Title: Medium/large vehicle tracking system

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Need

We exist currently in a world which has a global trading market responsible for transporting trillions of dollars annually in products worldwide using ships, aeroplanes and trucks. With it comes the need for global precision tracking. The ever-changing need, however, of suppliers, customers and insurers introduces yet another unique opportunity. This opportunity we propose to exploit using a constellation of low cost nanosatellites providing both precise and near real-time tracking. The use of nanosatellites offers a fast track, low cost solutions with up to date technology to this rapidly growing and changing market. This is in contrast to large satellites which have a typical development time between three and seven years and costing typically over fifty million dollars (US$).

Mission Objectives

The mission can be divided into the proof of concept (POC) and the overall system.
The mission objectives are:

- To use a constellation of nanosatellites to track medium/large vehicles.
- To launch 7 satellites into one polar orbit for the POC to achieve 16% coverage.
- To fill 6 polar orbits, each with 7 satellites for the overall system to achieve 100% coverage.
- To use inter-satellite communication to deliver near real-time tracking data.

Concept of Operations

The fundamental concept behind this mission idea is to enable a low cost and robust global tracking system for aircraft, ships and land based transport. The location and custom data will be made available to the client in near real-time due to an intelligent routing algorithm whereby data is relayed via the Low Earth Orbit (LEO) satellite constellation; this is illustrated in Figure 1.

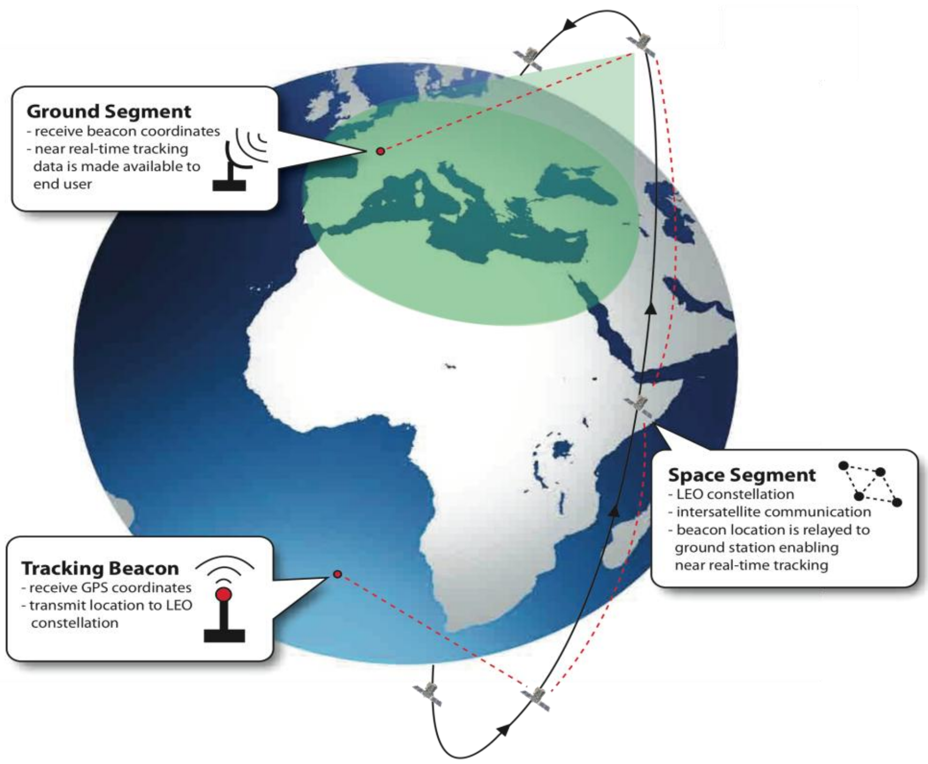

Figure 1: **Mission concept of operations**

Key Performance Parameters

- Worldwide continuous tracking of medium/large objects with 42 nanosatellites.
- 1st launch: 7 satellites providing 12 hour update intervals to a single ground station.
- Full constellation: 42 satellites providing a 15 minute update interval to the ground station.
- Inter-satellite communication allows tracking data to be retrieved from the entire constellation.

Space Segment Description

The power system converts energy from the solar array, controls battery charge and discharge rates and distributes power to the various subsystems. A low speed S-Band transceiver is used in communications between satellites and a high speed S-Band transceiver is used for telemetry, tracking and control (TT&C) and payload data transmission. The VHF receiver will receive and process beacon signals. The attitude determination and control system (ADCS) system will accurately point the satellite to the ground station and to neighbouring satellites during communications. The onboard computer (OBC) will control the transfer of data between satellites. A VHF antenna for receiving beacon signals, S-Band quadrifiller helix antenna for TT&C, and another S-Band quadrifiller helix antenna for inter-satellite communications will be implemented onboard the satellite.

