Title: NANOSATELLITE CONSTALATION
Primary POC : ZELALEM ABEBE AND LETA TESFAYE P.O.Box. 144/1048
Organization: ADDIS ABABA UNIVERSITY FACULITY OF SCIENCE
POC email: abezelalem@gmail.com / leta.2010@yahoo.com
POC tel. No.: +251-911 942328/ +251-917 852741

Promising Science, Nano science

Nanosatellites, also called "nanosats", are a relatively recent term used to describe artificial satellites with a mass between 1 and 10 kg (2.2–22 lb). Larger satellites are often called microsatellites, while smaller satellites are called picosatellites. The idea of a nanosatellite has absolutely nothing to do with nanotechnology, a term that refers the precise engineering of materials on atomic and molecular scales.

Nanosats are a new class of low mass satellite amenable to solar pressure propulsion. Satellites have become essential to military operations, worldwide commerce, and everyday life. Our increasing reliance on these space assets is creating vulnerabilities to attacks from both hostile nations and terrorists, thus placing increased demands on the military to protect space assets and analyze potential threats to them.

Nano Satellite could be developed that, not only provided valuable scientific researches, but also allowed completely new applications, Social & economic problems may be addressed by various applications of space technology. Such direct needs can be classified by geographical location, by the type of services & products or by the type of applications. Today it is usual to focus on problems such as communications or monitoring of remote areas agricultural land use and environmental protection. In addition to those direct needs, it is also important to realize that nano satellites can be the best way to test and validate new techndogy. Finally, the subject of academic training requires specific attention, as nano satellites can play a significant role there, especially for developing countries.

Objectives of the mission

1. Safe, low-cost, small payload delivery system for frequent access to Earth orbit.
2. To show the possibility that the new space payload paradigm can contribute to a simpler faster and much cheaper way of producing very small missions & perhaps to larger & more complex satellites.
3. A commercial capability for dedicated launches of small satellites at a cost comparable to secondary payload launches--a potential new market with Government, commercial, and academic customers.
4. To explore of nano satellite for applications of telecommunications, remote sensing, scientific research,Latest Technology demonstration & academic training, & which will stand for economic benefit of one country.
5. To apply a single mission objective by following electronic miniaturization, appearance of small launcher & nano machining technologies which enabled bulky electro mechanical sensors, such as accelerometer, to be replaced by very low mass low volume semiconductor sensors, Innovations in propulsion and other technologies as well as operations and management for broader applications in future launch systems.

What is possible?

When the ideas & concepts that are discussed as part of the nano technology revolution are fully implemented, what is possible? At this point many of the possible advancements that are discussed seem like science fiction.

1. All of recorded history will fit in a package that will fit in our pockets.
   This includes all written documents, all music & all movies.
2. Our world will be safer because the computers & sensing systems that fit in a package the size of a pill will be able to wrench is of dangers.
3. Life will be extended because we can Grate systems & modules that replicate the function & systems in our bodies
4. New types of " quantum computers" will make calculations billions of times faster than today digital computers.
5. We can create new types of molecules with the mechanical assembly of chemical systems instead of today's assembly by thermodynamic chemical relation

Namosatellite: Past dream is the present Reality and future work horse! It is one of the most promising and exciting product of nanotechnology involving a multitude of science and engineering disciplines,

with widespread application in electronics advanced materials, medicine and information technology.

Nano – Satellite Constellation

Mission objectives:

The main purpose of the nano satellites is to perform scientific mission in which the payload of the satellites depends on the scientific instruments that are used to take measurements of the earth or space.

Design Refinements:

The design requirements are divided in different tasks necessary for the space mission. The following list defines the design requirements for the nano – satellite:

1. Satellite

I. The mass of the satellite includes:

a) Structural mass
b) Payload mass
c) Propellant mass (if used)
d) Instrument mass

I. The dimension of each satellite should not exceed a cube with sides of **15** inches

II. The satellite is recommended to be designed as an axis metric body.

Cube Shape

2. **Orbit**

h. The satellites will be placed in a circular orbit with an approximate altitude of 600km.

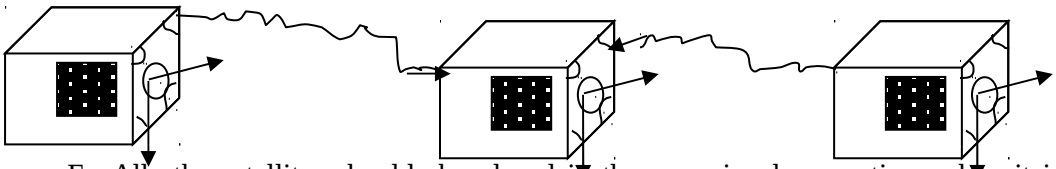
I. The approximate orbit lifetime of these satellites is less than 3 years.

