



Oide

Tacú leis an bhFoghlaim
Ghairmiúil i measc Ceannairí
Scoile agus Múinteoirí

Supporting the Professional
Learning of School Leaders
and Teachers

Radio Communication Support Materials








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This resource series is most suitable for an interested group of junior cycle or transition year students.

	Step 1	Step 2	Step 3	Step 4
	Fundamentals of Radio Communication 	Let's Communicate 	Building a Satellite Ground Station	Listening to EIRSAT-1
Year group	1st - TY	1st - TY	TY	TY
Type of activity	Classroom discussion/information	Hands-on STEM activity	Hands-on STEM activity	Hands-on STEM activity
Resources	Two PowerPoints and support document <ul style="list-style-type: none"> • Step 1a Fundamentals of Radio Communication • Step 1b Radio Waves 	Micro:bits  PowerPoint support document <ul style="list-style-type: none"> • Step 2 Lets Communicate Open mind (no prior experience necessary)	Weather Satellite Receiving Kit -available for a small number of schools	Connect with a local HAM radio club.

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Note: These materials are supported by three PowerPoint presentations.

Fundamentals of Radio Communication

The importance of radio in our society

Ask anyone what they understand by the word radio and most will say it's a device we listen to at home in the kitchen! If in a car or a bus, you might hear the driver singing along to the radio!!



A radio entertains us with music and chat in real-time. It is a reliable source of news, providing us with up-to-date information. It can be a companion for those who live alone connecting the listener to the world.

However, the radio is more than just what you listen to at home. It is more than the radio presenters, the news and the music we listen to...

Can you think of other uses of radio in the world?

What words do you associate with radio?

Satellite Communication

Satellites are objects that orbit the earth. The moon is a natural satellite but there are also artificial satellites¹!

Two examples of artificial satellites are used for communication and weather forecasting.



<https://www.eirsat1.ie/>

Did you know: Ireland will soon launch its very first satellite EIRSAT-1. EIRSAT-1 stands for the Educational Irish Research Satellite 1. It is a satellite about the size of a shoe box, called a CubeSat. It is a small-scale satellite but still needs the same functionality as a large mission. The satellite must be able to power itself, orientate itself in space, communicate to the ground station being built on the roof of the UCD School of Physics and collect data from the three science experiments on-board.

How do these satellites communicate with us? How are the weather images beamed back to earth? Radio signals!!

Can you think of other uses for satellites?

¹ Source: https://en.wikipedia.org/wiki/Earth_observation_satellite#/media/File:A-Train_w-Time2013_Web.jpg

Mobile Phones

Did you know that the first mobile phones were radios?

They were two-way radios which means you could talk **and** listen. They allowed taxi drivers and emergency crew to communicate.



The Father of the Cellphone



<https://www.youtube.com/watch?v=bodPO9PWwcl>

“Did you know?”

Motorola was the first company to mass produce the first handheld mobile phone. These early phones were called OG or ZERO Generation²



Nokia 6110, released in 1998

Phones used to have an antenna that you could **see**. Although your smartphone is packed full of the latest technology, it still uses radio waves to communicate to the world (cell towers, WiFi nodes etc.). Modern phones have at least four antennas. It should be called a “smart radio”!!

² Source: <https://www.firstversions.com/2015/01/motorola.html>

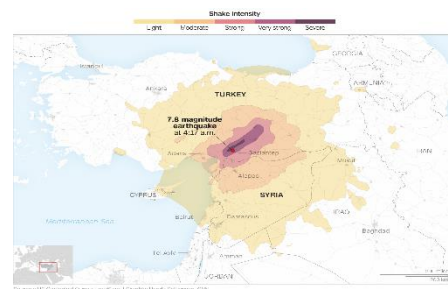
Radio as a Hobby

Before the days of mobile phones and the internet, people relied on the radio to communicate with each other. Today, Amateur radio (also known as HAM radio) is a popular fun and educational hobby worldwide.



People use HAM radio to talk to people all over the world – all without using mobile phones or the internet! They can even talk to astronauts on board the International Space Station (ISS)³.

In the recent devastating earthquake in Turkey and Syria, many Radio Amateurs were brought in to help the emergency response teams⁴.



Amateur radio operators come from all walks of life and all ages!