The satellite will have a mass of 12 kg and a volume of 19683cm^3 (27cm X 27cm X 27cm). 12 Watt is available for peak power needs while the satellite uses 7.5 Watt on average. The link budget for the various communication systems is shown in Table 1.

Table 1: Link budget

	Downlink/ TT&C Uplink	Inter-Satellite Link	Beacon Uplink
Frequency	S-Band	S-Band	144-146MHz (VHF)
TX-Power	1 W	1 W	20 mW
TX Antenna Gain	10 dBi (Helix)	12 dBi (Helix)	0 dBi (Monopole)
RX Antenna Gain	39.2 dBi (5 m parabolic reflector)	12 dBi (Helix)	0 dBi (Monopole)
Data Rate	10 MBit/s	9600 Baud	9600 Baud

Orbit/Constellation Description

The planned orbit type is a near polar, sun-synchronous orbit. This orbit allows the satellites to cover the entire earth and always pass over the ground station at a specific time of day. The orbit height is 800km as it is stable and requires no orbit correction. In addition, the link budget for the communication subsystem is realisable at this altitude.

A simulation was done by setting satellites at an inclination of 98^o and selecting a time interval such that there was a 15 minute period between an overpass of one satellite and the next satellite. In doing this the last satellite in the string will pass over an area 90 minutes after the first satellite.

