Phase C

EPFL Ground station description

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INTRODUCTION

This document describes the EPFL ground station. It is located on the roof of the ELB building at EPFL.

This ground station will be automated, and will be able to be controlled by internet.

National and international frequency coordination has been achieved through the OFCOM (Federal Office of Communications) and the USKA (Union of Swiss Short Wave Amateurs) for national frequency coordination and through the ITU (International Telecommunications Union) and the IARU (International Amateur Radio Union) for international coordination.

The assigned frequencies are 145 MHz for the uplink and 437.505 MHz for the downlink.

1 DESCRIPTION OF THE GROUND STATION AT EPFL.

This is a brief description of the Ground Station at EPFL. It is an example of a compatible ground station that can be used to communicate with the Swisscube. Ground stations with different designs can also be used, as long as they are able to send and receive the RF signals described in chapter 4 correctly.

The ground-station will be built on the roof of the EL building of the EPFL. One part, the antenna system, will be installed outside on a mast. The other part, the control electronics, will be located in a storage room on the last floor of the building.

The design was proposed by radioamateurs from the RAV club (Club des radioamateurs vaudois) and was approved by the system engineering team.

Figure 1 shows the system Block Diagram for the Ground Station. It shows all connections and devices. Table 1 also shows the planned manufacturer and model of the devices.

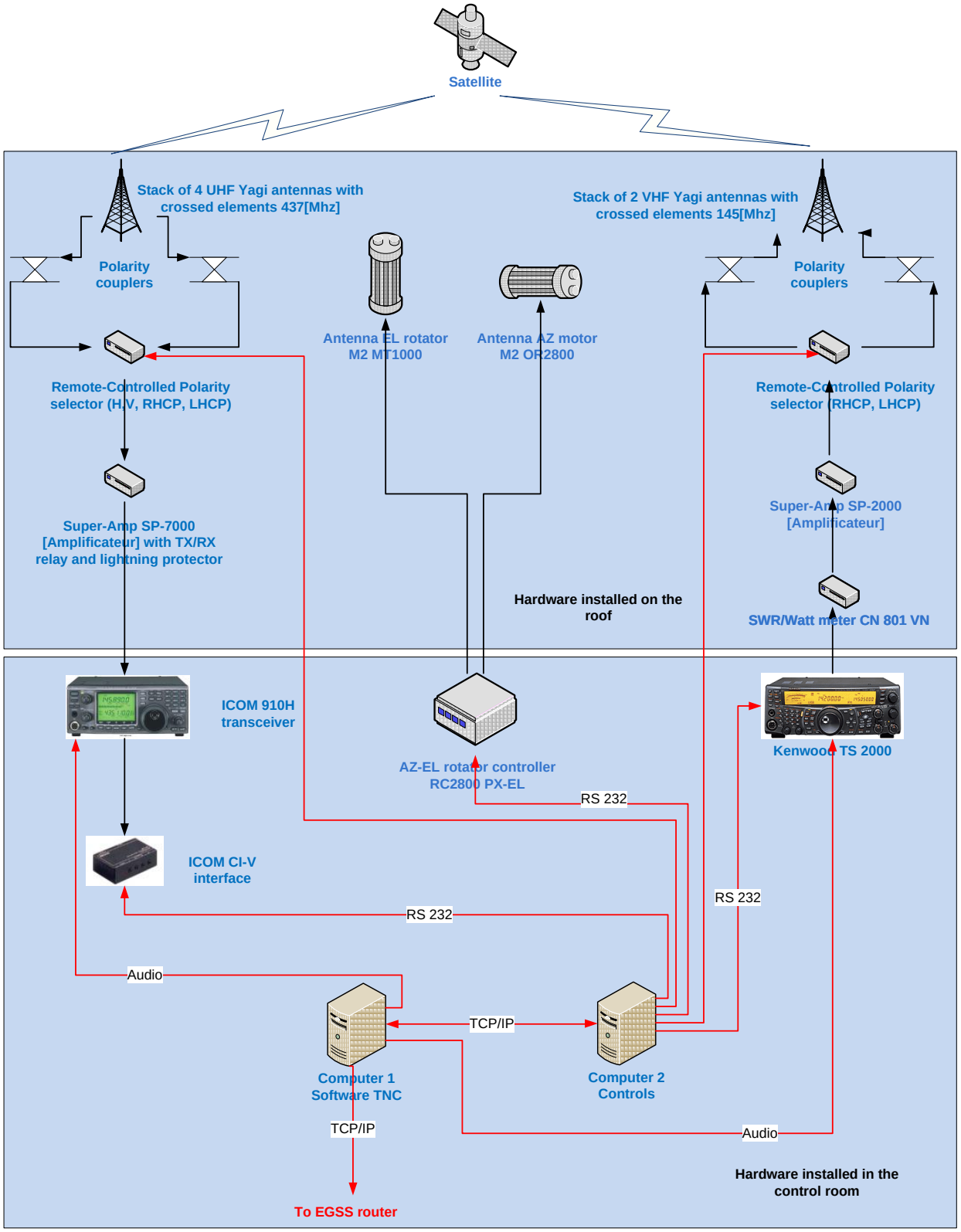

Figure 1: EPFL Ground Station block diagram.

