#AlcarazISS Project

Summer Activity Report

Content

Overview

High School SSTV Event and listening to an ARISS Contact

During June 9 and 10, the Moscow Aviation Institute (MAI-75) conducted an experiment of transmitting SSTV images from the International Space Station over amateur radio, giving the opportunity to any person with the required radio equipment and located along the ground track of the orbits in which the transmitter is turned on.

The SSTV images were transmitted in the usual PD-120 format, and at an also usual 145.800 MHz frequency. The topic of the images was the Russian Buran shuttle.

On June 10, an ARISS contact was also celebrated between the ISS crewmember Shane Kimbrough and the St Joseph's Catholic Primary School. The contact was established through a telebridge with IK1SLD's Ground Station in Italy, and that is why we were able to listen to the contact at the 437.525 MHz frequency. ARISS contacts usually use the 145.800 MHz frequency, but this time, SSTV images were being transmitted simultaneously at that frequency.

At the IES Pedro Simón Abril high school, located in Alcaraz, Albacete (Spain), we received successfully both images and voice.

Thanks to Sacam Radio, one of our partners in this project, we were able to share ARISS' mission, do a little talk show about the ISS' new iROSA solar panels and broadcast live the voice we received through commercial FM. It was listened from not only mainland Spain, but the Canary Islands too. Sharing ARISS' mission, activities and getting as many people involved with those activities as we can is one of the main objectives of the #AlcarazISS project and we are very delighted to do it.

Project Presentation for ERASMUS+ youth exchange program

Youth from four European countries came to Alcaraz as part of the ERASMUS+ youth exchange program. We organized an event to present them the #AlcarazISS project and also to do an astronomical observation with the help of Juan Parras, a local astronomy expert.

Introducing the Alcaraz Ground Station Network

We have developed a system that automatically decodes SSTV images and uploads them to the Cloud. It works thanks to local radio amateurs' ground stations.

SSTV workshop

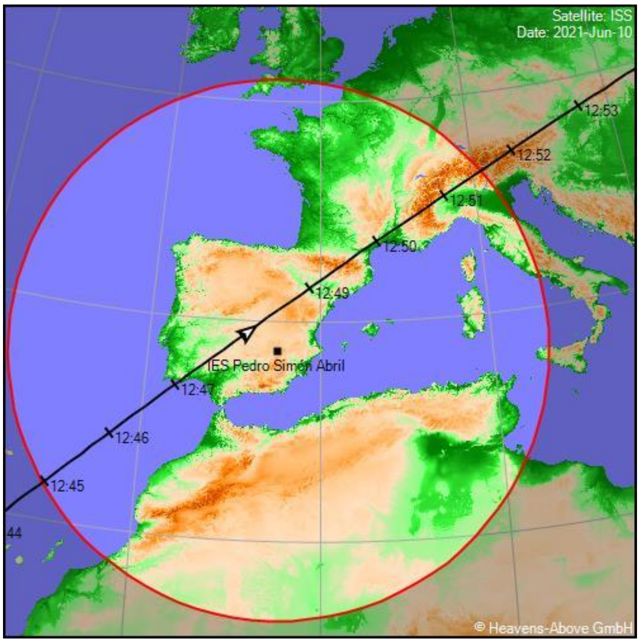
We organized an SSTV workshop together with Studio 21 Alcaraz radio station and the Alcaraz Town Council and taught the event attendees how to receive and decode SSTV images from the ISS.

Listening to an ARISS Contact

As we introduced previously, on June 10, an ARISS contact was celebrated between the ISS crewmember and NASA astronaut Shane Kimbrough and the St Joseph's Catholic Primary School in Bombala, NSW, Australia.

AOS (Acquisition of Signal) at IK1SLD's Ground Station was at 10:45:26 UTC or 12:45:26 CEST, but for us, it was at 10:44:53 UTC or 12:44:53 CEST. We had to wait around a minute until communication checks between the ISS and the ground station started to happen.

Here is the ground track of the pass:



The audio was heard on two receivers: our main RTL-SDR with a V-Dipole antenna, and a Baofeng GT-3 handheld radio. Signal was strong, and voice was fully understandable.

The voice we received can be heard at our YouTube Channel: https://youtu.be/NORQsZRzMq4?t=1224

SSTV Event at our High School

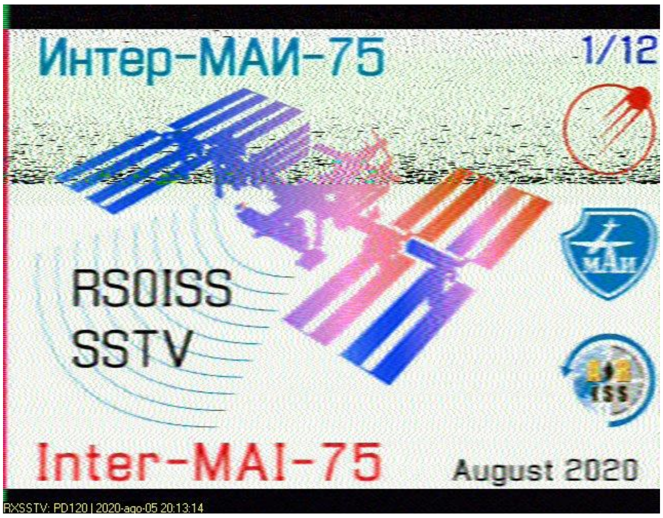
Introduction to SSTV

Slow Scan Television (SSTV) is a method of image transmission through radio. It's a slow method – it can take from eight seconds to a few minutes to transmit a single frame.

The ISS transmits images in a PD-120 format. In this format, each image lasts 120 seconds to be transmitted, and a 640x496px resolution image is got.

Images have to be encoded before transmitting and decoded after or during reception.

This method was used to get the first image of the dark side of the Moon.



SSTV image decoded by the Studio21 Alcaraz / #AlcarazISS team last summer.

Transmitter uptime

To receive the images, it is essential to know when the transmitter onboard the ISS is turned on. As the experiment is carried out by MAI-75, the transmitter was turned on during orbits flying over Moscow.

June 9		
Event	**UTC time**	**CEST time**
Transmitter is turned on	09:35	11:35
Transmitter is turned off	13:50	15:50

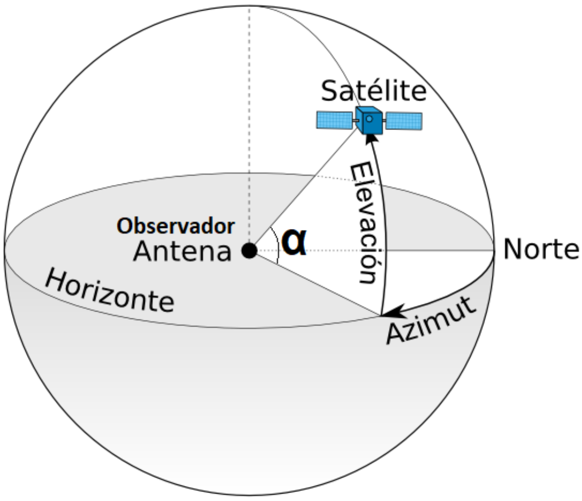
June 10		
Event	**UTC time**	**CEST time**
Transmitter is turned on	08:55	10:35
Transmitter is turned off	15:50	17:50

Understanding ISS passes

The orbital period of the ISS (time the ISS takes to make a complete revolution of the Earth) is around 93 minutes, so we had several occasions during both days to receive signals. By using orbital tracking software (Heavens-Above and gpredict), we have obtained the ISS flyovers over Alcaraz during both days.

