University of Stuttgart

Title: FoNC – Fire observing Nanosatellite Constellation

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Need

Each year disastrous forest fires occur all over the globe. They do not only threaten densely populated areas but also influence the world's climate. Current satellites map these fires, however it takes valuable time until local fire fighter units receive the data for most effective use.

Mission Objectives

1. Elapsed time: How much time does it take from the satellite gathering the data until local fire fighting units receive the data?

2. End-user costs: How expensive and complicated is the handling of the ground equipment?

3. Fire fighting communication: Does a special communications gateway exist for area coordination of the fire fighters?

4. Coverage: How often is one particular fire being overflown and analyzed by the same satellite type to achieve comparable results?

5. Open architecture: How easily could third-parties provide an additional satellite or ground station or create a new application for the acquired data?

Concept of Operations

The space segment consists of a fleet of eight nanosatellites arranged symmetrically in one sun-synchronous low earth orbit plane at an altitude of 680 km. Each satellites is equipped with a bolometer payload to detect heat signatures of forest fires. The gathered data is then analyzed on board to later save bandwidth and then constantly relayed to the ground using amateur radio.

On the ground only small inexpensive receivers are necessary. They can be plugged into common audio inputs. As smartphones with GPS are increasingly available at low costs, they could serve as the ground segment for the actual user. An App using the smartphone's GPS could process the received data and pinpoint the firefighters to the next fire almost in real time thus saving valuable time comparing to existing structures and procedures. The receiver could also use the uplink capability to upload the location and status of the local unit which is then directly relayed by the satellites to other fire fighting units or a command post in real time.

Key Performance Parameters

Special orbit selection for multiple nanosatellites and their orbital plane configuration:

- each location is overflown as often as possible for a high location and time resolution
- almost global coverage to cover all import vegetation areas with forests in the world
- (exact orbit parameters are described in Orbit and Constellation Description)

Bolometer:

- Three Bolometers with a combined swath of 1000km with a ground resolution of 40m for optimal coverage and sufficient resolution for fire fighting.

Use of Amateur radio:

- inexpensive and technical proven payload equipment
- small and inexpensive ground receivers
- sufficient data rate of approximately 19,2 kbit/s at VHF/UHF.
- already a large user base which could provide ground support at the moment of operations
- no license costs for frequencies

Space Segment Description

Key specifications of ONE nanosatellite	
Mass	15 kg
Payload: Bolometer (3)	Combined 40m/1000km swath
Link budget	approximately 19,2 kbit/s at VHF/UHF
Average Power	25W
Peak Power	40W
Power generation & storage	Solar cells & Lithium-ion batteries
AOCS actuators	Reaction wheels & magnetorquers
Orbit altitude	About 680 km
Single location overflown	Every 12 hours

Due to the nature of a preliminary analysis all values are not definite.

