SGAC Global Satellite Tracking Initiative

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Abstract

The Global Satellite Tracking Initiative aims to support international students and young professionals to set up ground stations to download real-time data and images from satellites orbiting above their regions. The objective is to empower and build capabilities among space enthusiasts around the world and to promote the space sector through hands-on activities and real space technologies related to satellite communications.

The Space Generation Advisory Council, together with SatNOGS as an integral part of the Libre Space Foundation, have been supporting the initiative to enhance the development of a global open source network of satellite ground stations. The initiative will be providing all the resources, hardware, and know-how that is needed to set up ground stations. A competition was launched by the end of 2021 to select teams of space enthusiasts and supply them with a kit and step-by-step instructions on how to build their own ground stations.

By setting up ground stations in backyards, local universities, or maker clubs, teams are not only self-learning about telecommunications and satellite technologies, but they are creating a meaningful impact in their local communities by bringing the broad society closer to science, technology, engineering, mathematics and, in particular, space. The initiative also intends to support space missions while engaging local communities from different regions around the world in the space sector through appealing imagery and tools.

After closing the Call for Applications in this pilot initiative, 10 winning teams were selected upon receiving almost 200 applications from more than 60 countries. The selected winners are based in the following emerging space faring nations: Benin, Bolivia, Egypt, Ethiopia, Nepal, Peru, Philippines, Rwanda, Vietnam, and Zimbabwe. They are being supplied with a basic Ground Station Kit and instructions on how to receive live images and data from different space missions, starting with the following frequency bands:

- 137 megahertz: To receive images from National Oceanic & Atmospheric Administration satellites.

- 144-146 megahertz: To receive images and data from the International Space Station.

- 440 megahertz: To receive data from numerous scientific and educational small satellites.

Those teams that manage to set up the basic ground station kits and conduct some outreach and educational activities will receive a more advanced system. This paper captures the process to be followed by the selected teams, from the unboxing of the hardware to the reception and processing of data from operational space missions.

Keywords

Education, Satellite tracking, Ground station

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Acronyms/Abbreviations

SGAC	*Space Generation Advisory Council*
GSTI	*Global Satellite Tracking Initiative*
NOAA	*National Oceanic & Atmospheric Administration*
ISS	*International Space Station*
SDR	*Software Defined Radio*

1. Introduction

The Space Generation Advisory Council (SGAC) is the global network for students and young professionals interested in the space industry, with more than 15000 members globally from more than 150 countries. SGAC supports the United Nations Programme on Space Applications, with the vision of employing the creativity and vigour of youth in advancing humanity through the peaceful uses of space. SGAC organises events worldwide, on a local, regional and international level, as well as several space related projects within specific working groups.

As members of SGAC, the authors determined that the organisation could enhance its impact by engaging in hands-on activities for the benefit of young space enthusiast around the globe. A proposal was submitted and the SGAC Global Satellite Tracking Initiative was selected to join the first cohort of the SGAC Incubator Programme [1].

The Global Satellite Tracking Initiative (GSTI) [2] aims to facilitate students and young professionals to set up ground stations and download real-time data and images from satellites flying above their regions. Due to the nature of the activities, the GSTI team got in touch with SatNOGS [3], an initiative by the Libre Space Foundation that operates an Open Source global network of satellite ground stations. The objective is that, once the GSTI teams have become familiar with the operation of the basic ground station kit provided by the GSTI, they keep developing their skills and capabilities while interacting with other space enthusiasts by joining SatNOGS operational collaborative network.

2. Selection Process

The funding secured through the SGAC Incubator Programme, together with in kind contributions from partner organisations, allowed for the procurement and delivery of ten basic ground station kits. In order to choose ten teams from around the globe, a two-step selection process was launched in October 2021. The selection criteria used were:

a) Motivation: the responses ranged from university students trying to get involved in hands-on projects to local communities involved in scientific outreach interested in widening their portfolio of activities.
b) Feasibility: the answers received included individuals trying to set-up a ground station in their own backyard, as well as teams that had secured access to dedicated facilities already hosting telescopes and other receivers.
c) World Location: the teams were asked to explain why their geographical location was adequate for the project while being invited to check the existing coverage in the SatNOGS network. Applications from more than 60 different countries were received.
d) Outreach and impact: the responses went from university professors interested in offering their students a chance for practical training, to individuals in remote locations planning to help their local communities to be more engaged in science and technology.

The first step was an online application form, which allowed for a pre-selection of 20 teams among the close to 200 applications received. During December 2021, the GSTI team interviewed these 20 teams to come up with the 10 awardees. The selected team names and nationalities are listed in Table 1 and their approximate geographical locations are shown in Figure 1.

