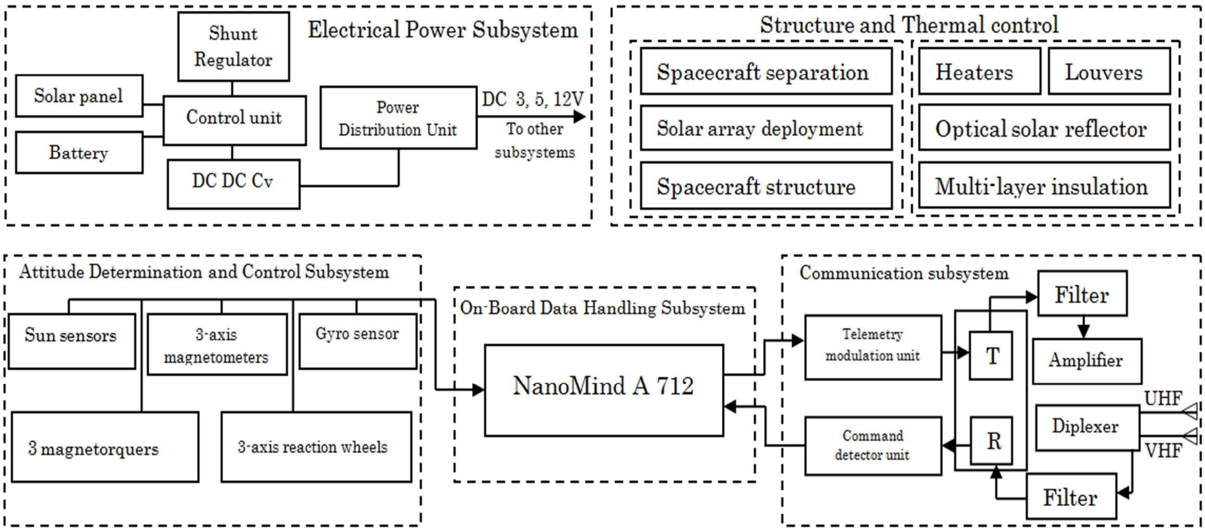

Fig.3. Diagram system overview

An overview of the different budgets is illustrated in the table.1

	Mass, peak power and link budget		Mass (g)	Peak power (w)	Qty	Cost $
Satellite bus	ADCS	Attitude determination and control (3-axis magnetometer, gyro and reaction wheels, sun sensor, 3magnetorquers	336	1.670	1	27,890.00
	OBDH	(GomSpace NanoMind A702)	50	0.564	1	4,750.00
	COMM	Communication subsystem (ISIS TRXUV VHF/UHF transceiver)	85	1.55	1	9,850.00
		Deployable antenna system for cubesats	100	2.0	1	6,100.00
	EPS	1U cubesat EPS with integrated battery	163	0.1	1	4,250.00
	STTC	Structure and thermal control (ISIS 1U CubeSat structure)	213	-	1	2,150.00
POWER	Solar panel	Clyde space 1U slide solar panel w/MTQ	60	-	6	16,800.00
	Battery	10 whr integrated battery	-	-		-

Link budget				
item	symbol	units	Uplink(UHF)	Downlink(VHF)
frequency	f	MHz	437	145
Transmitter power	p	dBW	0	2
Transmit line loss	L_i	dB	-1	-1
Transmit antenna gain	G_T	dBi	4.5	0
Equiv. Isotropic Radiated Power	**EIRP**	**dBW**	**3.5**	**1**
Free Space Loss	FSL	dB	-140.89	-131.23
Modulation type	-	-	AFSK	BPSK
Bit rate	-	bps	1200	9600

Tab.1. Different budgets overview of satellite

ADCS: The attitude determination and control subsystem (ADCS) has the task to estimate, control the position and the trajectory of our satellite. The purpose of ADS is rapidly providing accurate attitude to investigators through other subsystems such as the OBDH and the communication subsystems. Concerning the ACS, a 3-axis attitude stabilization is needed which is composed of three magnetorquers and a 3-axis reaction wheels.

Orbit/Constellation Description

In order to cover the entire earth, a circular polar low earth orbit was selected. Table 2 present the orbital parameters.

Tab.2. Orbital parameters

Orbital parameters	
ε	0
a	600 Km
i	98°
RAAN	306.14°
TA	54.8°

9 satellites form a constellation for this mission are distributed in three orbital plans (3 sats per plan). In order to assure a long life time for this mission, we propose to launch this constellation in three steps based on the number of patients which is predicted to increase with time.

Figure.4 shows the ground track of one satellite in polar low earth orbit.