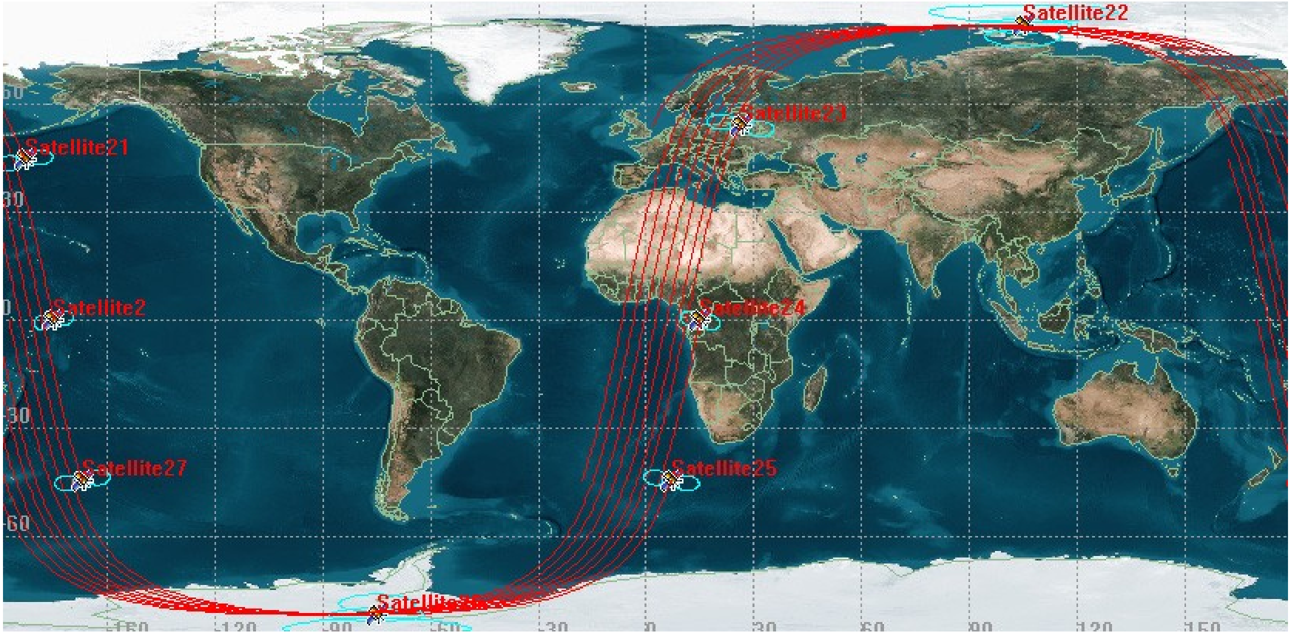
Orbit and Constellation Description

All satellites are arranged symmetrically in one sun-synchronous low earth orbit plane at an altitude of 680 km. In order to increase ground coverage a high amount of satellites is preferred.

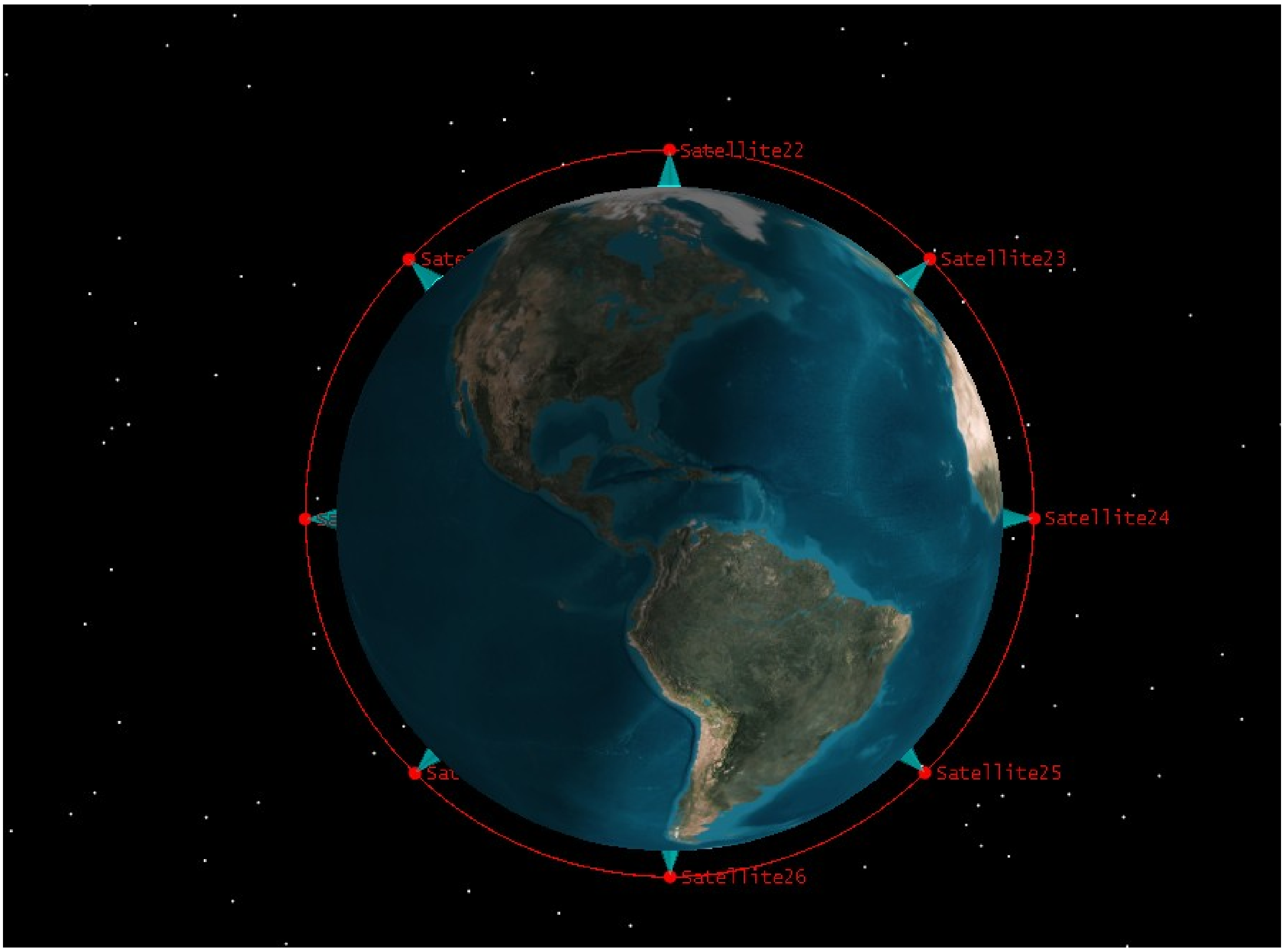
A sun-synchronous orbit has several advantages over a standard polar or non-polar orbit, such as having non-varying sunlight conditions, which benefits solar power generation as well as providing the same lighting for earth-observation at any time.