To understand the data shown on the following data tables, it is necessary to understand the following concepts:

Elevation: To understand elevation, imagine that you are looking at the satellite and there is a line that goes from you to the satellite. And imagine that the ground is a plane. The α angle formed by the intersection of the line and the plane will form the elevation. The elevation is always between 0 and 90 degrees. When the elevation is 90 degrees, the satellite will be over your head. That is why a pass with a higher elevation is more optimal for signal reception, and a lower pass is less optimal due to the signal being less strong and the satellite getting out of range sooner.



AOS (Acquisition of signal): This is the moment when the receiver starts to pick up the signal, as it is inside of the range reached by the satellite signal.

Highest point: Moment of highest elevation.

LOS (Loss of signal): This is the moment when the receiver losses the signal, as it is outside of the range reached by the satellite signal.

Day	AOS		Highest point		LOS		Visibility
	Time	Elevation	Time	Elevation	Time	Elevation	
Jun 09	11:56:28	10°	11:59:04	21°	12:01:41	10°	daylight
Jun 09	13:32:31	10°	13:35:42	39°	13:38:53	10°	daylight
Jun 09	15:11:57	10°	15:13:15	12°	15:14:33	10°	daylight
Jun 09	18:26:21	10°	18:29:07	23°	18:31:52	10°	daylight
Jun 09	20:02:49	10°	20:06:04	45°	20:09:16	10°	daylight
Jun 10	11:10:24	10°	11:11:49	12°	11:13:13	10°	daylight
Jun 10	12:44:53	10°	12:48:13	65°	12:51:34	10°	daylight
Jun 10	14:23:37	10°	14:25:33	14°	14:27:30	10°	daylight
Jun 10	17:39:11	10°	17:41:30	17°	17:43:49	10°	daylight
Jun 10	19:15:19	10°	19:18:41	84°	19:22:02	10°	daylight

We had to discard the passes in which the transmitter was turned off:

Day	AOS		Highest point		LOS		Visibility
	Hour	Elevation	Hour	Elevation	Hour	Elevation	
09 jun	11:56:28	10°	11:59:04	21°	12:01:41	10°	daylight
09 jun	13:32:31	10°	13:35:42	39°	13:38:53	10°	daylight
09 jun	15:11:57	10°	15:13:15	12°	15:14:33	10°	daylight
10 jun	11:10:24	10°	11:11:49	12°	11:13:13	10°	daylight
10 jun	12:44:53	10°	12:48:13	65°	12:51:34	10°	daylight
10 jun	14:23:37	10°	14:25:33	14°	14:27:30	10°	daylight
10 jun	17:39:11	10°	17:41:30	17°	17:43:49	10°	daylight

As the activity was done on schooltime, we discarded the passes out of schooltime:

Day	AOS		Highest point		LOS		Visibility
	Hour	Elevation	Hour	Elevation	Hour	Elevation	
09 jun	11:56:28	10°	11:59:04	21°	12:01:41	10°	daylight
09 jun	13:32:31	10°	13:35:42	39°	13:38:53	10°	daylight
10 jun	11:10:24	10°	11:11:49	12°	11:13:13	10°	daylight
10 jun	12:44:53	10°	12:48:13	65°	12:51:34	10°	daylight
10 jun	14:23:37	10°	14:25:33	14°	14:27:30	10°	daylight

We also discarded low elevation passes, but we used them as practice passes and successfully got partial images:

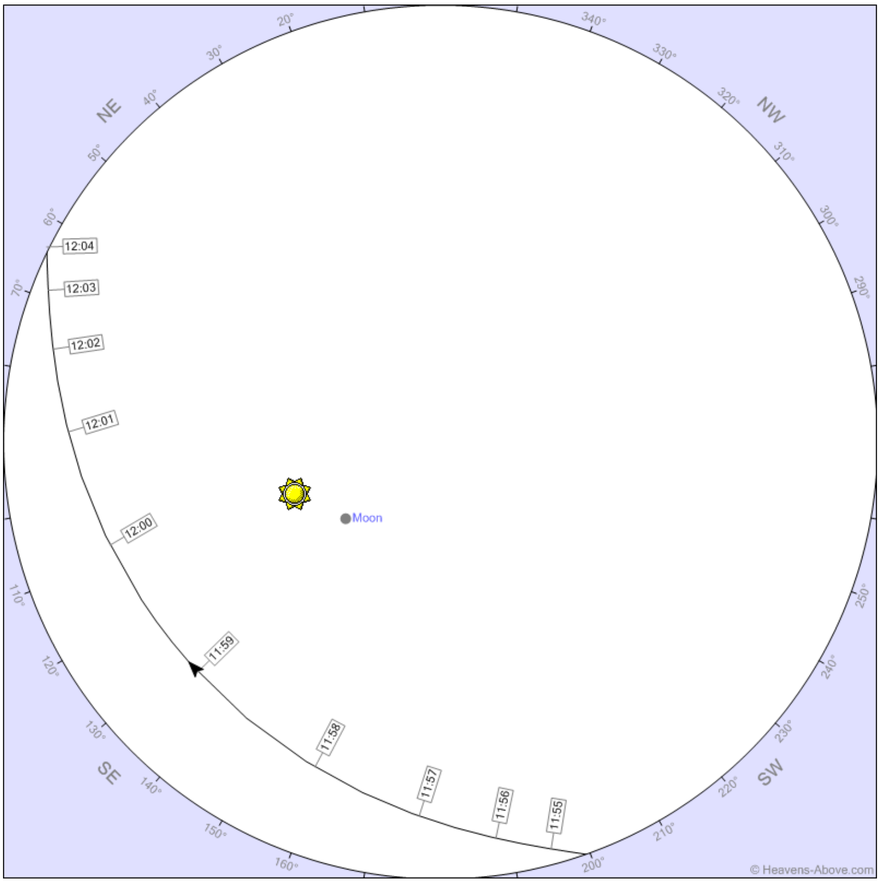
Day	AOS		Highest point		LOS		Visibility
	Hour	Elevation	Hour	Elevation	Hour	Elevation	
09 jun	11:56:28	10°	11:59:04	21°	12:01:41	10°	daylight
09 jun	13:32:31	10°	13:35:42	39°	13:38:53	10°	daylight
10 jun	12:44:53	10°	12:48:13	65°	12:51:34	10°	daylight

The best pass was the one at 12:44 on June 10. We used this pass to broadcast the signal we received both in our YouTube channel and through the Sacam Radio station (Commercial FM)

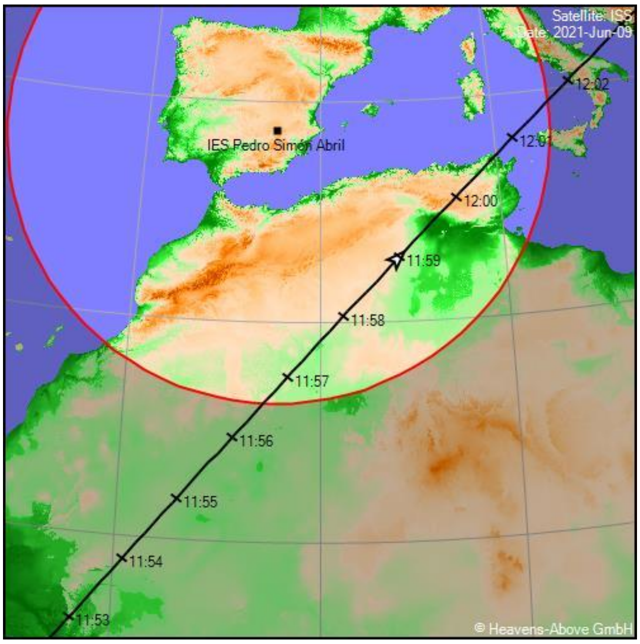
Here are the sky charts and ground tracks for each of these three last passes. In the sky charts, the ground track is shown in the sky as well as the most relevant celestial bodies.

