Spaceport UK



Activities for 7-11 year olds based on how to build a spaceport and launch satellites into Earth orbit.

UK SPACE AGENCY

Spaceport UK

Activities for 7-11 year olds about how to build a spaceport and launch satellites into Earth orbit.

These activities look at the development of a UK Spaceport and the launch of satellites into Earth orbit. Individual activities can be undertaken, or used together as part of an extended programme.

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Acknowledgements

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Authors: Sue Andrews and Cliff Porter

01

Where to build a UK Spaceport

The UK is planning to develop several spaceports to launch rockets carrying satellites into space. In this activity, children consider the key criteria for a rocket launching site before making a final choice for a UK based spaceport.

Where to build a UK spaceport

Context: Satellites are vital for navigation, weather reporting, communication and spotting potential disasters on Earth. All of this depends on a rocket launch to send these satellites into orbit. The UK is planning to develop several spaceports to launch rockets carrying satellites into space. In this activity, the children will take on the role of space scientists to consider the key criteria for a rocket launching site and the suitability of several possible sites in the UK, before making a final choice for a UK based spaceport.

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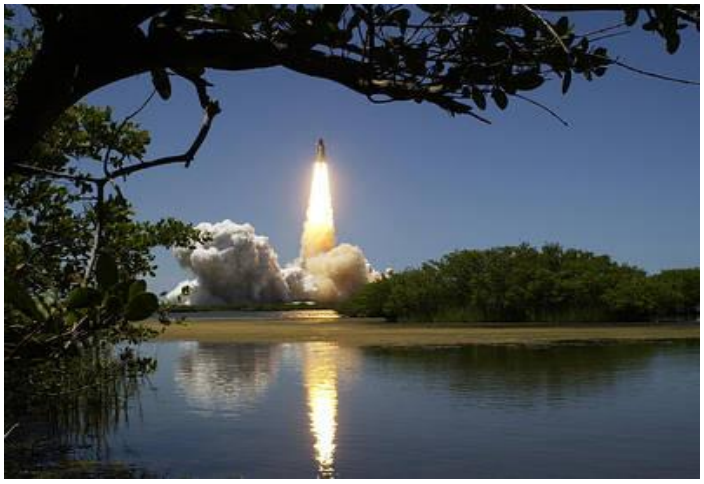


Image: NASA.

Curriculum links & skills

Science: **forces, friction**

Explain that unsupported objects fall towards the Earth due to gravity.

Geography: describe key aspects of physical and human geography; interpret a range of sources, use geographical skills.

English: reading factual information, discussing, debating, considering different points of view.





Sentinel satellite; Rama, Creative Commons

Lesson Starter: Show the children the video of the launch of ESA's 50th successful launch of Ariane V rocket https://youtu.be/nMFotrkgF-w and ask *Why are rockets sent to space*? Explain that rockets carry satellites and sometimes humans into orbit around Earth. Satellites help us to do lots of important things such as find our way or forecast the weather. Lots of countries around the world are launching rockets from special sites called spaceports. Soon the UK will be building spaceports to launch rockets carrying satellites! Read together the Press release about a proposed UK spaceport on Activity sheet 1a and watch this animationhttps://youtu.be/f1SQoe5spXo explaining how UK spaceports can launch rockets vertically or horizontally along a runway, just like planes!

Main activity Choosing a suitable location for a spaceport from the wide variety of different sites and types of terrain across the United Kingdom is challenging. Ask the groups to discuss factors they think would be important when deciding where to build a spaceport. *Where should it be? Why? What would be needed?* Safety is a key consideration, far away from dense population. Having good transport links and space for development are important factors. Further information may be found in the teacher support notes. After a class discussion, draw ideas together and try to decide on a set of criteria for an ideal site. Display this on the whiteboard. Next, using the map on Activity sheet 1b showing locations for 'fictitious' space port sites 1-6, the children use the keys on Activity sheet 1c to discover the features of each and decide whether it would be a suitable or unsuitable location for a spaceport and why. *Which would be their first choice and why?* They could record their choices on the table on Activity sheet 1d. Each group explains its decisions to the class. Collect and display the results. *Which spaceport site did each decide as an ideal location and why? Did the groups agree? Were there any difficult decisions?*

The children then study the map of the British Isles on Activity sheet 1e, showing the location of eight UK Space Agency finalists hoping to obtain funding to develop spaceports, labelled A to H. Using the information on Activity sheet 1f, they use geography skills to match each to its location.

Plenary: Reveal the names of the spaceports matching each location. Show the Power Point of images of the finalists in the UK Space agency competition and note the important features of each potential spaceport site. *Which one would the children choose to develop?* Finally, reveal Sutherland as UK Space Agency's first choice for development and revisit the key criteria for choosing the ideal spaceport site whilst watching a video of the plans for the Sutherland site.



Artist impression Spaceport Sutherland

Credit H & I Enterprise Zone

Extension and further activities:

Use the internet to learn more about the locations of the proposed sites for the UK spaceports.

Write a newspaper report describing the opening of a new UK spaceport.

Record a video interview of local people giving their views about a local spaceport development.

Use the internet and Earth observation images to research other possible locations for future spaceport sites and list reasons for their choices.

Hold a class debate on the advantages and disadvantages of spaceport development.

STEM/ vocabulary: friction, gravity, horizontal, vertical, North, South, East, West South West island. peninsula, coast, population

Activity sheet 1a

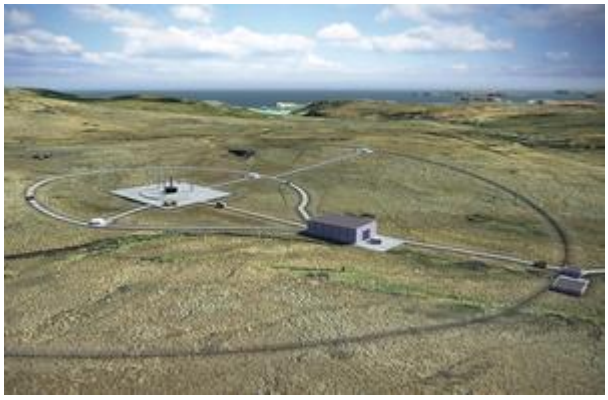
Press Release

One giant leap: Vertical launch spaceport to bring UK into new space age

The UK is set to build on its world leading expertise in aerospace with the development of vertical and horizontal spaceports

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Published 15 July 2018



The UK Space Agency has chosen the first site for the vertical launching of satellites and is helping to fund the building of other vertical and horizontal launch sites across Britain. This is exciting news. Hundreds of new jobs could be created. Britain could be the first place in mainland Europe to launch satellites.

Activity sheet 1b

This map shows six different UK locations marked 1-6. Use the information for each location on Activity sheet 1c to decide whether you think it would be a good site for a spaceport.



Activity Sheet 1c



Here is some information about six locations marked 1-6 on the UK map on Activity sheet 1b. Which site would be a suitable place for a spaceport?

Site 1. Coast River Buildings Population high Railway Main roads Motorways	**Site 2.** Mountains Mountain railway Reservoirs Lakes Nature reserve Forests Narrow roads
Site 3. Inland Flat land Woods RSPB site Airport Population low Near main roads	**Site 4.** Coast Castle Outstanding natural beauty Forests Population low Main road Railway
Site 5. On the coast Flat land Remote Good roads Airport Long runway Buildings for storage Population low	**Site 6.** Island Ferry boat access Flat land No people No airport No roads Trees Sheep

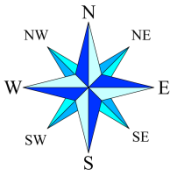
Activity Sheet 1d



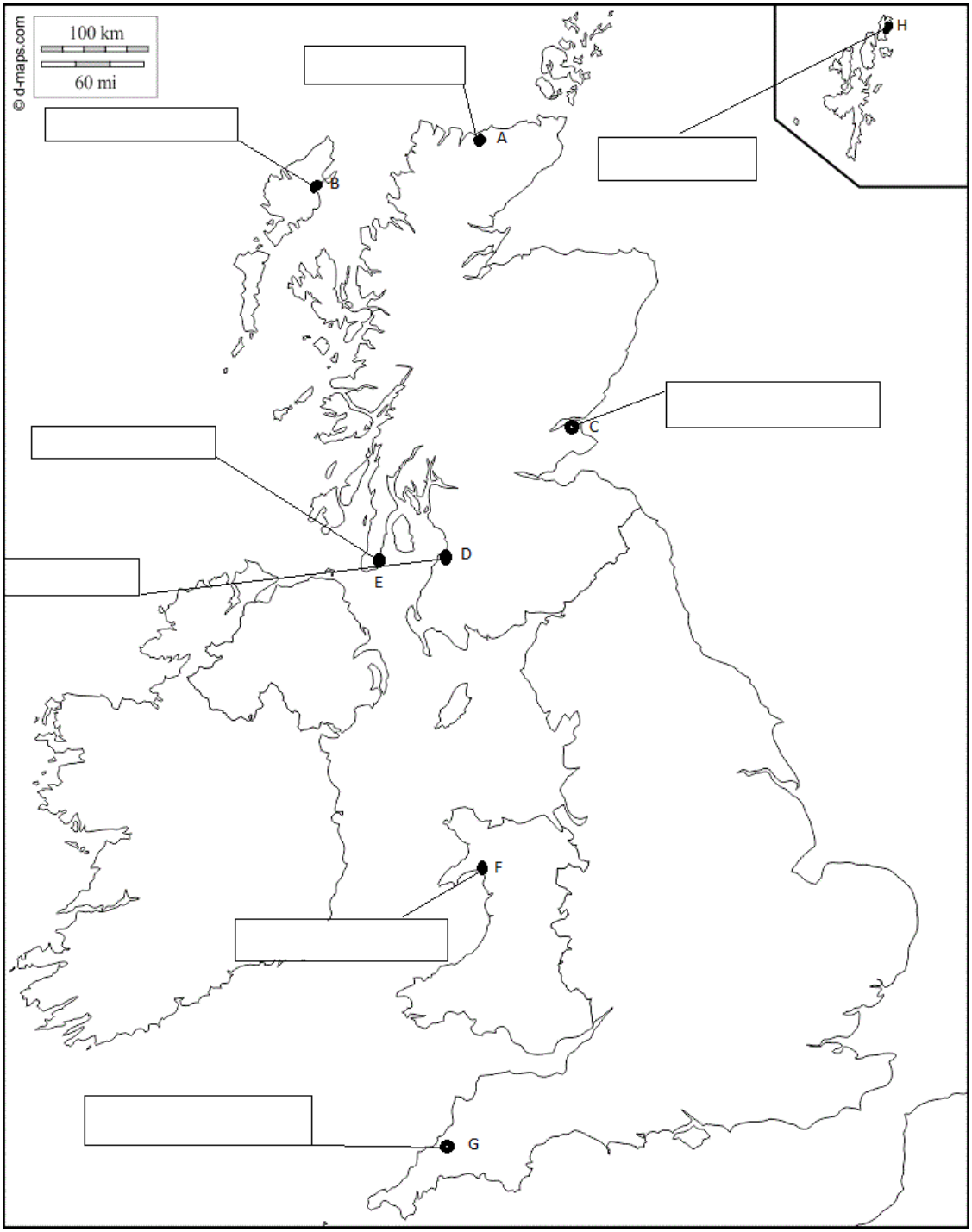
Look at the locations 1-6 on the UK map on Activity sheet 1b. Read the information about them on Activity sheet 1c. Which site would be a good place for a spaceport?

Location	Suitable✔ Unsuitable ✘ Maybe?	Why?
Site 1		
Site 2		
Site 3		
Site 4		
Site 5		
Site 6		
The most suitable location for the spaceport is …….because		

Activity sheet 1e



This map of the British Isles shows eight possible sites for UK spaceports, labelled A to H. Can you match each spaceport to its location from the descriptions? Write the spaceport names in the boxes.



Activity sheet 1f

Read the information and match these spaceports to their locations A to H on the map.

Newquay Cornwall Spaceport will be built on the South West tip of England and is hoping to become a horizontal launch site. The airport has one of the UK's longest runways, has access to the sea and a very low population density. Very few planes fly in the sky over the site. It has good links to London and other major cities in UK.
Spacehub Sutherland is on the North coast of Scotland. It is surrounded by countryside and is by the sea. It is ideal for launching satellites that will orbit Earth in a polar orbit, flying over the North and South poles of Earth. It is expected that up to 400 jobs will be created.
Spaceport Snowdonia is on the West coast of Wales. It is next to the sea, easy to travel to and far away from towns and villages. It is safe for launching rockets vertically as they can fall back down into the sea. It also has very few aeroplanes flying overhead. It might also be ideal for horizontal rocket launching. Some buildings on the site need to be renovated. The spaceport could provide many jobs for local people. Plans for the site include a hotel, planetarium, astronaut training centre and air ambulance facilities.
Glasgow Prestwick Airport has two runways and could become a site for a future spaceport. It is located on the West coast of Scotland. It hopes to become one of only three sites for horizontal rocket launching in the UK. It has a good location, satellites are built nearby and lots of businesses linked to the space industry are already there.
A site on the North West coast on the island of Uist in the Outer Hebrides, the **Western Isles of Scotland** is hoping to be a vertical rocket launch site. The site faces North across the sea. Rockets could launch out across the Atlantic Ocean. The development could provide up to 70 jobs. The island has very few inhabitants.
The northern tip of the Island of Unst, one of the **Shetland Islands**, is the most northerly inhabited part of the British Isles. It is 240 km off the Northern part of Scotland and hopes to be one of the UK's spaceports for vertical launching of rockets. It has oil and gas supply, very few people and is very remote. Many jobs could be provided for local people.
There is a plan to develop a horizontal launch spaceport at a remote site where there is low air traffic at **Campbeltown** on the west coast of Scotland. Its runway is almost 3km long. It overlooks the Atlantic Ocean and is suitable for landing and take-off.
RAF Leuchars used to be a Royal Air force base on the East coast of Scotland and has a long runway 2,500 m. There are good transport links and a rail station. It is close to the sea.

Teacher support materials

Activity 1 Where to build a UK Spaceport

These notes accompany the activity titled ‘Where to build a UK Spaceport?’ to support teachers in carrying out the activities. They provide background information, tips for advance preparation, opportunities for cross curricular links and useful website links for enrichment.

Background information

Spaceports are places where space craft are launched into space. Spaceports are sufficiently far from populated areas or bystanders, in order to avoid risk should the launch fail. Proximity to water is a key consideration, to ensure that any rocket components potentially fall into water and not on populated areas. There must be a supply of fuel and storage facilities plus transport links for essential supplies. Many spaceports around the world make use of existing airport facilities, particularly runways. Most spaceports are situated near to the equator to enable rockets to take advantage of the spin of the Earth at these latitudes to accelerate into higher orbits.



Image shows a communications satellite.
By USAF (Los Angeles AFB) – Commons wikimedia

The UK sites will allow rockets to carry satellites into polar orbits, orbiting the Earth over the poles from North to South and Sun-synchronous orbits where they will orbit over the place on the surface of the Earth at the same time each day with the Sun in the same place in the sky. From here, daily detailed observations can be made. Some sites-Sutherland, Shetland and Western Isles- will support vertical launches whilst further funding of others will allow horizontal launches using runways at locations in Cornwall, Glasgow Prestwick and Snowdonia.

A vertical launch is the term used when a rocket is fired straight up into the sky; fuel is ignited and the two or three stages of the rocket fall to Earth once the fuel is used.

During horizontal launches, an aircraft carrying a rocket takes off along a runway situated far away from populated areas. Once the aircraft is safely airborne, the rocket is released, its fuel ignites and it continues into space. Sutherland, on the north coast of Scotland, an ideal place for launching small and medium sized satellites, is remote and has a 4km exclusion zone; it was the first site to be awarded funding from the UK Space Agency to develop a vertical launch port.



Image shows a Delta IV rocket launching vertically: NASA public images



A Lockheed L-1011 carries the Pegasus rocket attached to its belly. The plane drops the rocket at 11,887 metres where it freefalls for five seconds before the first stage motor ignites: NASA public images



The Pegasus air-launched space booster was carried under the right wing of a B-52 carrier aircraft: NASA public images

Advance preparation

Read the key considerations involved in choosing a location for a space port listed below:

- Safe site.
- Close to water.
- Remote location.
- Flat land.
- Long runway for horizontal launches.
- Airport ideally already in place.
- Road transport links.
- Infrastructure already in place.
- Fire station, ambulance, air ambulance development areas.
- Storage for rocket propellant and aviation fuel.
- Buildings for future development and storage.
- Businesses nearby such as satellite construction.
- Not impinging on nature/areas of outstanding natural beauty.

Prepare a set of Activity sheets for each group.

Make available a set of atlases or maps/OS maps of UK.

Provide tablets or access to the internet.

Curriculum links and skills

- Observe that rockets must overcome the force of gravity in order to launch.
- Describe key aspects of physical and human geography; interpret a range of sources, use geographical skills.
- Reading factual information, discussing, debating, considering different points of view.

Lesson Starter

Show the children the video of the launch of ESA's 50th successful launch of Ariane V rocket from its spaceport in French Guiana: https://youtu.be/nMFotrkgF-w and ask *Why are rockets sent to space*? Explain that rockets carry satellites and sometimes humans into orbit around Earth. Satellites help us to do lots of important things such as finding our way or forecasting the weather. Lots of countries around the world are launching rockets from special sites called spaceports. Soon the UK will be building spaceports to launch rockets carrying satellites! Read together the Press release about a proposed UK spaceport on Activity sheet 1a and watch this animation: https://youtu.be/f1SQoe5spXo explaining how UK spaceports will launch rockets vertically or horizontally along a runway, just like planes! The video showing the launch of ESA's Ariane rocket offers an opportunity to talk about the thrust needed to overcome the force of gravity pulling the spacecraft back to Earth. Another impressive video https://youtu.be/vHWDNrrfhnI?list=RDCMUCIBaDdAbGlFDeS33shmlD0A shows a Soyuz rocket blasting off from the same spaceport and the release of ESA's Sentinel-1 satellite.

Press release: The UK government launched a competition in 2014 to encourage applications to develop a spaceport site. Six sites were shortlisted but the competition ended in 2016 without a selection. The rules were modified so that any suitable location might become a spaceport. The Civil Aviation Authority suggested several potential sites based on meteorological, environmental and economic considerations.

Main activity

The first activity involves considering the pros and cons for each of six 'fictitious' potential spaceport locations. There children should be encouraged to discuss the advantages and disadvantages of each site and their reasons for their final decisions. The children could cut out the six key cards on Activity sheet 1c and match them to the locations on the map on Activity sheet 1b. Site 1 is obviously not ideal, as it is an urban location with high population density. Site 2 is mountainous with poor roads, so not suitable. Sites 2 and 3 are near to nature reserves or areas of outstanding natural beauty. Site 5 would appear to be the best choice, as it is on the coast in a remote location with an airport and long runway already in place. Some might think site 6 ideal, but the absence of good road links for transporting rockets and fuel would preclude the choice.

Finally, the children read the information about eight actual sites in the UK that have the potential for spaceport development. Can they use this information to match each to its correct location on the map on Activity sheet 1e?

