Status of ground radiocommunication system of OUFTI-1 nanosatellite as of mid-2012: design, implementation, and tests

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Abstract

We describe the ground-segment component of the radiocommunication system of the OUFTI-1 nanosatellite system, comprising a ground station and a suitably modified D-STAR repeater.

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The primary goal of the educational OUFTI-1 nanosatellite is, in a nutshell, to place a D-STAR radiocommunication “repeater” in space, thereby extending to space the existing and evolving D-STAR network. D-STAR is an amateur-radio, digital communication protocol allowing simultaneous voice and data communications. Our space-based “repeater” is, however, quite different from commercially-available repeater systems; one immediately-visible difference is the size: a 10 x 10 cm electronic board vs. a rack full of equipments.

This presentation focus on the ground segment of our satellite system. This segment consists in two main elements: (1) a ground station (GS) for controlling the satellite (plus a duplicate, distant backup GS), and (2) an interface/extension to a standard (ground-based) D-STAR repeater.

The first element (GS) consists of a control computer (possibly a tablet or a smart phone), radio equipments, and (steerable,) tracking x-quad antennas, located at our institute. The GS is fully automated and routinely used to track and listen to amateur satellites. The “brain” of the GS is the control computer's “mission control center (MCC)” software tool, which manages the sending of telecommands (TC's) and the receiving of telemetry (TM's) to & from the satellite, using the standard, amateur-radio AX.25 protocol. After a long debate and several changes of strategy, we have now settled on UHF (435 Mhz) for AX.25/D-STAR uplink and VHF (145 Mhz) for the corresponding downlink (as well as for the always-active OOK beacon). We designed the TC/TM's according to the strict CCSDS ESA standards.

The second element (interface/extension) routes the communications from the worldwide D-STAR network to & from the satellite, and thus to & from a user located at the intersection of the transmit and receive footprints of the satellite antennas (VHF and UHF). However, two users located in the intersection footprint can also communicate directly via the satellite. Our ground-based D-STAR repeater consists of a control computer, radio equipments, and a dual-band, vertical antenna located about 1.5 km from our GS. The interface/extension consists in a control computer, a standard UHF D-STAR repeater transceiver, a home-made, computer-controlled VHF-to-UHF frequency converter - allowing (1) the uplink and downlink signals to both go through this transceiver, and (2) the application of the appropriate Doppler frequency corrections to the uplink signal -, and a tracking antenna, all at the same location as the D-STAR repeater. (The downlink Doppler corrections are done on-board – according to uplinked, precomputed correction tables - so that users can use standard, unmodified D-STAR transceivers.) The ground-based repeater has been operational for several years, and has been regularly upgraded and improved. It was the first Belgian D-STAR repeater connected to the internet.

We designed our GS (and MCC) so that it could be integrated into the worldwide GENSO satellite tracking network. This will be invaluable to control the satellite when it is not in view of our OUFTI-1 facilities.

Our presentation will center on a block diagram of the complete radiocommunication system of the ground segment of the OUFTI-1 system. It will also discuss the constraints and choices that led to the present ground-segment architecture.