June 9 at 11:56 pass
Max elevation of 21º

Celestial card



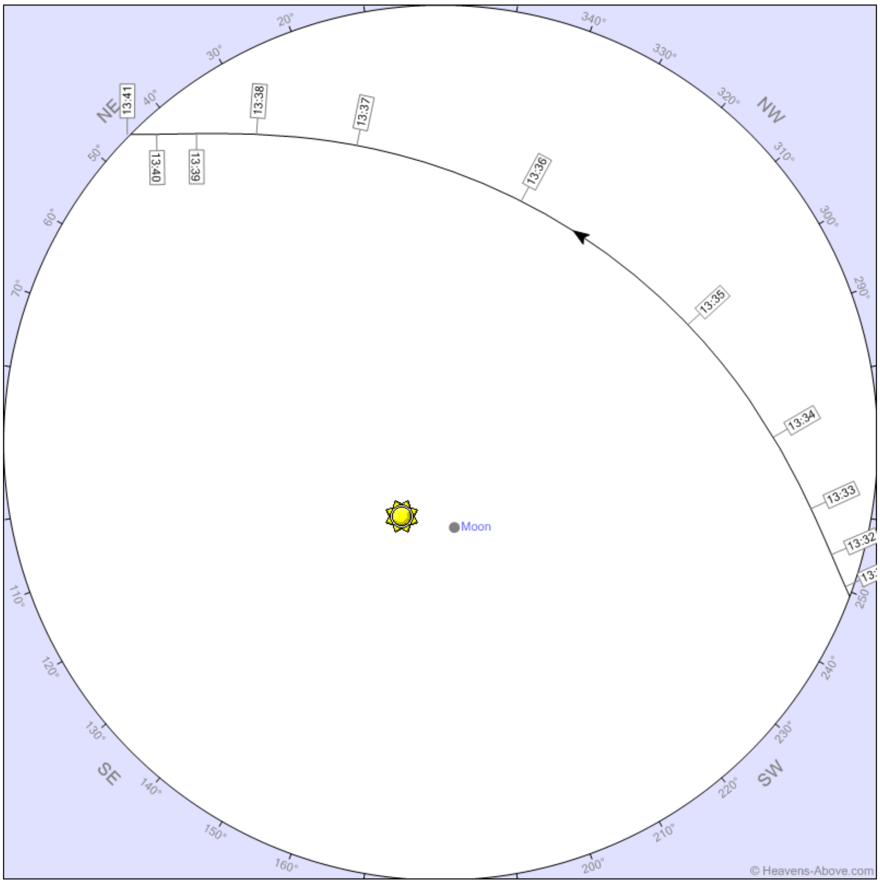
Ground track



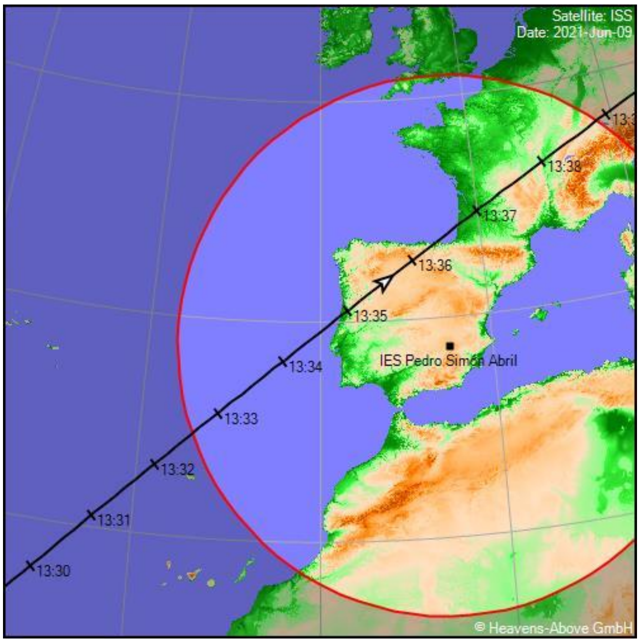
June 9 at 13:32 pass

Max elevation of 39º

Celestial card



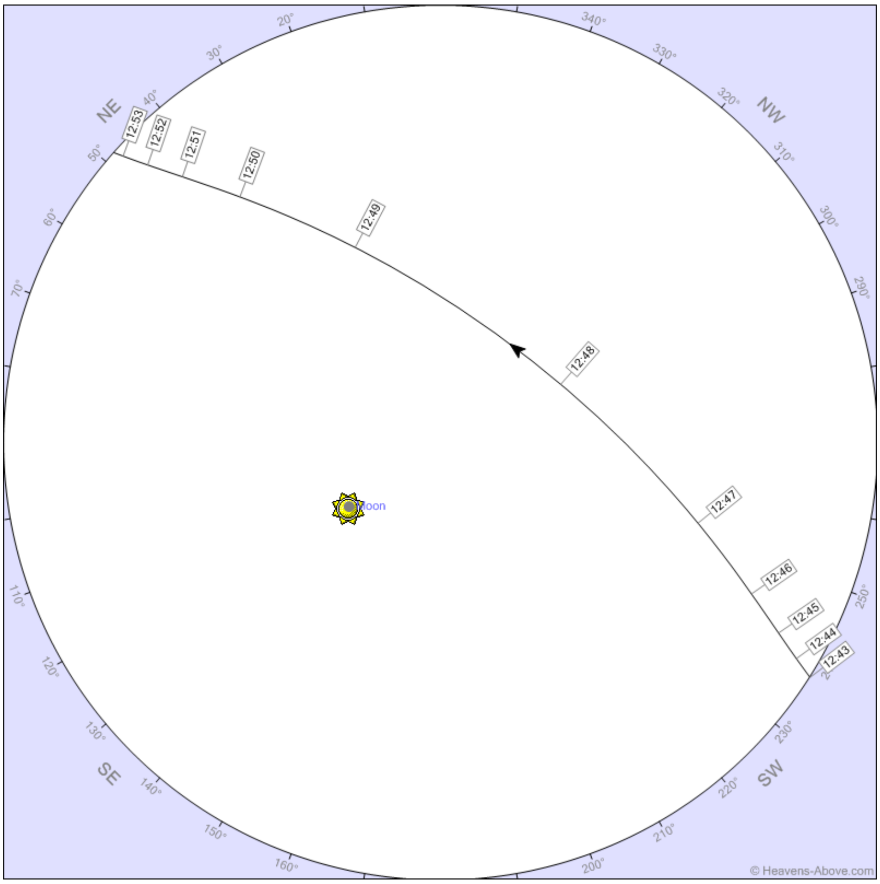
Ground track



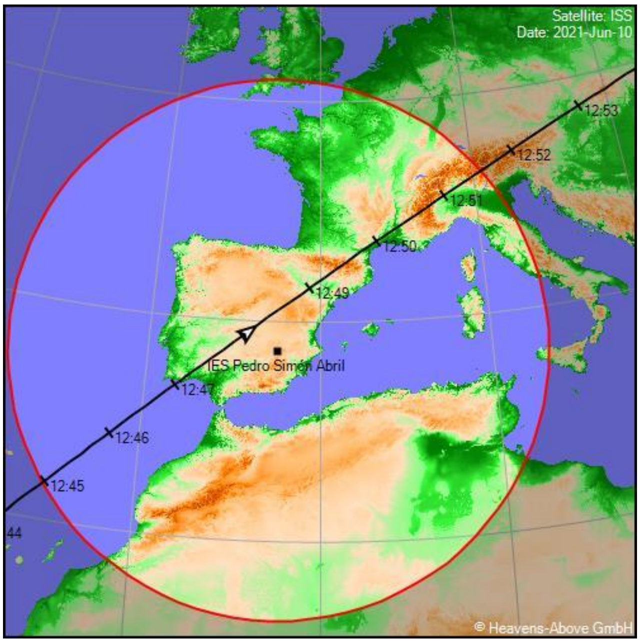
June 10 at 12:45 pass

Max. elevation of 65º - ARISS contact pass

Celestial card



Ground track



Antenna setup and hardware

Having a clear horizon and uninterrupted internet and power access is essential to develop the activity.