Plenary

Reveal the names of the potential spaceports next to the locations. In 2018, the UK Space Agency selected Sutherland as the first vertical launch site and made available funding to boost horizontal spaceport development across Britain. Reveal Sutherland as the UK government's first choice for a spaceport. *Did they agree or were they surprised?* Remind the children of the key considerations when choosing spaceport locations whilst watching the excellent video of the plans for the future development ideas for the Sutherland site by clicking the link on the final slide:

https://vimeo.com/415894044

RAF Leuchars, originally considered as a candidate, has been precluded as it will become an army base but may be used in the future as a temporary facility.

Extension and further activities

The children could do further research of the spaceport locations. They could produce a persuasive piece of writing in favour of one of the locations. A class debate might be held, for or against a particular site.

They might use OS maps of the potential spaceport sites to identify symbols used and identify national parks, RSPB sites, forests, mountains and roads.

Cross curricular links

The activity provides opportunities for further research and practical investigations in several areas of the curriculum, including:

Science: Space: investigating the Solar system, model or act out orbits of Earth and Moon. Forces: building and launching rockets, changing angle of launch from horizontal to vertical and comparing distance travelled, altering fins to observe the effect of air resistance

Geography: recognising and following directions. Using geographical skills, comparing contrasting locations in UK e.g. urban and rural, areas of outstanding natural beauty, national parks, locations suitable for purpose; looking at Earth observation images and identifying a variety of terrain; developing and using map legends and keys; identify polar regions and equator, lines of latitude and longitude

English: Speaking and listening, debates, presentations, conducting interviews, reading for information. Writing for different purposes and in different styles such as non-chronological reports, newspaper reports, letters and emails.

Maths: Measures: use everyday examples to understand rocket length, satellite sizes and runway length.

Useful website links

Maps of UK, free to use

https://d-maps.com/pays.php?num_pay=218&lang=en

Shetland spaceport on the island of Unst

https://shetlandspacecentre.com/launch-site-facilities/

Newquay Cornwall

https://spaceportcornwall.com/

Campbeltown, Machrihanish Spaceport

http://www.discoverspaceuk.com/

The UK Space agency is responsible for all strategic decisions on the UK civil space programme.

https://www.gov.uk/government/organisations/uk-space-agency

The European Space Agency has a wealth of information about space missions and has a section for teachers very informative and interactive website for children.

https://www.esa.int/

https://www.esa.int/kids/en/home

NASA provides a wide range of ideas for teachers and children plus an image gallery.

https://www.nasa.gov/

https://www.nasa.gov/stem/image-galleries

ESERO UK is the UK space education office and provides exciting STEM based free resources for schools.

https://www.stem.org.uk/esero

Tim Peake blasts off to the International Space Station.
https://www.youtube.com/watch?v=sc6msv9u6AE

02

Satellites

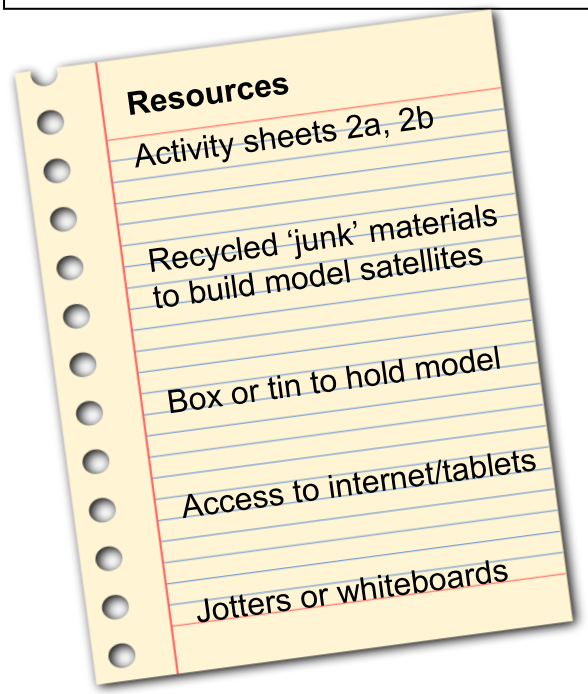
In this activity, children discover what satellites are, their key components and roles they perform. They design, build and test a model satellite to see if it is ready for launch.

Satellites

Context: The UK is a world leader in satellite design and construction and is planning to launch satellites from sites in the UK. In this activity, the children discover what satellites are, their key components and how they are vital for navigation, weather reporting, communication and spotting potential disasters on Earth. They take on the role of space engineers to design and build a model satellite before carrying out a practical investigation to test how robust their models are. This extended activity may be divided into two shorter sessions.



Image: Artemis satellite: ESA/J.Huart

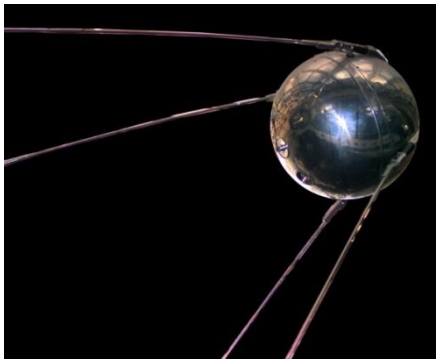


Curriculum links and skills

Science: Solar system, Earth Moon orbit

Design technology Designing, making, evaluating

Engineering: problem solving, adapting, improving, communicating ideas



Replica of Sputnik 1 - first artificial satellite
Image Wiki Creative Commons

Lesson Starter: *Does anyone here have Satellite tv or a system in their car to help find the way? Have you heard of satellites? Does anyone know what they are? What do they look like? What do they do?* Explain that there are two types of satellites; some like our Moon are natural and orbit planets but some are made and sent into space where they orbit around Earth. Show the children the video https://youtu.be/RLw3veKBqo0 depicting the launch and deployment of NASA's Soil Moisture Active Passive satellite. Satellites help us to do lots of important things such as finding our way or forecasting the weather. Show PowerPoint 2 and highlight the key components of satellites. Sputnik 1 was the first artificial satellite launched by the Russians; it travelled around Earth for three weeks before its batteries died. Listen to the sound Sputnik transmitted using this link: https://upload.wikimedia.org/wikipedia/commons/c/c6/Sputnik_beep.ogg Soon the UK will be launching rockets carrying its own satellites into space!

Main activity Read the email from the UK Space Agency on the final slide of PowerPoint 2 or Activity sheet 2a. Explain that today the children will be taking on the role of space engineers. Their task is to design and build a model of a new satellite. They must decide which instruments it will have and what important science it will perform. Perhaps the satellite will take measurements of temperature or photos of the Earth or may travel to other planets to search for new planets in distant galaxies? It must also be able to withstand the vibrations of launching. Remind the children of the key satellite parts and the variety of tasks they perform by showing slide 4. More information may be found in the Teacher Support notes. The children use this information and satellite images and start to plan their designs. They might like to record their ideas on Activity sheet 2b. Next, show the children your pre-constructed satellite model, discuss its instruments and what it is designed to measure or observe. *How might we test whether the model satellite is strong enough to be sent to space?* Ideas might include shaking the satellite models in a large container such as a tin or shoe box. *Do they think your model will pass the test?* Try it! *Was it damaged? Any improvements needed?* Explain that on completion, each of their models must be tested. *How might we make the test fair?* Suggestions might include the same number of shakes, distance shaken or person in charge of the test. Once designs are complete and materials decided, the children construct their models. Teachers may prefer to organise the lesson into two sessions. When all models have undergone the vibration test, the children share their results.

Plenary:

The children present their satellite models and explain the features of each. *Did they survive the shake test? What improvements would they make to their models? Would they change any of the materials used?* Explain that engineers design, build, test and then adapt their models often many times. Conclude the lesson by showing a video of the testing of the James Webb space telescope https://svs.gsfc.nasa.gov/12546

Extension and further activities:

Use the internet to learn more about the James Webb space telescope and different kinds of satellites.

Write a newspaper report or record a podcast describing the launch of a new satellite.

Present the weather using satellite reports and Earth observation images.

If you could interview a real space engineer, what questions would you ask?

Plan an interview with Tim Peake. What would you ask him about his time on the International Space Station?



Example of a model of a satellite.

STEM/ vocabulary

Satellite, natural, launch, vibrate orbit, spacecraft, mission

Activity sheet 2a

From: ukspaceagency

To: Pupil Space Engineers

Subject: Design a satellite

Dear Pupil Space Engineers,

We understand that you have been finding out about satellites and how important they are in lots of ways, such as helping us to plan a journey or find directions, watching television, or letting us know what the weather will be like. Some send photos of our Earth from space, helping scientists to warn us of major events such as floods or hurricanes.

Here in the UK, space scientists and engineers are busy designing and building different kinds of satellites. Soon, we will be launching them into space from spaceports in the UK!

The UK needs scientists and engineers like you. Maybe one day you might like to have a job connected with space? Could you use your skills and imagination to be creative and design some model satellites? Think about what science instruments they might have and what information they might collect. Remember, satellites need to be strong so they will not break when the rocket launches or when they are orbiting our Earth. So, you will need to think of a way of testing your models.

We would love to hear about your investigations.

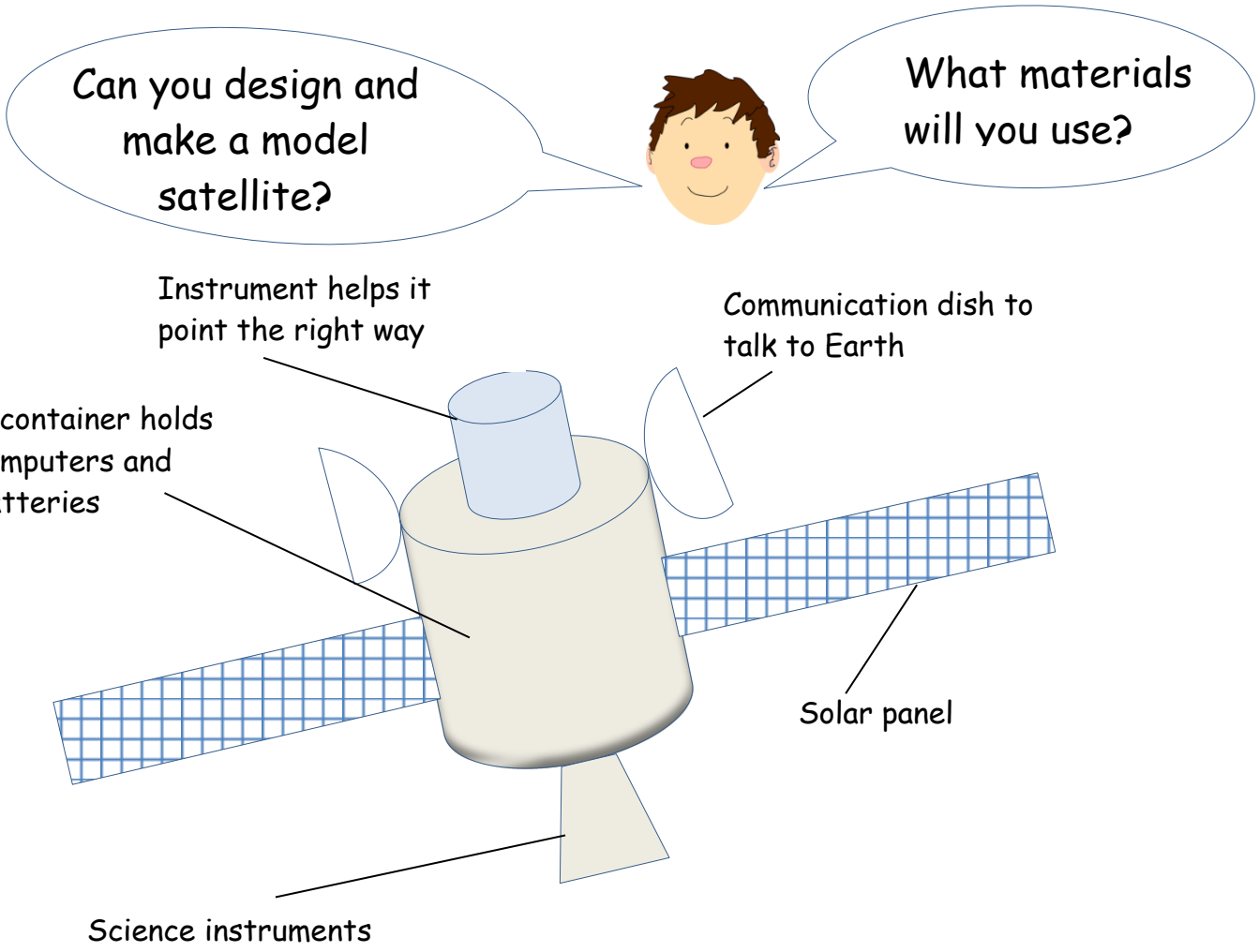
Good luck!

Phil Weaver

Manager

UK Space Agency Space for All Project

Activity Sheet 2b



Design your satellite  What will it measure or observe?

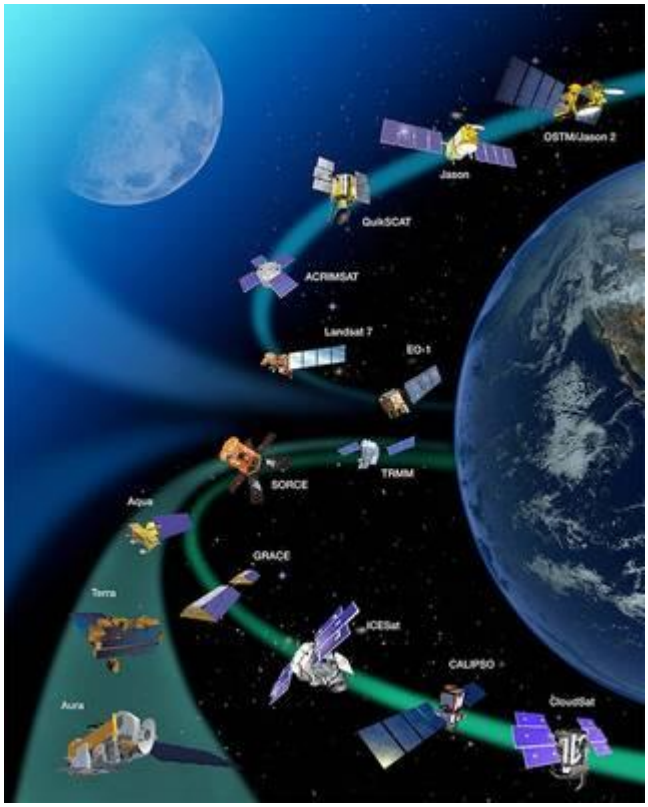
Teacher Support Information

Activity 2 Satellites

These notes accompany the activity titled ‘Satellites’ to support teachers in carrying out the activities. They provide background information, tips for advance preparation, opportunities for cross curricular links and useful website links for enrichment.

Background Information

A satellite is a moon, planet or machine that orbits a planet or star. For example, Earth is a satellite because it orbits the sun and the Moon is a satellite because it orbits Earth. Usually, the word "satellite" refers to a machine that is constructed, launched into space and moves around Earth or another body in space.



NASA has more than a dozen Earth science satellites in orbit. They help NASA study the oceans, land and atmosphere.
Image: Credit NASA

Earth and the Moon are examples of natural satellites but thousands of artificial satellites orbit planet Earth. The first artificial satellite was Sputnik 1 launched by the Soviet Union in 1957. Sputnik 1 was a very simple satellite comprising a beach ball sized aluminium ball with four antennas. It was powered by batteries and its transmitters sent out a ‘beep beep’ signal. Modern satellites are more complicated. Some are used for GPS navigation, whilst others are used for communication, for TV or phone calls. Others can track planets or stars in far off galaxies, helping scientists

to better understand the universe; these space satellites work better than Earth based telescopes as they are positioned above the clouds and dust in the atmosphere. Detailed satellite imaging of the Earth and fast data collection is vital in helping us to avoid disasters or forecast the weather.

The UK and European Space Agency are involved in many satellite-using missions to help us understand and monitor how our planet is changing. Many provide detailed images of our land, seas and oceans to monitor underwater ecosystems and vegetation. The image below was captured by Copernicus -3A satellite using its ocean and land camera.

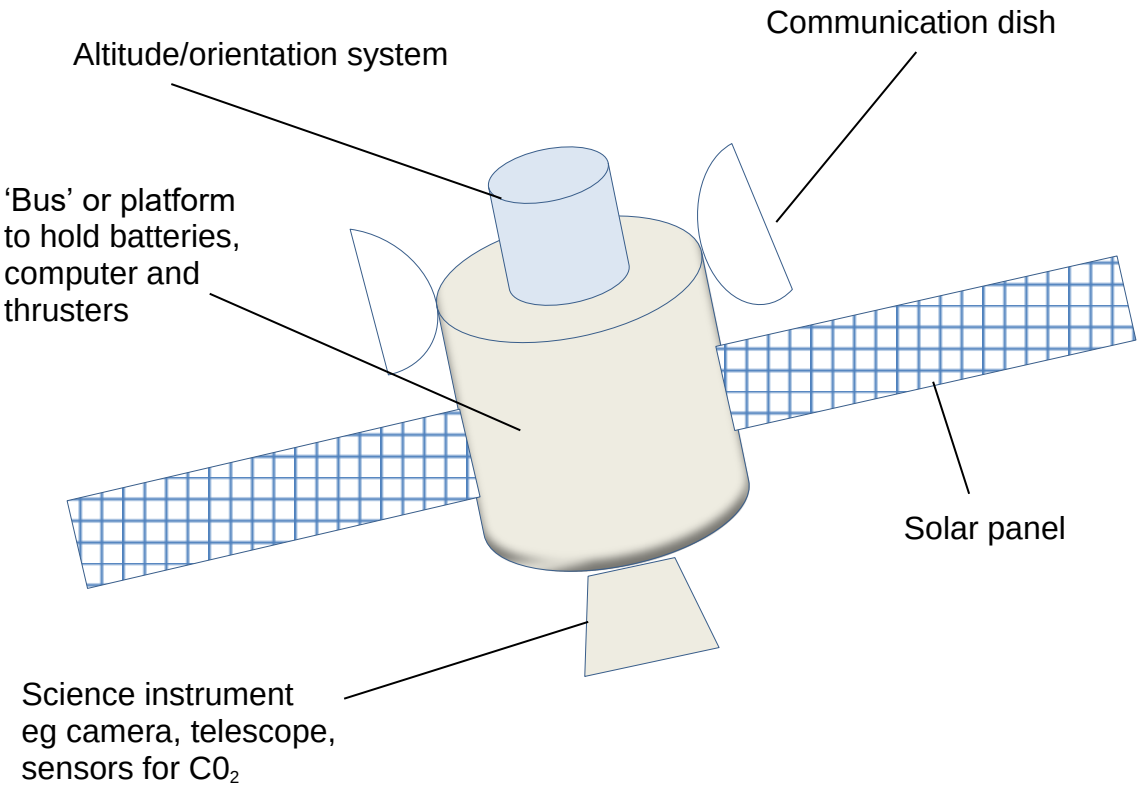


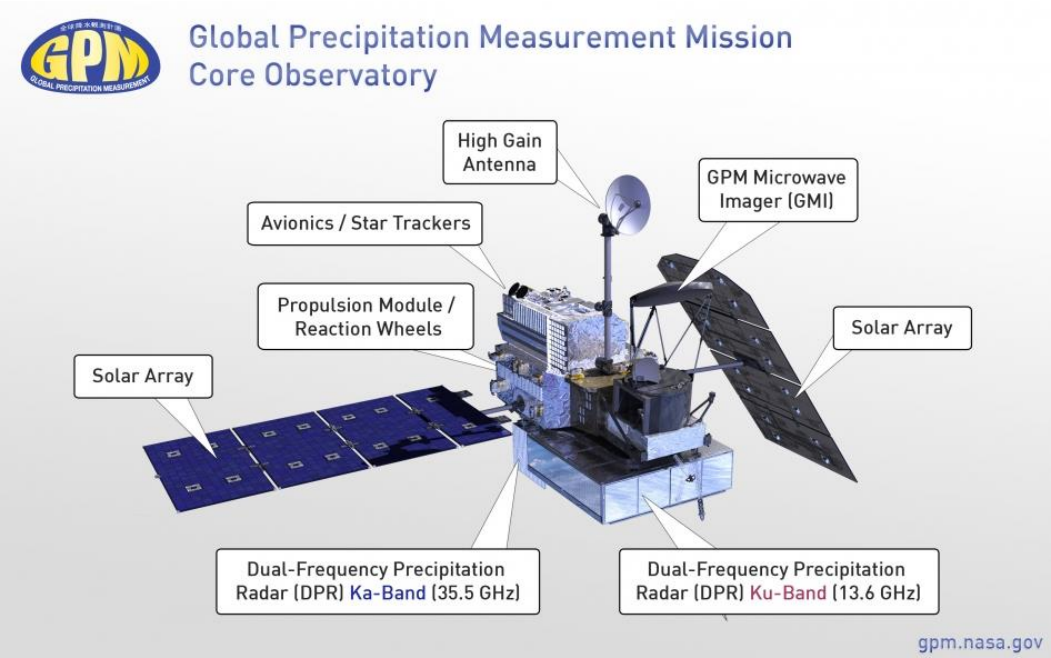
Image: European Space Agency - http://www.esa.int/spaceinimages/Images/2018/03/Italy_and_Mediterranean, CC BY-SA 3.0-igo, https://commons.wikimedia.org/w/index.php?curid=67488209