Diana Eng, HAM radio enthusiast⁵

Did you know? Radio hobbyists from South Dublin Radio Club provided advice to the EIRSAT-1 team, Ireland's first satellite



³ Source: <https://www.ariss.org/contact-the-iss.html>

⁴ Source: <https://www.iaru-r1.org/2023/turkiye-earthquake-6-february-2023/>

⁵ Source: <https://makezine.com/article/technology/5-ham-radio-projects-with-diana-eng/>

Write down any questions you might have about radio.

A large, empty rectangular box with a thin black border, intended for the student to write down any questions they might have about radio. The box occupies most of the page's vertical space.

Radio Waves

What is a Wave?

Q. Where have you heard the word ray before?

A ray is a very simple way to think about a wave.

A wave is one way that energy can be transferred from one place to another. Waves can be described as oscillations.

Sound waves

When you hear something, your ear is picking up sound waves that have travelled through the air.

The sound waves cause air particles to vibrate back and forth – your eardrum picks up this sound wave and turns it into an electrical signal that your brain can understand⁶.



Water waves

In water, it is easy to “see” waves. The ripples in water cause water particles to vibrate up and down⁷.



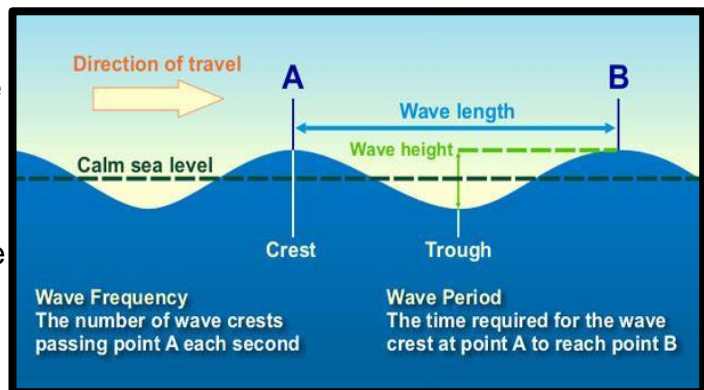
Q. What other types of waves can you think of?

⁶ Image source: https://commons.wikimedia.org/wiki/File:2006-01-14_Surface_waves.jpg

⁷ Image source: <http://www.earassociates.com/ear-education-how-we-hear-san-jose-ca.html>

Frequency and Wavelength

The highest part of a wave is called the **crest** (also called the peak). The **frequency** of a wave is the number of wave crests that pass a point every second. The wavelength is the distance between two crests^s



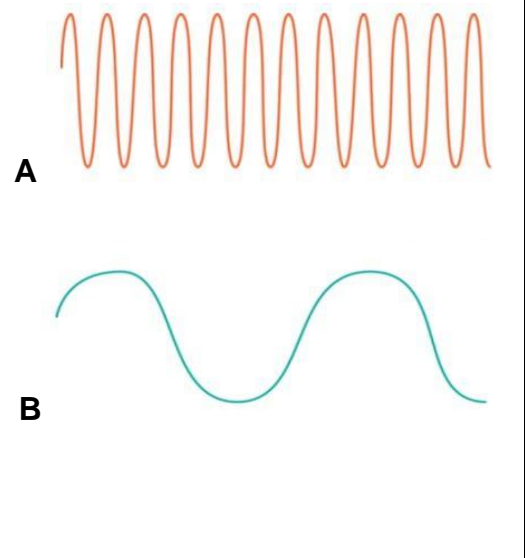
Frequency is measured in **Hertz**.

1Hz equals 1 wave passing a fixed point in 1 second. Wavelength is measured in metres.

- Look at the two waves A and B

Which wave has the higher frequency?

Which wave has the longest wavelength?



We have looked at two different types of waves: sound waves and water waves. Water waves transfer their energy through water and sound waves transfer their energy through air. You may have thought about other examples of waves, e.g. the wave you make with a slinky and a Mexican wave! There would be no slinky wave without the slinky and there would be no Mexican wave without people! All these waves are called **mechanical waves** because they need a medium to travel through.

But what about the other types of waves such as radio waves and x-rays?

