Title: NetCubeSat and SDR based communication system for climate change understanding.

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（ x ）**We apply for Student Prize.**

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

Need

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), the temperature projected to experience an increase of 0,3 to 4,8 °C by 2100. The air pollution is among the arguments of temperature's rising. Thus, in December 12, 2015, COP21 provides an international climate agreement, applicable to all countries, setting a target of limiting global warming between 1,5 and 2 ° C. All contributions are intended to both mitigate the greenhouse gas emissions by providing the national economy development, and adapting the living conditions for people in actual or anticipated climate change. The objective of COP21 is to achieve, for the first time, universal and binding agreement to fight effectively against climate change in order to limit air pollution and the warming. Therefore, developments in the field of wireless communications for a real time air monitoring reduce the problems of distance and time. Thus, the nanosatellites technology presents an interest solution for air monitoring in real time aiming to limit and control the air pollution. It offers the possibility to integrate the wireless air monitoring system with the climate administrator server. The purpose of this mission is to give a permanent coverage for a real time monitoring, thus we focused to cover the areas in the countries under development which are often regions without infrastructure (eg.North Africa) for about all the day as part of a collaborative project using a nanosatellites constellation based on Software Defined Radio (SDR) technology.

Mission Objectives

The main objective of this proposal would be the demonstration of integrating the nano satellites technology in air monitoring routine for climate protection purpose. Thus, this objective is to provide a low cost solution for a real time monitoring by means of wireless wide band communication using the SDR in order to give a new application for a telemetry purpose. The complete mission objectives are as follows:

1. Fight against air pollution in order to limit the temperature rising.
2. Provide a low cost system for a real time air quality monitoring.
3. Integrate the nanosatellites technology to improve the monitoring service.
4. Lower the barriers to transmit data in the region without infrastructure in real time.

Concept of Operations

The main architecture of the air monitoring system shown in fig. 1 consists in three segments:

<u>Space segment</u>

To accomplish this goal we propose to launch a constellation of 9 nano satellites conceived to use the 1 U standard in order to be launched using Poly-Pico Satellites Deployed (PPOD) launcher system. In addition, the nano satellite conception is based on COTS components.

Users Segment

Installing reference air quality monitoring systems based on gas analyzer technology is one way to measure road, motorway, highway and factories emissions. But their cost and size limits the number of monitoring locations. In addition, analyzers log only every 30 or 60 minutes, which is often not sufficient temporal resolution for the measurement of air quality.

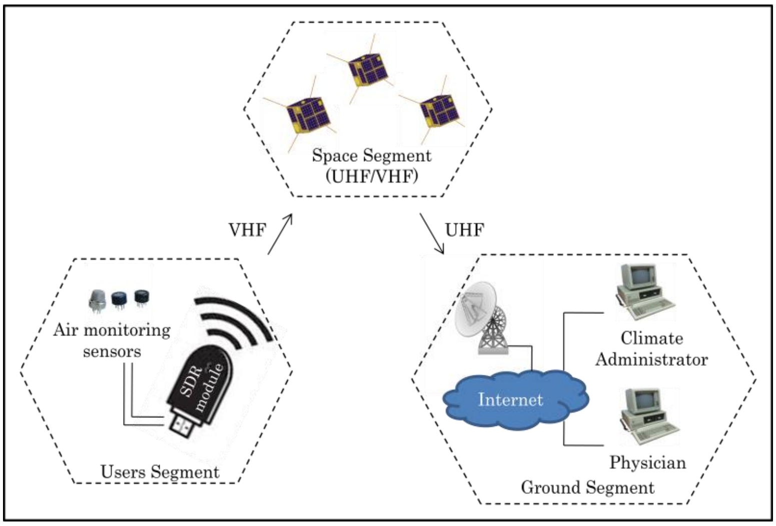

Figure 1. Air Monitoring System Architecture

Thus, we propose to use sensors rather than analyzers, which give two big advantages; parameters can be measured and logged every minute and sensors are cheaper than analyzers, and enabling more instruments in the field. Thus, the users segment consists of an air monitoring sensors fixed on the top of buildings with an SDR module in order to use the nano satellites technology for a real time air monitoring transmission via the VHF protocol. The users-space interface based on VHF band. The SDR module adapts the signal received from the sensors to the appropriate protocol of communication and transfer it to the nano satellite.