Satellite design

Satellites are designed to be strong and light. They are usually powered by large light sensitive solar cells like wings which are folded during the launch and later open out. They collect sunlight but when in shadow, the satellite is powered by rechargeable batteries. Since the side of a satellite facing the Sun can get very hot, whilst the side in shadow can be very cold, this can affect the sensitive instruments on board. Layered blankets similar to aluminium foil can protect the instruments, whilst radiators can release heat. A platform called a ‘bus’ contains all the main systems, including the batteries, computer and thrusters. Attached to the bus are antennas, solar arrays and science equipment. Satellites come in many shapes and sizes but they consist usually of four main parts:

- a power system which may be solar, battery or nuclear ; solar panels make power by turning sunlight into electricity
- antennae to transmit and receive information
- a system for controlling altitude
- a ‘payload’ comprising scientific instruments such as cameras, telescopes, particle detectors or sensors to collect information.





Sometimes these instruments face toward space to collect data from the solar system and universe, and some like the GPM in the image above, point toward Earth to gather information about its land, air and water. The diagram shows the solar panels on the wings providing power, scientific instrument measuring precipitation, wheels attached to motor for propulsion, tracking or navigation device and antenna for receiving and transmitting information via radio waves.

Satellites facing Earth	Provide information about the weather such as rainfall and gases such as carbon dioxide. Monitor events such as wild fires and natural disasters. Information helps farmers and emergency workers.
Satellites that face toward space	Send information about the history of our solar system, activity on the surface of the Sun or look for comets, asteroids and stars.
Some satellites fly near or orbit other planets.	These spacecraft can take pictures of other planets

How Do Satellites Orbit Earth?

Satellites are launched into space on rockets to a chosen orbit and then released. When its speed is balanced by the pull of Earth's gravity a satellite will orbit Earth, without flying in a straight line off into space or falling back to Earth. Satellites orbit Earth at different heights, different speeds and along different paths. There are three types of orbit: "geostationary", “Sun synchronous” and "polar." A geostationary satellite travels from west to east over the equator. It moves in the same direction and at the same rate Earth is spinning. From Earth, a geostationary satellite looks like it is standing still since it is always above the same location. Sun-synchronous orbits allow satellites to pass over the Earth at the same time of day providing a constant amount of sunlight; these orbits are useful for satellites taking images of Earth. Polar-orbiting satellites travel in a north-south direction from pole to pole. As Earth spins underneath, these satellites can scan the entire globe, one strip at a time.

Space debris

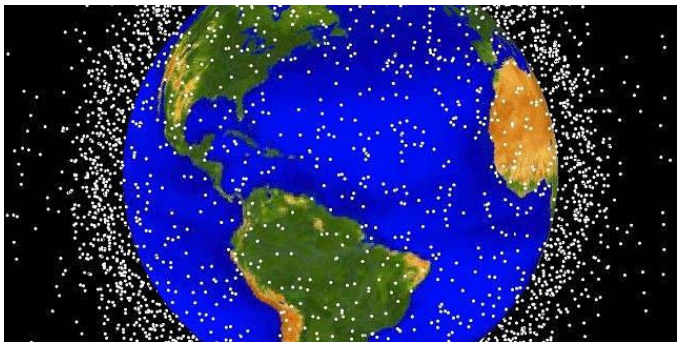


Image :
https://www.nasa.gov/sites/default/files/4-8-nrc-evaluates-nasas-orbital-debris-programs.jpg

Satellites are placed in orbits designed to avoid other satellites, but orbits can change and as the number of satellites increase, so too does the possibility of collision. Debris from such collisions can damage satellites critical for systems on

Earth. Space agencies, such as the European Space Agency, are currently involved in designing ways of not only capturing space debris but in ensuring that future satellites are programmed to move themselves to safer orbits or burn up in Earth's atmosphere when they are no longer useful.

Advance preparation

Collect a variety of containers and recycled model making materials such as cereal packets, bottle tops, juice containers, sponges, straws, tins, pre-formed cardboard trays, plastic cups, nuts, bolts, polystyrene spheres, tubes, lids, aluminium foil, glues and sticky tape.

Study the basic make up of a satellite and use everyday materials to construct a model satellite to show to the children and to demonstrate the 'shake test'. A shoe box or tin large enough to fit the model could be used for the test.

Curriculum links and skills

- Science/Space: Orbits. Learning that artificial satellites can be made and launched into orbit around the Earth
- Design and technology skills of designing, making, evaluating
- Engineering skills of problem solving, adapting, improving and communicating ideas

Lesson Starter

The introductory video https://youtu.be/RLw3veKBqo0 shows a Delta II rocket and computer animation to depict the launch and deployment of NASA's Soil Moisture Active Passive satellite. Emphasise that the satellite will experience forces and vibration during the launch. The images in Power Point 2 show the wide variety of satellites and the scientific data they collect. The notes under each slide provide more details of each satellite. The email from the UK Space Agency poses a challenge to the children.

Main Activity

The lesson is an extended activity comprising the introduction, planning and designing of model satellites followed by their construction and testing. Once their designs are complete and materials decided, the children construct their models but the activity may be split into two sessions if required; teachers may choose to leave the construction and testing to a later session. Read the email from the UK Space Agency on the final slide of PowerPoint 2 or Activity sheet 2a. Explain that today the children will be taking on the role of space engineers. Their task is to design and build a model of a new satellite. They must decide which instruments it will have and what important science it will perform. Perhaps the satellite will take measurements of temperature or photos of the Earth or may travel to other planets to search for new planets in distant galaxies? It must also be able to withstand the vibrations of launching. Use slide 4 to point out to the children the key satellite parts and the variety of tasks they perform. Additional information can be found in these notes.

The children may wish to use Activity sheet 2b for recording their designs. Testing satellite prototypes to measure their ability to withstand the forces generated during a rocket launch is a vital stage in satellite design. Encourage the children to suggest ideas for testing their own models. One idea is to place the model in a container such as a box or tin. Demonstrate using your pre-made model. They should consider how to ensure that each model is tested in the same way. Suggestions might include the same number of shakes, distance shaken or person in charge of the test. Moving the box rapidly from left to right along a premeasured distance marked on a surface, for example 30cm, would ensure each model is treated fairly.

Plenary

The plenary provides the opportunity for the children to describe their models to the class and to consider possible improvements. Emphasise that space engineers will experience many challenges when designing satellites and that changing and improving designs is all part of the engineering process. Thorough testing is vital to prevent damage to the satellites during launch or in orbit. Conclude the lesson by showing a video of the testing of the James Webb space telescope https://svs.gsfc.nasa.gov/12546

Extension and further activities

The **James Webb space telescope** is an infrared observatory that will replace the Hubble space telescope and is a collaboration between ESA, NASA and the Canadian Space Agency. The primary mirror is composed of eighteen hexagonal mirrors made from gold-plated beryllium. It must be kept very cold to observe in the infra-red area of the electromagnetic spectrum. It will find the first galaxies that formed at the beginning of the Universe. STFC and the UK Space Agency have supported the construction of an important instrument for the mission, called MIRI- short for ‘mid-range infra-red instrument’. Further information about the space telescope can be found here: https://stfc.ukri.org/research/astronomy-and-space-science/astronomy-space-science-programme/james-webb-space-telescope/

https://en.wikipedia.org/wiki/James_Webb_Space_Telescope

The **International Space Station** is the third brightest object in the sky. It is a habitable artificial satellite in low Earth orbit and is a multinational collaboration between five participating space agencies: NASA, Rocosmos (Russia), JAXA (Japan), ESA (Europe) and CSA (Canada).

https://www.nasa.gov/mission_pages/station/main/index.html

Launching a satellite

This extension activity challenges the children to devise a method of launching a satellite. Use something small to represent the satellite, such as a plastic bottle lid or a mini marshmallow. Ideas for launching might include using a catapult or perhaps attaching the mini satellite to a balloon rocket travelling along a string. Ensure that launches are aimed away from others for safety reasons.

Cross curricular links

The activity provides opportunities for further research and practical investigations in several areas of the curriculum, including:

Science: Insulation investigations. Investigate ways of keeping a cup of warm water warm, or cold water cold. Try different insulation materials. How will you make sure the test is fair?

Researching planets in the Solar system, recognising constellations and our galaxy The Milky Way

Music: Make satellite inspired music. Listen to Sputnik1 and replicate patterns. Compose repetitive rhythms and transmit using percussion instruments to represent satellite transmitters.

PE: Creative dance using satellite launch, orbit and deorbit as inspiration.

English: Speaking and listening: presentations, interviews and debates. Non-chronological writing:

Geography: Using satellite images of Earth, recognise key geographical features of Earth; comparing and contrasting topography.

History: Produce a timeline for satellite development.

Useful links

European Space Agency site for children
https://www.esa.int/kids/en/search/(q)/Satellites

History of NASA Satellites

https://www.jpl.nasa.gov/infographics/infographic.view.php?id=11182

How can a satellite stay put over the same spot on Earth?

https://spaceplace.nasa.gov/space-place-live/en/

A blog featuring Sputnik1 https://spacecentre.co.uk/blog-post/sputnik-changed-world/

A podcast from FunKids about who will use spaceports/satellite launches

https://www.funkidslive.com/learn/deep-space-high/spaceports/will-spaceports-look-like

03

Rocket fuel flow

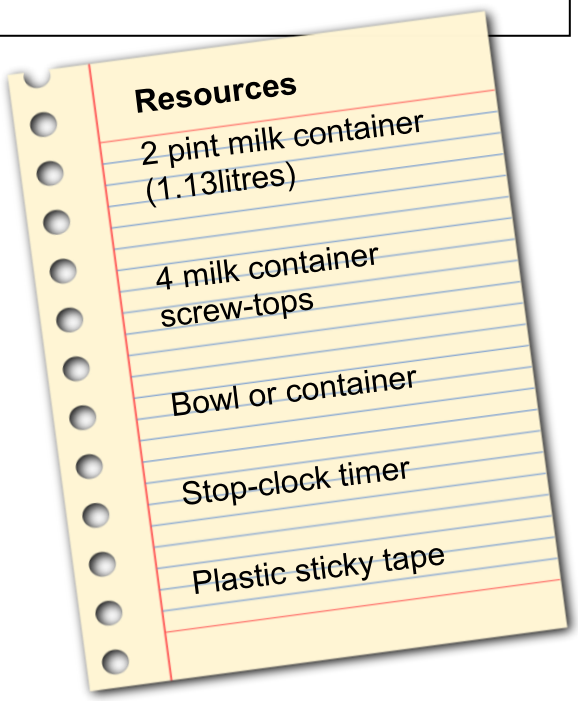
In this activity, children investigate the flow of water out of a container to model the fuel flow of a rocket motor.

Rocket fuel flow

Context: During a launch, it takes approximately 8 minutes to reach the low-earth orbit into which satellites are typically delivered. During this time, the rocket accelerates to a speed of around 8 kilometres per second (5 miles per second or nearly 18,000 miles per hour).

The thrust for this acceleration is provided by rocket motors, burning fuel.

In this activity, children investigate the flow of water out of a container with a set of screw tops, each with a different number of holes. This models the flow of fuel with multiple rocket engines.





Space shuttle Discovery during launch, showing two solid fuel booster rockets and three liquid fuel motors.
Image credit: NASA

Curriculum links and skills

Science: Working as a scientist to make observations, take measurements, record and present results.

Presentation of data in a table and graph.

Looking for patterns and using these patterns to make predictions.

- Fractions
- Collaborating and working as a team.

Lesson Starter: View the video clip of a rocket launch – European Space Agency's Ariane rocket https://youtu.be/nMFotrkgF-w. Describe the stages (guidance notes in teacher support materials).

Use the presentation to pose the question:

> "Let's see if we can make a scientific model, to find out how quickly fuel would be used up with different numbers of engines."

Main activity:

The scientific model consists of a milk container, with different numbers of holes drilled into its screw top. Children measure the time it takes for the water (fuel) to drain out for each number of holes (engines) to model how the number of engines affects the time it takes for the fuel to be used up.

Children will need to work in groups of three or four. The test is simple but coordination is required between the person holding the container and the person filling it with water.

1. Start with a top containing one hole in its screw top.
2. Cover the hole in the screw top with sticky tape (and a finger for insurance). This needs to be in place while the container is being filled. Have a tab in the tape to allow it to be easily removed.
3. Add the water to the 800ml mark. Alternatively use a 1pint container (568ml as a consistent volume).
4. Release the tape stopper and start the timer. Collect the water in a container.
5. Stop the timer when the flow of water ends and record the time taken.
   If appropriate, repeat to calculate an average.
6. Repeat with tops containing two, three and four holes.

STEM vocabulary:

Volume

Thrust

Gravity

Fuel

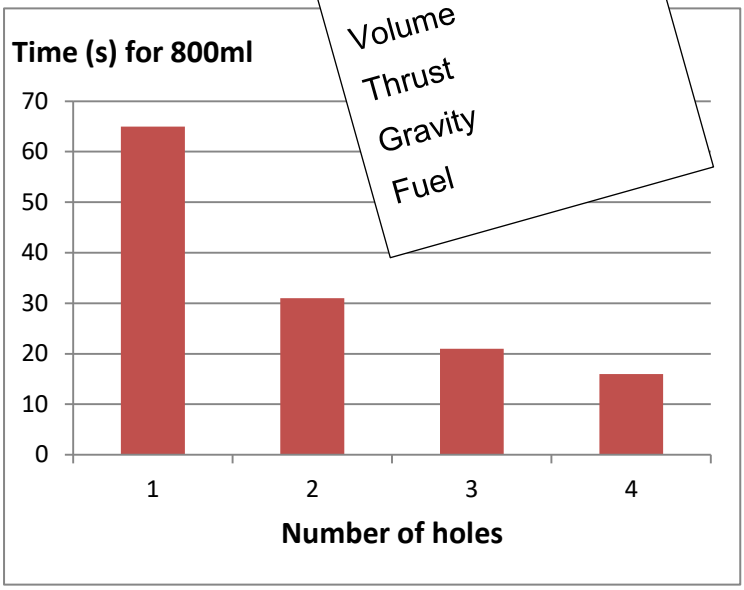
Plenary: *What pattern can children see? What fraction of time, compared with the single hole, is seen in the other ones?*

• 2 holes = half the time of one hole.
• 3 holes = one third of the time of one hole.
• 4 holes = a quarter of the time for one hole.

What times would children predict if they were to use five or six holes?

Discuss accuracy and how slight errors could be accounted for. *How could the method be adjusted to try and remove these inaccuracies?*

Conclude by saying that engineers need to do these types of experiments when they are designing and building rockets for launch into space.



Sample results with 4mm diameter holes.

Extension:

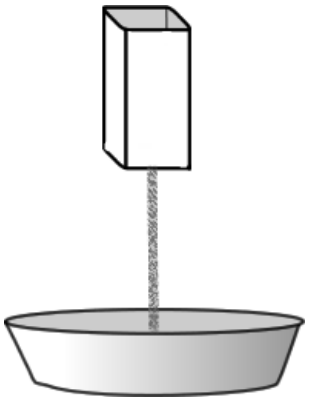
Children can be challenged to make an electric circuit that indicates in some way when the fuel tank (milk container) has been filled to the correct level. Stress that the wires must not enter the fuel tank, as in a real fuel tank this could ignite the fuel.

One approach is to use a polystyrene float whose upper surface rises above the top of the tank to push wires or tin foil together and complete a circuit to switch on a light or sound a buzzer.

Activity sheet 3a



How quickly will fuel be used up with different numbers of engines?



1. Start with a screw top containing one hole.
2. Cover the hole with sticky tape (and a finger).
3. Hold the container over the sink or bowl.
4. Carefully add the water.
5. Release the tape and start the timer.
6. Collect the water in the bowl.
7. Stop the timer when the flow of water ends.
8. Record the time taken in seconds.
9. Repeat with tops containing two, three and four holes.

Number of holes (number of engines)	Time for water to empty (fuel to be used up) Seconds

How can you show these results on a graph?

What pattern can you see in the times for the different holes?

How long does it take to empty with one hole? Compare this with the time for two holes. What is the fraction?

Teacher support information

Activity 3 - Rocket fuel flow

These notes provide background information, tips for advance preparation, opportunities for cross curricular links and useful website links for enrichment.

Background information

During a launch, it takes approximately 8 minutes to reach the low-earth orbit into which satellites are typically delivered. During this time, the rocket accelerates to a speed of around 8 kilometres per second (5 miles per second or nearly 18,000 miles per hour). To put this into a context, use a recognisable land mark to illustrate this speed. For example, Liverpool to London (370km) in 46 seconds (distance in km ÷ 8 kilometres per second).

The thrust for this acceleration comes from one or more rocket motors. There are, broadly, two types of rocket motors and both can be seen on this image of the space shuttle Discovery during one of its launches.

Solid Fuel rocket booster

This type of engine can be likened to a firework, packed with a solid fuel mixture. Once lit, the fuel burns explosively to propel the rocket forwards until all of the fuel has been used. The boosters are then jettisoned from the craft. In the image of the space shuttle, the solid rocket booster can be seen on both sides of the main liquid fuel tank.

