ASTRA Satellite Sensing Station at OST Rapperswil

Advancing Space Situational Awareness over Switzerland

Student

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Introduction: The Automated Sensor Tasking for Reporting and Analysis (ASTRA) Project, led by Space Campus at EPFL, is a collaborative initiative involving several Swiss universities. ASTRA aims to establish a network of radio frequency (RF) sensing stations across Switzerland to detect satellite signals. The relative motion between a satellite and the sensing station produces a frequency shift in the received signal. Tracking this Doppler shift over time produces a Doppler curve (Fig. 1). By comparing these curves to a database, satellites can be identified.

This master's project focuses on setting up an ASTRA station at OST in Rapperswil and integrating it into the ASTRA network. Key objectives include deploying an SDR-based receiver, optimizing satellite signal reception by improving the receiver signal chain, and simulating antennas to identify suitable designs for this application.

Approach: The ASTRA station at OST was developed similarly to the prototype station at EPFL. Its architecture features a rooftop receiver antenna connected to a software-defined radio (SDR) via low-loss coaxial cables. A Raspberry Pi 5 serves as the station computer, managing the SDR and the connection to the ASTRA network.

Initial measurements at 400 MHz revealed strong interference caused by a strong Polycom signal around 393 MHz. Without a suitable bandpass filter, satellite signals could not be detected (Fig. 1). To improve the signal-to-noise ratio (SNR) and capture weaker signals, a low-noise amplifier (LNA) was installed near the antenna (Fig. 2). Beyond 22 dB amplification, this LNA reduces the receiver chain noise figure from 10 dB to 2.8 dB, thereby significantly increasing the number of detectable satellite signals.

Two antennas, a crossed-dipole ("turnstile") and a so-called "eggbeater" antenna, were simulated using the electromagnetic field simulation software ANSYS HFSS. The key characteristic for this application is the radiation pattern. To optimize satellite signal reception across the entire sky, the antenna should provide full-sky coverage while minimizing interference from ground-based signals. Simulation results (Fig. 3) show both designs are suitable: the turnstile antenna offers a narrower beam and higher gain, while the eggbeater antenna provides wider coverage with peak gain at lower elevation. The radiation pattern can be tuned by adjusting the reflector's distance (D) to the active elements of the antenna.

Result: The OST station has been successfully integrated into the ASTRA network, enabling remote operation through a web application. Incorporating the bandpass filter and LNA significantly enhanced satellite signal reception. This optimized setup can now detect very low-power satellite signals in the 400 MHz band, contributing to the overall performance and reliability of the ASTRA network and advancing space situational awareness over Switzerland.

Fig. 1: Frequency Spectrum. Left: With interferences. Middle: With bandpass filter. Right: With bandpass filter and LNA.
Own presentment

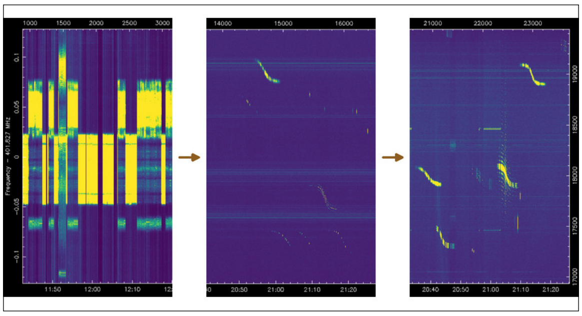


Fig. 2: Left: Station setup. Right: Receiver signal chain.
Own presentment

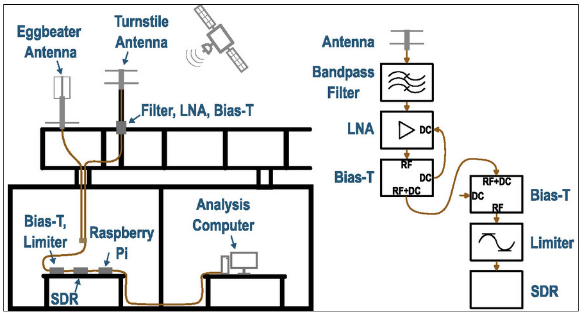
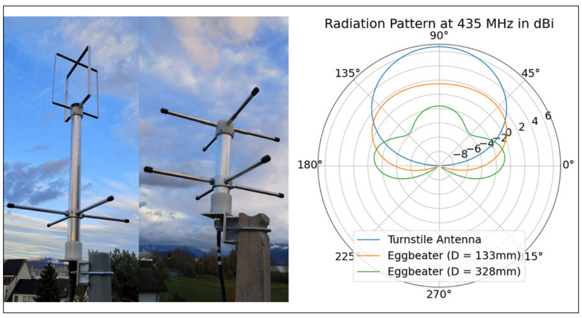


Fig. 3: Left: The "eggbeater" and "turnstile" antennas. Right: Simulated radiation patterns.
Own presentment



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