^s Image source: https://commons.wikimedia.org/wiki/File:Water_wave_diagram.jpg

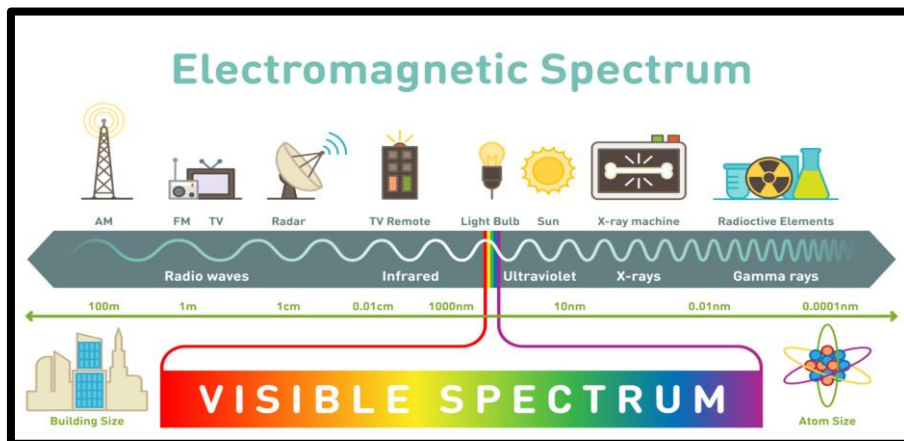
Electromagnetic Spectrum

The Electromagnetic (EM) spectrum is the range of all the different types of waves that do not need anything to travel through (they don't need water or air).

EM waves travel very fast, at the speed of light!

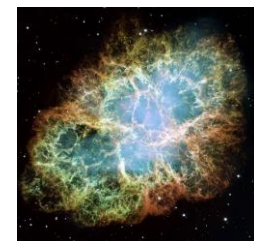
EM waves include radio waves, microwaves, visible light, ultraviolet (UV) radiation, X-rays, and gamma rays..

All these waves have different wavelengths and frequencies. We can only “see” a very small section of the EM spectrum - “visible light”⁹



Some radio waves have a wavelength that is a similar size to a building while Gamma rays have a wavelength the size of an atom!

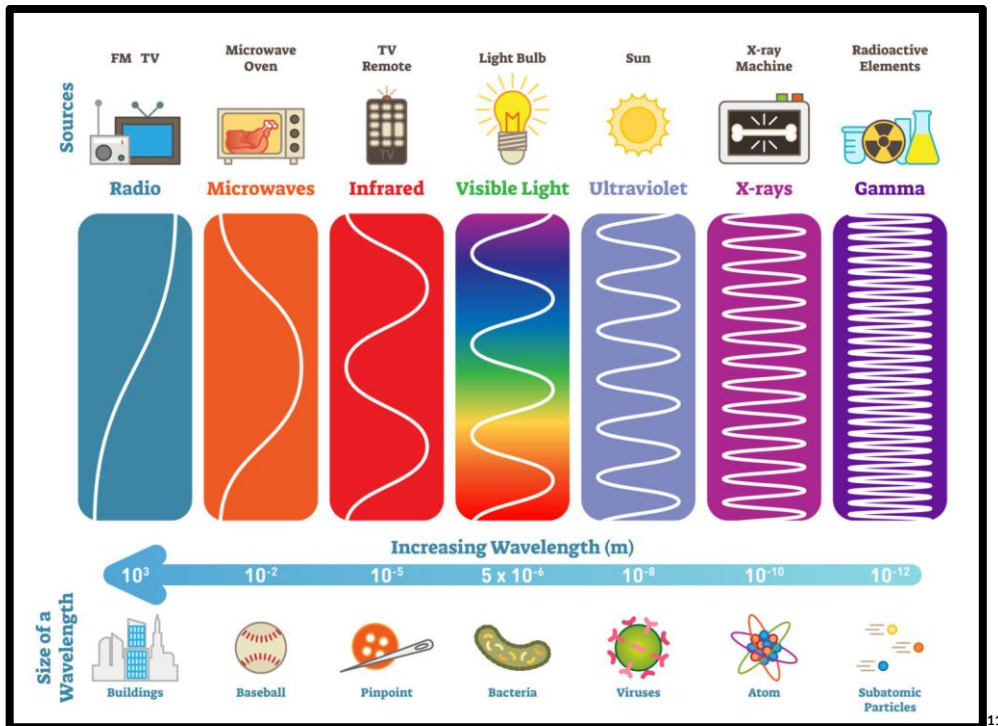
Did you know: Gamma-rays can't pass through the earth's atmosphere. The EIRSAT-1 satellite will be running an experiment on board to detect and record gamma-rays! Gamma-ray bursts are often created by events in the early universe. There's a lot about the early universe that we don't yet understand, and gamma-ray bursts are one of the best tools for investigating it¹⁰