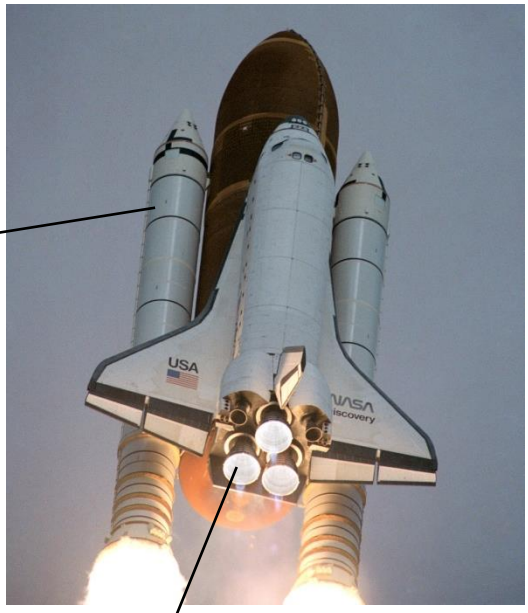


Image: NASA/JSC

Liquid fuel rocket motor

These three rocket motors uses a liquid fuel mixture containing a fuel component, and an oxidiser to provide oxygen for combustion. The fuel ignites in a combustion chamber to generate the forward thrust.

This type of motor can burn fuel in a more regulated and variable manner than a solid rocket booster, and can be turned on and off when required during a mission.

Activity overview

In this activity, children measure the time it takes for a volume of water to flow through one, two, three or four nozzles of the same size. It uses the context of liquid fuel flowing into a rocket motor and the launch vehicle having one, two, three or four liquid fuel motors. Refer back to the image of the space shuttle to see that this has three liquid fuel rocket motors.

Children measure the time it takes for a defined volume of water to flow out of a container which has one or holes at its base. Children first predict the effect of the number of nozzles on the rate of fuel (water) flow.

Advance preparation

Each group needs:

- 1 x 2 pint (1.13 litre) plastic milk container – empty and clean.
- Total of four milk container screw-tops (can be shared between different groups).
- Bowl or container to receive up to 1 litre of water.
- Stop-clock timer.
- Sticky tape to cover holes in screw top when filling the container with water.
- Measuring jug (optional) or empty and clean 1 pint milk container (568ml).

There is some advance preparation of the milk container and screw tops (see the images below).

Remove the base of the container by cutting around the bottom at a height of about 2cm. Cover any sharp edges with plastic tape.

The milk container is used upside down, with water being poured in through the now open cut end.

If the children do not have access to measuring jugs, with the screw top in place, pour in 800ml of water and mark the level on the side of the container with a permanent marker. This is the volume of fuel for each test. If a measuring jug is available, children can measure out this volume themselves. Alternatively, a 1 pint (568ml) milk container, filled to the top, will give a consistent volume of water for each test.

After the mark has been added, empty the container and remove the screw top.

An adult must prepare the screw tops. Use a drill bit to make a single hole in the screw top. A hole of 4mm diameter gives a good flow rate. Repeat this with the other tops so that there are tops with one, two, three or four holes. These represent rockets with different numbers of liquid fuel motors.

The container and screw tops are shown in the images below.





An alternative approach is to drill different numbers of holes into the base of several milk containers and swap these between groups. This avoids the chance of screw tops being put on loosely but does make it harder to fill the container prior to each test.

Curriculum links and skills

- Working as a scientist to make observations, take measurements, record and present results.
- Presentation of data in a table and graph.
- Looking for patterns and using these patterns to make predictions.
- Fractions.
- Collaborating and working as a team.

Lesson introduction

Video clip of launch – total time 3min45sec.

View one of the video clips that shows the launch of a European Space Agency (ESA) Ariane rocket (https://youtu.be/nMFotrkgF-w) from the ESA Spaceport in French Guiana.

During the launch, describe the things that are happening:

- The rocket stands on the launch pad. Most of the rocket is the engine and fuel. The payload, such as a satellite or supplies for the international space station, are packaged into the nose at the top of the rocket.

- In the first stage of the launch, the Ariane has two solid fuel booster rockets and one liquid fuel engine.
- Ignition sees the rocket motor fuel entering the combustion chamber at the base of the motor and being ignited to generate the thrust. This is called the first stage rocket motor.
- The attachments to the support tower and ground are released and the thrust from the rocket engine pushes the rocket upwards.
- At 2 minutes 20 seconds into the launch, the solid fuel booster rockets have used most of their fuel and are jettisoned from the main rocket.
- Once the main rocket motor has done its job, and the rocket is nearly in orbit, then it is also jettisoned. Further propulsion is produced by the second stage liquid fuel rocket motor which then carries the satellite to its desired orbital position.

Presentation

Show the PowerPoint presentation.

Slide 1 - highlight the liquid fuel rocket motors on the space shuttle and point out that there are three of them, needed to generate enough thrust to be able to launch the craft and also for its operation during the mission.

Slide 2 – have children identify the solid fuel boosters and liquid fuel engine on the Ariane 5 rocket (same type as shown in the video clip).

Slides 3 and 4 – pose the question: *Let's see if we can make a scientific model, to find out how quickly fuel would be used up with different numbers of engines.*

Discussion

Show the children the scientific model that you have prepared. The milk container represents the fuel tank and the holes in the screw caps represent one, two, three or four engines.

Either in groups, or as a whole class, discuss how the model could be used to see how the number of engines affects the time it takes for the fuel to be used up.

- *What needs to be kept constant?*
  Volume of the fuel used in each test. Diameter of the hole for each engine.

- *What needs to be varied?*
  The number of holes in the cap that is used.

- *What needs to be measured?*
  The time for the fuel tank to empty.

- *How will this be made as accurate and repeatable as possible?*
  Repetitions for each cap could be taken and an average time calculated. Care must be taken to accurately measure the same volume of water each time.

- *How will the children decide when the flow stops?*

- *How will the measurements be recorded and displayed?*
  A table can record the times for each hole configuration. They can then be shown graphically. Discuss the type of variable in the experiment (hole numbers) and is this a discrete or continuous variable. What type of graph is appropriate? (Discrete variable and a bar chart).

Activity – investigating fuel flow

Perform an appropriate risk assessment before undertaking the activity. Do not work near any sources of electricity or other areas where water could cause damage. Wipe up spillages immediately to avoid any slip hazards.

Children will need to work in groups of three or four. Working in a sink or large tray will help to contain any water spillages. Remind children to ensure that the screw cap is firmly attached prior to each test.

Each test is simple but coordination is required between the person holding the container and the person filling it with water.

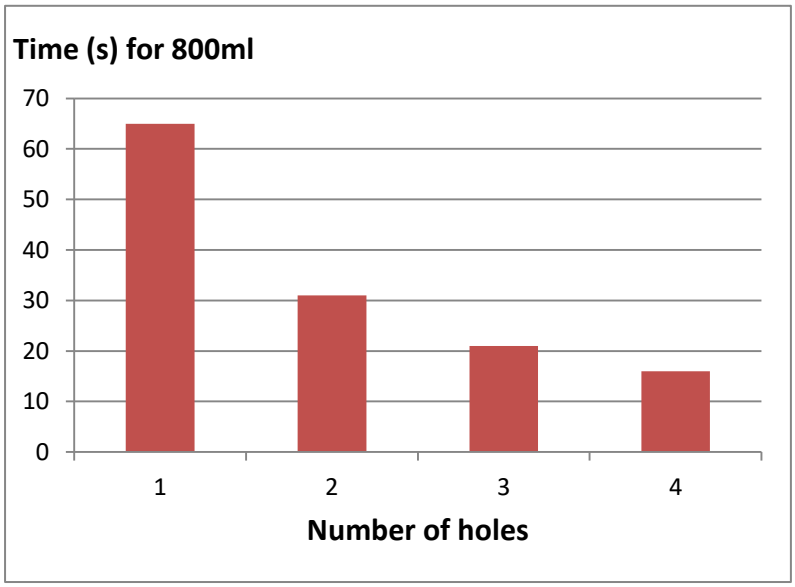
Demonstrate to the whole class the procedure before individual groups undertake the activity.

1. Start with a top containing one hole.
2. First seal the hole in the screw cap with sticky tape. Incorporate a tab so that the tape can be removed easily.
3. Screw the top onto the milk container and ensure a leak-proof fit. For additional security, place a finger over the tape to prevent leaks.
4. Hold the container over the sink, tray or bowl to catch any water.
5. Add the water to the 800ml mark (or use a full 1pint container).
6. Hold the container securely and remove the tape stopper. Start the timer. Make sure the water is collected in a container.
7. Stop the timer when the flow of water ends and record the time taken.
8. If appropriate, repeat to calculate an average.
9. Replace the screw top with one containing two holes and repeat, up to the maximum four holes.

Results

Below is a set of results that were obtained using 800ml flowing through approximately 4mm diameter holes.

Number of holes	Time (s) for 800 ml
1	65
2	31
3	21
4	16



Plenary - looking for patterns

What pattern can children see? What fraction of time, compared to the single hole, is seen in the other ones?

- 2 holes = half the time of one hole.
- 3 holes = one third of the time of one hole.
- 4 holes = a quarter of the time for one hole.

What times would children predict if they were to use five or six holes?

Children will note that the times they have recorded are not exactly a half, third, or quarter. This leads to a discussion of accuracy and how these slight errors could be accounted for. *How could the method be adjusted to try and minimise any inaccuracies?*

Conclude by saying that engineers need to do these types of experiments when they are designing and building rockets for launch into space. They must design engines

that will burn for long enough to get the rocket into orbit and tanks that will hold enough fuel.

Why cannot engineers simply make very large tanks, to hold much more fuel than is needed? What would this do to the weight of the rocket?

Adding larger tanks and more fuel would add weight, which in turn would need more engines to lift the weight, which would use more fuel, needing bigger tanks. Engineers need to make the rocket as light and efficient as possible. A big part of this is finding the minimum amount of fuel needed.

Extension

Children can be challenged to make an electric circuit that shows when the fuel tank (milk container) has been filled to the correct level. Stress that the wires must not enter the fuel tank, as in a real fuel tank this could ignite the fuel.

One approach is to use a polystyrene float whose upper surface rises above the top of the tank to push wires or tin foil together and complete a circuit to switch on a light or sound a buzzer.

Cross-curricular links

Science: Working as a scientist to make observations, take measurements, record and present results. Presentation of data in a table and graph. Identifying patterns and trends.

Maths: Considering variables, drawing and interpreting graphs, fractions.

Citizenship: Collaborating and working as a team.

Useful links

Simple, short animation showing how a rocket motor works:
https://www.youtube.com/watch?v=ebhOnf65N9Q

Testing a rocket motor
This is a hybrid rocket that is intended to power the Bloodhound Supersonic Car in its attempt to break the land speed record. It is being developed with the European Space Agency and may power space rockets in the future.
https://youtu.be/Tk67Z_mai_k

04

Water rocket lift-off

In this activity, children use the launch of a water-powered rocket to investigate forces and gravity.

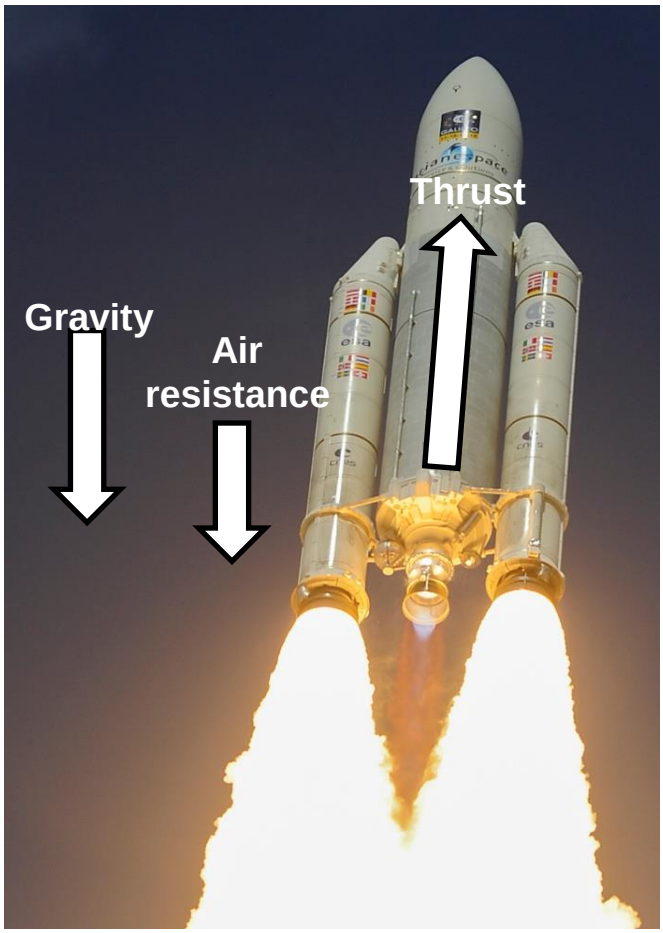
Water rocket lift-off

Context: During its launch, three main forces act on a rocket:

- **Gravity** – pulls the rocket down towards the Earth.
- **Thrust** – the rocket engines burn fuel to create expanding gases that push the rocket upwards.
- **Air resistance** – friction of air against the rocket's surface.

The rocket moves upwards because the thrust is greater than gravity and air resistance.

This activity uses water-powered rockets to simulate a rocket launch and can illustrate these forces.



Forces acting on an Ariane 5 rocket during launch. Image: ESA



Curriculum links

Science: Working as a scientist to make observations.

Presentation of data in a table and graph.

Forces, friction and gravity.

Lesson Starter: View the video clip of a rocket launch – European Space Agency's Ariane rocket https://youtu.be/nMFotrkgF-w. Have children describe the forces acting on the rocket on the launch pad before the rocket motors ignite and then the forces when the rocket is moving.

Show the video clip of the water rocket launch and again have children describe the forces.

Pose the question, *"How can we get the best range or straightest flight?"*

Main activity:

This activity needs a large open space into which the water rocket can be launched. Conduct a full risk assessment before carrying out the activity. Three possible activities are suggested:

- Demonstration launch and discussion of the forces acting on the rocket.
- Design, make and test fins added to rockets to see how to get the best range or straightest flight.
- Investigate how the amount of water (100, 200, 300, 400 and 500ml) affects the rocket's range. This models rockets with different amounts of fuel.

Inexpensive, commercially available water rocket kits are available. They use a clean and undamaged 2litre plastic drinks bottle. Use a tablet computer to make a video recording of each launch.

Plenary:

What forces are acting on the rocket during launch? Do different types of fins or attachments help to improve the rocket's range or direction?

What distance has each rocket travelled? How do the distances compare for each amount of water?

Other than the amount of water, what could influence the distance the rocket travels?

Discuss accuracy of any comparisons and any improvements (especially if the range has been paced-out).

STEM vocabulary:

Volume

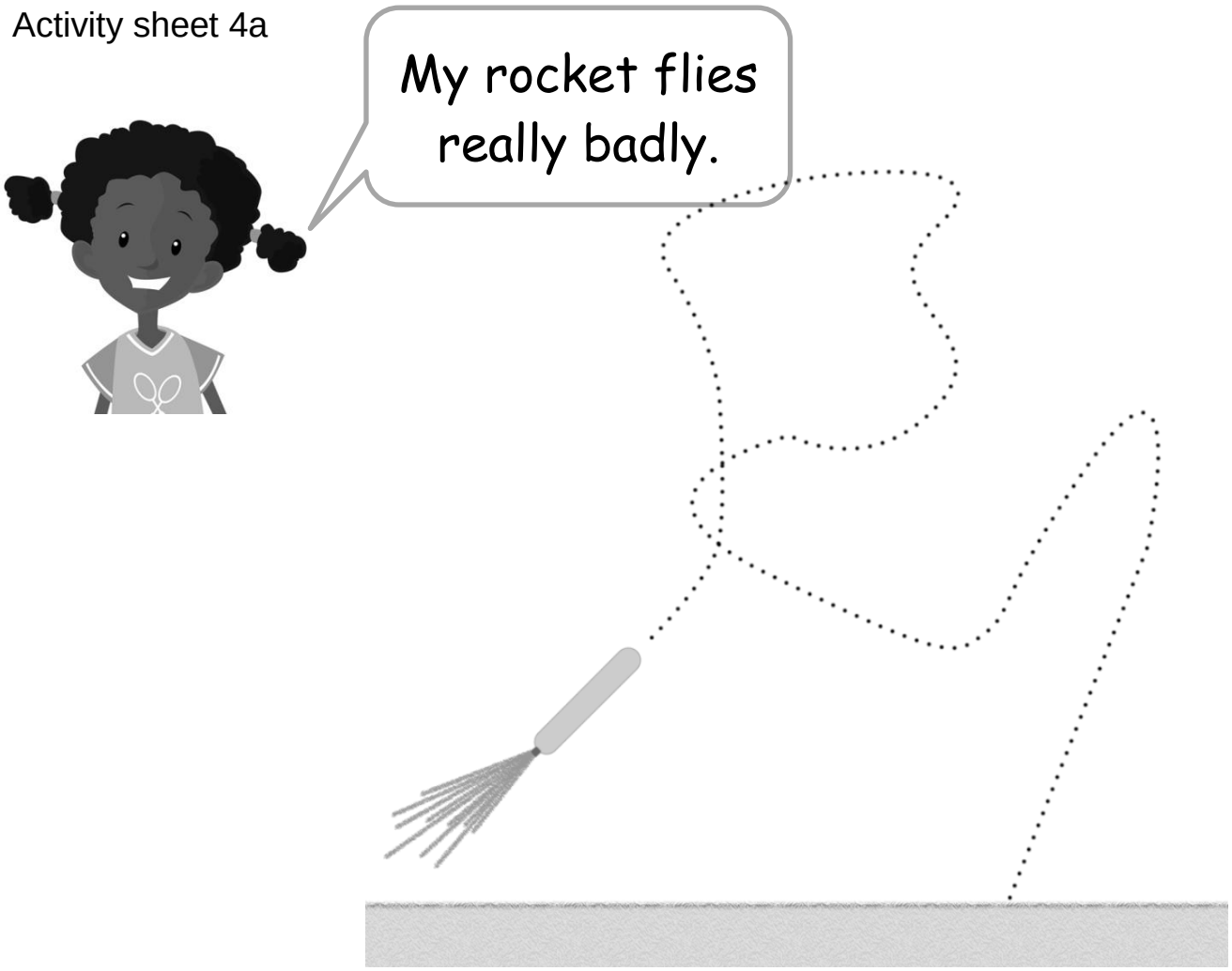
Thrust

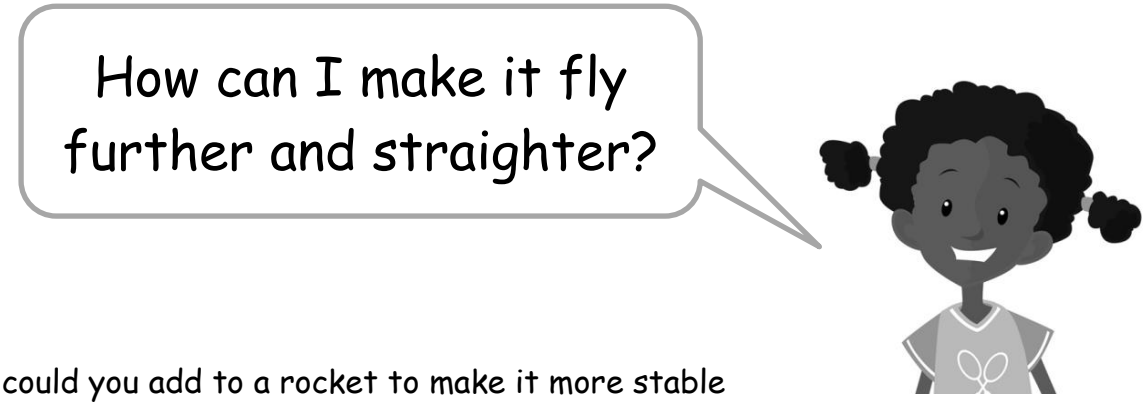
Gravity

Extension:

Working in groups children design, make and test a parachute system to return the rocket safely to the ground.