b. The inclination angle of the satellite will be between 15 and 20 digress

II. This indignation angle will provide maximum communication time of 4 to 8 minutes.

3. Formation Flying

a) The constellation should include at least two satellites.
b) One of the satellites will collect the information from the other satellites taking measurements.
c) The other satellites will carry the instruments
d) The separation distance of the pair of satellites should be between 5 to 8m, and the satellites should not be closer than 2m.
e) The constellation can have any geometrical shape depending on the number of nano – satellite



F. All the satellites should be placed in the same in plane motion unless it is required by the mission to place some satellites in the out of plane motion

By the above constalation the One satelite is as asurver for the rest, by exchange of different information from each satelite, and it also carry different instruments for the sattelite and networking of all satelites by this system. If this satellites are Networked they support to each other for the same mission. And the surver satellite communicate to the ground station.

4. **Attitude**

a. The Nanosatellite should be 1 3 – axis spin stabilized system.
b. The nadir error point should be less than 0.05 degrees
c. The attitude control system (ACS) may contain
   i. Magnetic Sensors
   ii. Reaction wheels
   iii. Gravity gradient stabilization

5. Power Sources

a. The power source should be 12 or 24 volts dc.
b. If there is occurance of eclipes the battery above will be used. Other wise it can use solar cell.
c. The power generated should come from solar cells to charge the power source.

6. Thrusters

a. The satellite should use ion thrusters or a similar to correct the position of the satellites.

b. The thrusters will be used to correct the position of the satellites or to correct the formation.

Require Software:

1. **MATLAB and Montecarlo** a. this software can be used to simulate the dynamic equations, control systems, and other effects on the satellites.

2. Satellite Tool kit software (STK)

a. The software can be used to model the orbital mechanism, attitude motion, and launch trajectories for the satellites

3. NASTRAN (or any other finite element software)

α. This software can be used to model the structure of the satellite

Nano Constellation - will allow the world space industry & scientific community to extend their already dominate positions in small sat technologies & stellar astrophysics

- The constellation will consist of more than 20 virtually identical nano satellites each about **4Kg** in mass and 15 x 15x 15 Cm^3 in dimensions
- This constellation aims to be a modest sized instrument operating in low earth orbit, about the effects of the atmosphere, capable of fulfilling the science objectives.

From each equipped with a small lens telescope, able to observes & stand for single mission different celestial bodies, with a sampling time of once per satellite orbit (typically & minutes)

Nano satellites will fill an important & potentially very constellation valuable void in a astrophysical datasets.

Nano satellite propulsion challenges (challenges)

Prolusion is on demand for advanced nano satellites for the following reasons:

* Small satellites are usually launched as a secondary payload. The limited number of such opportunities restricts variety of available small satellite orbits.
* Atmospheric drag compensation extends the spacecraft's lifetime
* Recent demand for bi-spacecraft inspection & services (space stations, spacetshuttie, Hubble, etc) in orbit requires Propulsion for spacebars proximity ' operations including small satellite docking.

Finally, the shortage of small satellite propulsion missions at present is caused by poor performance of existing small satellite propulsion systems. For the most of the propulsion missions, space venire velocity changes (Δv) on the order of > 50 m/se are desirable while the existing small satellite propulsion systems can provide only 3 – 24 m/se.

* One of the most important reasons four performance of existing small satellite propulsion is that the unique challenges imposed on propulsion system by the spacecraft's small size have yet been resolved.
* Small satellites are usually designed to be compact. Tight envelope, in turn, imposes constraints on small space crofts subsystems such as propulsion and power . Since propulsion system relies on power generated outboard the spacecraft the last one also becomes a major an constraint. Space – limited, the existing power systems (typically using Si or GaAS solar arrays and Ni – Cd batteries) are capable of supplying small satellites with limited power.
* Deployable solar panels would increase the small satellite power budget as well as its complexity (sun pointing) deployment mechanisms, etc) and cost.
* Typical values of constraints for nano satellites are given in table below
* Lack of miniature propulsion system components such as thrusters, valves, pressure regulators, etc. The problems that have to be tackled for propulsion components miniaturization are not only of technical but often fundamental kind.

⇒ Manufacture of miniature propulsion system components, therefore, requires significant research and development affords

So who pay for this?

Big aero-space companies are careful investing in such Research and Development work till they see big business coming since nano satellites are cheap, it would require building them in bigger numbers (perhaps dozens or hundreds) than now to get those companies interested .

* Less change of velocity(ΔV) performance of exiting systems is among the main technical reasons responsible for sharp drop in small satellite propulsion. For the time being mass optimization of nano

satellites Either propulsion systems are efficient for ΔV performance enhancement that specific impulse improvement Application of propellant less propulsion (solar cell inparticular) is the way to extend nano satellite propulsion mission to interplanetary scale

So What?