⁹ Image source: <https://www.science-sparks.com/what-is-the-electromagnetic-spectrum/>

¹⁰ Image source: <https://www.space.com/13838-nasa-gamma-ray-targets-blazars-fermi.html>

The smaller the wavelength the more energy the wave has. Radio waves can travel through your body but are harmless. However, gamma rays have much more energy as they have the highest frequency in the EM spectrum. They can cause damage to you but can also be used to treat cancers.



Radio waves

Did you know that radio waves are like the secret messengers of the electromagnetic spectrum?

They're invisible, but they can travel through walls and zip through the atmosphere to deliver information from one place to another, even to and from space!

With the help of devices like radio receivers, we can pick up these secret messages and convert them into sounds that our ears can understand or even dance to.

¹¹ Image source: <https://www.science-sparks.com/what-is-the-electromagnetic-spectrum/>

Radio waves can pass through many materials, including buildings and the human body. Radio waves transfer power over long distances.

If we zoom into the lower end of the EM spectrum, we can see the radio waves up closer.



- VLF: Very Low Frequency
- LF: Low Frequency
- MF: Medium Frequency
- HF: High Frequency
- VHF: Very High Frequency
- UHF: Ultra High Frequency
- SHF: Super High Frequency
- EHF: Extremely High Frequency

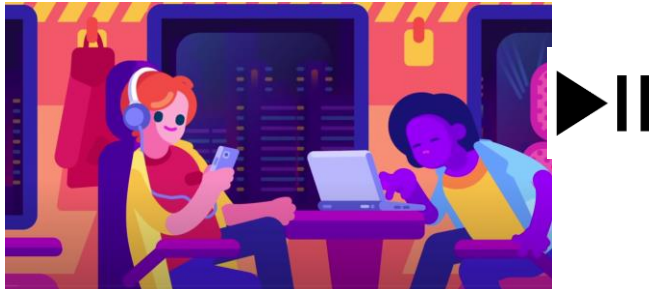


Did you know:

EIRSAT-1 will communicate in the UHF and VHF parts of the EM spectrum

Further resources and information

1. What is a satellite? <https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-satellite-58.html>
2. EIRSAT-1 website <https://www.eirsat1.ie/>
3. How students build Ireland's first satellite
<https://www.youtube.com/watch?v=mTrfaTchBWk> ow students built Ireland's first satellite - YouTube
4. Irish Radio Transmitters Society (IRTS) - Amateur Radio in Ireland
<https://www.irts.ie/cgi/index.cgi>
5. How big are radio waves?
<https://www.nasa.gov/directorates/heo/scan/communications/outreach/funfacts/what-are-radio-waves>
6. Introduction to Waves <https://spark.iop.org/waves-cpd-videos#introduction>
7. Kurzgesagt video: Could your Phone Hurt you? Electromagnetic Pollution
<https://www.youtube.com/watch?v=FfgT6zx4k3Q>



8. What is the Electromagnetic Spectrum <https://www.science-sparks.com/what-is-the-electromagnetic-spectrum/>

Let's Communicate

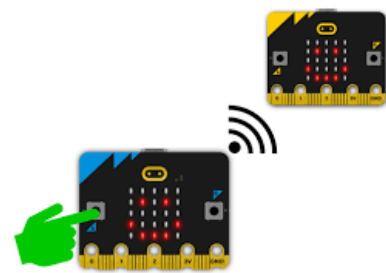
What is the micro:bit?

The micro:bit is a cool little computer board that you can use to learn how to code and make all kinds of fun projects!

With the micro:bit, you can make your own games, build robots, create digital art, and so much more. It has a bunch of sensors and input/output pins that you can use to interact with the world around you.

You are going to learn how to...