Activity sheet 4a



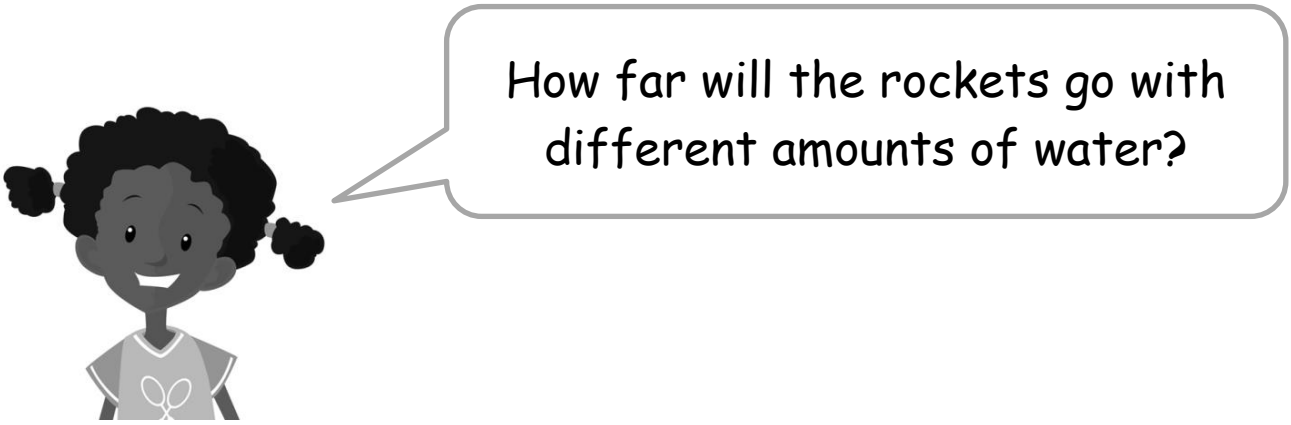


What could you add to a rocket to make it more stable when it is flying?

Remember though, if it is too heavy the rocket won't go as far.

How can you reliably compare each group's design?

Activity sheet 4b



Volume of water in the rocket (ml)	Distance travelled
100	
200	
300	
400	
500	

How can you show these results on a graph?

Is there a link between the amount of water and the distance the rocket travels?

What other things could influence the distance the rocket travels?

How could we make our investigation more accurate?

Teacher support information

Activity 4 - Water rocket lift-off

These notes provide background information, tips for advance preparation and useful website links for enrichment.

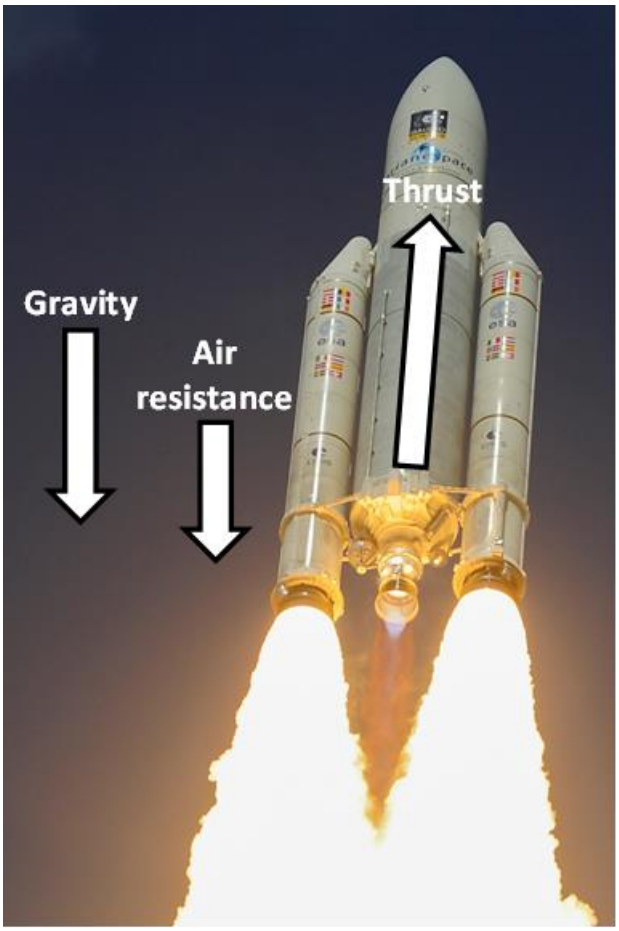
Background information

There are three main forces that act on a rocket during its launch.

Gravity

Gravity acts to pull the rocket, and its satellite payload, down towards the Earth. Even when it is in orbit around the Earth, gravity still acts on the satellite. Indeed, it is the force of gravity that keeps the satellite in orbit.

Imagine a tennis ball attached to a piece of string. When swung around, it is the string that pulls on the tennis ball to keep it moving around in a circle. This is the effect of gravity on the satellite. If the string was cut, the tennis ball would fly off outwards.



Thrust

The rocket motors burn fuel to produce gases that expand out of the back of the motor. These gases provide a thrust that pushes the rocket forward. During launch, the large stage one booster and main rockets provide enough thrust to overcome the total weight of the rocket (gravity) and air resistance.

When in orbit, smaller thrusters are able to manoeuvre the satellite.

Air resistance

During its launch the rocket passes through the Earth's atmosphere. Air friction against the rocket's surface produces a 'drag' that acts against the thrust. At lower altitudes the air is more dense and so the resistance is greater. As altitude increases, the air's density decreases until at around 100km it is negligible and the rocket is considered to be in space.

Activity overview

In this activity, the flight of an inexpensive, commercially-available water rocket is investigated. A suitable rocket is available from: https://waterrokit.com/ . Alternatively, instructions for making water and air-powered rockets can be found at: https://www.npl.co.uk/skills-learning/outreach/water-rockets/wr_booklet_print.pdf or using an internet search.

Safety note

A full risk assessment must be carried out before undertaking the activity.

These rockets use plastic drinks bottles, which are pressurised with air and water at launch. Ensure that the plastic bottles are not damaged in any way before they are used.

The rockets can fly tens of metres and must be used outdoors in a large outdoor space, where damage will not be caused by the water they eject and when they land. Rockets launch with great force and eject a water spray, so spectators must stand well back. An air pump with a long hose attachment will help the launcher from getting too wet. A brief video clip is attached to show what can be expected.

Advance preparation

Several different approaches can be taken to the activity.

The easiest way is to buy an inexpensive commercially-available water-powered rocket. These require a foot pump, or a stirrup-style high pressure bicycle pump. The activity can use just one empty and clean 2 litre plastic drinks bottle which is launched and retrieved. More bottles will be required if children are challenged to design, make and test rockets with their own design of fins and aerodynamic attachments. A consistent launch angle allows better comparisons, and this can be achieved by making an inclined launch ramp using a piece of wood propped up at one end by suitable supports.

Curriculum links and skills

- Working as a scientist to make observations, take measurements, record and present results.
- Forces on an object: weight, gravity, air resistance, pushing forces (thrust).
- Design, make and test aerodynamic attachments.

Lesson introduction

Presentation

Use the presentation to discuss the forces acting on a rocket during its launch, and also the forces acting on a satellite when in orbit.

Slides 1 and 2 – on the launch pad, the weight of the rocket (due to gravity) pulls downwards. Some children may also mention sideways winds, but considering the

size of the rocket, their effects are usually negligible (although there will be a maximum wind speed in which a launch can proceed).

Slides 3 and 4 – during launch, gravity continues its downwards force but thrust and air resistance also come into play.

Slides 5 and 6 – gravity still acts when the satellite is in orbit.

Video clip of water rocket

Use the video clip of a water rocket launch to show the children what they are going to do. Conclude by asking the children what they could investigate about the rocket launch. This could include:

- How the amount of water used affects the distance or height.
- What impact does the angle of launch have?
- How extra fins or aerodynamic features (nose cone) have an effect.

In reality, it is difficult to get consistent, reliable and repeatable measurements of the range due to the effects of wind, launch angle and the rocket's instability. However, the activity provides an opportunity to discuss the ideas of variability and external influences on their rocket's flight.

Activities

Several suggestions are presented. They could be tackled individually or as a series of activities.

Demonstration launch

The water rocket can be launched purely as a demonstration and to engage children in thinking about rockets and the forces acting on them during a launch. It can be a starter activity to gather suggestions about how the range and flight of the rocket can be improved.

Improving the rocket's flight

Working in small groups, children design, make and attach aerodynamic fins and a nose-cone to improve the rocket's stability in flight. These can be tested to judge which gives the best range or the straightest flight.

To make tests more comparable, a piece of wood propped up at one end can be used to give an incline for the rocket to launch off.

Investigating water rocket range

In this activity, rockets are loaded with different amounts of water to see if it influences their range. Results can be quite varied as the wind will greatly affect the rocket's flight.

1. Prepare an inclined launch ramp as described above.
2. For the first launch, add 100ml of water to the rocket.
3. Measure the range (long tape measure or have one person count the number of paces to retrieve the rocket).
4. Repeat the launches with 200, 300, 400 or 500ml of water. These are designed to model rockets with different amounts of fuel.
5. For added interest, use tablets to make a video recording of each launch.
6. Return to the classroom and present the data as a table and graph.

Plenary - looking for patterns

- Ask the question*, "Does more water give a longer range?"*
- *What distance has each rocket travelled? How do the distances compare for each amount of water?*
- *Other than the amount of water, what could influence the distance the rocket travels?*
  In this case, the main influence will be the air, especially as the plastic bottle is so light once its water has been expelled. As wind direction and strength is a big factor, try to choose a time with as little air movement as possible. The other feature will be the angle of launch, and so this should be kept as constant as possible.
- Discuss accuracy and how the method could be adjusted to improve accuracy (especially if the range has been paced-out).
  Repetitions of launches for each volume could be used to give average distances.
  Clearly the best way to measure the range is to use a long tape measure (such as one used in field athletics) but if this is not possible then pacing out each rocket is necessary. In this instance, having the same person pace each rocket for consistency is one way of improving accuracy. The distances could be paced out by different people and an average found.
  This opens up a good opportunity for ideas on how to improve accuracy.

Extension activity

Have groups design a parachute system that will deploy once the rocket has reached the top of its flight and allow the rocket to return slowly to Earth.

This requires a parachute made from thin bin bag plastic and attached by cotton threads to the top of the bottle. It is packaged within a detachable nose cone which falls off (hopefully at the top of the rocket's flight) and the parachute deploys.

Cross-curricular links

Science: Working as a scientist to make observations, take measurements, record and present results. Forces on an object: weight, gravity, air resistance, pushing forces (thrust).

Technology: Design, make and test aerodynamic attachments.

Information technology: Use video to capture a dynamic event.

Useful links

An extensive guide on making, modifying and testing air and water-powered rockets. https://www.npl.co.uk/skills-learning/outreach/water-rockets/wr_booklet_print.pdf

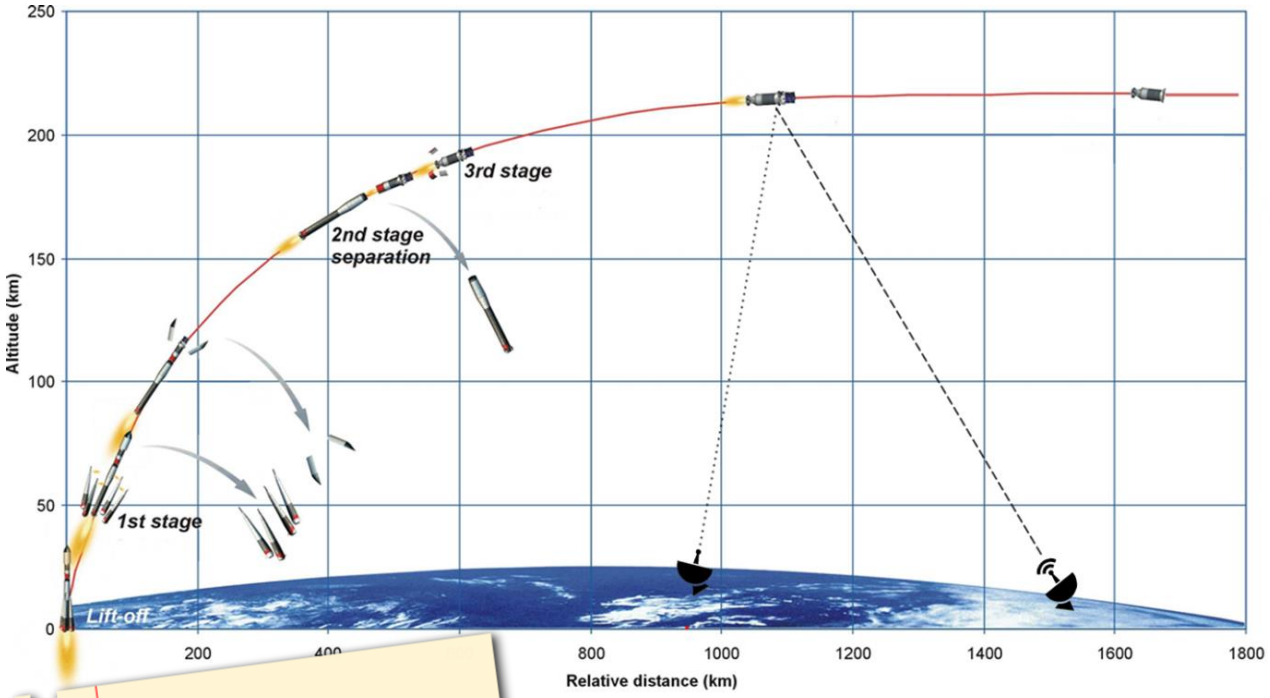
05

Tracking lift-off

In this activity, children investigate the trajectory of a ball in flight and model how RADAR is used to track a rocket’s path.

Tracking lift-off

Context: To achieve orbit around the Earth, a rocket must not only gain altitude but it must also gain horizontal speed. The trajectory a rocket takes is therefore important and mission control will monitor the path the rocket is taking. Children look at the trajectory of a ball in flight and model how RADAR is used to track a rocket's path.



Trajectory taken by a rocket to deliver a satellite into Earth orbit. The path is monitored by ground-based RADAR stations.

Resources

Camera, tablet or mobile telephone with video recorder.

Beach ball, netball, tennis ball.

Torches, protractors and metre rules.

Curriculum links

Science: Forces and gravity on an object.

Measuring and drawing .

Maths: Fractions, drawing and using scale diagrams.

Representing locations using horizontal and vertical co-ordinates in one quadrant.

Technology and computing: making and analysing video recordings using a tablet computer or video camera.

Lesson Starter: View the video clip of a rocket launch – European Space Agency's Ariane rocket https://youtu.be/nMFotrkgF-w.

Use the presentation to discuss the trajectory that the rocket needs to take to achieve Earth orbit.

How can the trajectory of an object in flight be tracked?

Main activity: **investigating the trajectory of an object in flight**

This activity needs an open space such as the school hall. Use a tablet computer to make a video recording of a ball being tossed from one person to another.

Different sizes and weights of balls can be compared. For example a tennis ball, netball and a beach ball. The throw needs to be a reasonable distance (5-10 metres), so that the video can be more readily analysed.

Once the recordings have been made, the ball's trajectory can be analysed in the classroom. The clips can be viewed by the whole class using an interactive whiteboard.

A short video clip example is included in case this proves difficult.

STEM vocabulary:
Gravity
Motion
Trajectory

Plenary:

What are the forces acting on the ball once it has been released?

Are the shapes of the trajectory similar for different balls?

Does the weight of the ball make a difference?

Balls should follow an arching trajectory. Gravity always acts downwards and initially slows the upward flight before pulling the ball downwards. Horizontal motion will be fairly constant with slowing by air resistance negligible in most balls. The exception will be the beach ball which is more affected by air resistance due to its relative size and weight.

Activity 2: Modelling RADAR.

Children model the tracking of a rocket by RADAR. Using torches and protractors children estimate the height of the classroom ceiling.

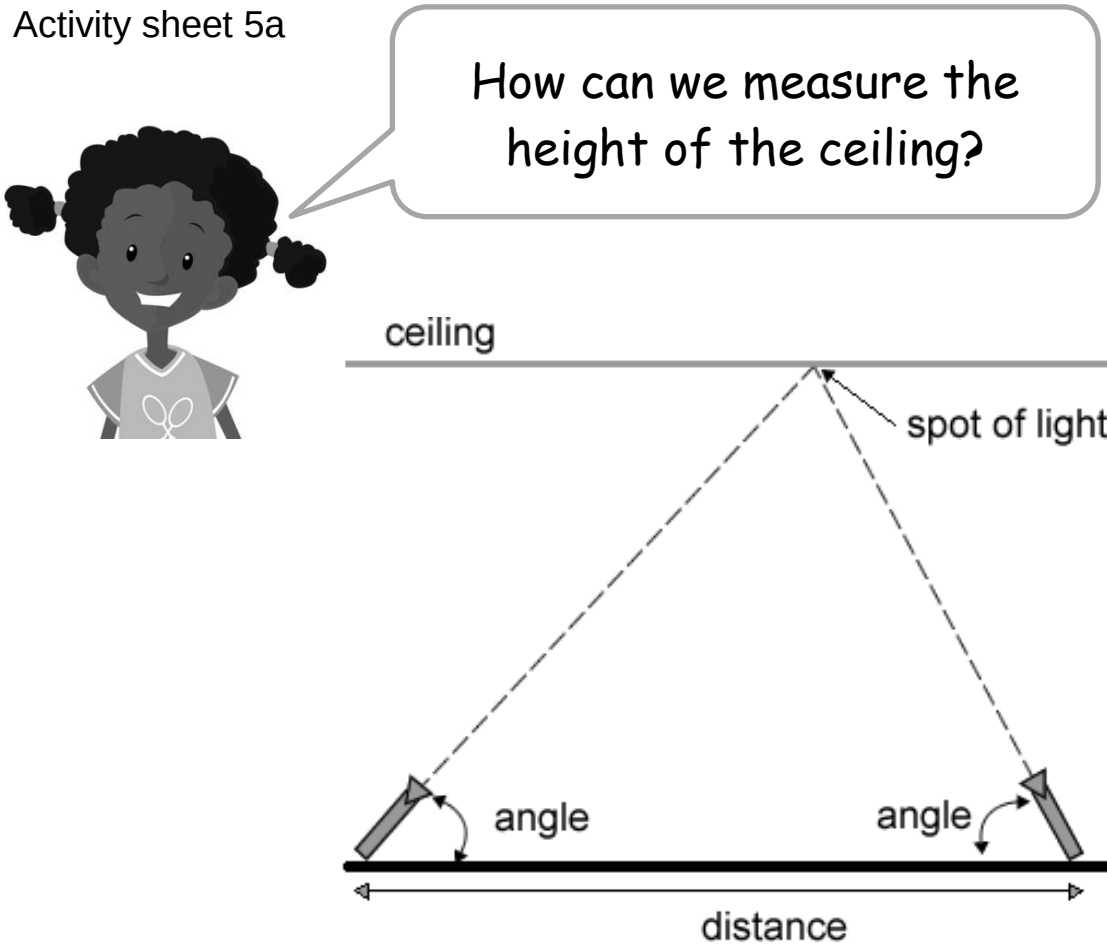
This is achieved by using torches, protractors and metre rule and graph paper to make a scale drawing.