Mass optimization will help to reduce Mr. ratio for small satellite propulsion missions, and therefore, results in higher ΔV performance. Enhancement of propulsion system ΔV capabilities would stimulate further increase in number of nano satellite propulsion missions . Enhancement by specific impulse improvement is only efficient if

$$\Delta V = - I_{sp} g \ln(m_f/m_i), \quad m_f/m_i < 1/e$$

where ΔV – Vehicle velocity change, $\frac{M}{S}$;

g – acceleration of gravity g – 9.81$\frac{m}{s^2}$

I_{sp} – Specific impulse, S

m_f -- final vehicle mass, kg

m_i – initial vehicle mass, Kg

$f_{pd} = \frac{M_{pd}}{M_{ps}} \Rightarrow$ Propulsion dry mass fraction

* $M_r = \frac{M_{rp}}{M_{ps}} \Rightarrow$ mass ratio

Where $M_{ps} = M_{pd} + M_p \Rightarrow$ propulsion system mass, Kg:

M_{pd} = propulsion dry mass, Kg:

M_p = propellant mass, Kg

$M_{rp} = M_i - M_{ps}$ -- mass of the rest of the spacecraft

[i,e payload mass, structure mass & instrument mass] excluding propulsion, Kg.

Whence, vehicle mass ration can be written as:

$$\frac{M_f}{M_i} = \frac{Mr + f_{pd}}{m_r + 1}$$

The above equations together demonstrate that reduction in propulsion dry mass fraction (f_{pd}) is beneficially for ΔV performance enhancement.

Scope of Nano satellite applications

Social & economic problems may be addressed by various applications of space technology in particularly those using small satellite such direct needs can be classified by geographical Location, by type of services and products or by type of applications today. It is usual to focus on problems such as communications or monitoring of remote areas, agricultural land use and environmental protection. In addition to those direct needs, it is also important to reality that nano satellites can be the best way to test and validate new technology. Finally the subject of academic training require specific attention, as satellites can play a significant role there, especially nanosat for developing countries

Possibilities of low cost launchings of nano satellites

The low cost access to space is critical enabling capability in particular for developing countries with limited erasures to expand their initial space activates. Raunchy opportunities for satellites include launch on a dedicated expendable nano launch vehicle, launch as a secondary or piggyback" satellite on or large expendable launch vehicle. The choice of one of these in valves an assessment of the unique mission requirements against the capabilities, costs and contentions of the launch options. The most important considerations are flexibility as regard data of launch & bit (in the case of shared launch) and the value of

the spacecraft, Accord consideration should be the reliability record or flight history of the potential launch vehicle those launching a serves of low cost payloads may be willing to take the risk of a new lower cost launch vehicle with an unproven record. Once a commitment is made to a particular venire, the spacecraft with its payload may require some modifications if it is to be launched on a vehicle different from that for which it was originally designed

Project Sustainability

This is what we have to emphasis because if the project lacks sustainability, we can miss lot of functionality of the constellation. Therefore, the first round constellation and the second round constellation should sustain in the next technical ways. Without making gap, for different instance, during collection of scientific data from remote area, it should have continuity, so that the cost for next constellation should be from customer

Infrastructure

Infrastructures are also the basis for the project infrastructures like GPS, using nano satellite different stations for rocket launchers radiation constellation would, the impact of lost would be huge, so that the project will be sustainable.

Implementation of the mission

ADDIS ABABA UNIVERSITY BY LETA TESFAYE and ZELALEM ABEBE and engineers (Satellite Engineers) to gather with AXELSPACE corp. oration who is the organizer of the contest & Nano satellite center, Co – organizer of the project, will come together & realize the nano satellite constellation mission so that the idea come to reality under the supervision of Japanese government owing the project .

Project organization

ADDIS ABABA UNIVERSITY
POSTGRADUATE PROGRAM
PHYSICS DEPARTEMENT

LETA TESFAYE JULE and

ZELALEM ABEBE BEKELE

Eg. The data made by nano satellite constellation would increase the number of customers & potential customers

To show the possibility of nano satellite constellation to address and solve the problems related to social & maximize the economic benefit of one county

Eg.

Top risks or

Expected challenges / obstacles which may face the project

1. Propulsion challenges:
   One of the most important reasons for poor performance the unique challenges imposed on propulsion system by the spacecraft small size have yet been resolved
2. Volume of Bus
   Volume is often the most sever constraint for small space crafts due to the shortage of space available under the fairing, that is intern affect space craft sub system & power.

3 Required software programmed

Availability of software's other than MATLAB STK (satellite tool kit software & NASTRAN to model the constellation, launch trajectories, control systems & other effects of satellites

1. Support of training for the project
   To achieve the mission objective successfully & efficiently it needs special training an orbital mechanics, space flight & control systems, and space environment
2. A availability of some of the technology needed & monopoly situation of space sector where competitiveness is diminished like nano technology machining, sensory are few mentioned.