- use the radio on the micro:bit
- make a model satellite and ground station



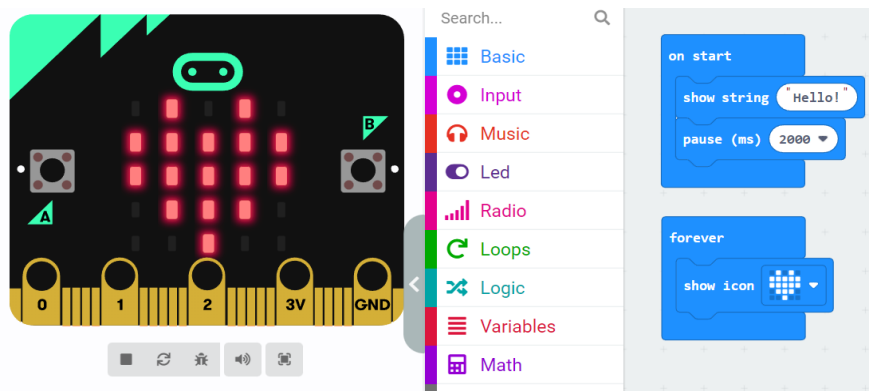
1. First steps with the micro:bit

Let's learn how to display a love heart and a message on the micro:bit using the online simulator.

Open up the Micro:bit make code editor: <https://makecode.microbit.org/> and click on "new project". Give your project a name "myFirstProject".

On the left you can see a "virtual" micro:bit. On the right you can see the space where you write your code. To make a programme you click on the menu in the middle and drag the blocks to the right hand side.

See if you can write the programme below:



To test your programme click on the micro:bit on the left. You should see the message "Hello" appear on the micro:bit for 2 seconds and then you will see a love heart appear on the display.

Change the message on the micro:bit to say something else.

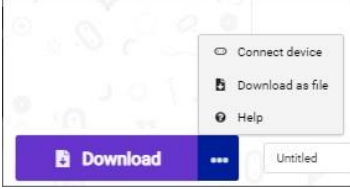
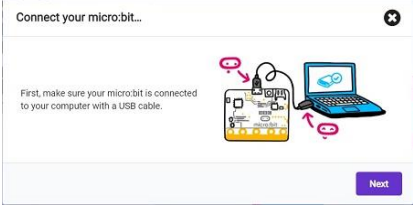

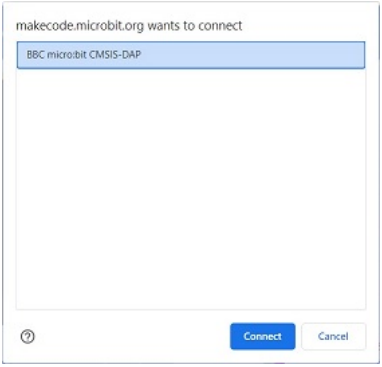
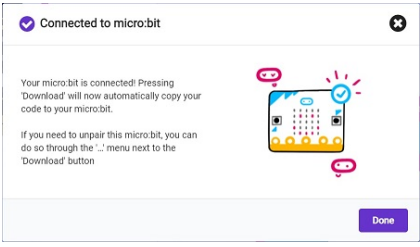
Show a different image on the micro:bit.

For tons of tutorials to help you click here: <https://makecode.microbit.org/tutorials>

2. Transferring the code onto your micro:bit

Most of the time you will write and test your code in the simulator. You are now going to download the programme onto your micro:bit.

(These instructions can be found here <https://makecode.microbit.org/device/usb>)

<ul style="list-style-type: none"> ● Connect your micro:bit to your computer with the Micro USB cable ● Open a project ● Click the triple dot icon on the Download button and then click Connect device. 	
<ul style="list-style-type: none"> ● In the connection message window, click Next. 	
<ul style="list-style-type: none"> ● Another message window will display telling you which device you should pair with. Click Next to go to the device list. 	
<ul style="list-style-type: none"> ● Select BBC micro:bit CMSIS-DAP or DAPLink CMSIS-DAP from the list and click Connect. 	
<ul style="list-style-type: none"> ● When your micro:bit is connected, you'll see the Connected to micro:bit message window. Click on Done and you're ready to go 	

Can you download your programme onto your micro:bit?

Have you ever used walkie-talkies?

Walkie-talkies use radio waves to communicate.

