The OUFTI-1 nanosatellite system in mid-2012: architectures of ground and space segments

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Abstract

We describe the current status of the OUFTI-1 nanosatellite project, the main payload of which is an innovative D-STAR radiocommunication system. We describe the architectures of the ground and space segments.

We present a bird's eye view of the complete OUFTI-1 satellite system, i.e. its ground and space segments, and their interconnection. The OUFTI-1 project was launched in September 2007. The OUFTI-1 nanosatellite is a one-unit (1U) CubeSat, i.e. a "cube" 10 cm on a side. The main satellite payload is, in essence, a D-STAR repeater in space (potentially the first one ever); D-STAR is an amateur-radio ("ham"), digital radio-communication protocol (with associated equipments) allowing the simultaneous transmission of voice and data (such as GPS coordinates and call-signs).

To gain time, we purchased the metal structure of the satellite (from the Pumpkin company), thereby (1) guaranteeing a maximum of compatibility with CubeSat standards and with the P-POD container (which typically holds a set of three CubeSat in the launcher and releases them in space), and (2) allowing us to focus on the design of the mission and of the satellite subsystems (electrical, mechanical, and thermal). Our electronics consists in five boards: electrical power supply (EPS); radiocommunications (COM); main, homemade on-board computer (OBC); backup, commercial, off-the-shell OBC with flight history (from Pumpkin); a board initially intended for an experimental, digitally-controlled EPS, but which may be used as an overflow board for the COM.

The COM subsystem, which enables the link between space and ground, provides three capabilities: D-STAR voice and data communications, AX.25 telecommand and telemetry (TC/TM), and OOK emergency beacon transmissions. The satellite simultaneously receives and decodes potential D-STAR and AX.25 communications, but transmits in only one of these modes at a time. To make the beacon maximally reliable, we implemented it as two parallel, independent (except for a transfer of parameters to be transmitted) chains up to, but excluding, the radiofrequency (RF) power amplification, and we decoupled it as much as possible from the rest of the electronics. The chains operate in alternation, each sending 12 vital parameters to the ground, four of which are common.

The ground segment consists in a ground station, a standard D-STAR repeater (for ground communications), and a satellite extension to the latter. The ground station consists in fixed RF installations (in Liège and Redu, both in Belgium) and one or more control computers (implementing the "Mission Control Center"), which can be laptops, tablet-computers, or smart phones, making it possible to control the satellite from anywhere in the world via internet. The control station is fully automated and has been operational for two years. It is used routinely for tracking amateur-radio satellites. It will be used to send telecommands and to receive telemetry, both in AX.25. The detailed format and usage of the TC/TM has been defined. It obeys the ESA CCSDS standards. Furthermore, the ground station meets the ESA GENSO standards, meaning that it can be integrated into the worldwide GENSO satellite-tracking network.

The first experimental setup of our D-STAR repeater became operational in January 2008; more advanced setups, with a better location and successively better antennas, became operational in April 2008 and June 2009. The D-STAR satellite extension has been designed and some elements developed and tested, but it still needs to be implemented. The role of the extension is essentially to add OUFTI-1 to the worldwide network of D-STAR repeaters, which are connected via the internet and microwave links.

We will present system block diagrams of the satellite, the control station, and the D-STAR repeater and its satellite extension, and discuss the reasons that led to the current architecture of the overall OUFTI-1 system. We will also report on the state of implementation and test. The whole system is expected to be fully operational in mid-2013.