Ground Segment

The ground segment consists of a ground station connected with the climate administrator and the physician servers which encompass a network of air monitoring service.

The space-ground interface based on UHF band. The nano satellites constellation uses the UHF band for downlink. After being received across the ground station, the data are distributed through Internet.

Key Performance Parameters

The mission idea belongs to the air monitoring mission in order to be transmitted in real time using the nano satellites technology. The key performance parameters which lead the success of this mission are listed below:

- Low cost sensor networks are an exciting idea with great potential. These instruments can be configured to log real time data on gas, particulate, noise and weather parameters. In addition data can be transmitted wirelessly. Thus this system is a great platform for air quality monitoring with a good accuracy.
- In order to benefit the nano satellites technology we used the SDR module to send the collected monitoring data via VHF protocol.
- The data transmission speed is 9.6 kbps for both the downlink and the uplink.

Space Segment Description

The idea requires a 1 U cubesat in order to launch with PPOD launcher system. The main architecture of the cubesat shown in fig. 2 which contains the main subsystems of the nano satellite. In order to manage satellites data we propose to use the NanoMind A 712 as an OBDH. In addition a sun sensor, a 3-axis magnetometers, a gyro sensor, a 3 magnetorquers and a 3-axis reaction wheels as an ADCS. The SDR hardware is becoming smaller and more capable. It offered high performance small size, and low power consumption. Thus, we propose to integrate an SDR module for satellite-ground and inter-satellites communications in order to offer a new low cost solution. Indeed, the application of SDR payloads is a recent innovation in satellite systems [1]. With large parts of the radio waveform defined in software, the radio waveform can be changed in operation through software control, and additional waveforms and modifications can be implemented with software changes, all without modification of the SDR platform [2]. SDR is the core enabling technology for cognitive radio, it offers the possibility of adaptive and cognitive operation, multi-band and multimode operation, radio reconfiguration, remote upgrade and the potential to accommodate new applications and services without hardware changes. An additional benefit of the SDR is the portability of the software waveform applications.

The satellite includes VHF/UHF channels. One channel is used to communicate to the Earth ground stations, while the other channel is used for users system and satellite link.