The height of the orbit has to be selected so that depending on the number of satellites gap-free ground coverage can be provided.

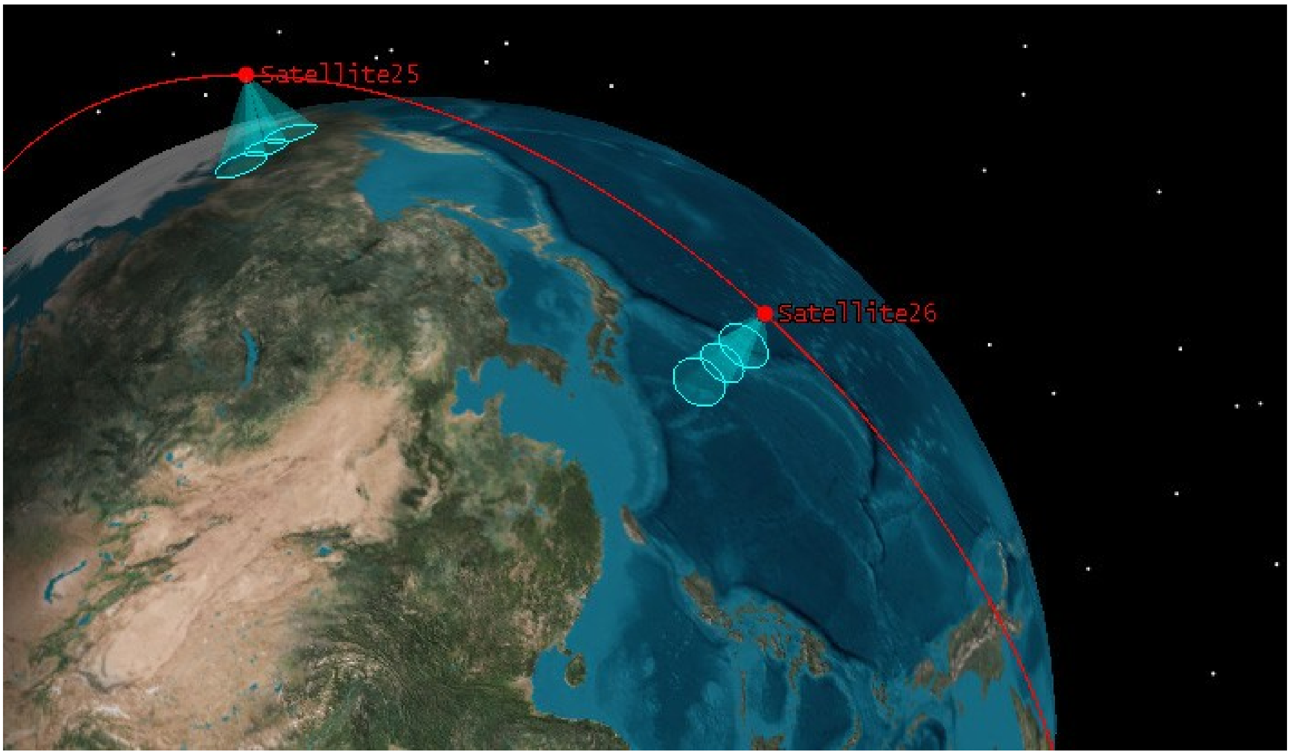
With respect to these requirements a total number of eight satellites would provide sufficient ground coverage while also giving the possibility of maintaining an inter-satellite link between all fleet satellites. Simulations with the *STK-tool* Astrogator show that with this satellite constellation each place on earth can be observed several times per day in an repeating interval of 12 hours (day- and night-observation) and contact to a ground facility can be established up to ten times a day with a duration of 350 seconds average.