Plenary: Have children discuss the accuracy of the method and how it could be improved.

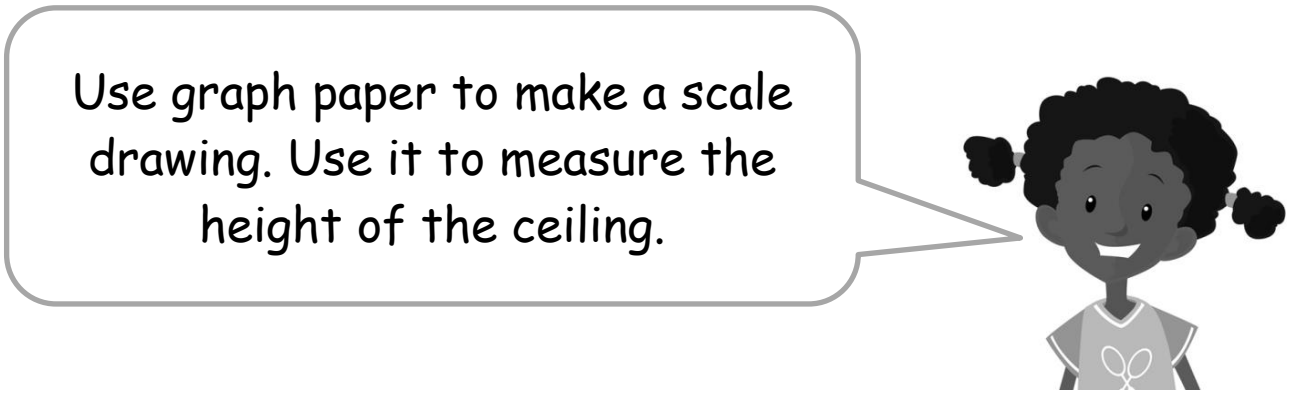
Extension:

Children use data provided to plot a line graph showing the trajectory taken by a rocket during its launch.

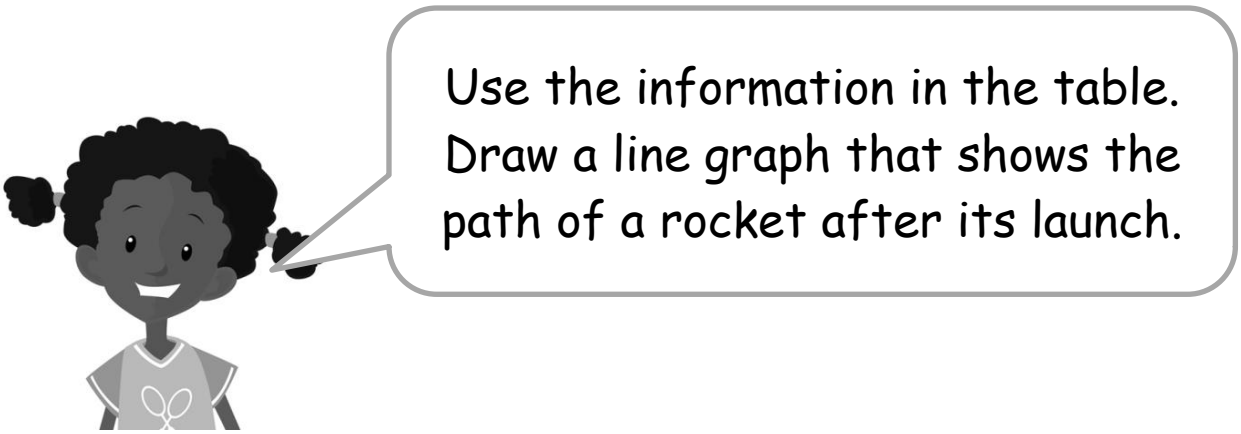
Activity sheet 5a



1. Put your torches on the ground and aim them at the same spot on the ceiling.
2. Measure the angle of each torch and write it down.
3. Measure the distance between the torches and write it down.



Activity sheet 5b -Tracking trajectory



Horizontal distance travelled from launch pad (km)	Height of rocket (km)
0	0
200	120
400	170
600	195
800	210
1000	220
1200	225
1400	225
1600	225

What are the horizontal distances the rocket has travelled when it reaches heights of 50km, 100km, 150km and 200km?

Teacher support information

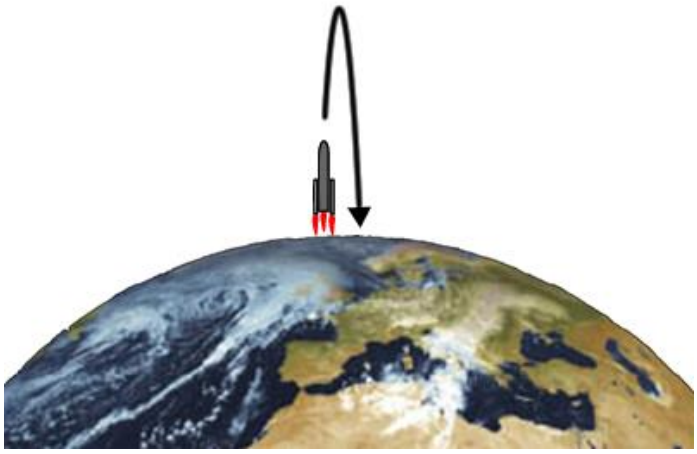
Activity 5 - Tracking lift-off

These notes accompany the section titled ‘Tracking lift off’ to support teachers in carrying out the activities. They provide background information, tips for advance preparation and useful website links for enrichment.

Background information

During a launch, it is easy to think that the rocket just takes-off vertically. This is not the case. It is intuitive that the rocket needs to achieve height in order to reach its orbit, but less obvious is the need to achieve a horizontal movement as well. The diagrams below illustrate this point.

Vertical trajectory
The rocket will rise vertically but once its fuel runs out, will fall back to Earth in the same location. It will not achieve orbit.



Vertical launch but with insufficient horizontal speed
The rocket rises in altitude but again, gravity will pull it back to Earth.



Vertical launch but with sufficient horizontal speed

The rocket attains sufficient altitude and also sufficient horizontal speed. When the rocket engines are turned off, gravity pulls the rocket (or satellite) downwards. However, because of the Earth's curvature, the rocket's horizontal speed means it never hits the ground. The constant pull of gravity ensures it remains moving in orbit around the Earth.





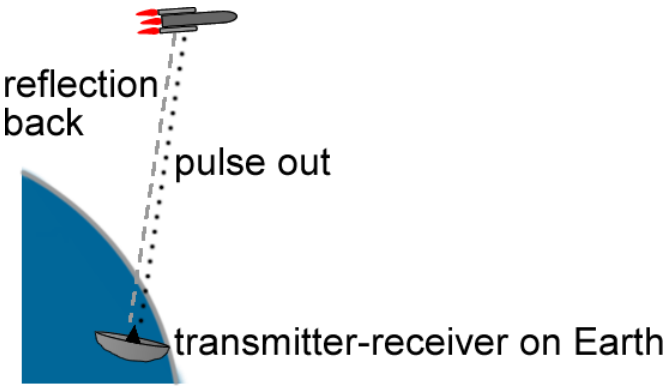
For a satellite to remain in a 200km orbit from the Earth's surface, it needs to achieve a horizontal speed of around 27,000km per hour.

This principle was first suggested by Sir Isaac Newton over 300 years ago. Rather than a rocket, he imagined a cannon ball being fired into the sky and calculated the trajectory it would need to reach orbit. For this reason, the idea is sometimes referred to as 'Newton's cannon.'

Tracking trajectory

During a launch, it is important to track the path or trajectory that the rocket is taking. Deviations from the planned trajectory can suggest a problem.

One way of tracking the rocket is with RADAR. This uses a ground-based transmitter, which sends out a series of radio wave pulses. These hit the rocket and bounce back to a receiver. The position of the rocket can be calculated by knowing the angle of the pulse and the time it takes to go from the transmitter, to the rocket, and back to the receiver. RADAR like this is commonly used to track aircraft in flight.



Activity overview

In this activity, children use video to record and analyse the trajectories of different types of balls as they are thrown in the air. They then consider how a rocket needs to achieve both height and horizontal speed to enter orbit. Finally, children use torches and protractors to model tracking a rocket's trajectory.

Advance preparation

There is very little advance preparation required, other than gathering the necessary equipment:

- Tablet, smart 'phone or camera with video function to make video recordings.
- Selection of balls (e.g. tennis ball, netball, beach ball, table tennis ball).
- Space to throw the balls.
- Torches (with a beam that can be focused if possible).
- Protractors and graph paper.
- Metre rules or tape measure.

Curriculum links and skills

- Forces: understand how gravity acts on an object.
- Measuring angles.
- Representing locations using horizontal and vertical co-ordinates in one quadrant.
- Making scale-diagrams and converting to actual distances.
- Technology and computing: making and analysing video recordings using a tablet computer or video camera.

Lesson introduction

Presentation

Use the presentation to discuss the forces acting on a rocket during its launch, and also the forces acting on a satellite when in orbit.

Slide 1 – Set the scene by posing the question, *"What direction must the rocket take?"*

Slide 2 – Have children suggest what will happen if the rocket is launched vertically. Click the launch button to see what happens. Describe how gravity pulls the rocket downwards and when the fuel runs out, the rocket is pulled back to Earth. Pressing the Launch button again repeats the launch.

Slide 3 – This slide shows what happens if there is insufficient horizontal speed.

Slide 4 – This slide shows how the rocket is pulled into an orbit by gravity when it reaches a sufficient horizontal speed. This slide can be repeated three times.

Slide 5 – This image shows the trajectory that the launch takes and can also be used to illustrate the different stages of the launch. Each stage is jettisoned as it begins to

run out of fuel. These stages fall back to Earth but the payload (satellite or astronauts) continue, pushed on by the next stage in the rocket.
Describe how RADAR can be used to track the trajectory.

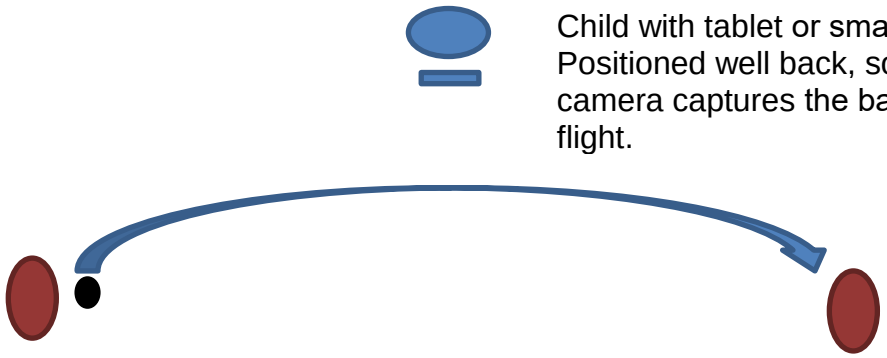
Slide 6 – This image shows the path of a satellite in a polar orbit. As the UK spaceport is quite a way north of the equator, the UK spaceport will be especially useful for placing satellites in this type of orbit.

Activity – investigating the trajectory of an object in flight

This activity should take place in a hall or open space. Ensure that there are no objects that could be damaged as children throw the balls. Carry out a full risk assessment before undertaking the activity.

Have three children work together as shown in the plan view below.

Different sizes and weights of balls can be compared. For example a tennis ball, netball and a beach ball. The throw needs to be a reasonable distance (several metres), so that the video can be analysed. Have the thrower practise a few times to get a consistent under-arm throw.



Child with tablet or smart ‘phone. Positioned well back, so that video camera captures the ball’s full flight.

After a ‘countdown’ the ball is tossed to the receiver.

Receiver catches the ball.

Use the tablet to make video recordings of throws with each of the balls. Make sure that the person recording the throws keeps the tablet still. They should not try to follow the flight of the ball. If a video recorder can be set up on a tripod, this will give even better results. If the camera has a slow motion option, this can be used. To aid with focus, if indoors, have the thrower near a wall.

If it proves too difficult to obtain a good recording, a video file is included which shows the trajectory of a bean-bag filmed on an iPad using the slow motion feature.

Results

Once the recordings have been made, the ball’s trajectory can be analysed in the classroom. The clips can be analysed by the whole class using an interactive whiteboard.

Transfer the video clips so that they can be viewed on the interactive white board or large screen. It is a little tricky but use the timeline controls and pause button to freeze the location of the ball at several points in its flight. Mark these positions.

Do not use anything that may damage or permanently mark the screen. These points can then be joined to record the trajectory of the ball.

If a whiteboard is not available, children can use a piece of clear acetate placed over the tablet screen to carefully mark the positions of the ball in flight. Use a felt-tipped pen and **do not use** anything that could mark or damage the screen.

Plenary - looking for patterns

- *What are the forces acting on the ball once it has been released?*
  Once released, there is no longer a forward push. The main force acting will be gravity pulling downwards. The objects should take a gentle arch (see the video clip provided). Depending on the type, size and weight of the ball, air resistance will have more or less effect. This will be seen with a beach ball.

- *Are the shapes of the trajectory similar?*
  With balls that are heavy, and less affected by air resistance, the trajectories should be the same shape. This is because gravity acts equally on all objects in free flight. The beach ball may 'stall' and fall short because the air resistance is more significant.

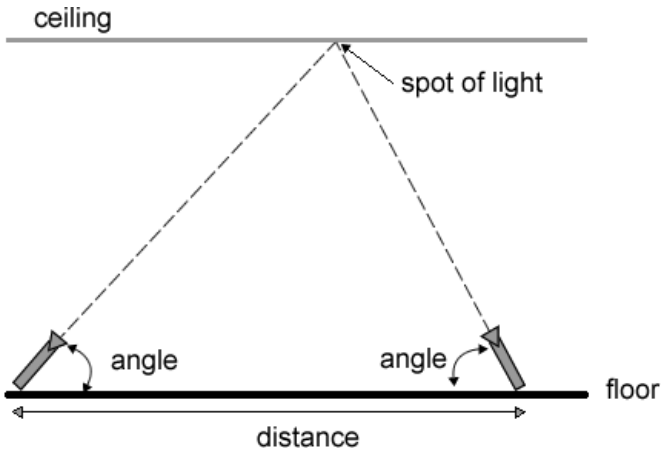
- *Does the weight of the ball make a difference?*
  Two balls of similar size, and thrown in the same way, should follow the same trajectory. This is because gravity acts equally on all objects. If the experiment could be performed in a vacuum, with no air resistance, the beach ball would follow the same trajectory as the netball.

Activity 2: modelling RADAR

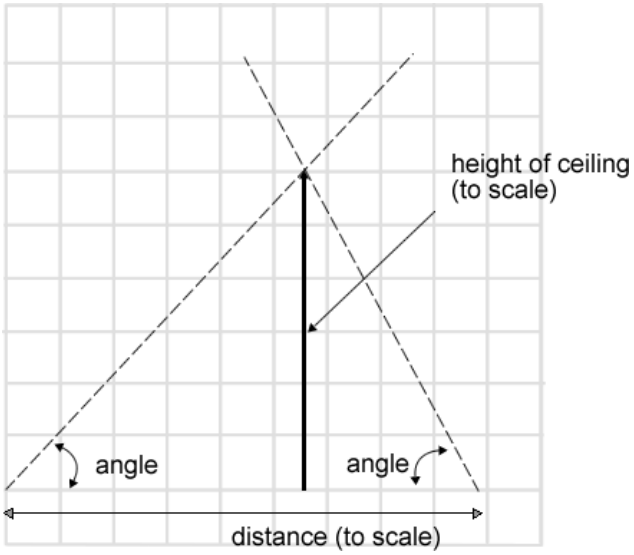
This activity is a good opportunity to discuss the ideas of accuracy and reliability. Working in groups of four, children use torches and protractors to estimate the height of the ceiling on the school hall (or classroom). This models the use of RADAR to monitor the trajectory of a rocket during launch.

1. Each group splits into two and moves a distance apart in the hall.
2. They place their torches on the floor and shine them up to form a spot on the ceiling.
3. Keeping their torches in contact with the floor, each pair adjusts the angle so both spots of light merge as they hit the same spot on the ceiling.
4. Each group then measures the angle their torch makes with the floor.

5. One person measures the distance between the two torches.



6. Draw a scale diagram and use it to estimate the height of the ceiling (right).
7. Results can be combined to get an average height.



Plenary

This activity gives a wide variation in results as getting a true measure of the angles is tricky. It gives children a good opportunity to think about how the accuracy can be improved. For example, repeat measurements at different separations, and the best way to measure the angle as accurately as possible.

Extension: tracking a rocket's trajectory

In this activity, children use the data on the tracking trajectory worksheet to draw a line graph showing the path taken by a rocket during launch.

Cross-curricular links

Science: Forces: understanding how gravity acts on an object.

Maths: Measuring angles, representing locations using horizontal and vertical co-ordinates in one quadrant. Making scale-diagrams and converting to actual distances.

Technology and computing: making and analysing video recordings using a tablet computer or video camera.

Useful links

These water fountain jets follow the same trajectory as a ball in flight. This short video clip shows jets of illuminated water in a commercial water feature.
https://youtu.be/5CNTj4Psr4w

Newton's cannonball thought experiment explained
Short video clip showing the motion of a cannonball. Video quality is not high definition but the narration is very good.
https://youtu.be/ALRdYPMpqQs

06

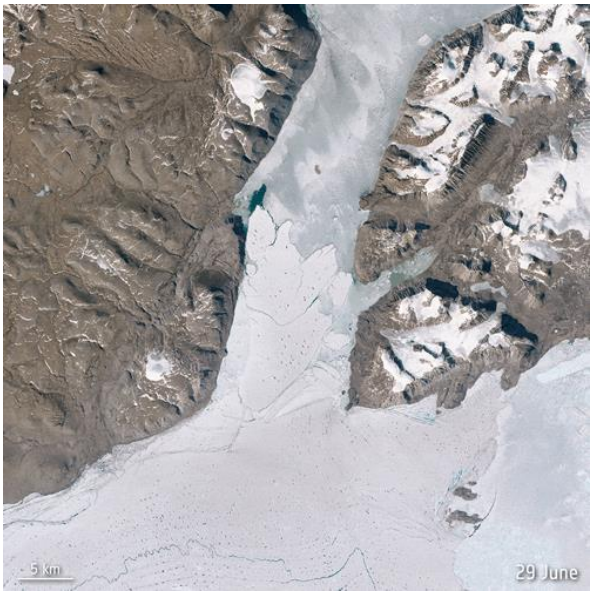
Earth observation

In this activity, children look at images from one of the European Space Agency’s Sentinel satellites.

