Title: Space Advertiser (S-VERTISE)

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Need

Worldwide companies need more creative advertisement ways. Conventional ways repeat themselves and people are getting less and less interested about these advertisements. This project aims building an orbit constellation with three identical satellites that will project company logo etc. with their laser emitters to the clouds in night time. It might bring excitement from the points of advertisement and technology. It may also become a profitable business opportunity. Furthermore, precise position/attitude determination and attitude control system for nanosatellites will be developed. Building a large advertisement satellite system is too expensive for this purpose and this kind of system can be realized by nanosatellites by using current technology.

Mission Objectives

- Creating new generation of advertisement technique and preparing it for profitable business ideas
- Acquiring precise attitude/position determination and attitude control for nanosatellites

Concept of Operations

All segments of satellite advertisement system are focused on simplification of the operations. This approach brings cheaper and reliable satellites. Moreover reduced production time for identical satellites can be achieved.

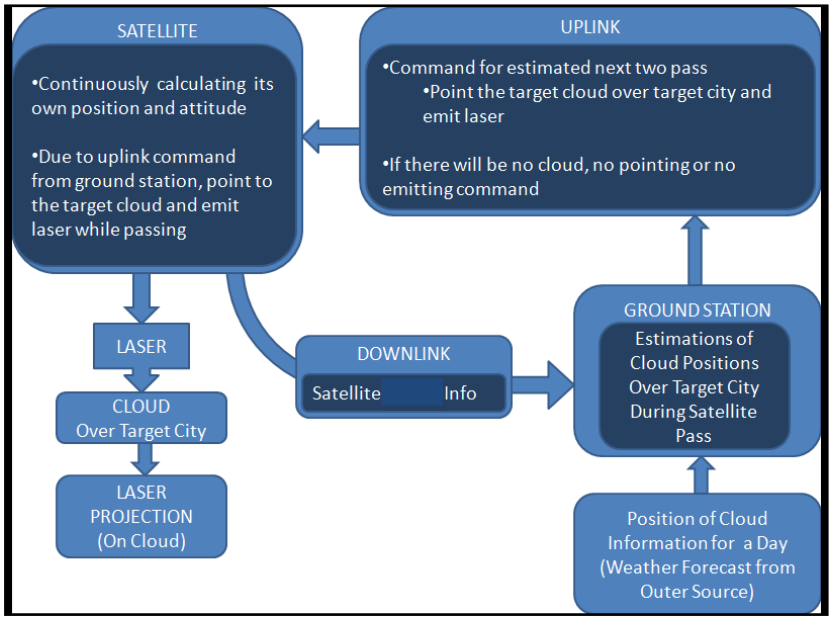

Figure 1 – Concept of Operations

Ground segment will receive attitude and position information from each satellite. Therefore the satellite position and passing times will be known precisely. It also store weather condition (from free outer source) for desired location (where advertisement will be broadcasted). Then according to weather condition, ground segment will send a signal that tells the satellite "emit laser when you are passing on desired location" (if the location has cloudy sky).

Space segment will consist of three identical satellites in nearly circular orbits with an altitude of 400 km. More satellites bring higher frequency for numbers of passes on desired location. They determine their own position and attitude. When a satellite passing above the desired location it will orient itself to target and emit its laser according to signal received from ground station.

Launch may be accomplished by any reliable polar launcher, while the altitude of the orbits and the total mass of the system are not excessive values. This mission is not dependent on launch site.

Key Performance Parameters

Each satellite of the system will have simple design so that it will just execute its mission. Precise attitude/position determination (0.01 degree for attitude and about centimeters for position) and precise attitude control (up to 0.01 degree) is required.

Lifetime of the satellite with a ram surface of 600 square centimeters and the altitude of 400km will be more than 2 years, considering the aerodynamic drag and other orbital disturbances. After 2 years lifetime, the satellites will not be space debris due to their quick descending time. [1]

Space Segment Description

Body of the satellite will be shaped as 10cm x 10cm x 60cm tetragonal prism that one of the square faces will be pointing to the earth. This side of the satellite also contain hole for laser output. The heavier parts (like reaction wheels and star sensors) will be placed upper part of the satellite. So the satellite's center of the mass will be carried to near upper segments. This settlement will configure moment of inertia distribution so that the satellite will behave as it is stabilized by a ***gravity gradient boom.*** Thereby, it will contribute to the satellite's nadir pointing accuracy.

