Montsec Ground Station

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Abstract
In every space mission, the ability to contact the satellite to transmit or receive telecommands and data is one of the critical parts, so having a good ground segment is fundamental.

In support to 3Cat-2 operations a ground station was first developed by the UPC NanoSat Lab at UPC Campus Nord premises. However, due to increasing radio frequency interference it was moved to the Institute Space Studies of Catalonia (IEEC) - Observatori del Montsec (OdM), located in Sant Esteve de la Sarga, Lleida. This location has outstanding reception conditions in terms of very weak interference levels, and excellent elevation mask (i.e. satellites can be tracked even below the horizon).

The ground station is equipped with a TX/RX Yagi antenna for amateur bands VHF (144-146 MHz) and UHF (435-438 MHz), and it also includes an S-band 3-meter dish in the commercial band (2025-2110 MHz, 2200-2290 MHz) for reception that will be upgraded for transmission in 2022. The antenna rotors, receivers etc. are remotely controlled to the operation-center in Barcelona and operations can be automated.

Nowadays, the ground station is jointly operated by the UPC NanoSat Lab and the IEEC in support to the Catalan New Space strategy, in addition to the upcoming UPC missions.

Keywords
CubeSat, Ground Segment, S-Band, UHF, VHF

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Acronyms/Abbreviations

BDA	*Bi-Direccional Amplifier*
IEEC	*Institut d'Estudis Espacials de Catalunya*
LEO	*Low Earth Orbit*
LNA	*Low Noise Amplifier*
OdM	*Observatori del Montsec (Montsec Observatory)*
PA	*Power Amplifier*
UPC	*Universitat Politécnica de Catalunya*
SDR	*Software Defined Radio*
SSO	*Sun Synchronous Orbit*
TT&C	*Telemetry, Tracking and Control*

1. Introduction

As cubesats are in expansion due to affordable launch and procurement components.

The UPC Nano-Satellite and Payload Laboratory, NanoSat Lab, an initiative of the Dept of Signal Theory and Communications with the support of the School of Telecommunications Engineering of Barcelona to design and develop nano-satellite missions focused on the exploration of innovative small spacecrafts, subsystems and payloads for earth observation. In order to control, tracking and receive the data generated by satellites. It develops its ground station system. A VHF/UHF [1] and S-Band ground stations [2] were placed in Montsec mountain range with collaboration with IEEC.

And in addition, to control and operate the ground segment an operation center [2] was designed and implemented.

2. Barcelona station and issues

With the mission of ^{3}Cat-2, NanoSat Lab needs a ground station to perform the operations.

Its first option was place an UHF/VHF ground station in the top roof of UPC Campus Nord building in Barcelona.

The station was capable of VHF RX and UHF RX & TX (half duplex).

But due to the noise floor of this location is high and also tall buildings and mountains block part of the field of view. The station is not suitable to becomes the main operation VHF/UHF ground station of NanoSat Lab missions.

3. Montsec Observatory

The OdM is a scientific infrastructure manage by IEEC. It is located at altitude of 1570 meters in the Montsec montain range (Catalan Pre-Pyrenees), in Sant Esteve de la Sarga.

The area is recognized as one of the most suitable in Europe for conditions and low effect of light pollution.

As there are good conditions of signal reception due to very low noise floor and has good elevation masks. OdM was choose to place the UPC NanoSat Lab ground stations.

3.1. Satellite pass characteristics

In Montsec location the passes of SSO LEO satellites have an average time pass of 7.5 minutes and each day a satellite can view our ground stations an average of 3 or 4 times per day.

As Montsec location has very good elevation masks in some occasions the satellite signals can be receive below the horizon.

Figure 1. Montsec UHF/VHF antennas

4. Montsec VHF/UHF TT&C station

The VHF/UHF TT&C station, **Figure 1** is designed to have VHF RX and UHF TX and RX same as Barcelona ones and it is developed with full SDR capabilities.

The VHF Yagi antenna has vertical and horizontal polarization components. And the antenna has a gain of 10.5 dBi. On the other hand, UHF antenna also has vertical and horizontal polarization components and its gain is 12.8 dBi.

The Rotor is an azimuth/elevation Yeaesu rotor controlled by an own design controller based and commanded via Ethernet by ground station computer.

This station was used in 3Cat-1 missions and it will be used in 3Cat-4 missions that will be launched soon.

5. Montsec S-Band TT&C Station

With FSSCat mission, the winner of the 2017 Copernicus Master ESA Small Satellite Challenge S^3 and Overall Winner. That it consists in an innovative concept of two federated 6-unit Cubesats, called 3Cat-5/A and 3Cat-5/B.

To download the scientific data an S-band downlink was required.

Therefore, the UPC NanoSat Lab designed and implemented a S-band ground station located in Montsec Observatory.

So far the station has only downlink capabilities but to achieve the full operations for NewSpace strategy satellite missions of government of Catalonia and also future 3Cat missions as 3Cat-6/RITA payload. The S-band ground station also needs to have the uplink.

As the implementation and installation of upgrades is performing now. The uplink upgrade will be ready soon.

Figure 2. Montsec S-Band Antenna

5.1. Main characteristics

The ground station is composed mainly by RF chain, antenna, rotor and controllers. With an antenna of 3-meter diameter dish, **Figure 2**, it can achieve 35 dBi as antenna gain.

Using a Bidirectional amplifier (LNA+ PA) near the feeder makes that ground station has maintained a low noise level on downlink channel. The other RF chain parts are located in rack cabinet inside the building with the Azimuth/Elevation controller, SDR, ground computer, and other related parts.

5.2. Downlink capabilities

With the described characteristics the S-band downlink can achieve better and bigger capabilities than VHF/UHF ground station, **Table 1**

Table 1. S-band Downlink Capabilities

Parameter	Value	Unit
Pass Duration	7.5	Min
Passes each day	3	-
Velocity	2	Mbps
Download data per day	337.5	MBytes
Download data per month	10.125	GBytes

6. Operation Center

To control VHF/UHF and S-band Montsec ground stations all its elements are managed by operation center and it can control remotely.

The operator can debug all the elements remotely if it is necessary. And also can manage and introduce new passes for each satellite.

To track a satellite, the ground station uses the TLE, orbital parameters, that each satellite has, propagating its orbit, its orbital position is obtained at any point of time and the antenna can track and move it to follow it.

In addition to visualize the satellite passes the operation center has a live viewer to control the movement of antenna, the orbital location of the satellite and the received signal, **Figure 3**.

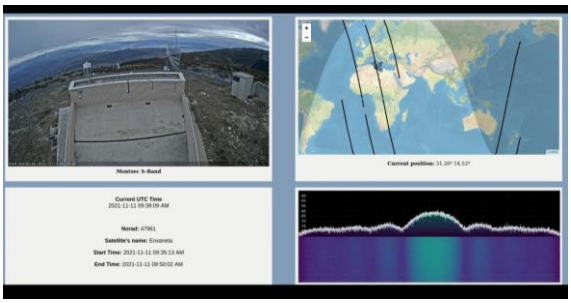

Figure 32. Montsec S-band viewer during 3B5GSAT (Enxaneta) pass

7. Conclusions

The ground stations located in Montsec, Observatory in special the S-band ground station has become an indispensable piece of excellent results of missions as FSSCat mission.

The ground stations will continue use for next launches of 3Cat missions as 3cat-4 and 3Cat-6/RITA Payload and also for the NewSpace strategy satellites missions.

To increase the capabilities to download more data in Montsec. The X-band downlink capability also will be acquiring.

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