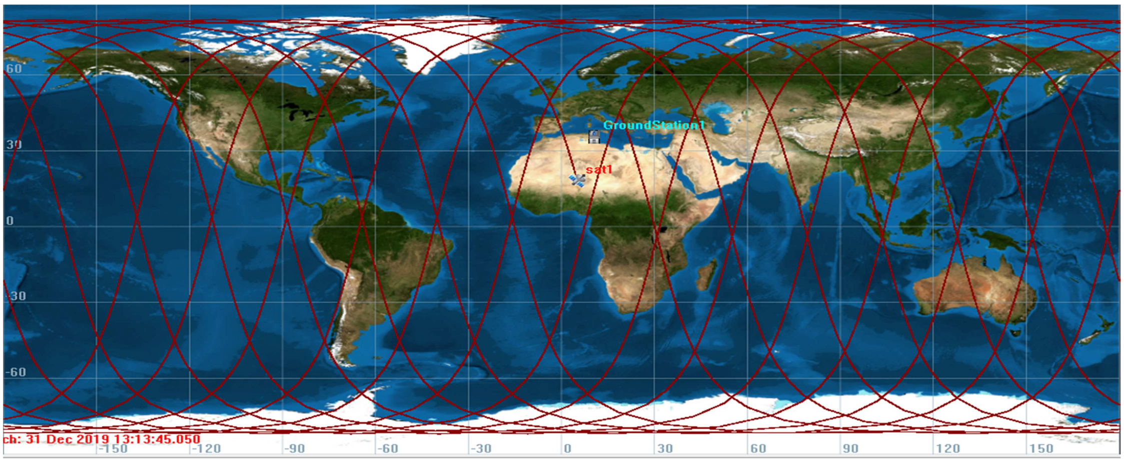

Fig.4. Satellite ground track

Implementation Plan

<u>Organization:</u> microelectronic and instrumentation is an established nanosatellite research laboratory in Tunisia. Figure.5 presents the hierarchy of our mission implementation including the project manager, Ph.D, master and engineering students.

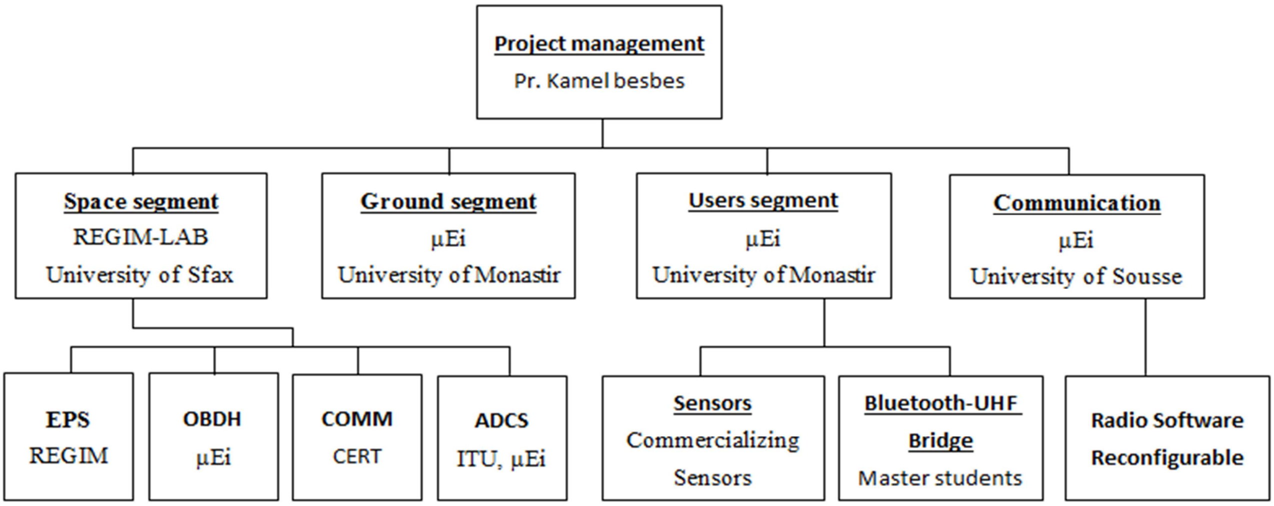

Fig.5. Team for mission implementation

UNISEC Tunisia is a new Tunisian University Network to develop researches and training in space engineering. A partnership from UNISEC University members, clinics and/or private industries will be sought.

<u>Cost</u>: in order to reduce the cost, we propose an initial version of our mission for simply demonstration composed by three cubesats and one ground station. After the success of the mission, we will predict to find the necessary funding of full scenario mission.

Tab.3. mission costs

constellation	$215,910.00
launch	$300,000.00
testing	$300,000.00
Ground station	$50,000.00
Bridge bluetooth-UHF	Developed in laboratory
Operation cost(per year)	$100,000.00
total	$965,910.00

<u>Schedule</u>: table4 illustrates the schedule of our mission.

Tab.4. mission schedule

Conceptual design	Jan 2015-june 2015
Engineering model	Jan 2016
Flight model	2017
constellation	2018
Constellation launch	2019

<u>Risk</u>:

1. Funding for the satellite development and the launch.
2. The failure and interference of transmit signals from the bridge bluetooth-UHF.
3. The indifference to this system by medical centers and the limited number of participate patients.

References

[1] http://mobihealthnews.com/19963/report-about-300k-patients-were-remotely-monitored-in-2012

[2] R. Jafari, A. Encarnacao et al. Wireless Sensor Networks for Health Monitoring, ACM/IEEE International Conference on Mobile and ubiquitous systems, pp.479-481, 2005