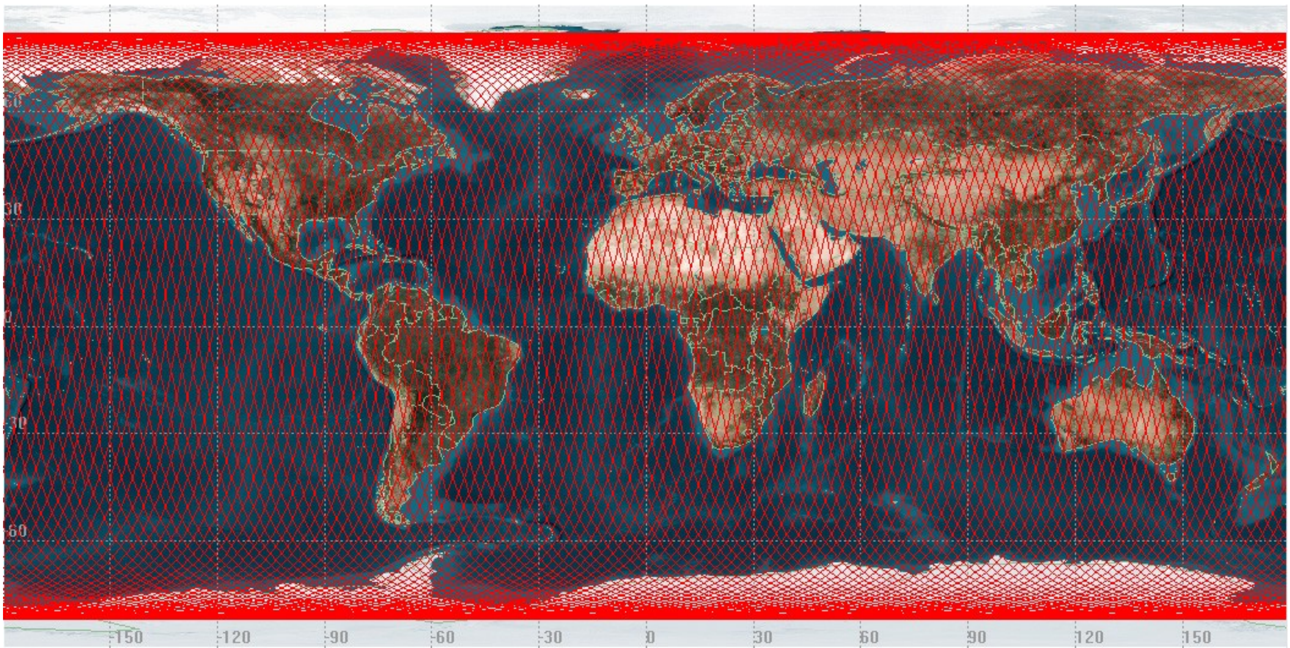
One orbit-cycle, Distribution of Satellites



Lateral view, Constellation of eight satellites



Orbit view in detail



Ground-coverage per day

Implementation Plan

The Institute of Space Systems at the University of Stuttgart where we study is capable of providing the infrastructure needed to design, develop and build the satellites. An existing ground station offers the possibility of providing telemetry, tracking and command services for the satellites. However as part of the open architecture idea all kinds of cooperation are conceivable and planned.

The development time would particularly profit from a common effort of different organizations and a time frame of less than two years will be feasible.
Talks to experts revealed that the estimated total costs for one nanosatellite including its development and service are below 800 000 dollars excluding launch costs.
At this point it is believed that the FoNC – project can be realized without exceeding the maximum budget of six million dollars. First this is based on the previously stated building costs for one nanosatellite. Moreover initially eight satellites are planned for the FoNC – project, it can be assumed that the relatively high number of identical satellites will lead to scaling effects which decrease the costs perceivably.

Initial operational capability of the system can be achieved with one secondary launch. Compared to large satellites the fleet can be easily extended and updated inexpensively and incremental investments without interrupting the provided service.
The open architecture makes it feasible to easily integrate FoNC – Satellites from other operators or which are located in other orbital planes.

During the UN climate summit in Cancun, Mexico in December 2010 it became clear that forests play an essential role for the global climate and the protection of present areas will become increasingly important.
FoNC does not only provide the opportunity to constantly monitor forest fires but also offers assisting capabilities for rapid fire fighting, its open architecture will offer new opportunities for both the nanosatellite builders and the people concerned with forest fires.