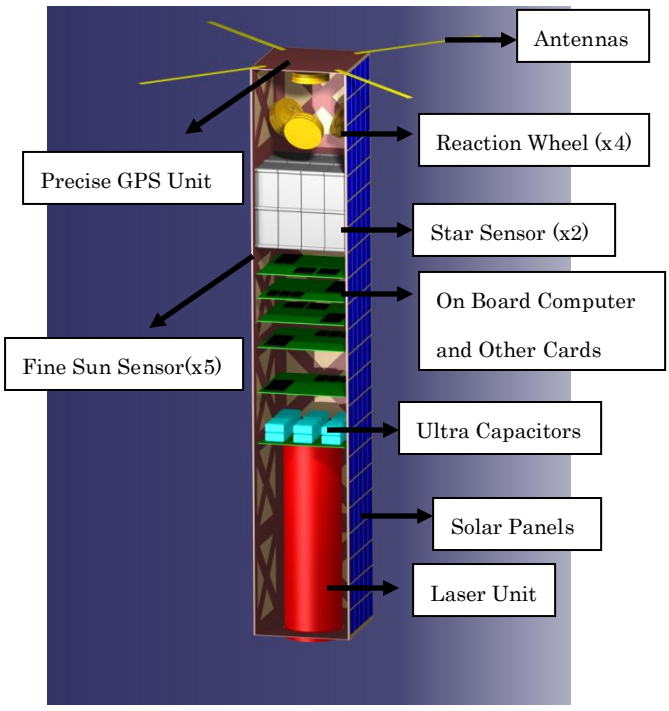

Figure 2 - Representative Design of the S-VERTISE

Power requirement of the satellite will be excessive for nanosatellites. The desired laser power pushes up the instantaneous peak power of the satellite up to 175 Watts (with the %10 safety margin). Conventional batteries for nanosatellites cannot handle this kind of power. But ***ultracapacitors*** [2] can overcome this power need and they can be used for this mission.

Position determination of the satellite will be acquired by GPS receiver and accelerometers. Their combination with proper algorithm (ex. Kalman Filter) gives position of the satellite with the margin of error in centimeters.

Attitude determination of the satellite will be acquired by 2 star sensors (orthogonal placement to each other) and 5 analogue fine sun sensors (1 for each face of the satellite except laser output face). Their combination with proper algorithm (ex. Kalman Filter) gives attitude of the satellite with the margin of error in 0,01 degree.

Attitude control will be done with reaction wheels with quartet placement, each weighs less than 1kg mass. The pointing accuracy is the maximum that can be achieved by the current hardware and software technology.

Uplink and downlink requirement of the satellite and ground segment will be few. Only command signal will be send to the satellite via uplink and satellite information will be send to ground via downlink. ***VHF Band*** will be sufficient.

Mass of the satellite will not exceed 15 kg consisting of 4 reaction wheels (each is under 1 kg), 2 star sensors [3] (each is 0.45kg), aluminum body frame 1,5 kg, cards and cabling 2 kg, power subsystem (ultracapacitors and solar panels) almost 2 kg (with interfaces, small parts of the subsystems…etc and even %10 margin of security).

Payload of the satellite will be laser emitter unit that projects advertising company logo to the cloudy sky at night time. The laser emitter system will have no movable elements. Both internal parts and interface parts of the emitter should be rigid. The laser unit's lenses will focus to infinity, that will be sufficient for 400 km altitude projection. Power consumption of the laser emitter will be up to 150 Watts which will be overcome with ultracapacitors.

Orbit/Constellation Description

Orbits of the system will be selected as polar and near circular with altitude of 400 km and 89 degree of inclination. All identical three satellites will have same orbital parameters except the Right Ascension of Ascending Node. Their RAAN's differ from each other with 120 degrees. This ***constellation*** structure brings more coverage and higher frequency number of passes for any desired location. Each satellite will pass above target location at least 2 times in night time (for 24 hours period) and all three satellites will pass ***6 times in night time in total (for 24 hours period).*** Two and three dimensional representations of the orbit constellation are shown below.