To find the best place to develop this activity, we checked all our high school terraces to know which one was the best for each of the passes listed before.

We also tried to find a place where only the antennas needed to be outside, to avoid overheating problems on our computers and radio receivers, and, to make radio operators' tasks easier.

In activities like this, setting up a redundant system is recommended: in case of a system failure, there always will be a backup unit, allowing the activity to be developed normally.

We decided that the best terrace was the west-facing one, as every ISS pass was from east to west.

Then, we placed the V-Dipole antenna included on the RTL-SDR Blog V3 Kit. To match the antenna configuration with the ISS VHF frequency wavelength (145.800MHz), we had to extend the legs of the antenna to an approximate length of 50 centimeters and set an angle of 120 degrees between each leg.

The sum of the length of the two legs of the V-Dipole antenna (both legs have the same length) is obtained from the following formula: $\frac{150}{Frequency\ (MHz)}$. The result is obtained in meters. If we divide the result by two, we obtain the length of one single leg.

We placed the antenna with "the tip of the V" facing to the east and mounted it on top of a camera tripod with a standard ¼ screw.

The antenna was connected to the SMA connector on the RTL-SDR dongle trough the extender cable included in the RTL-SDR V3 Kit. The dongle was connected to a USB 3.1 Type-A port on our computer, also using an extender cable.

As images were being transmitted, the voice had to be transmitted simultaneously through a different frequency (437.525MHz) which is on the UHF frequency band. We calculated the antenna leg length, which was approximately 17 centimeters.

Then we discovered a problem: the small antenna set was not long enough at its longest extension configuration (15cm), and the large antenna set was too long at its minimum extension configuration (20cm). We decided the smartest move was to approach the calculated length as much as we could. That decision made the experiment a total success.

Here is a detailed description of each hardware component:

V-Dipole Antenna

Simple antenna formed by two rectilinear conductors of the same length with an angle of 120º between them.

RTL-SDR radio receiver

The RTL-SDR receiver is a Software Defined Radio, which is a radio communication system where components that have been traditionally implemented in hardware are instead implemented by software on a computer. To understand it easily, we can say that the computer's processor replaces the hardware (transistors, capacitors...) of a standard radio receiver.

Computers

We used Intel x86 based laptops running Windows with additional monitors connected so we could use more applications easily and visualize them at the same time. We also used Android phones and tablets to decode signal received by our handheld radios. By having more than one decoder running, we ensure a successful decode in at least one device.

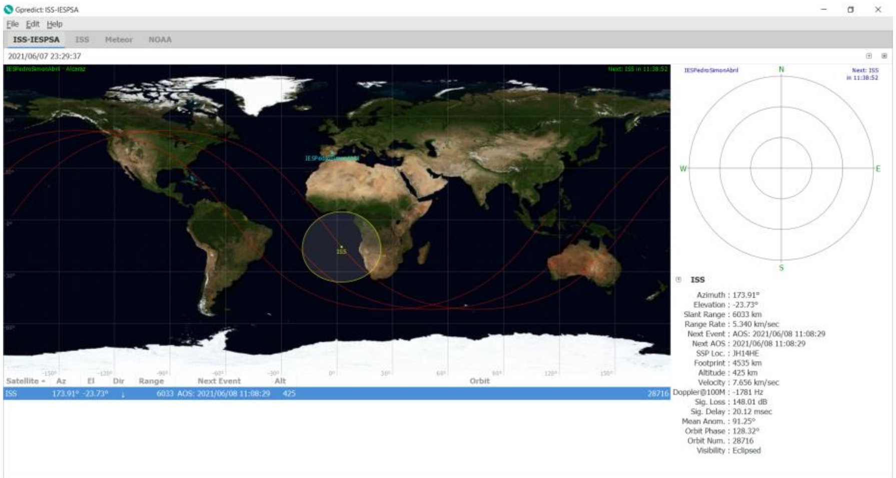
Network

We connected a CAT-7 ethernet cable (to have as fast as possible internet) in the nearest Ethernet point from the selected terrace where we developed the activity. At the place where the activity was developed, we set up a temporary AP (Access point) equipped with dual-band (2.4 and 5 GHz) WiFi-6. We have 1Gbps internet at our High School, so no problems occurred.