The telecom data protocol between the ground and the space systems is the AX.25 protocol and was chosen for its wide-spread use in the Amateur Radio community.

Element	Model	Function	Choice Rationale	Purchased
Control electronics				
Transceivers	Kenwood TS-2000 ICOM 910H	Kenwood for transmission ICOM for reception	See Note 1.	Yes
TNC	Software TNC developed at EPFL with help from the radioamateurs	AX.25 packet FSK/AFSK modem	Allows for custom-made signal processing	Is being developed.
Controller PCs	1) 486 IBM PC 2) DELL Optiplex 755 MT	1) Control the antenna positioning motors for tracking of the satellite and Doppler compensation, controls the transceivers and the polarity selectors. 2) software TNC	1) Available and free. 2) Powerful enough for comfortable software signal processing.	Yes
Rotator controller	RC2800 PX-EL Controller	Command the rotator's position		Yes
SWR meter	CN-801VN	Check the quality of the match between the antenna and the transmission line		Yes
Power supply	GSV-3000			Yes
Antenna System				
Tx Preamp	SSB-Elektronik SP-7000	Low noise amplifier	Recommended by radio amateurs	Yes
Rx Preamp	SSB-Elektronik SP-2000	Low noise amplifier	Recommended by radio amateurs	Yes
Lightning protection	Lynics 20310-3	Protect from lightning damage		No
Polarity couplers				yes
AZ-EL rotator	EL: M2 MT1000 AZ: M2 OR2800	Antenna rotators		yes
Uplink Antennas 2-m	2 CP: 2MXP20 Yagis		Good G/T Optimized for stacking	yes
Downlink Ant. 70-cm	4 CP: 436CP42 Yagis		Gain and F/B are excellent	yes
Mast			Donated by radio amateur	yes
Additional clamping, beams and mounting HW				In process.

Table 1: EPFL Ground Station hardware.

Note 1: The criteria for the choice of the transceivers were:

- Band of frequencies adapted to the frequencies of the CubeSat radio amateurs (145 MHz for upload and 437.5 MHz for download).
- The transceiver must be able to recognize all the modes used for satellite radio amateur operations: FM, USB, LSB, CW, AM, AFSK, 9600 bauds packet, 1200 bauds packet.
- Possibility of controlling the transceiver by PC.

- Good compensation of the Doppler Effect: the step of the synthesizer must be to the maximum of 1 kHz.
- Full Duplex: broadcast on a band and reception on the other one (VHF > UHF or UHF> VHF). The full duplex mode is currently not a requirement for the SwissCube but it is or might be for other satellites.
- Software support.
- There are 2 transceivers. One Kenwood TS-2000 for the uplink and one ICOM IC-910 for the downlink. There are several reasons for having two transceivers:
    a. Experience has shown that the ICOM 910 receiver has better performances than the Kenwood TS-2000 receiver.
    b. Both transceivers handle duplex communications. As such, one transceiver can handle all the communications with the satellite if the other transceiver fails.
    c. Interfacing the transceivers in simplex mode with the computer and the TNC (be it software or hardware) is simpler than in duplex mode.

Figure 2 shows the existing antenna mast on the EL Building. The mast and antennas have been removed.

Figure 2: Current installation on the roof of the EL building.

The EPFL Ground Station has a stack of 4 Yagi UHF antennas for the downlink signal and a stack of 2 Yagi VHF antennas for the uplink.

Figure 3 shows the baseline layout of the ground-station with two circularly polarized 2m Crossed-Yagi antennas for the uplink and four 70cm antennas for the downlink. Figure 4 shows the radiation patterns of available Yagi antennas for 2m and 70 cm.