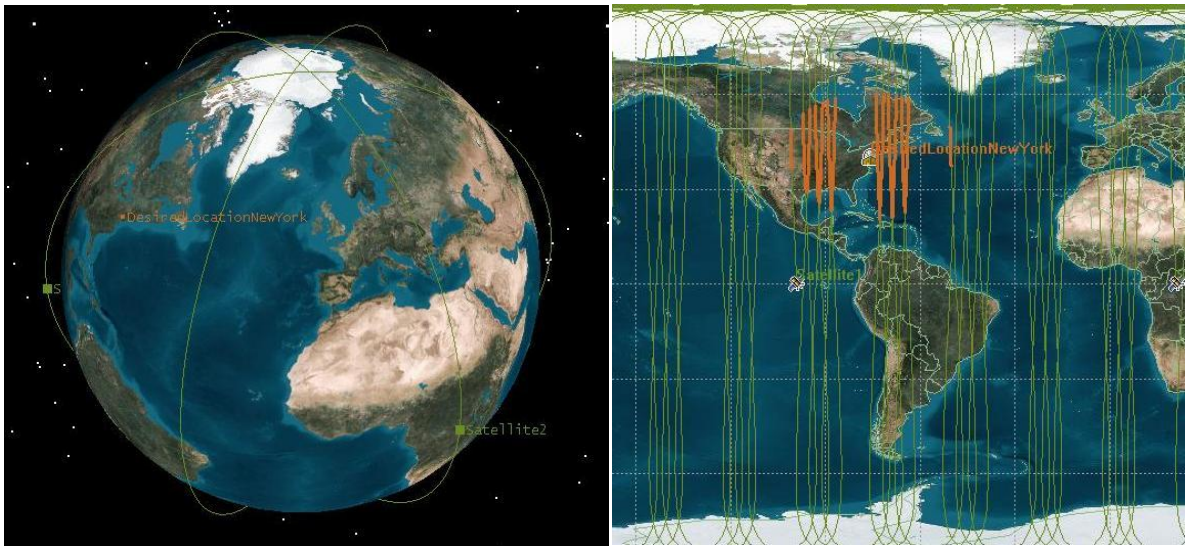

Figure 3 – 3D View and Ground Track Representation of the Orbit Constellation of S-VERTISE

Implementation Plan

The S-VERTISE will be realized by multi-disciplinary effort of engineering faculties. Space System Design and Test Laboratory will cooperate with Aerospace Engineering, Electronic Engineering and Mechanical Engineering Faculties to lead this project to success.

Operation	***Time***	***Financial Budget***
Research & Design	9 Months	1 050 000 $
Development & Optimization	6 Months	490 000 $
Assembly & Integration (An Engineering Model)	3 Months	800 000 $
Testing	3 Months	650 000 $
Assembly & Integration (Three Flight Models)	2 Months	2 600 000 $
TOTAL	21 Months	5 890 000 $

Table 1 – Operation - Time - Financial Budget (for All Three Satellites and an Engineering Model)

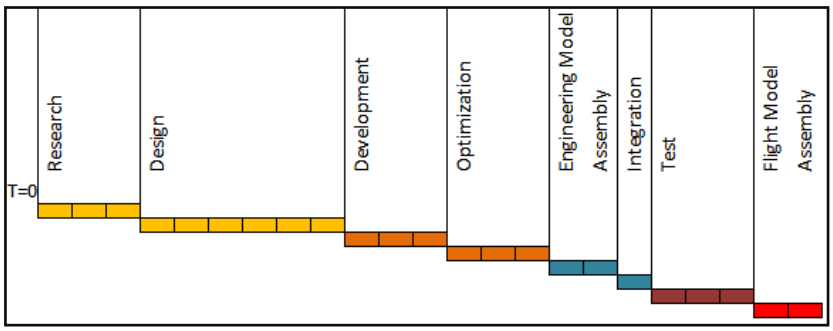

Figure 4 – S-VERTISE Project Timeline (Each Box Represents a Month)

Operation name, required time, financial budget of S-VERTISE is shown in Table-1 and S-VERTISE Project Timeline is shown Figure-4. The determined values allow a safety gap (1 Months for time and 110 000$ for budget) to satisfy M.I.C. requirements.

Istanbul Technical University has laboratory potential to test nanosatellites by thermal & vacuum chamber (for space environment conditions), acoustic vibration conditions (for launch phase), electromagnetic tests (for communication phase) and operational tests. The outer sources will also be considered to reduce production time and operational risk. Space qualified sensors and actuators will be bought from companies like ClydeSpace, Axelspace etc.

This project also aims developing ***profitable business*** which will determine the mission's sustainability. The key element of profit is customers. Considering the whole world coverage and system cost (6$ million for three satellites excluding launch), the customers must be worldwide companies. The worldwide companies' advertisement budgets should be taken into consideration. For example, two worldwide companies' 2009 advertisement budgets were;

- Microsoft → 518$ million
- Apple → 249$ million

The minimum 2 year mission time and low production cost make buying this kind of advertisement service sensible. Moreover, applying such a technique makes this project so spectacular that the worldwide companies' attention can be drawn. The next round constellations will be developed and produced more quickly than the first one.

Launch can be organized with Indian PSLV, Russian DNEPR-1 or European VEGA (if it will be operational on desired time). Their Delta-V values and payload capacities are sufficient for S-VERTISE launch scenario.

The ground station will send command signals (uplink) and receive satellite information (downlink). The need of antenna construction and other hardware for ground station will be simple due to low requirements VHF band communication hardware.

Risks of the S-VERTISE project are;

- The projection of the laser must be targeted to the places where no aircraft traffic occurs. If this kind of demand (project the laser to the cities where air traffic running) comes from companies, it should be negotiated for "no air traffic" places.
- S-VERTISE system is planned for projecting only one company's advertisement. It is restrictive for long term advertisement projects.
- If the emitted laser misses the cloud, the image projection will occur on the ground and may cause problems.

References

[1] http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19640002805_1964002805.pdf

[2] http://www.maxwell.com/products/ultracapacitors/product.aspx?PID=PC10-SERIES

[3] www.axelspace.com/product/AxelStar_e.pdf