Software

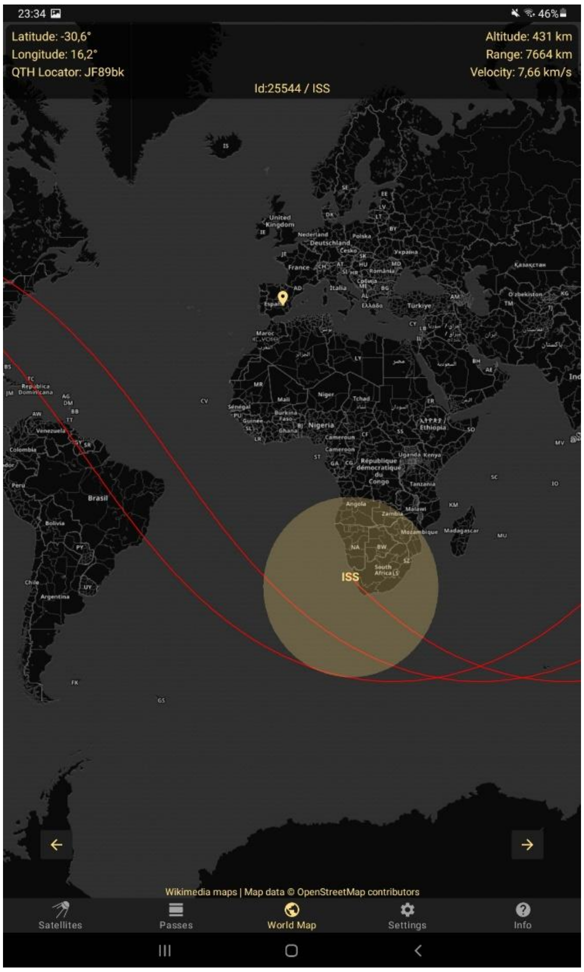
Tracking software

Gpredict version 2.3.37 for Windows



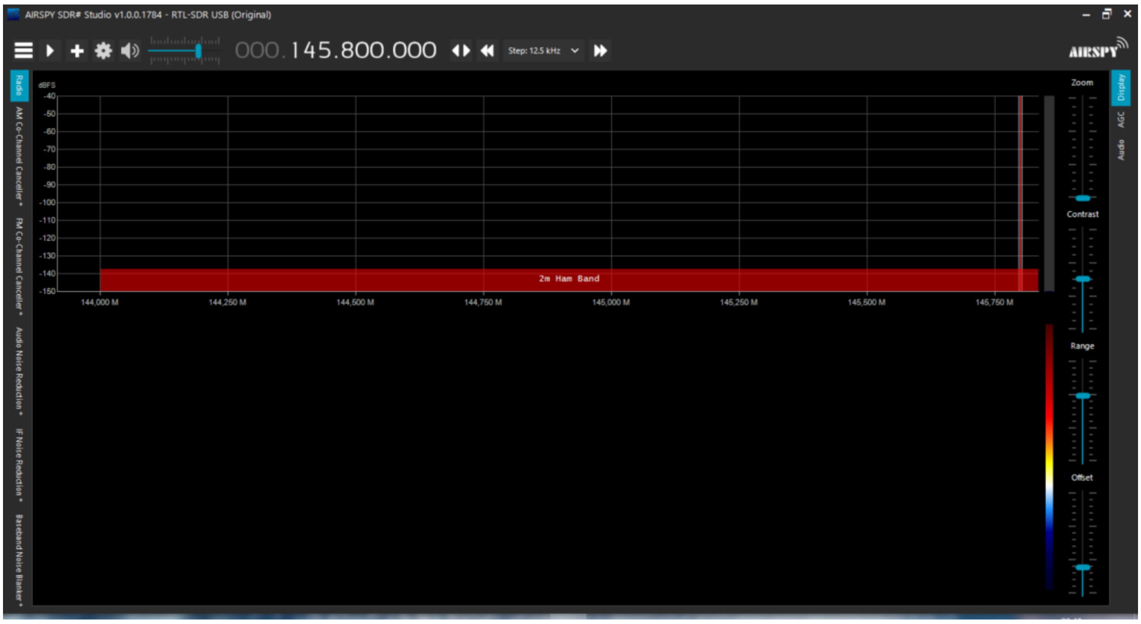
Heavens-Above version 1.71 for Android

Look4Sat version 2.5.2 for Android



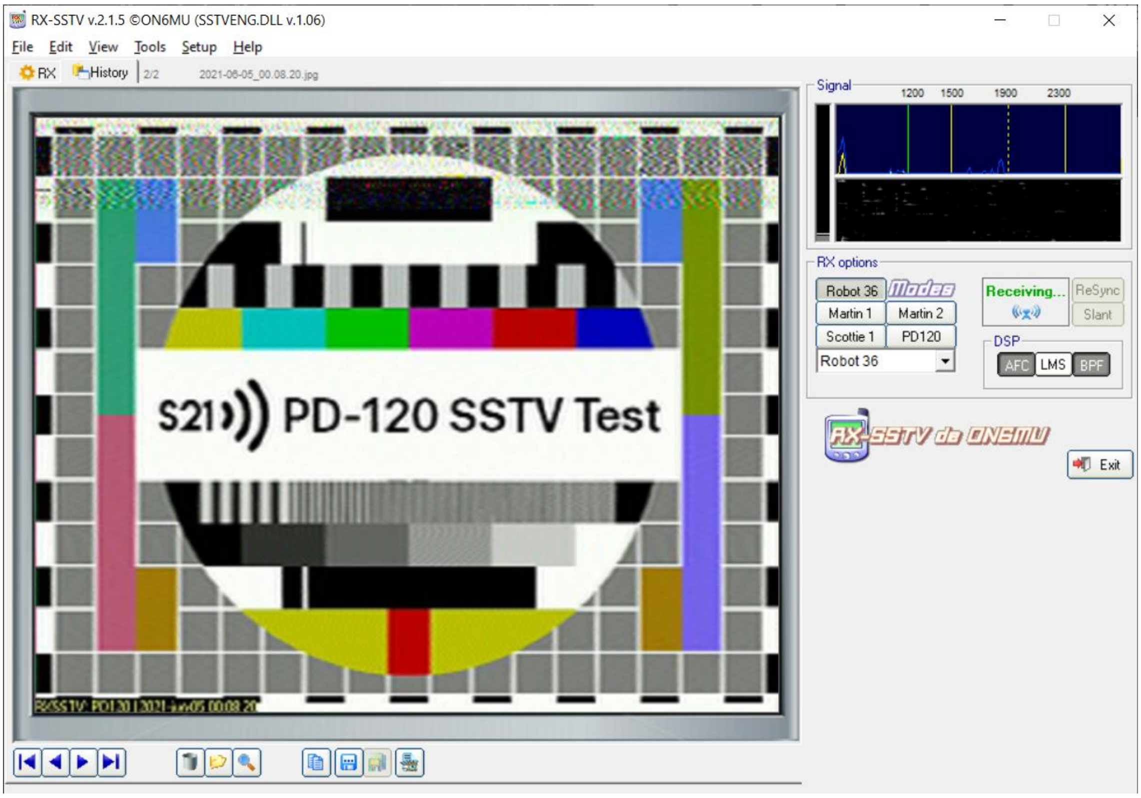
SDR Software

SDRSharp version 1.0.0.1784 for Windows

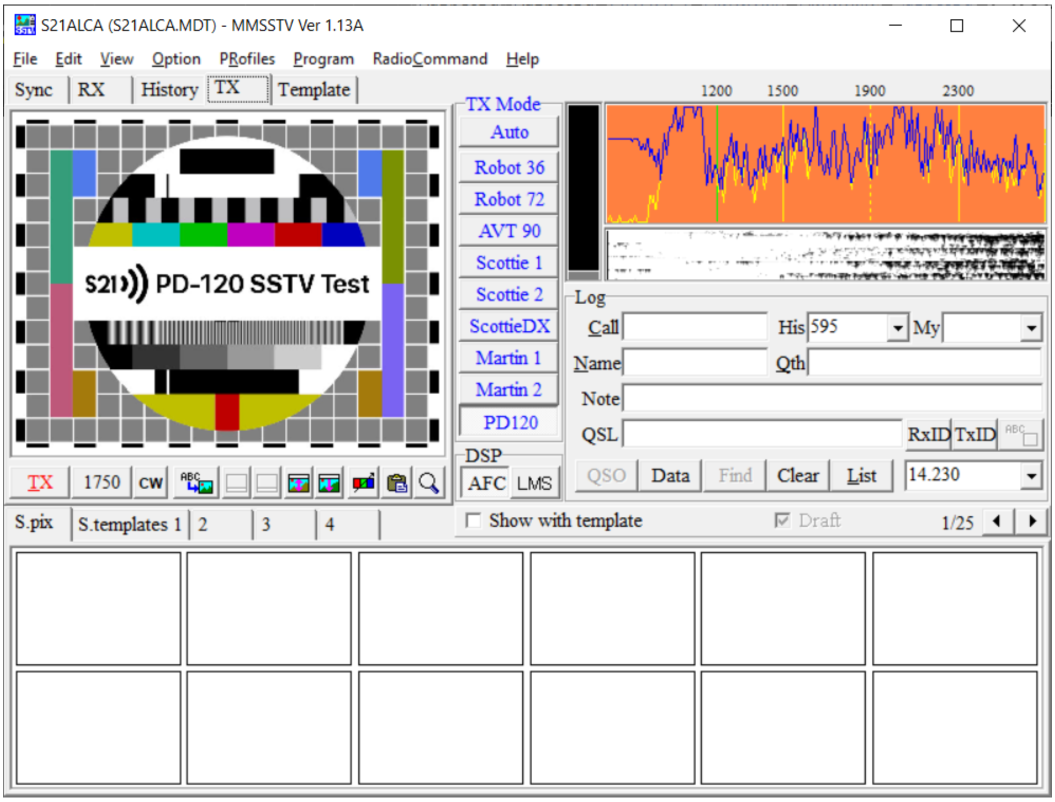


SSTV Decoder

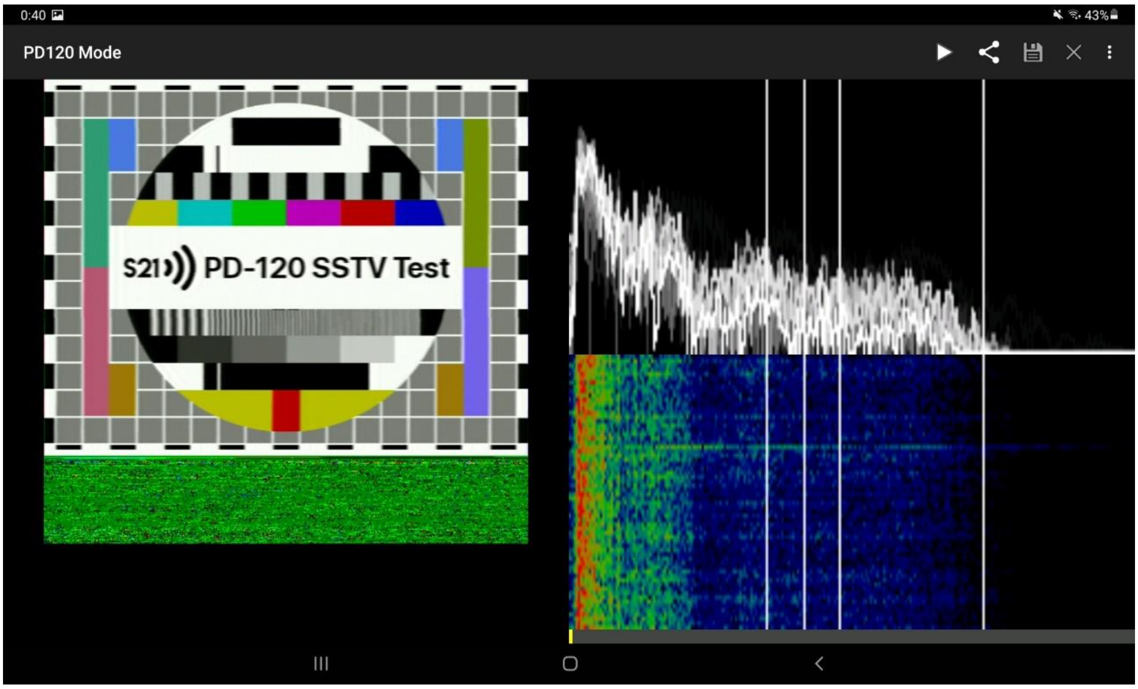
RX-SSTV version 2.1.5 for Windows



MMSSTV version 1.13A for Windows

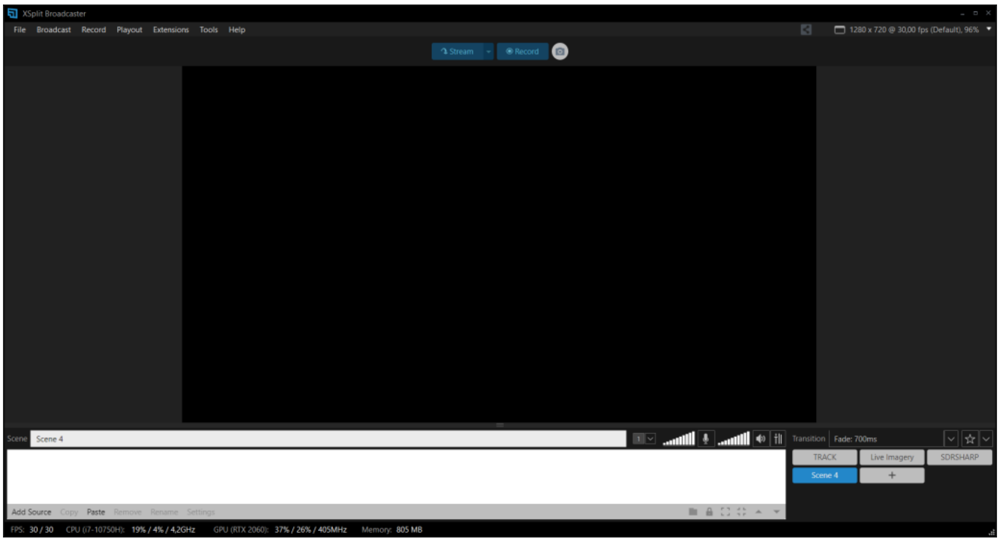


Robot36 version 1.44 for Android



Recording software
Techsmith Camtasia Recorder

Broadcast software
Xsplit Broadcaster version 4.0.2007.2918 for Windows.



Broadcasting

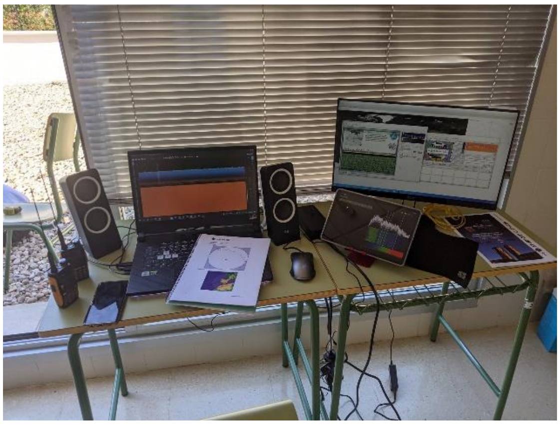
We broadcasted the ARISS contact that happened in June 10 straight from our radio receiver to our YouTube Channel, and thanks to one of our partners in the #AlcarazISS Project (Sacam Radio, which is a Commercial FM Radio Station), we were also able to broadcast the contact through commercial FM, and it was not only heard in mainland Spain but in the Canary Islands too.

To broadcast the event, we used the software listed in this document, Xsplit Broadcaster. We used the NVIDIA NVENC encoder on the Turing architecture-based NVIDIA GPU installed in our laptop. (TU106 chip).

The event was broadcasted in a 1280x720 resolution (720p), to avoid overloading computer and network resources. The audio was uplinked at a 128kbps bitrate.

The live stream started approximately 30 minutes before the contact. Just after we started broadcasting, Sacam Radio connected with our live stream.