Earth observation

Context: Satellites in orbit are able to gather an amazing amount of data about the Earth's surface. These Earth Observation (EO) satellites have many uses, such as mapping, monitoring earthquakes, tracking weather systems, seeing the effects of climate change and air pollution.

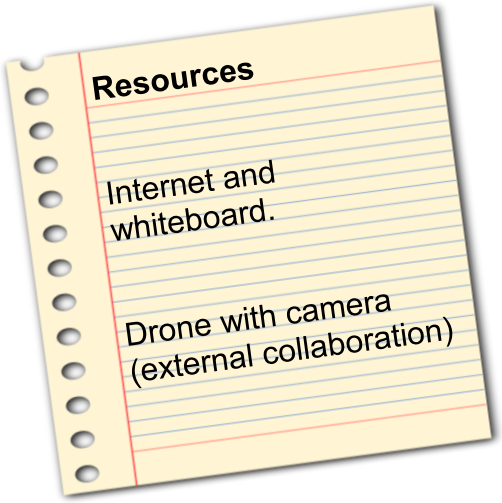
In this activity, children look at images of the school from one of the European Space Agency's Sentinel satellites. An extension activity is suggested in which a 'school selfie' is taken using a remote-controlled drone and camera.





Images showing the break-up of the Greenland ice shelf, showing the effects of rising global temperature.

Images: ESA.



Curriculum links

Geography: Human impacts on the environment.

Develop geographical knowledge of location and place.

Use of digital and computer mapping.

Types of settlement and land use.

Identify topographical features.

Information technology skills.

Maths: Scale and proportion.

Lesson Starter: Introduce the idea of Earth observation (EO) satellites by showing the video clip at: https://youtu.be/NRNtCetfkeg, produced by Surrey Satellite Technology Limited. The clip showcases images from one of their Earth observation satellites, taken from an orbit of around 500km from the Earth. They can see objects down to about 1m in size.

Have children suggest what kinds of features it would be useful to be able to monitor using an EO satellite. The presentation (Earth Observation) uses climate change, weather and air pollution as examples.

Main activity: **using digital mapping**

Use an interactive whiteboard with internet access.

Use the SeDAS web site (http://geobrowser.satapps.org). Use the *Search for Data* tab to the top left of the page and select enter the school's location. Zoom in so that features become recognisable, such as things like markings on the school playground.

Have children think about the size of the objects that are being seen from the satellite in orbit over 500km from the Earth.

Use the scale bar (grey portion in the bottom right corner) to measure the size of school buildings, playgrounds or other visible features.

Plenary:

The children discuss in groups the applications of this type of Earth observation. Feedback examples which could include:

- Data for maps and to keep satellite navigation up to date.
- Monitoring the impacts of climate change.
- Looking at deforestation and agriculture.
- Monitoring natural disasters - forest fires, earthquake damage, floods.
- Tracking pollution in the seas and in the air.

STEM vocabulary:

Orbit

Scale

Detail and accuracy

Extension

This activity gives an opportunity to collaborate with an external partner who can safely fly a remote-controlled drone. These could include: commercial providers of aerial photography, local secondary schools or Police force. It can be used to discuss the work of the partner and demonstrate how mapping data can be collected from a lower altitude.

Gather the class (or more children if available) in the school playground and fly the drone so that the school buildings and children can all be captured in a 'school selfie.'

Teacher support information

Activity 6 Earth observation

These notes accompany the section titled ‘Earth observation’ to support teachers in carrying out the activities. They provide background information, tips for advance preparation and useful website links for enrichment.

Background information

There are thousands of human-made satellites orbiting the Earth that help to deliver services including: communication links; satellite navigation; astronomy; and Earth observation.

Earth observation (EO) satellites gather all types of data. Just a few examples include: mapping; tracking the effects of climate change; viewing agriculture; help with disaster relief; and monitoring air quality.

Satellites are also able to gather data from space. This has the advantage of removing interference from the Earth’s atmosphere. Perhaps the most famous example being the Hubble Space Telescope, which has given us stunning images of the universe.

Satellites play a vital part in monitoring climate change and its effects. Airbus UK has recently (2020) been awarded a contract to prepare a mission to measure the energy coming into the Earth from the Sun, and the light reflected back from Earth’s surface. This will improve our understanding of climate change and human impact on the planet.

A European Space Agency (ESA) project (Copernicus) monitored changes in air quality over many cities during the 2020 Covid-19 pandemic. It was able to show a decrease in air pollutants related to the reduced use of vehicles when people were told to stay at home.

Activity overview

This activity looks at mapping data gathered from orbiting satellites. Children will be familiar with applications such as Google Maps. In this activity, children use data available from **geobrowser.satapps.org** to view the school and locations familiar to them. This gathers data from ESA’s Sentinel satellites.

It also suggests inviting in a parent or external collaborator to use a powered drone, equipped with a camera, to take a ‘school selfie.’ This offers an opportunity to collaborate with local secondary schools or industrial partners, or to invite into school parents who may own a drone.

Advance preparation

Preparation for the first activity simply requires familiarisation with the Sentinel Data Access Service (SeDAS) web site. This provides high quality optical images of the Earth's surface.

1. Navigate to: http://geobrowser.satapps.org
2. Use the *Search for Data* tab to the top left of the page and select the *Type place name* from the drop-down list.
3. Type in the school's location (remembering that you may need to include the country as well.
4. Move the map and zoom in to view the school as seen by the Sentinel satellite in orbit.

Curriculum links and skills

- Human impacts on the environment.
- Developing geographical knowledge of location and place.
- Use of digital and computer mapping.
- Types of settlement and land use.
- Identifying topographical features.

Lesson introduction

Introduce the idea of Earth observation (EO) satellites by showing the video clip at: https://youtu.be/NRNtCetfkeg Surrey Satellite Technology Limited is a world-leading company in the production of small satellites. The clip showcases one of their Earth observation satellites in action and shows amazing detail of cities around the world. Remember to stress that these images are being taken by cameras in orbit around 500km from the Earth. They can see objects down to about 1m in size.

Have children suggest what kinds of features it would be useful to be able to monitor using an EO satellite. Suggestions will be varied, so use the presentation to show some real-life examples. These include:

- Changes in vegetation, glaciers or ice sheets to look at climate change.
- Monitoring temperatures at the Earth's surface.
- Weather patterns and clouds to help weather forecasters.
- Tracking deforestation.
- Air quality monitoring.

- Gathering images for maps.

Click forward and backwards through the slides to show the changes. The examples are:

Spalte glacier, Greenland

Four Copernicus Sentinel-2 images captured between 29 June and 24 July 2020, shows the break-up of a segment of the largest ice shelf in the Arctic.

With climate change, the ice shelf has retreated by about 23 km since 1990, with the rate increasing over warmer summers.

Mediterranean hurricane

The Copernicus Sentinel-3 mission captured this image of the Mediterranean hurricane, crossing the Ionian Sea and approaching Greece. It brings hurricane-force winds and heavy rain. Mediterranean hurricanes can form over cool waters and move from west to east.

Monitoring air pollution

The final two slides show data from the Copernicus Sentinel-5P satellite and shows the average nitrogen dioxide concentrations from March to April in 2019 (normal activity) and March to April 2020 (Covid pandemic lockdown). The effects of reduced traffic during the lockdown is seen in the decrease of nitrogen dioxide air pollution.

Activity: using digital mapping

Use the SeDAS web site (http://geobrowser.satapps.org) to show a satellite's view of the school. Zoom in so that features become recognisable, especially things like markings on the school playground. Have children think about the size of the objects that are being seen from the satellite in orbit over 500km from the Earth.

The display has a scale bar (grey portion in the bottom right corner) which can be used to measure the size of school buildings, playgrounds or other visible features.

Plenary

Go outside with the children to look at these features on the ground and talk about how amazing it is to be able to see these from orbit.

Children in groups discuss the applications of this type of Earth observation. Feedback examples might include:

- Data for maps and to keep satellite navigation up to date.
- Monitoring the impacts of climate change.
- Looking at deforestation and agriculture.
- Monitoring natural disasters - forest fires, earthquake damage, floods.
- Tracking pollution in the seas and in the air.

Extension activity: Taking a school selfie by drone

Applications such as Google maps use both satellite data and also images from aircraft and drones to give detail from a lower altitude.

Whilst not at the same altitude as the Earth observation satellites, this activity requires a person with a remote-controlled drone. It provides an opportunity to collaborate with local commercial providers of such services to come into school and talk about their work. Or collaboration with a local secondary school that may have access to a drone. Your local STEM or Space Ambassador may be have access to a drone, or your local Police force may have a drone operator who could be contacted.

Gather the class (or more children if available) in the school playground and fly the drone so that the school buildings and children can all be captured in a 'school selfie.'

Ensure that the drone operator is fully certified, has any necessary insurance and is competent. Perform a full risk assessment before carrying out any activity.

- The Civil Aviation Authority (CAA) has a list of authorised commercial drone operators (search 'CAA drone operators').
- A search for local aerial photographers will show commercial operators in your area.
- A company, at https://dronesaferegister.org.uk , provides a searchable database of their registered users.

Cross-curricular links

Science: Understanding human impacts on the environment.

Geography: Develop geographical knowledge of location and place, use of digital and computer mapping, types of settlement and land use. Identify topographical features.

Art: consider perspectives and have children draw a bird's eye view of a scene.

Useful links

NASA Earth Observatory
https://earthobservatory.nasa.gov

How things work: environmental satellites
Useful article for teacher giving background information on earth observation satellites.
https://ourworld.unu.edu/en/how-things-work-environmental-satellites

Video explaining how earth observation satellites work
Quite technical but good for teachers. Children may benefit from up to about 2mins10seconds.
https://www.youtube.com/watch?v=EnF_ljgk3gk

07

Design a UK spaceport

In this activity, children take on the role of architects to design and make a plan of a new UK spaceport.

Design a UK spaceport

Context: Spaceports are rather like airports except space craft are launched from them. Europe's Spaceport is in Kourou, French Guiana but the UK is planning to build its very own spaceports to launch rockets carrying satellites into space. In this activity, the children are introduced to the main features of a spaceport, interpret symbols and keys and take on the role of architects to use imagination and creativity to design and make a plan of a new UK spaceport. An extension to the session allows for the construction of a model spaceport based on these plans.



ESA : Kourou Spaceport, French Guiana

Curriculum links & skills

Science: Solar system, Earth orbit, gravity

Design technology Designing, making, evaluating **English:** describing**,** communicating, explaining, reading for information, presenting **Geography** locations, directions**,** using maps and keys, drawing plans and symbols

Resources

- Activity sheet 7a
- Globe
- Maps of the world
- Access to internet/tablets
- Paper
- Glue sticks
- Jotters or whiteboards
- Power point 7showing Europe's spaceport

Extension activity:
Recycled 'junk' materials to build model spaceport



Image Wikimedia/Spotting973 (CC-by-SA 2.0). Ariane V rocket launches from Kourou

Lesson Starter: *Do the children remember what a spaceport is*? Soon the UK will be launching rockets and spaceplanes carrying its own satellites into space from spaceports in the UK! Explain that there are spaceports in different countries around the world, such as the USA and Russia and Europe has a spaceport in Kourou, French Guiana in South America. Show Powerpoint slide 2.*Can the children find South America, French Guiana and the UK on the map and globe?* Mark the two locations on the globe using cocktail stick flags attached by stickytack. Rockets launch to the East from the Kourou spaceport gaining some extra speed from the Earth's own West to East rotation. Demonstrate Earth's rotation by spinning the globe anticlockwise. Explain that spacecraft launching from the UK will enter a polar orbit and travel over the Earth from North to South. As the UK is nearer to the North Pole, it is ideally positioned for launching satellites into polar orbits. The animations on slide 3 and image on slide 4 show polar orbits.
https://commons.wikimedia.org/wiki/File:Polar_orbit.ogv

Main activity Explain that today the children will take on the role of architects, commissioned by the UK Space Agency to design a new spaceport for the UK. They are to use imagination to produce plans for a future spaceport; these plans can be creative but must include key features. This short video link on slide 5 https://www.funkidslive.com/learn/deep-space-high/spaceports/will-spaceports-look-like/# explains that traditionally, rockets launch vertically from launch pads but spaceplanes as well as rockets can also be launched; they take off horizontally using long runways. *What kind of features might you see in a spaceport?* After discussion, show PowerPoint 7 slides 6-18 featuring images from Kourou spaceport. Text on each slide explains each feature. Throughout, discuss which might be included in a future UK spaceport. Notes under each slide provide further details for teachers' use. Next, look at Activity sheet 7a that has examples of features that might be found at a spaceport. Ask *Which features are essential? Which are desirable but not essential?* The children then begin to discuss their ideas for designs for a UK spaceport. They may wish to draw its outline on a large sheet of paper, perhaps adding roads, rail links and a port. They could draw a picture or symbol on each of the cards that they wish to use from Activity sheet 7a, cut them out and position them on their plan. Encourage the children to add their own ideas. They should remember to add a key to their plans, explaining any symbols or features drawn. Teachers may wish to extend the lesson or plan a second session to allow time for building models from the spaceport designs. The teacher support notes provide further information and a template for a certificate that could be awarded for each completed plan.

Plenary: The children present their spaceport designs and explain the key features and symbols included. Show the plans of the Kourou spaceport site and artist's impression of a UK port on slides 19-21. *How similar are their designs? Would they change their plans? If so, what would they change and why?* Remind the children of the benefits of launching satellites from UK sites as the UK is ideally positioned geographically for polar orbits. Conclude by showing slide 22 featuring some exciting spaceport designs from around the world: https://edition.cnn.com/style/gallery/spaceports-spc-intl/index.html?gallery=%2F%2Fcdn.cnn.com%2Fcnnnext%2Fdam%2Fassets%2F200910153945-03-spaceports-houston.jpg



Artist impression of a spaceport © UK Space Agency

Extension and further activities:

Build a model spaceport using your design.

Use the internet to learn more about spaceports around the world.

Write a newspaper report describing the opening of a new UK spaceport.

Design a brochure to advertise a new spaceport

If you could work at a UK spaceport what job would you do and why?

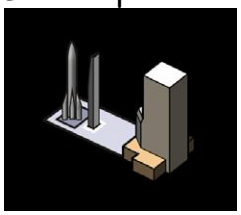
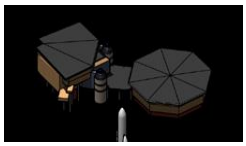
STEM/ vocabulary

Fuel, launch pad, vertical, horizontal, vibrate, orbit, equatorial, polar, spin, spacecraft, spaceplane, spaceport

Activity sheet 7a



Use these cards to help you design a spaceport for the UK. You can add your own ideas too.

Launch pad 1 	Rocket booster preparation building	Rocket booster engine test site	Rocket fuel storage
Fuel mixing	Fire engines	Medical unit	Vehicle to pull the rocket
Mission control 	Satellite preparation building	Water tower	Telescopes
Administration	Weather station 	Long runway	Final rocket assembly
Technical centre	Viewing area	Hotel	Education centre
Shops	Restaurant	Museum	Souvenirs

Teacher support materials

Activity 7 Design a UK spaceport

These notes accompany the activity titled ‘Design a UK spaceport’ to support teachers in carrying out the activities. They provide background information, tips for advance preparation, opportunities for cross curricular links and useful website links for enrichment.

Background information

Spaceports are places where space craft are launched into space. They are positioned sufficiently far from populated areas or bystanders, in order to avoid risk should the launch fail. Proximity to water is a key consideration, to ensure that any rocket components potentially fall into water and not on populated areas. There must be a supply of fuel and storage facilities plus transport links for essential supplies. Many spaceports around the world make use of existing airport facilities, particularly runways. Most spaceports are situated near to the equator to enable rockets to take advantage of the spin of the Earth at these latitudes to accelerate into higher orbits. However, the UK is in an ideal position to launch rockets into polar orbits.



© UK Space Agency Image shows an artist impression of a future UK spaceport

Spaceports require not only launch pads but other key buildings such as warehouses, tanks for storing rocket fuel, places for building the different stages of the rockets, laboratories for testing, a control centre for managing launches and

medical and fire engine facilities should accidents occur. A visitor centre would enable spectators to watch a launch.

Advance preparation

Have a globe of the World available plus two small flags on cocktail sticks to attach to the globe with sticky tack.

Prepare a set of Activity sheets 7a for each group or individual.

Provide sheets of paper large enough to allow the children to draw an outline of a spaceport and position the small cards and symbols to the plan.

Upload the PowerPoint 7 showing polar orbits, a world map, Europe's spaceport in French Guiana and a link to future spaceport designs.

Become familiar with the key areas of the site and notes shown on the PowerPoint. You may wish to watch the link to the introduction to the Europe's spaceport (see useful website links) prior to the lesson.

Provide tablets or access to the internet

Print out a set of certificates for awarding to the children on successful completion of their plans

Curriculum links and skills

- Use a model to demonstrate direction of rotation of Earth on its axis.
- Identify locations on maps and plans.
- Use creativity and imagination to design, draw plans, keys and symbols.
- Evaluate and adapt plans.

Lesson Starter

Remind the children that spaceports are a bit like airports, except rockets can be launched from them. The UK is planning to build its own spaceports to launch rockets carrying satellites into space but currently, UK satellites are launched from Europe's Spaceport in Kourou, French Guiana, on the North Atlantic coast of South America. Challenge the children to find South America and French Guiana and the UK on the world map on slide 2 of the preloaded PowerPoint. One of the children could place a small flag on the globe to mark the position of French Guiana. Kourou is located at the equator. A second volunteer could mark the position of the UK. The Earth spins on its axis from West to East, and at the equator, Earth is travelling at a speed of approximately 1,000 miles/hour or 460 metres/second. Satellites launch from Kourou towards the East and benefit from the extra push from the Earth's spin. Demonstrate the Earth's spin by spinning the globe anticlockwise. Explain that since the UK is in the northern hemisphere, it is ideally positioned to launch rockets carrying satellites designed to



orbit Earth in polar orbits i.e. travelling around the Earth from North to South. Show the children the animations/videos of polar orbits on slide 3. Here are the links from the slides: https://svs.gsfc.nasa.gov/10372

https://commons.wikimedia.org/wiki/File:Polar_orbit.ogv

Teachers may also like to show the children a gif of a polar orbit by using the following link: https://spaceplace.nasa.gov/review/geo-orbits/poes.en.gif



Slide 4 shows an image of sun synchronous polar orbit (A sun synchronous orbit means a satellite passes over the same place on Earth at the same time each day) : https://www.esa.int/var/esa/storage/images/esa_multimedia/images/2020/03/polar_and_sun-synchronous_orbit/21862754-4-eng-GB/Polar_and_Sun-synchronous_orbit_article.png

Main activity

Explain that today the children are going to take on a challenge to design a new spaceport for the UK. *Do they know what we call people who design new buildings, creating plans and detailed drawings?* Some may know the term 'architect'. They will be architects for this task. *Can they suggest what you might see at a spaceport?* This fun, short 3m 43s video link on slide 5 explains what future spaceports might be like: https://www.funkidslive.com/learn/deep-space-high/spaceports/will-spaceports-look-like/#

Explain that they are now going to have a look at photos of Europe's spaceport in order to help them to understand key features and to help them with their own designs.