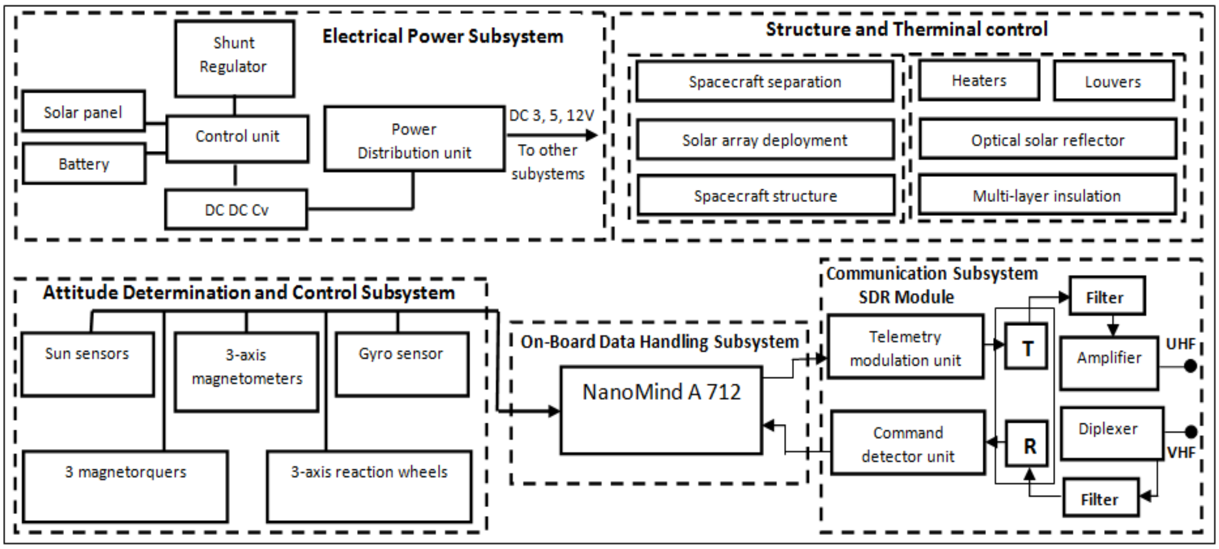

Figure 2. Satellite main architecture

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

Table 1. Overview of the satellite budgets

	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, 3 magnetorquers)	336	1.670	1	27,890.00
	OBDH	GomSpace NanoMind A702	50	0.564	1	4,750.00
	COMM	Communication subsystem SDR module	$\simeq$ 100	2.0	1	1,295.00
		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	10whr integrated battery	-	-		-
	Total		**1022**	-	**12**	63,235.00

Link budget

Item	symbol	units	UHF downlink	VHF uplink
frequency	f	MHz	437	145
Transmitter power	p	dBW	10	10
Transmit antenna gain	G_T	dBi	3	3
Equiv. Isotropic Radiated Power	**EIRP**	**dBW**	**30**	**30**
Free Space Loss	FSL	dB	200.8	191.229
Modulation type	-	-	BPSK	AFSK
Bit rate	-	Kbps	9.6	9.6

Orbit/Constellation Description

As a first step of the mission we propose to cover the North Africa along about all the day. Thus, 9 nano satellites form a constellation for this mission are distributed in 5 orbits as shown in table 2.

Table 2. Initial parameters of 9 nano satellites

	Sat-1	Sat-2	Sat-3	Sat-4	Sat-5	Sat-6	Sat-7	Sat-8	Sat-9
a (Km)	600	600	600	600	600	600	600	600	600
e	0	0	0	0	0	0	0	0	0
I (°)	36	36	36	36	36	36	36	36	36
Ω (°)	0	0	72	72	144	144	216	216	288
TA (°)	0	180	0	180	0	180	0	180	0

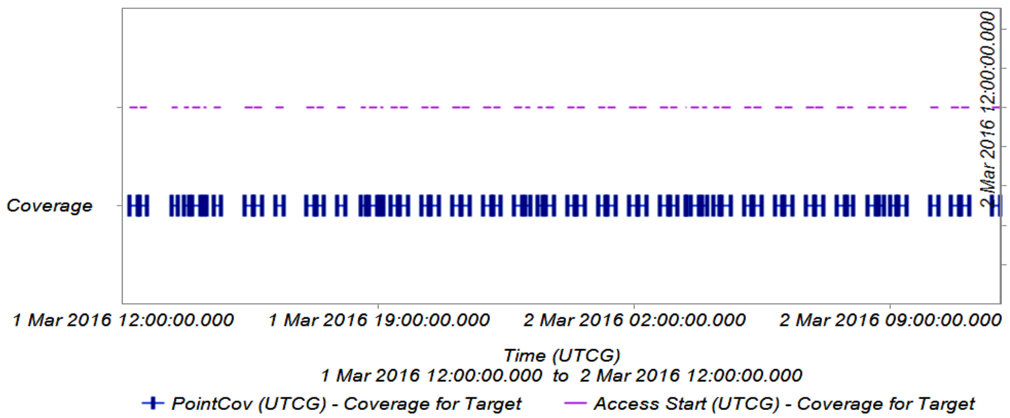

Figure 3. Coverage intervals of nano satellites constellation

Figure 3 shows the coverage intervals of the 9 nano satellites.