We did a preshow in which we talked about ARISS' mission and activities – including contacts, SSTV events... -, which is one of our main objectives. Also, we talked generally about the ISS to introduce more people to it and finally, we talked about the new iROSA solar panels that were installed on the ISS.



Images received

Translation:

Recibida el – received at

Receptor – receiver

Antena – antenna

Decoder – decoder

Leyenda - caption

IMAGEN 3/12

Programa Burán

RECIBIDA EL

09-06-2021 11:58 CEST

RECEPTOR

RTL-SDR

ANTENA

V-Dipolo

DECODER

RX-SSTV

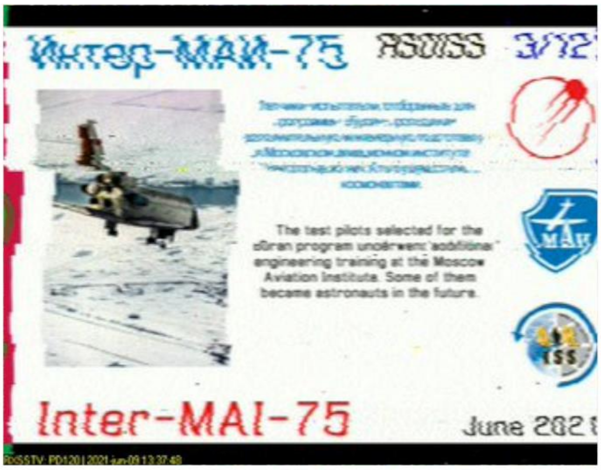
LEYENDA

The test pilots selected for the Buran program underwent additional engineering training at the Moscow Aviation Institute. Some of them became astronauts in the future.

Los pilotos de prueba seleccionados para el programa Burán recibieron capacitación adicional en ingeniería en el Instituto de Aviación de Moscú. Algunos de ellos se convirtieron en astronautas en el futuro.

IMAGEN 3/12

Programa Burán



RECIBIDA EL

09-06-2021 13:37 CEST

RECEPTOR

RTL-SDR

ANTENA

V-Dipolo

DECODER

RX-SSTV

LEYENDA

The test pilots selected for the Buran program underwent additional engineering training at the Moscow Aviation Institute. Some of them became astronauts in the future.

Los pilotos de prueba seleccionados para el programa Burán recibieron capacitación adicional en ingeniería en el Instituto de Aviación de Moscú. Algunos de ellos se convirtieron en astronautas en el futuro.