Team Name	Country
Chasqui 2	Peru
Fly by encounters	Egypt
GST Benin	Benin
Hanos Orbit	Ethiopia
Ludibrium	Vietnam
Pacha	Bolivia
Rwanda Space Agency Team	Rwanda
SEDS-MSU	Zimbabwe
Team Deep Space	Philippines
Team Everest	Nepal

Table 1. Selected teams

Figure 1. Selected teams map

3. Ground Station Kit

The Ground Station Kit was designed with the objective of minimizing cost, size and complexity. This was intended to maximize the number of kits that could be delivered within the available financial envelope while allowing for a rewarding experience from the participating teams in receiving their first space data.

3.1. Kit Size and Content

The kit was designed to fit in a plastic container box of 30 x 20 x 10 centimeters. When assembled, the size of the system is enlarged primarily by the deployment of a V-dipole antenna, composed of two rods of around 50 centimeters each at an angle of 120 degrees.

The components of the kit are listed below:

- Raspberry Pi 4 model B
- SANDISK Extreme class 10 microSDHC memory card of 32 Gigabytes
- RTL-SDR V3 dongle
- Dipole antenna base with 60 centimeters of RG174 coaxial cable
- Two telescopic antennas of 23 to 100 centimeters
- 3 meter RG174 extension coaxial cable
- Flexible tripod mount
- Suction cup mount
- 3-D printed dipole antenna support at an angle of 120 degrees

Figure 2. RTL-SDR dongle and antenna set

3.2. Power Requirements

The kit uses power output from a standard USB port. Most USB ports supply 5 Volts of electricity with a maximum current of 0.5 Amperes. This leads to an overall power output of 2.5 Watts.

3.3. Targeted Satellites and Applications

The main objective of this initiative is to acquire signals from orbiting spacecraft for educational, inspirational and capacity building purposes. For this reason, the targets for signal acquisition will be spacecraft emitting openly, including:

- National Oceanic and Atmospheric Administration (NOAA) satellites, which provide timely access to global environmental data. Frequency band of 137 megahertz.
- International Space Station (ISS), since it is deemed that in listening to a spacecraft that permanently hosts humans in space will be very motivational. Frequency band of 144-146 megahertz.
- Educational and scientific satellites (especially CubeSats) in Low-Earth orbit. There is the potential of contributing to the Launch and Early Operations Phase through collaborative networks such as SatNOGS. Frequency band of typically 440 megahertz.

4. Receiving and Processing Satellite Data

The process of assembling and setting up an operational ground station can be challenging for people with no previous experience in using similar technologies. In order to flatten the learning curve and make the encouraging experience of receiving and processing data from orbiting satellites more accessible, the GSTI includes a set of instructions and exercises that enable a gradual approach.

The instructions of the SGAC Global Satellite Tracking Initiative Kit are divided in two procedures:

- Procedure-1 (basic): focused on receiving weather data from NOAA satellites using a personal computer.
- Procedure-2 (advanced): focused on setting-up a Raspberry Pi with SatNOGS software, leading to an autonomous online ground station.

GSTI is currently working with the selected teams to implement Procedure-1, which is summarized in this section.

4.1. *Antenna setup*

Procedure-1 starts with the assembly of the kit components and the deployment of the V-dipole antenna. The two telescopic antennas need to be extended to 52 centimeters of length [5] and inserted through the dipole antenna support to secure the 120-degree angle before connection to the dipole antenna base. Figure 3 shows the system assembled on the flexible tripod mount.

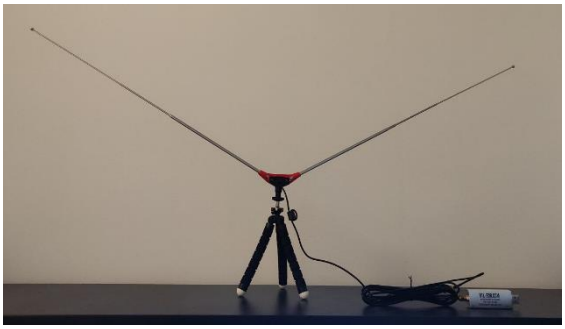

Figure 3. Antenna assembly

4.2. *Downloading and installing the software*

GSTI relies on the use of free-to-use software. The main software products required to complete Procedure-1 are:

- SDR# [4]: Software Defined Radio (SDR) software to tune into different frequencies.
- WXtoImg [5]: Fully automated weather satellite decoder.
- Satellite Tracking Software: Such as Orbitron (personal computer) [6] and Heavens Above (smartphone) [7], which facilitate the visualization of satellite orbit geometries and make it easier to understand where to point the antennas.

4.3. *Hands-on exercises*

Procedure-1 considers three main exercises to help users to gradually become familiar with the kit and exploit its capabilities.

4.3.1. *Exercise 1*

The first exercise invites users to connect the RTL-SDR V3 dongle to their personal computer and configure it as the source within SDR# to listen to a local radio station. This helps the users to become familiar with the SDR# software, its configuration options and user interface.