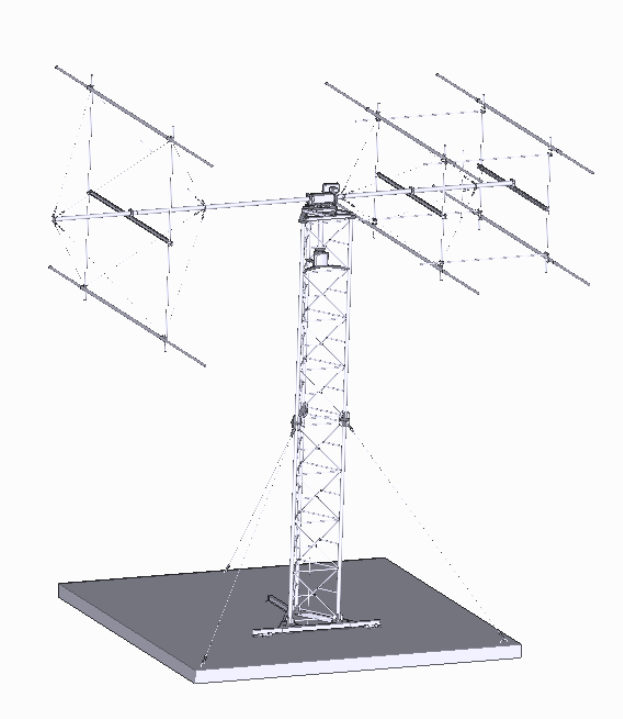

Figure 3: Antennas layout.

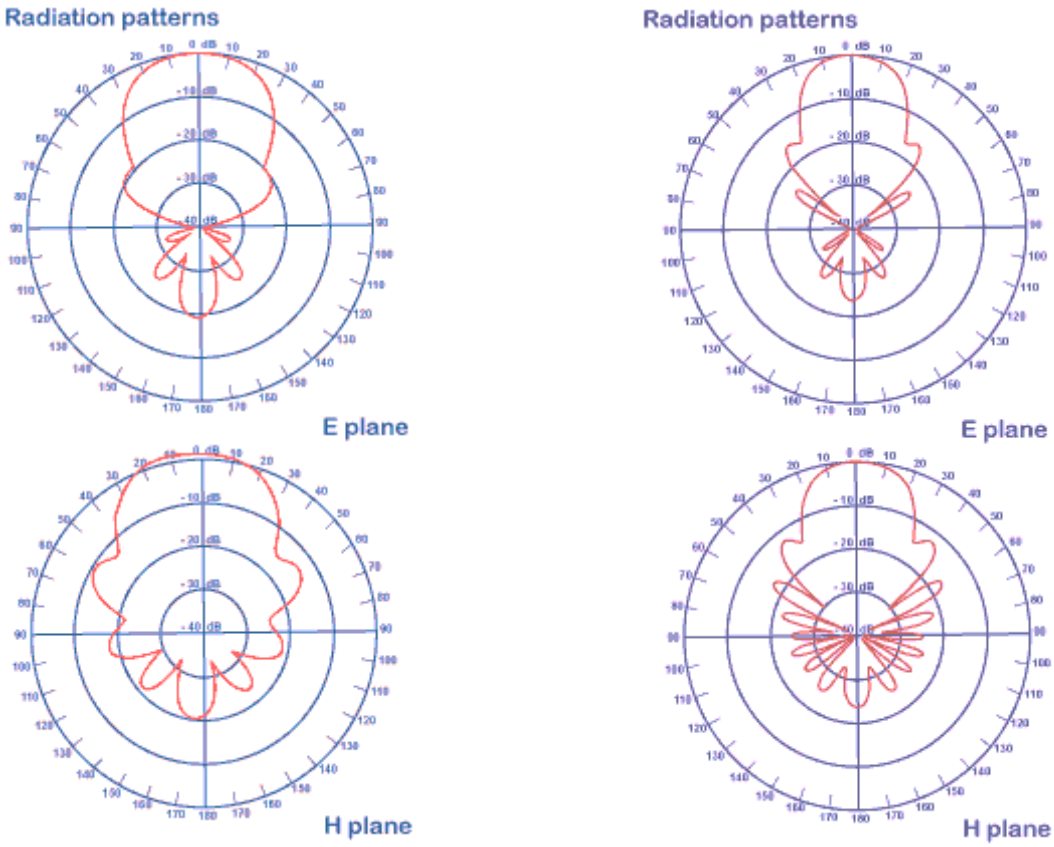

Figure 4: Radiation pattern of a 2m and 70cm Yagi Antenna

Specifications	Antennas uplink 145.98 MHz		Antennas downlink 437.505 MHz	
	Single antenna	Stack of 2 antennas	Single Antenna	Stack of 4 antennas
Model Number	2MCP22	2MCP22	436CP42UG	436CP42UG
Frequency range	144 to 146 MHz	144 to 146 MHz	430 to 438 MHz	430 to 438 MHz
Gain	10.11 dBi	13 dBi	14.66 dBi	20.46 dBi
Beamwidth	38 degrees	19 degrees	21 degrees	10 degrees
Polarity	RHCP or LHCP		RHCP or LHCP	
Front to Back	25 dB typical		25 dB typical	
VSWR	1.4:Max		1.5:1 & Better	
Feed Impedance	50 Ohm Unbal.		50 Ohm Unbal.	
Connector	N Female		N Female	
Elements	2*11	2*2*11	21H and 21V	4*2*21

Table 2: Specifications of the EPFL ground station antennas.

Software.