IMAGEN 2/12

Transbordador Burán

RECIBIDA EL

09-06-2021 13:34 CEST

RECEPTOR

RTL-SDR

ANTENA

V-Dipolo

DECODER

RX-SSTV

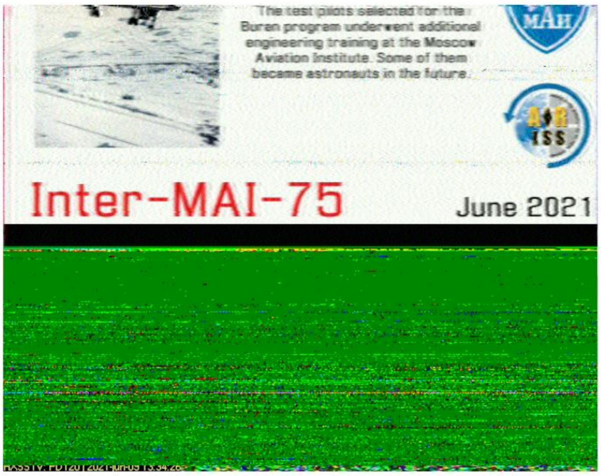
LEYENDA

The Buran programme was started in 1974 by the Soviet Union as a response to the United States Space Shuttle programme. The project was the largest and the most expensive in the history of Soviet space exploration. The project was officially terminated on 30 June 1993

El programa Burán fue iniciado en 1974 por la Unión Soviética como respuesta al Transbordador Espacial estadounidense. El proyecto fue el más grande y más caro en la historia de la exploración espacial soviética. El proyecto se dio por terminado oficialmente el 30 de junio de 1993.

IMAGEN 3/12

Programa Burán



RECIBIDA EL

09-06-2021 11:58 CEST

RECEPTOR

Baofeng GT-3

ANTENA

Stock

DECODER

Robot36

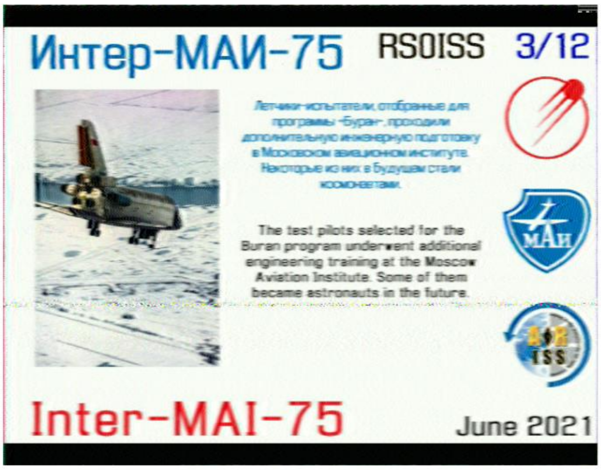
LEYENDA

The test pilots selected for the Buran program underwent additional engineering training at the Moscow Aviation Institute. Some of them became astronauts in the future.

Los pilotos de prueba seleccionados para el programa Burán recibieron capacitación adicional en ingeniería en el Instituto de Aviación de Moscú. Algunos de ellos se convirtieron en astronautas en el futuro.

IMAGEN 3/12

Programa Burán



RECIBIDA EL

09-06-2021 13:37 CEST

RECEPTOR

Baofeng GT-3

ANTENA

Stock

DECODER

Robot36

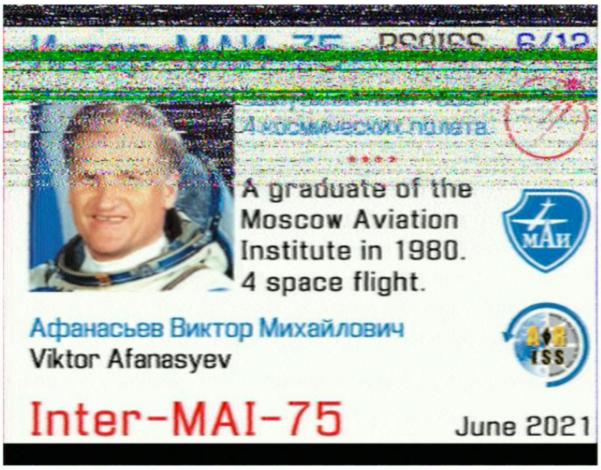
LEYENDA

The test pilots selected for the Buran program underwent additional engineering training at the Moscow Aviation Institute. Some of them became astronauts in the future.

Los pilotos de prueba seleccionados para el programa Burán recibieron capacitación adicional en ingeniería en el Instituto de Aviación de Moscú. Algunos de ellos se convirtieron en astronautas en el futuro.

IMAGEN 7/12

Graduados del MAI



RECIBIDA EL

10-06-2021 12:48 CEST

RECEPTOR

Baofeng GT-3

ANTENA

Stock

DECODER

Robot36

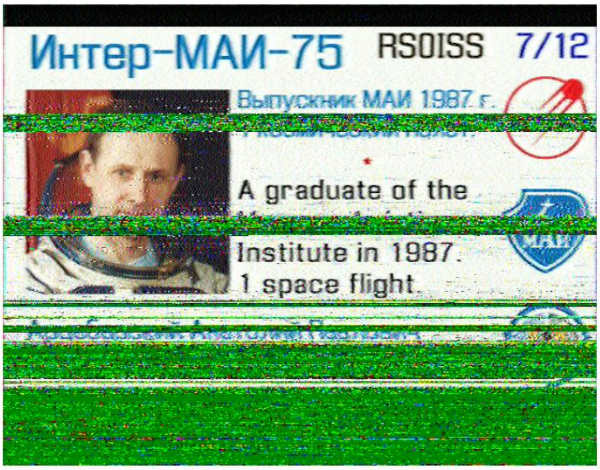
LEYENDA

A graduate of the Moscow Aviation Institute in 1980.
4 space flight.
Viktor Afanasyev.

Un graduado del Instituto de Aviación de Moscú en 1980.
4 vuelos espaciales.
Viktor Afanasyev.

IMAGEN 7/12

Graduados del MAI



RECIBIDA EL
10-06-2021 11:12 CEST
RECEPTOR
Baofeng GT-3
ANTENA
Stock
DECODER
Robot36
LEYENDA
A graduate of the Moscow Aviation Institute in 1987.
1 space flight.

Un graduado del Instituto de Aviación de Moscú en 1987.
1 vuelo espacial.

Experiment results

All the students and teachers taking part in the activities were extremely astonished and surprised about the fact that they were hearing the voice of the astronauts aboard the ISS, a satellite that orbits 400km over us. It was a fun activity since we all learned from each other and we all helped each other. Sadly, and due to the COVID situation, not all students from the High School could attend to the activity, but they were viewing the activity from their classrooms thanks to our YouTube broadcast.

We made an exhibition of the images in the hall of our high school.

Introducing the Alcaraz Ground Station Network

AGSN

ALCARAZ GROUND STATION NETWORK

We are very pleased to introduce the Alcaraz Ground Station Network.

The AGSN, as its name indicates, is a network of ground stations, and consists of temporary or permanent stations that are connected to each other, some having the possibility of automatically carrying out the process of receiving signals, decoding images, uploading them to the cloud and the publication of these in social networks. These stations can only receive data, but not transmit.

The creation of the AGSN has needed research and installation of technical equipment (such as radio receivers, sound cards, network) as well as the implementation of the Studio21 Cloud services (part of Studio21 Alcaraz, the radio station of our high school and main collaborator of the #AlcarazISS project) to be able to carry out all the automation tasks. (More details below)

The network has been designed, programmed and put into operation by the students participating in the project, who have had the help of the teachers. Local radio amateurs have been very important in the creation of this network since they have provided us with equipment and material. The knowledge they have shared with us has also been very important.

