Satellite Builder - Teacher Guide

Authored by Chris North, Sarah Eve Roberts, Stuart Lowe
Acknowledgements: Brychan Govier, Emma Foxell

Keywords: Science, Space, Astronomy, Satellite, Rocket, Web app, Interactive, Satellite, Technology
Level: Primary-High School
Duration: 30-60mins

The UK Space Agency is planning its next satellite mission. They've asked you to help design it!

This app challenges students to design and launch a satellite that can perform a specific role related to communication, navigation or earth observation. They'll need to select the size of their satellite along with its instruments and power supply. Once completed, they'll be challenged to design a rocket capable of launching the satellite into orbit.

Older or more capable students may want to use Intermediate and Advanced mode. Intermediate mode challenges students to build their satellite and launcher on a strict budget. Advanced mode provides a much greater range of options and challenges students to select the correct orbit for their satellite based on its purpose.

www.satellitebuilder.org.uk

Materials:

- Computer or tablet w/ Internet connection per 1-2 students
- Satellite builder slides (Keynote, powerpoint or PDF)

Goals:

- Understand the roles played by satellite technology and how it affects our everyday lives.
- Understand the components of a satellite mission: size, instruments and orbital path, in addition to constraints such as budget, power and thrust.

Learning objectives:

- Learn about three different types of satellites, with examples of their specific uses: Communications, Earth Observation or Navigation.

- Build a satellite designed to fulfil a specified purpose Select all components including size, instruments, power source, orbital path, as well as a launch vehicle with adequate size and thrust.
- Complete your mission within specific budget constraints.

Background information:

History: The first artificial satellite to orbit Earth was Sputnik 1, which was built by the Soviet Union and launched on 4 October 1957. Sputnik had an elliptical orbit, ranging in altitude from 225 to 950 km. and was capable of broadcasting a steady signal of beeps for 21 days before it burned up in Earth's atmosphere upon reentry on 4 January 1958.

Satellite types: Today almost 4,000 satellites orbit our planet, carrying out various roles that have become essential to our everyday lives. These satellites include communications satellites, navigation satellites, Earth observation and astronomical satellites.

Communication satellites are used for broadcasting television, phone or internet transmissions. Navigation satellites are often part of a satellite constellation including several satellites which word together; the difference in time for signals received from each satellites is used to calculate the exact location of a receiver on Earth. Earth observation satellites are used to image clouds and measure temperature and rainfall, these include weather forecasting satellites, search and rescue satellites and disaster monitoring satellites.

Power: Most satellites have onboard computers and instruments that help with satellite operations and with the satellite's mission. They must carry their own power source because they cannot receive power from Earth, these can include batteries, solar panels or an RTG (radioisotope thermoelectric generator).

Orbit: To successfully carry out their roles, satellites must be placed into the correct orbit. Most satellites are sent to Low-earth orbit, at an altitude of around 400 kilometres. Satellites in low-Earth orbit pass over a different part of the Earth in each orbit and can look at small areas in high detail for short periods of time. It is cheaper to send satellites to Low-Earth orbit than other orbits and satellites here can be easily reached for repairs.

Satellites that need to see large areas of the Earth’s surface in lower resolution, such as navigation satellites, are sent to Medium-Earth orbit at an altitude of 2,000 kilometres. For satellites that need to stay above the same location on Earth, such as weather satellites, geostationary orbit is used at an altitude of 35,786 km. Satellites in this orbit stay above the same location on Earth near the equator and complete a full orbit in 24 hours. They are much higher above the Earth's surface than other orbits, so can see the entire hemisphere in less detail.

Satellites in highly-elliptical orbit are closer to the Earth at one point in their orbit than another, giving an elliptical rather than circular orbit. They are useful for covering areas including polar regions.

Instructions:

Begin by introduce the topic using the **Satellite Builder slides** provided. When this is done, have your students open any browser on their computers or tablets and go to:
www.satellitebuilder.org

1. Select a difficulty level: Beginner, Intermediate or Advanced.

Beginner level - there is no budget to worry about, students are simply challenged to make a satellite that fulfils its purpose and a launcher capable of reaching orbit.

Intermediate level - students have more flexibility, allowing them to select the size of satellite. They are also challenged to stick to a strict budget.

Advanced level - students are offered a much greater range of options, including new instruments, new power options and the ability to select a suitable orbit.

2. Select a type of satellite

Select from: Communication, Earth Observation or Navigation. Read the text provided for more details about each type of satellite. Click Mission in the top-right corner to continue.

3. Select the purpose of your satellite.

There are up to nine satellites to choose from, ranging from Satellite Telephone System to Natural Disaster Monitoring satellite.

4. Take note of the budget for your mission (Intermediate and advanced users only).

To successfully complete your mission, you will need to build and launch your satellite within budget. Keep track of how much you have spent in the toolbar at the top of the page.

5. Select the size of your satellite (Intermediate and advanced users only).

Select from: Large, Medium, Small or Cube sat advanced only).

The size of the satellite determines how many instruments it can carry, some missions require a large number of instruments or larger instruments, however users must note that larger satellites are more expensive.

6. Select an orbit for your satellite (Intermediate and advanced users only)

Select from: Geo-stationary, Highly-elliptical, Medium-Earth or Low-Earth.
A list of requirements has been provided to help your selection, a green tick will appear next to each requirement when it has been fulfilled. For more information on each orbit, read the text provided.

7. Select the instruments for your satellite

To complete your mission you will need the correct instruments. There are up to 21 instruments to choose from, including an Atomic Clock for measuring the time very accurately and a Radio Dish for controlling the satellite and transmitting data to the ground, as well as for the radar altimeter.

All instruments are colour-coded depending on their size. The available slots on your satellite are also colour coded but note that you only have a limited number of instrument slots, so choose wisely.

A list of requirements has been provided to help your selection, a green tick will appear next to each requirement when it has been fulfilled. Click Power to continue.

8. Select a power source for your satellite.

There are several ways to provide electricity to your satellite, you can use body-mounted solar panels on the sides of the satellite, deployable solar panels or an RTG, which uses nuclear technology to provide power. Batteries can store energy in order to power the satellite when it's not in direct sunlight, however they will not provide sufficient power on their own.

A power bar can be seen on the left-hand window, this must be at 100% or higher to successfully power your satellite. Note that the required power for your satellite can be seen in the toolbar at the top of the page.

9. Build your rocket

Now you have a satellite you need to build a multi-stage rocket capable of launching it into space. The top of the rocket will need to be large enough to hold your satellite, while each of the following stages must be big enough to support those above.

Your rocket must provide enough thrust to reach your chosen orbit. A gauge can be seen on the left-hand window, this must be at 100% or higher to successfully launch your satellite. Note that the required thrust is calculated based on the mass of your satellite , which can be seen in the toolbar at the top of the page.

Conclusion:

Each student should successfully build and launch a satellite capable of carrying out the assigned mission in the browser app.

Connection to school curriculum: KS3 Wales, NC Science:

Interdependence of organisms

1. Pupils use and develop their skills, knowledge and understanding by investigating how humans are independent yet rely on other organisms for survival, applying this to life in countries with different levels of economic development.

14. how human activity affects the global environment, e.g. acid rain, greenhouse effect, and the measures taken to minimise any negative effects and monitor them, e.g. by Earth observation satellites

15. applications of science, medicine and technology that are used to improve health and the quality of life, including those in countries with different levels of economic development."