Two computers are used for the Ground Station. The first one (Computer 1) runs a software TNC that will be developed at EPFL. This software will have the following functionalities:

- Software demodulator: the software will read the audio signal delivered by the receiver and demodulate it to extract the AX.25 frames. It will send these frames to the TMTC Front End through the EGSE router.
- Software modulator: the software will receive AX.25 frames from the EGSE router, and will modulate it into an audio signal that will be sent to the transmitter.
- Signal analyser: the software demodulator will also analyse the signal received (S/N ratio, frequency drift, frequency deviation, etc.). These parameters determine the corrections that are needed to the receiver parameters. The software will transmit these corrections to the second computer.

Meanwhile, the MixW32 software will be used for tests. A hardware TNC may also be used.

The second computer (Computer 2) runs 6 separate programs that interact together:

- Two programs (may be grouped into one single software) to control the two transceivers.
- One program to control the two rotors.
- One program to track the satellite. Orbitron or Nova. This software will give commands to the software mentioned above to correct the position of the two rotors.
- One program to manually input corrections to the transceivers' parameters or to the rotors' control. This software will also accept commands from the tracking software and the software TNC.
- One program to control the polarity selectors.

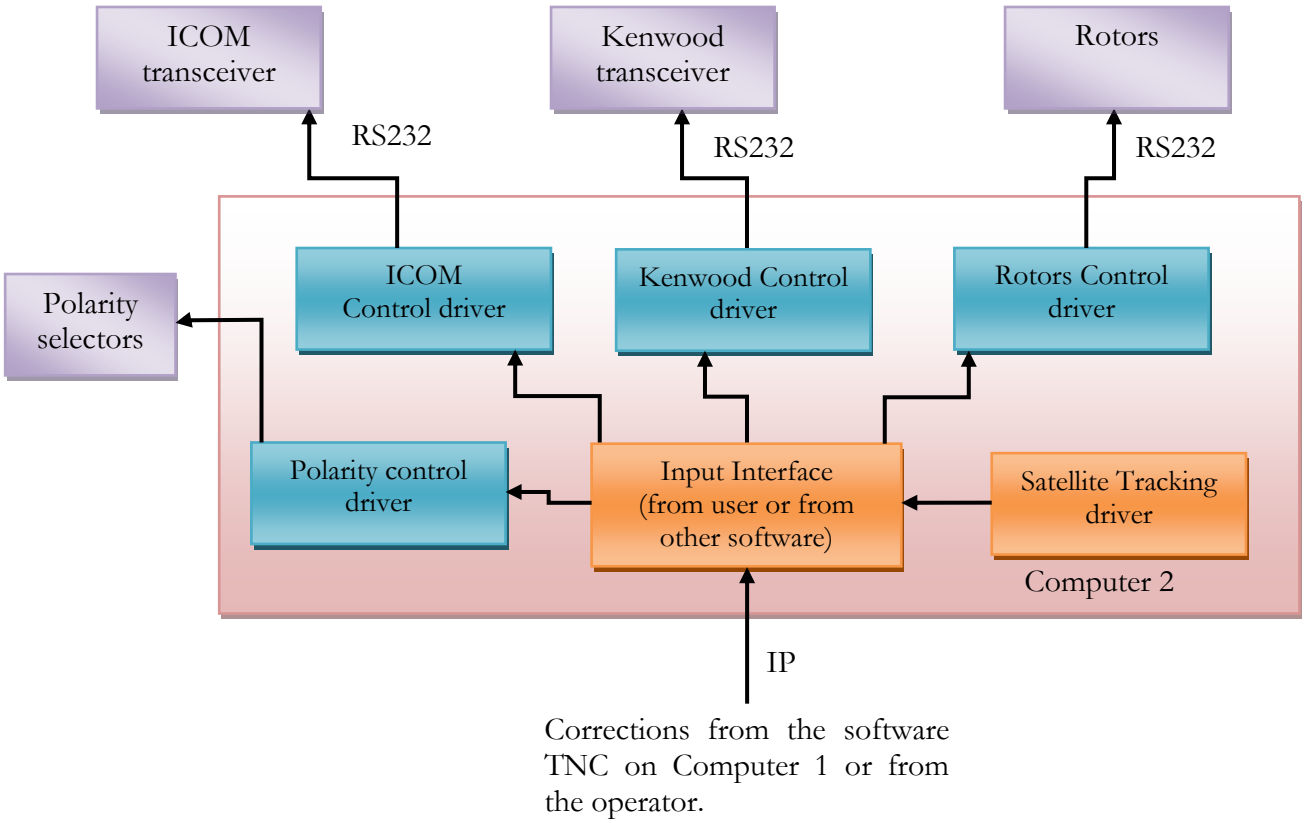

Figure 5 : Software and interfaces for Computer 2 of the EPFL Ground Station.