Currently, the first of six planned stations is active and in testing phase.

The active station and in testing phase is the N Alcaraz Station (North Alcaraz Station). The precise location of the station will not be published for privacy reasons, although we can tell you that it is in IM88sq (Location by grid square). It is an automated station.

The creation of these stations will not interrupt the manual activities scheduled for future SSTV events and school contacts, which will continue to be carried out as normal. The AGSN is a complementary system that will help us to receive the maximum number of images possible, even if there are no project members available to carry out the activities.

The following stations are currently planned:

Name	Location	Type	Details
HS-A Station (High School-A Station)	IES Pedro Simón Abril	Permanent	It will be automated in case of unavailability if it cannot be operated by students or teachers. Used in temporary mode for June activities.
HS-B Station (High School-B Station)	IES Pedro Simón Abril	Temporary	Handheld radios without the possibility of automation.
SW Alcaraz Station	Future FM Broadcasting Station - Studio21 Alcaraz	Permanent	Automated.
Castle -A Station	Alcaraz Castle	Temporary	No possibility of automation.
Castle -B Station	Alcaraz Castle	Temporary	Handheld radios without the possibility of automation.

Operation of permanent and automated ground stations:

The stations have as a receiving antenna an omnidirectional antenna, connected to a standard radio receiver or to an SDR, depending on availability. In the case of a traditional radio receiver, the audio output of the receiver is connected to the line input of a computer or an external audio interface.

In case of being an SDR, the computer receives the audio directly.

The SSTV decoders are always running on the computer, which is running Windows, and in case of working with an SDR, the SDR controller program will also be kept open, with a plugin to control the Doppler effect.

The decoded images are saved in the "C:\RX-SSTV\History" directory.

This is where the Studio21 Cloud services come into operation. Studio21 Cloud combines the best options of different cloud services (Google Cloud, Microsoft Azure, and Studio21's own infrastructure), synchronizing them with tools such as IFTTT to later publish the decoded images, as well as data about the images received in the different social networks and the project website.

The images saved on the computer are automatically synchronized with the corresponding Google Cloud folder, which activates an automation that sends the image to social networks. (Currently, the AGSN image sharing method is Twitter (@AlcarazGSN - https: //twitter.com/alcarazgsn).

The entire system can be observed in real time from the Studio21 Cloud platform - including information about each of the antennas, about the spacecraft and a gallery with the latest images obtained. You can access the website through the following link:

cloud.studio21alcaraz.com

Then, click on "Access" and you will be observing the system in real time. The website was available for the past SSTV event (MAI-75 on August 6-7), as well as the automatic Twitter posting.

Erasmus+ Project Presentation and Astronomical Observation

This summer, people from rural areas of Bulgaria, Italy, Croatia and Spain came to Alcaraz as part of the Erasmus+ youth exchange program.

We celebrated an astronomy night at Alcaraz Starlight Astronomical Viewpoint, where we talked about the Starlight project and the #AlcarazISS project.

We installed a projector for two purposes: to show them a presentation about the projects, and to show them a live-view of the telescope. We wanted to do a radio activity but sadly no activities were planned for the days they were here, so we talked to them about the activities organized by the ARISS organization and how we participate in them. They asked questions about it and some of them are in touch with us to participate in future events, as they showed a really big interest in some of the activities.

Then, we moved to the sky observation with the reflector telescope, which was operated by Juan Parras (Starlight project coordinator, and also involved with the #AlcarazISS project).

It was the first time for us to test a wireless connection to show a telescope view in a big screen, but it was successful. We were able to see the Moon, Jupiter and its moons, and also Saturn – with its rings visible! An ISS pass was also visible that night, but the clouds didn't allow us to see it.

"SSTV Party" – SSTV reception and decoding workshop

The #AlcarazISS project team together with Studio21 Radio Station and the Alcaraz City Council organized a SSTV workshop on August 6.

The workshop consisted of a talk about space and radio communications to introduce people into the event and of the signal reception and decoding itself.

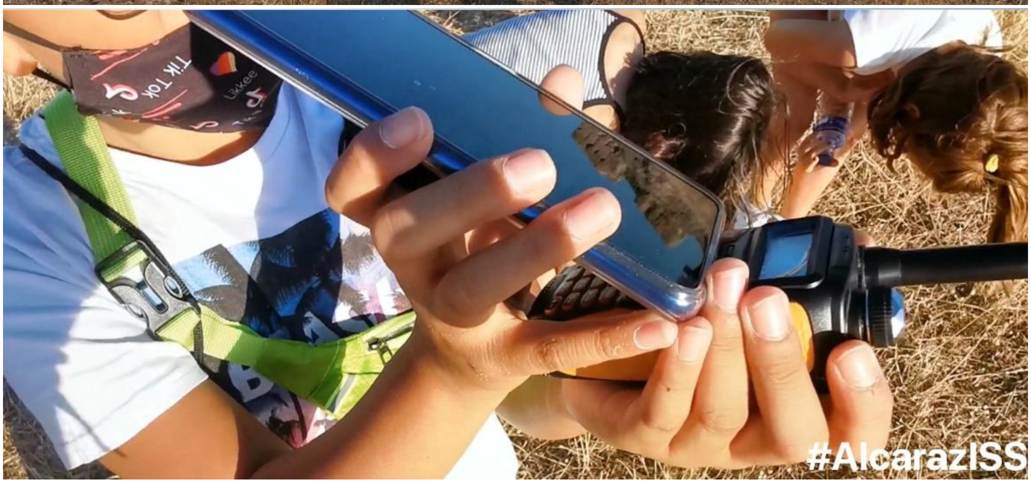
Three members of the project explained event attendees what the ISS is, the research that is done aboard the ISS and the radio communication activities ARISS organizes. We explained them what is SSTV and a little bit of its history, as it was used to transmit the first images of the dark side of the moon and some lunar landing images.

We also explained how to track the ISS and decode the signals by using their phones – and how it can be done using a computer.

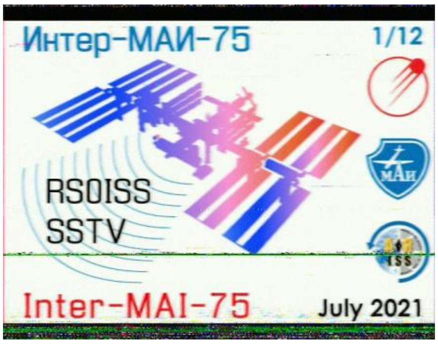
After the talk, we went to Alcaraz Castle to receive and decode the images.

Once we were at the highest point of the Castle, we also explained them how does the V-Dipole antenna work and how to set it up. Then, we made 4 workgroups as we had 4 handheld radios (3 Baofeng and 1 Yaesu, thanks to local radio amateurs that lent us them). Each workgroup also had a phone for image decoding.

The organization was telling to the workgroups the time left for signal acquisition. Once the ISS was above us, the signal started to sound through the handheld radios' speakers. Everyone was so excited at the moment, especially children, because this was their first ever ham radio experience, and they were receiving signals from the space station – a satellite orbiting our planet with astronauts living aboard.



Every workgroup received a full image, so the experiment was for them and all of us a total success!



People attending the event was extremely satisfied and they showed interest in the project. They asked us if we could listen through radio for a contact, and we're now preparing another workshop.

Special thanks

We would like to thank Alcaraz City Council, Tourism Office Alcaraz, Starlight (astrotourism foundation) for their collaboration and organizational support. We would also like to thank local radio amateurs that have helped us by lending handheld radios and equipment and explaining to us how that equipment works. And finally, thanks to ESERO Spain (European Space Education Research Office) for providing information and tutorials.