When you use a walkie-talkie you have to make sure both walkie-talkies are on the same channel.

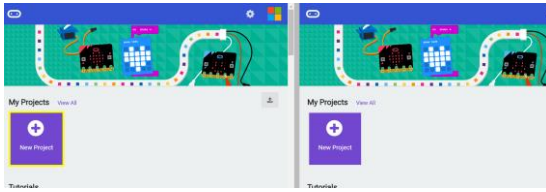
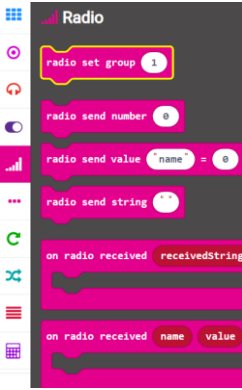
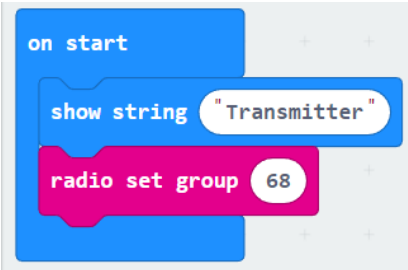
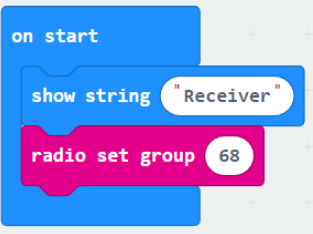
This means that the radio waves are the same frequency - they are in the same part of the EM spectrum.

These walkie-talkies are set to the same channel no "8"



3. Coding the micro:bits to communicate via radio

We are going to learn how to code two micro:bits to allow us communicate- one will be a transmitter and one will be a receiver. You will need two micro:bits.

<p>a) Open up the micro:bit multi-editor. https://makecode.microbit.org/v3.0--multi#</p>	
<p>b) Create a new project called “transmitter” on the left and “receiver” on the right.</p>	
<p>c) You will need to click on the pink radio menu to access the radio blocks</p>	
<p>d) If we want the micro:bits to communicate then they need to be on the “same channel” just like with the walkie-talkies. There are 256 channels on the micro:bits. We are going to use the number 68.</p>	
<p>Transmitter</p> 	<p>Receiver</p> 

Can you edit your programme to send a different message?

4. Telemetry

Ireland's first satellite EIRSAT-1 is going to be carrying out experiments in space!

