Implementation of D-STAR
and other radiocommunication protocols
aboard the OUFTI-1 CubeSat

Nicolas Crosset[$], **Valéry Broun**[+], **Amandine Denis**[†], **Jonathan Pisane**[*],
Jacques G. Verly[*], **Nathalie Vetcour**[$]

[$]*GRAMME Institute, Quai du Condroz 28, 4031, Angleur, Belgium*
[+]*HEPL, Engineering Department, Electronics Service, Quai Gloesener 6, 4020 Liège, Belgium*
[*]*Dept. of EECS, University of Liège, Grande Traverse 10, 4000, Liège, Belgium*
Tel: +32 4 366 2642, Fax: +32 4 366 2989, Email: jpisane@ulg.ac.be
[†]*LTAS, University of Liège, Chemin des Chevreuils 3, 4000, Liège, Belgium*

The main payload of OUFTI-1 is a D-STAR repeater. D-STAR is an amateur-radio protocol for digital voice and data communication. Among the several options, we use GMSK modulation and a rate of 4,800 bauds. The satellite also relies on the amateur-radio AX.25 protocol for telecommands and telemetry, using FSK at 9,600 bauds, and on a Morse-code beacon, using FSK at 12 words/minute. Uplink frequencies are UHF, and downlink frequencies are VHF. To perform the various modulations and demodulations, we use several ADF7021 VHF/UHF transceiver devices from Analog Devices. This transceiver contains 16 configuration registers that can be loaded via a serial line, allowing one to set the type of modulation, the center frequency, the frequency deviation, the data rate, and many other parameters.

Due to the fact that our CubeSat will move at about 8 km/h along its orbit, it is important to take into account the Doppler effect and to compensate for it. The equipments used by amateur-radio operators to deal with AX.25 data and with Morse code allow for the manual or automatic compensation of the Doppler effect. However, this is currently not the case for commercially-available D-STAR equipments. Therefore, since we cannot expect the average amateur-radio operator to physically modify his equipment to be able to communicate with the satellite, we have chosen to perform the Doppler compensation on-board, both on receive (Rx) and on transmit (Tx).

The D-STAR communication strategy is as follows. Amateur-radio operators will be able to reserve the satellite to communicate from one zone Z1 to one zone Z2, both necessarily in the footprint of the satellite. The corresponding Doppler corrections will be sent up by telecommand. One ADF7021 set in Rx mode will alternately scan on the two properly Doppler-compensated frequencies for a few milliseconds. The header of each D-STAR signal will be decoded by an MSP430 microcontroller to confirm the corresponding source zone and destination zone of the D-STAR signal. The Tx ADF7021 will then be set up for D-STAR communication. The MSP430 will decode the incoming D-STAR frames, re-encode them, and send the resulting data to an ADF7021 set in Tx mode.