Implementation Plan

Costs

The mission costs are listed in the table 2.

Table 3. Mission costs

Constellation	$569,115.00
Launch	$900,000.00
Testing	$900,000.00
Ground station	$50,000.00
Monitoring system	$1500.00
Operation cost (per year)	$100,000.00
Total	$2,520,615.00

Schedule

Table 3 illustrate the schedule of the mission.

Table 4. Mission schedule

Conceptual design	Jan 2016-june 2016
Engineering model	Jan 2017
Flight model	2018
Constellation	2019
Constellation launch	2020

Organization

Figure 3 presents the hierarchy of our mission implementation including the project manager, Ph.D, masters and engineering students. REGIM-Lab (Sfax University) will be responsible for the development of satellite's data processing algorithms as well as OBDH/EPS development and Cubesat bus design. While the Microelectronic and Instrumentation-Lab (μEi-Monastir University) will be responsible for the development of the air monitoring system and the ADCS system. To develop technical means, the ground station is under construction at the University of Monastir. It can be included in GENSO project. It's a radio amateur network which supports the university application related to the space technology. Communication network Management will be developed by VSEE team (Sousse University).

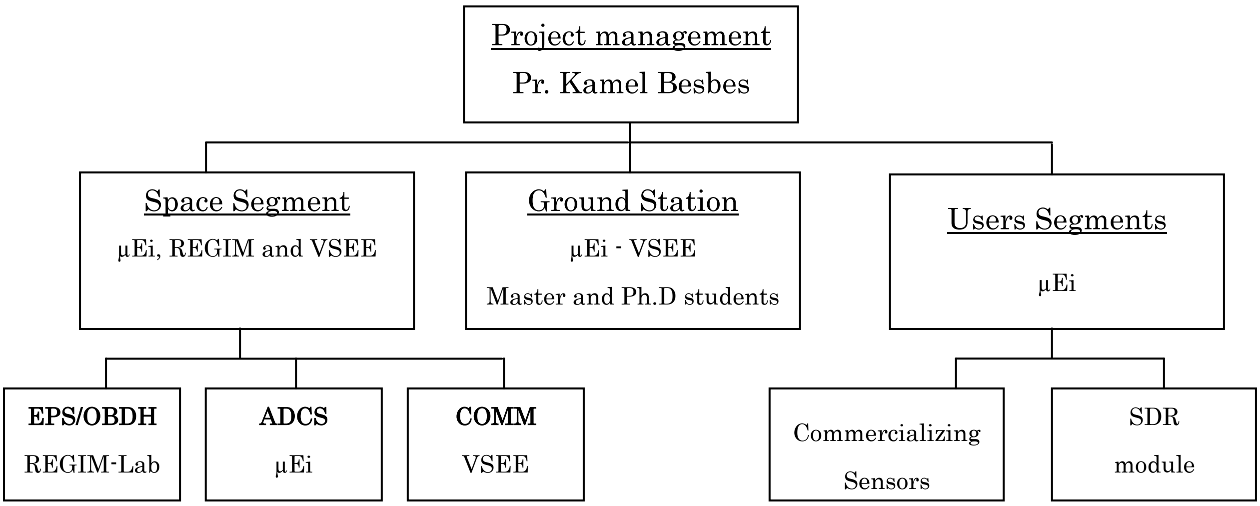

Figure 3. Mission implementation team

References

[1]:W. Chen, et al. "Software defined radio (SDR) payloads for microsatellite missions," in Proc. CASI Astronautics Conference, pp. 1-6, May 2010.

[2] T. Ulversøy, "Software defined radio: challenges and opportunities," in IEEE Communications Surveys & Tutorials, vols. 12, no. 4, 2010.