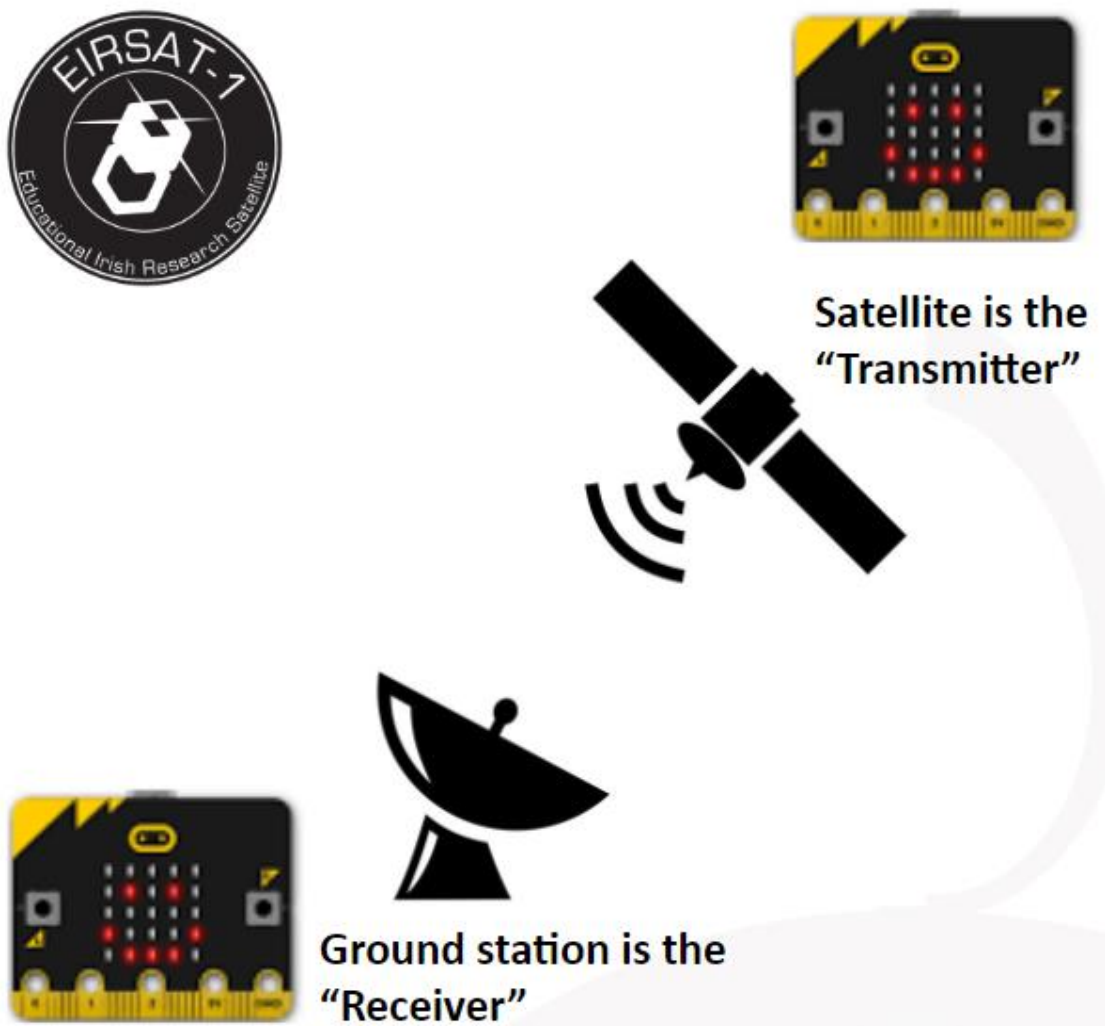


The data (or information) that is collected by EIRSAT-1 is going to be sent back to earth via radio signals. This data is going to be sent to ground stations. We call this process of recording and transmitting data **telemetry**.

What type of telemetry will EIRSAT-1 send?

The health of the satellite and experiment data such as the detection of Gamma rays

We are going to make a model of a satellite and a ground station. The satellite is the transmitter and the ground station is the receiver. We will use two micro:bits.



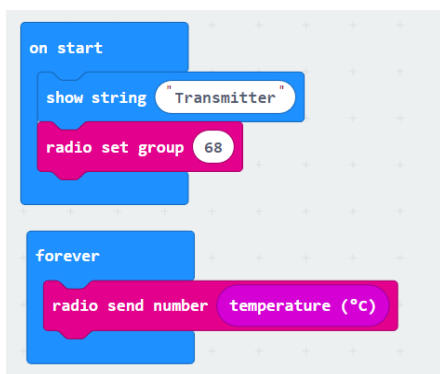
Before we make our model we need to be able to send telemetry on the micro:bit.

We already looked at sending a string (e.g. the characters “hi”) via radio.

Now we will look at sending data that the transmitting micro:bit is recording.

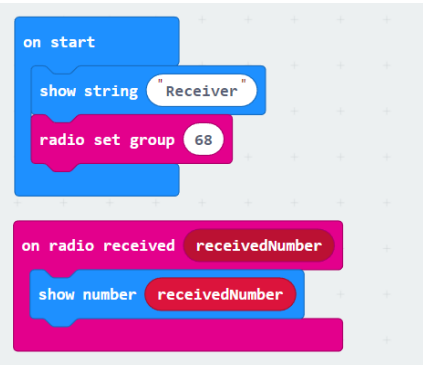
The transmitter will be **recording and sending** the data to the receiver. This is telemetry!

Now let's turn our micro:bit into a thermometer and send the telemetry to another micro:bit



```
on start
  show string "Transmitter"
  radio set group 68

forever
  radio send number temperature (°C)
```



```
on start
  show string "Receiver"
  radio set group 68

on radio received receivedNumber
  show number receivedNumber
```

Place your transmitter micro-bit outside. Is your receiver picking up the data?

Write a programme that will send different telemetry (e.g. light levels) to the receiver.

(Click here for a tutorial to measure light levels: <https://microbit.org/projects/make-it-code-it/sunlight-sensor/>)