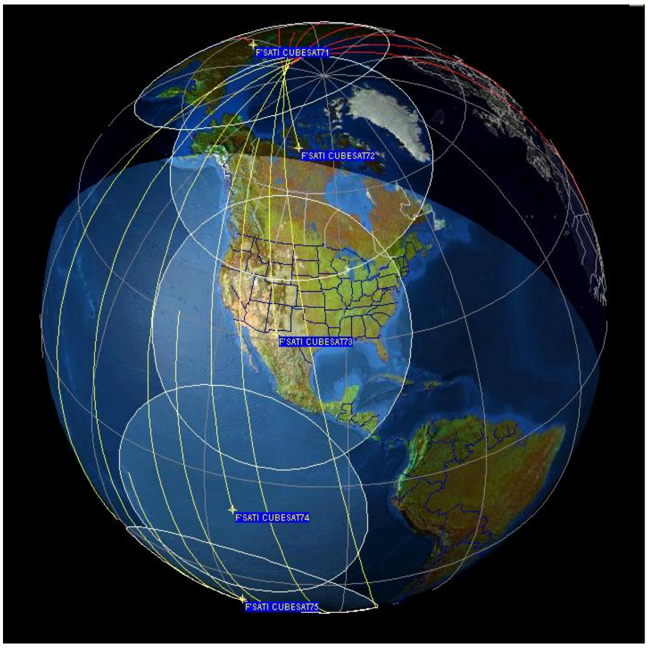

Figure 2: Constellation in global map

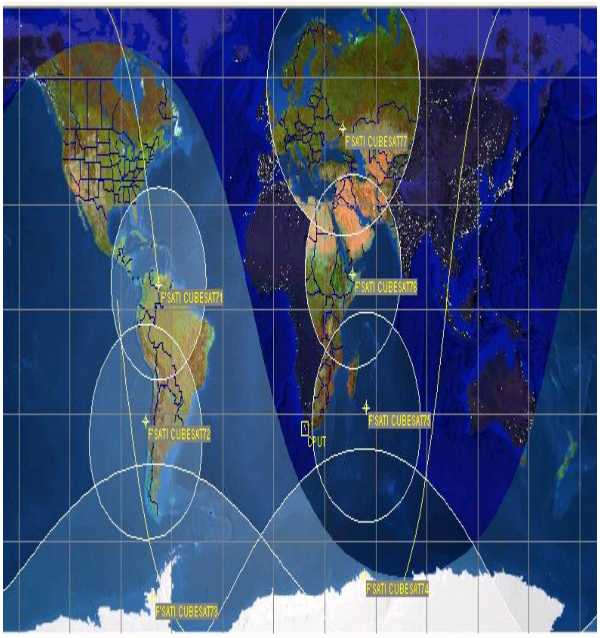

Figure 3: Constellation in a rectangular map

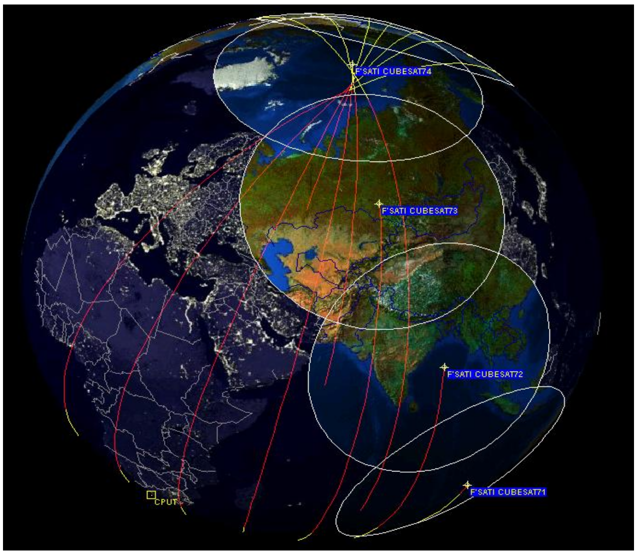

Figure 6: 7 Satellites global map

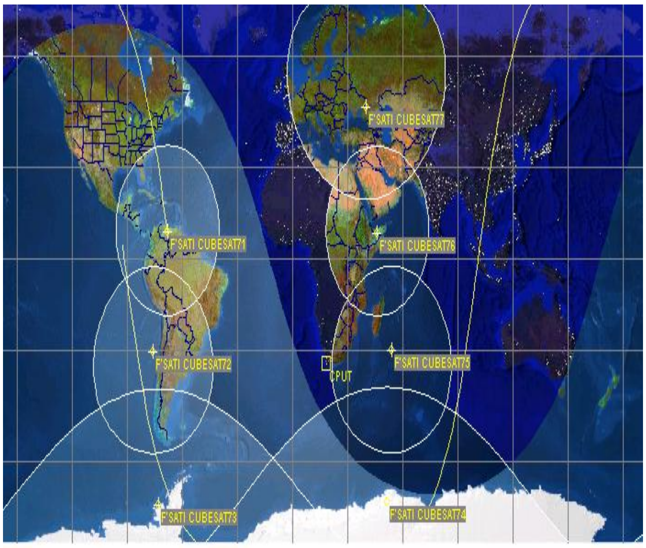

Figure 7: 7 Satellites in rectangular map

Implementation Plan

- Define the problem and summarise the mission objectives
- Define the system, satellite orbits, satellite bus, satellite budgets
- Design phase of the satellite bus and subsystems
- Testing and integration phase
- Launch and Operation

The team will consist of a project manager, system engineer and subsystem engineers who will be responsible for the design of the various systems onboard the satellite.

Implementation and Life Cycle of Project:

Our tracking service will be implemented by the use of 7 nanosatellites and tracking transponders. These transponders are typically 100 x 50 x 30 mm in size. These will log the GPS coordinates of the medium/large vehicle in intervals of 2-15 minutes and transmit these logs to the closest over-passing satellite.

Transponders are readily available and cost approximately US$500. Ideally we aim for global coverage. However, our initial launch of seven satellites in one orbit ("chasing each other") will have a total of 16% global coverage at any given time. The launch of additional satellites in the appropriate orbits to deliver global coverage will be developed from the sustainability phase of our project.

Risk Assessment:

1. The tracking market is currently monopolized by the use of Inmarsat satellites. They are established in the market place for over 31 years.
2. Inmarsat has a well-deserved reputation for precision tracking and excellent service to its clients.

3. Existing relationships with its partners and clients (very good brand establishment).
4. Existing global coverage versus our initial 16% of global coverage.
5. The need for compliance with the Communications Acts and Regulations national and international of our products and services.

How to successfully implement sustainability taking into account our risk assessment:

1. Various case studies proved that a market dominated by a corporative "giant" accepts very well the introduction of new competition.
    a. Examples are: Introduction of Cell C and Virgin Mobile into South Africa in the dominance of Vodacom and MTN.
    b. Introduction of Neotel in South Africa in the dominance of Telkom.
2. The shipping market specifically is growing very fast and introduces enough room for competition. Furthermore, we only provide the infrastructure and companies like Casper use this to market tracker service to clients. This will further provide direct price competition to Inmarsat.
3. Relationship establishment will first start with potential partners. These partners, e.g. Casper already have relationships with clients.
4. Nanosatellites are easy, time and cost effective satellites versus large satellites. This implies low cost and fast track development, meaning we can reach global coverage in short time span of approximately 1 - 2 years.
5. For Nanosatellites we use commercial off the shelf (COTS) components. We choose products which are already FCC Compliant.

References

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