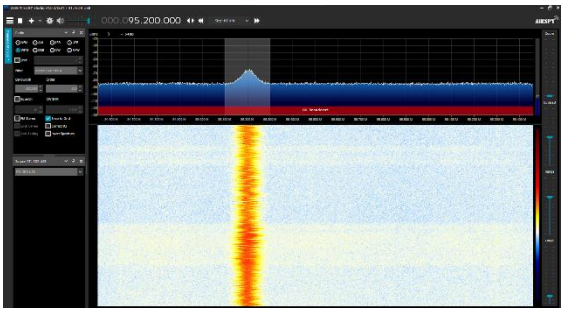

Figure 4. Local radio station signal in SDR#

4.3.2. *Exercise 2*

The second exercise focuses on decoding an image from the audio recording of a satellite signal [8]. This allows users to verify that they have understood how to carry out the record and image decoding functions in WXtoImg before attempting to capture a satellite pass.

4.3.3. *Exercise 3*

The last exercise of Procedure-1 consists on downloading an image from an operational NOAA satellite. The main steps are:

1. Plan a pass based on your geographical location and local time, making use of one of the suggested satellite tracking software products.
2. Configure SDR# to tune into the right frequency depending on the target satellite [9]:
    a. NOAA 15: 137.6200.
    b. NOAA 18: 137.9125.
    c. NOAA 19: 137.1000.
3. Record the pass and decode the images using WXtoImg.

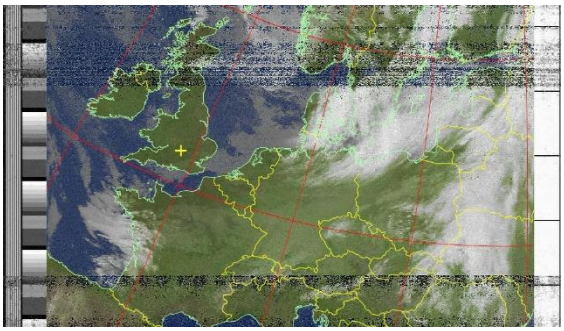

Figure 5. Decoded NOAA image using WXtoImg

5. Results and discussion

The SGAC Global Satellite Tracking Initiative received applications of close to 200 teams of space enthusiasts from more than 60 different countries. Due to funding constraints, only 10 of those teams are receiving a ground station kit.

However, GSTI aims to become a platform open to all the applicants in which the ground station kit and instructions will be made

available. The intention is to allow anyone to join the community, replicate the kit and benefit from the resources developed during the initiative.

The selected teams are starting to receive the funded ground station kits and complete the exercises proposed in Procedure-1. Once completed, they will have the chance to further develop their skills and start contributing to the SatNOGS network through Procedure-2, which is currently under development.

6. Conclusions

The success rate of the selection process suggests that there is an untapped interest among university students and young professionals to engage in hands-on space activities.

At the same time, this initiative provides an example of how the widespread availability of affordable consumer electronics and open software can be leveraged to interact with existing space infrastructure. This has the potential of making space more accessible to all, helping to promote and support education in science and technology and contributing to the creation and expansion of collaborative projects of tangible benefit to the space community, such as SatNOGS.

Acknowledgements

The SGAC Global Satellite Tracking Initiative would not have been possible without the support of our partners, who have facilitated access to hardware, knowledge and resources:

- SatNOGS, an integral part of the Libre Space Foundation, is designed as an open source participatory project based on the users operating a ground station that is accessed via a web page.
- RTL-SDR.COM is a blog all about low cost software defined radios and their applications. They also manufacture and sell the RTL-SDR V3 and various low cost SDR accessories.
- SDR-Technologies is a French company specialised in Software Defined Radio based ground stations for satellite communications.
- GPIO Labs builds high performance, user-friendly RF modules. Application areas include radio astronomy, satellite communication, airplane tracking, agriculture, test & measurement and more.
- Pimoroni Ltd is a hobbyist electronics company based in Sheffield, Yorkshire, UK.

References

Here you have some examples of references.

[1] SGAC Incubator Programme Website: www.spacegeneration.org/sgac-incubator-program, last visited: 20th March 2022.

[2] SGAC Global Satellite Tracking Initiative Website: www.spacegeneration.org/sgac-incubator-program/2021-cohort/global-satellite-tracking, last visited: 20th March 2022.

[3] RTL-SDR.COM Website: www.rtl-sdr.com/simple-noaameteor-weather-satellite-antenna-137-mhz-v-dipole, last visited: 20th March 2022.

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[5] Wraase Website: www.wraase.de/wxtoimg, last visited: 20th March 2022.

[6] Stoff Website: www.stoff.pl, last visited: 20th March 2022.

[7] Heavens Above Website: www.heavens-above.com, last visited: 20th March 2022.

[8] Youtube Website: www.youtube.com/watch?v=tHDFHc3JgpY, last visited: 20th March 2022

[9] RTL-SDR.COM Website: www.rtl-sdr.com/rtl-sdr-tutorial-receiving-noaa-weather-satellite-images, last visited: 20th March 2022