The images of the key areas from the Kourou spaceport and notes for the children are shown on slides 6-18. Notes *under* each slide are provided as extra background information for teachers. Encourage the children to think about what might be important in a future UK spaceport, whilst briefly explaining the key areas including

the rocket launch area, the satellite (payload) preparation area, rocket final assembly, fuel production and storage, hydrogen and oxygen gas plant, and control centre. Other areas are also important in a spaceport such as a weather station and telemetry and tracking area (for observing or tracking the rocket path after launch). The Kourou site covers 700 square kilometres and comprises the launch range, three operational launch complexes with another under development for a new rocket Ariane 6, and propellant manufacturing plants. (Rockets use what is known as propellant, a mix of fuel and oxygen and turn it into hot gas which pushes the rocket forward. Some rockets use solid fuel, some use liquid fuel and others use a combination of the two. Liquid oxygen or hydrogen is used to burn the engine fuel in a combustion chamber).

UK spaceports will use vertical launch pads but some will also launch spacecraft using long runways. *If they were designing a new spaceport in UK, what would they include? What exciting areas would they plan for visitors? Satellites are built in the UK. Maybe their spaceport will have satellite making businesses? Can they include a key with their plans?*

The children use the mini cards on Activity sheet 7a to choose which features they would include in their new design. Some are essential for a spaceport such as the fuel storage and mixing areas and the launch pads. Others such as shops or museums are non-essential but would greatly add to the spaceport, creating a visitor attraction, jobs and educational opportunities. A successful UK spaceport could become a popular visitor attraction in the future and a hub for innovation and science. The children should be encouraged to be creative and add their own ideas to the set. They could draw images or symbols on the cards, before cutting them out and positioning them on their plan drawn on a large sheet of paper.

Plenary

The spaceport plans can be displayed and used for discussions. *Can the children interpret the symbols or drawings used in the designs of others? Can they suggest improvements to the plans?* The designs can be compared and contrasted with the Kourou site plans on slides 19, 20 and artist's impression shown on slide 21. Spaceports of the future may well be very different from those we can see today. Follow the link on slide 22: https://edition.cnn.com/style/gallery/spaceports-spc-intl/index.html?gallery=%2F%2Fcdn.cnn.com%2Fcnnnext%2Fdam%2Fassets%2F200910153945-03-spaceports-houston.jpg to show some very creative and futuristic designs from around the world. This link features others from Japanese architects https://edition.cnn.com/style/article/spaceport-city-japan-spc-intl/index.html

Certificates could be awarded once all the plans have been finalised. A sample certificate may be found here in the teacher support notes. Finally, remind the children of the unique geographical advantage of building UK spaceports, as rockets can launch safely north over the sea to release satellites in a polar orbit.

Extension and further activities

If time allows, the children could proceed from designing to constructing models of their spaceports. Alternatively, a second session could be planned. A wide variety of recycled model making materials should be collected in advance.

Cross curricular links

The activity provides opportunities for further research and practical investigations in several areas of the curriculum, including:

Science: model rocket launching activities provide opportunities for using science skills of measuring, collecting and displaying data, pattern seeking and fair testing.

Geography: comparing two contrasting locations-the UK and French Guiana; looking at the climate, topography and animal life.

English: communicating, presentations, debates, explanations, reading for interest, research and gathering information, writing for different purposes and in different styles.

Useful website links

The European Space Agency has a wealth of information, a section for teachers and a very informative and interactive website for children

http://www.esa.int/Education https://www.esa.int/kids/en/home

NASA provides a wide range of ideas for teachers and children plus an image gallery

https://www.nasa.gov/ https://www.nasa.gov/stem/image-galleries

This video from UKSA explains what spaceports are.

https://youtu.be/f1SQoe5spXo

'Fun Kids High' with support from UKSA; a children's video about spaceports
https://www.funkidslive.com/learn/deep-space-high/spaceports/will-spaceports-look-like/#

This video introduction and tour of the Kourou spaceport on slide 7 is more appropriate for teachers, but sections would interest the children. Tour the Kourou site:
https://www.esa.int/ESA_Multimedia/Videos/2019/12/Europe_s_Spaceport_in_French_Guiana#.X5rMCpr4EQk.link

Facts about French Guiana may be found here:

https://en.wikipedia.org/wiki/French_Guiana



Certificate of Achievement



For completing a design for a UK spaceport

Awarded to _____

Signature _____ Date _____

UK SPACE AGENCY

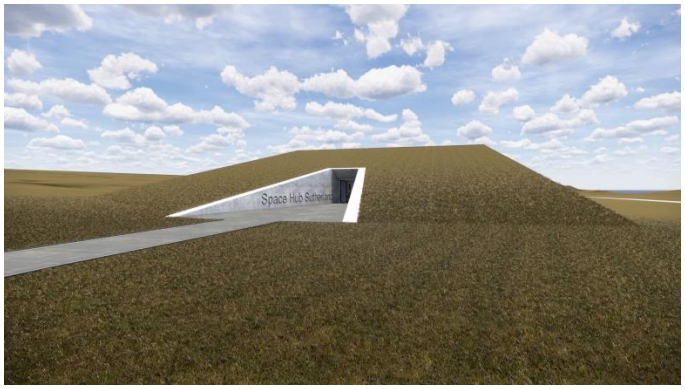
08

Launch day!

In this activity, children look at the events leading up to a satellite launch and perform a role play or school assembly to celebrate the future launch of the first satellite from a UK spaceport.

Launch day!

Context: The children are reminded that the UK is to develop its own spaceport to launch satellites from UK soil. They listen to a short podcast that describes the variety of jobs that a UK spaceport of the future could offer and play a 'match the job title to the job' game. Next, they sequence the order of events leading up to a satellite launch. They learn that they will be holding a special event, taking the form of a play or school assembly to celebrate the future launch of the first satellite from a UK spaceport. They begin to think about and plan the future celebration event.



Artist impression of entrance to Space Hub Sutherland.

Resources

- Set of spaceport job cards per group, plus one class set
- Set of launch sequence cards per group plus one class set
- Class set of event scripts
- Access to whiteboard and internet
- Jotters or whiteboards

Curriculum links & skills

Science: Earth orbit, gravity, science careers.

English: communicating, explaining, reading for information, sequencing, presenting.



Image: Wikimedia/Spotting973 (CC-by-SA 2.0). Ariane V rocket launches from Kourou

Lesson Starter:

Remind the children that the UK is going to build its own spaceport to launch satellites into space. This will be very exciting and create lots of jobs. Ask the children to listen carefully to this short podcast that describes a spaceport of the future and challenge them to remember as many different kinds of jobs as they can:
https://www.funkidslive.com/learn/deep-space-high/spaceports/jobs-uk-spaceports/
Make a list of jobs from the children's feedback. *Were they surprised to hear about how interesting a spaceport might be and how many different types of jobs it could provide?*
Let's find out a bit more about the wide variety of jobs at a future UK spaceport. Explain that the next activity challenges the children to match a job title with its description.

Main activity

Give a set of job title and role description cards from Activity sheet 8a to each group. Their challenge is to decide which job matches each description and match all the pairs. Finally, after feedback from the groups, reveal the matching pairs. *Did they find any difficult to match?* As reinforcement, a follow up 'find your partner card match game' may be played (see teachers' support notes). Next, show the children the video of the launch of satellite MSGS-4 from ESA's spaceport in French Guiana https://www.esa.int/ESA_Multimedia/Videos/2015/07/MSG-4_liftoff Explain that they are now going to learn the order of events and discover what each member of a spaceport team does in the lead up to, and on the day of, a launch. Remind them that in the previous lesson they saw images of the key areas of a spaceport used when launching satellites. Provide each team with a set of cards from Activity sheet 8b outlining different stages of a rocket launch. *Can they work together to sequence the stages from beginning to end?* After discussion, the groups try to put the cards in order. When they have completed the challenge, ask some children, each holding a card, to stand at the front of the class. The class provides suggestions to get them to stand in the correct order. Finally, reveal the correct sequence (see teachers' support notes). *Did the groups agree?* A successful launch requires good teamwork and cooperation. *Do they think they could work together to put on a play or assembly for their school to celebrate what that first satellite launch day from a UK spaceport might be like?*

Plenary: End the lesson by reading together the suggested script for a UK satellite launch day celebration (see Appendix). The script provides an opportunity to revise the stages of a satellite launch and to emphasise again the variety of jobs and the business opportunities offered by a new UK spaceport. The children begin to think about which characters they would like to be and why. Alternatively, teachers may wish to have the children compose their own play script in a separate session.



Mission control team Rosetta mission.

Image: ESA

Extension and further activities:

The children could work in groups to compose additional or alternative scripts or dialogue for the launch event.

Whom would they invite to a UK spaceport launch event and why?

Can they think of any other jobs that might be needed at a UK spaceport?

What science information might the first UK satellite collect after it is launched?

STEM/ vocabulary

Fuel, launch pad, mission control, satellite, boosters, countdown

lift-off

Activity sheet 8a Spaceport Jobs

Operations Director	I start the launch sequence.	**Flight Director**	I give the go ahead for a launch.
Satellite engineer	I design and test satellites of all shapes and sizes.	**Space scientist**	I design experiments for the satellites.
Visitor centre manager	I welcome visitors to the spaceport.	**Chef**	I cook meals in the restaurant.
Technical Director	I support all the engineers and computer staff.	**Communications manager**	I tell everyone about the spaceport.
Rocket systems engineer	I make sure all the different parts of the rocket work well together.	**Rocket propulsion specialist**	I work on rocket and plane engines, fans and turbo jets.
Spaceport Director	I am in charge of everything at the spaceport.	**Electrical engineer**	I check the electrical connections.
Mechanic	I help repair vehicles.	**Fuel delivery driver**	I bring the rocket fuel to the spaceport.
Health and Safety manager	I make sure the spaceport is safe.	**Administrative officer**	I work in the offices at the spaceport.
Computer technician	I keep the computers working.	**Meteorologist**	I study weather conditions at the spaceport.
Logistics manager	I work out how to fit everything inside the rocket.	**Air traffic control**	I make sure that planes can take off and land safely.

Activity Sheet 8b Stages of a satellite launch

The rocket boosters are tested at the Booster Test Engine stand.	The rocket main section is filled with fuel and the rocket boosters are filled.	The satellite and electrical connections are tested and the satellite is taken to the filling area.
The satellite is driven to Final Assembly building to be loaded onto the rocket.	The upper part of the rocket with the satellite inside is given a final check and filled with fuel.	The upper part of the rocket is attached to the lower part of the rocket.
The rocket is placed on a platform, pulled along to the launch pad and put into position ready for launch.	Liquid oxygen and liquid hydrogen are pumped into the rocket engine through big pipes.	Water is poured onto the launch pad to cool the area.
The Flight Director checks the weather conditions, checks the launcher and satellite are ready and gives the go ahead to start the launch.	The Spaceport Director checks with health and safety at the launch pad and decides it is safe to launch.	The Operations Director starts the launch sequence.
Lights on the control board turn green. The engines are switched on and final countdown starts. Lift-off!	After lift-off, the Director of Operations reports on the separation of the boosters and ignition of the final stage of the rocket.	The Director of Operations can announce that the mission has been successfully completed.

Teacher support materials

Activity 8 'Launch day!'

These notes accompany the activity titled 'Launch day!' to support teachers in carrying out the activities. They provide background information, tips for advance preparation, opportunities for cross curricular links and useful website links for enrichment.

Background information

A future UK spaceport has far-reaching benefits, supporting local businesses and providing jobs, not only for local people but across the UK, generating income for the local and national economy. A spaceport could create a vibrant technology hub attracting space-related companies such as satellite manufacturers and could inspire young people to consider the wide range of space-related careers. Launching rockets and space planes carrying satellites requires the cooperation of many people with a variety of key skills.

"*On launch day, a team of up to 150 people may be at the centre, carrying out final checks and controls before lift-off. All the team must carry out their well-defined roles with precision". ESA*

The Flight Director is responsible for deciding that the launch can go ahead, after checking the launcher and the satellite are ready and the weather at the launch pad is just right.

The Director of the Spaceport will authorise the launch having checked that all the technical components of the launch area are working perfectly and that all the Health and Safety requirements have been met.

The Director of Operations coordinates the launch sequence and the final countdown. Once all the lights on the control board turn green, he or she announces the start of the automatic seven minute final launch sequence.

Immediately after the green light signals that everything is working correctly on the launcher, the final seven minutes of the synchronised countdown begin. After that, the process runs automatically and no further human intervention is possible.

After lift-off, the Director of Operations reports on the status of the main events that were started automatically, such as the separation of the boosters and the ignition of the upper stage.

Once the satellite on board the launcher is safely in orbit in space, the Director of Operations can announce that the mission has been successfully completed.

Here is the sequence of main events on the day of a satellite launch.

- The rocket boosters are tested at the Booster Test Engine stand.
- The rocket main section is filled with fuel and the rocket boosters are filled.
- The satellite and electrical connections are tested and the satellite is taken to the filling area.
- The satellite is driven to Final Assembly building to be loaded onto the rocket.
- The upper part of the rocket with the satellite inside is given a final check and filled with fuel.
- The upper part of the rocket is attached to the lower part of the rocket.
- The rocket is placed on a platform, pulled along to the launch pad and put into position ready for launch.
- Liquid oxygen and liquid hydrogen are pumped into the rocket engine through big pipes.
- Water is poured onto the launch pad to cool the area.
- The Flight Director checks the weather conditions, checks the launcher and satellite are ready and gives the go ahead to start the launch.
- The Spaceport Director checks health and safety at the launch pad and decides whether it is safe to launch.
- The Operations Director starts the launch sequence.
- Lights on the control board turn green, the engines are switched on and final countdown starts. Lift-off!
- After lift-off, the Director of Operations reports on the separation of the boosters and ignition of the final stage of the rocket.
- The Director of Operations can announce that the mission has been successfully completed.

Activity overview

The children listen to a short podcast that describes a spaceport of the future and play a ‘match the job title to the job’ card game. The children watch a short video of the launch of a satellite from ESA’s spaceport and are reminded that the UK is to develop its own spaceport to launch satellites from UK soil. They recall learning about the key areas of a spaceport, covered in Activity 7 and use information in a card sort activity to sequence the order of events leading up to a satellite launch. They learn that they will be holding a special event, taking the form of a play or school assembly to celebrate the future launch of the first satellite from a UK spaceport. They begin to think about planning for the celebration event and read together a suggested script.

Advance preparation

a) Class session

Prepare a set of job title and job description cards from Activity sheet 8a for each group plus one class set.

Prepare a set of launch sequence cards for each group from Activity sheet 8b plus one class set.

Prepare to follow the link to the podcast: https://www.funkidslive.com/learn/deep-space-high/spaceports/jobs-uk-spaceports/

Load a video of a satellite launch: https://www.esa.int/ESA_Multimedia/Videos/2015/07/MSG-4_liftoff

Print the celebration event scripts.

b) Launch event celebration

Have available a hand held microphone or use voice recorders or tablets.

Load the short video of ESA Ariane V rocket launch https://youtu.be/nMFotrkgF-w

Load a countdown with sound video such as this: https://youtu.be/9HfzcqeS2SU

Print copies of the script.

Position a few props if required.

Curriculum links and skills

Science: Space, forces, gravity; space-based careers.

Reading for information, interpreting, sequencing.

Speaking: communicating, explaining, presenting to different audiences.

Lesson Starter

Remind the children that the UK is going to build its own spaceport to launch satellites into space. This will be very exciting and create lots of jobs. Ask the children to listen carefully to this short podcast that describes a spaceport of the future and challenge them to remember as many different kinds of jobs mentioned as they can: https://www.funkidslive.com/learn/deep-space-high/spaceports/jobs-uk-spaceports/. After the podcast, use the children's feedback to make a list of jobs on the whiteboard or flip chart. *Were they surprised to hear about how interesting a spaceport might be and how many different types of jobs it could provide?* The podcast mentions the possibility of space tourism flights to low Earth orbit but initially, most launches will carry satellites into space. In order to discover a bit more about the wide variety of jobs a future UK spaceport could provide, explain that the next activity challenges the children to match a job title with a role descriptor.

Main activity

Give a set of job title and role description cards from Activity sheet 8a to each group and explain that some of the cards have the name of a job at a spaceport whilst the others have a short description of a job. There are twenty jobs in total. Their challenge is to decide which job matches each description and match all the pairs. Allow time for discussion within the groups. Some children may need support with some of the text. Finally, after feedback from the groups, reveal the matching pairs. *Did they find any difficult to match?*

(*As an optional reinforcement activity, using an additional class set of job cards, the children can play 'find their partner' game. Distribute the spaceport job cards or have the children pick a card from a box. Depending on class size, some children may need to take a second card until all are allocated. Alternatively, reduce the number of cards to match the number of children in class but ensure that each job title card has a matching descriptor. Can the children find their partners by matching job to correct descriptor? This activity can be done in the school yard or in the hall if space is lacking in the classroom).*

Explain that all the jobs they have just matched are important at a spaceport. Lots of people must work together as a team in order to successfully launch a spacecraft. Next, show the children the video of the launch of ESA's Meteosat Second Generation satellite MSGS-4 from ESA's spaceport in Kourou, French Guiana https://www.esa.int/ESA_Multimedia/Videos/2015/07/MSG-4_liftoff

or watch this video clip from the Kourou control centre on the day of the exoplanet-hunting CHEOPS satellite launch; this is a useful clip for showing many people in the control room and others in the viewing gallery: https://www.esa.int/ESA_Multimedia/Videos/2019/12/Launch_highlights_Cheops_and_OPS-SAT

Point out the number of people in the control centre shown in the video. Discuss the organisation and preparation required for a launch. Emphasise the skills, teamwork and number of different jobs involved. Remind the children that the UK spaceport will require many such jobs too.

Explain that they are now going to learn the order of events and discover what each member of a spaceport team does in the lead up to, and on the day of, a launch. Remind them about the previous lesson showing the key areas of a spaceport used when launching a satellite. Provide each team with a set of cards from Activity sheet 8b outlining different stages of a rocket launch. *Can they work together to sequence the stages from beginning to end?* After discussion, the groups try to put the cards in order.

When they have completed the challenge, ask volunteers to stand at the front of the class and give each a card from the additional class set of cards. Ask the rest of the class to help you to sort the children into the correct order. Finally, if necessary move the volunteers into the correct sequence (see the sequence earlier in these support notes). *Did the groups agree?*

A successful launch requires good teamwork and cooperation. *Do they think they could work together to put on a play or assembly for their school to celebrate what that first satellite launch day from a UK spaceport might be like?* Explain that in this play, they are going to become the spaceport team. The spectators or visitors will be the children, teachers, parents and governors from school and perhaps even

representatives from the local newspaper or radio could be invited. In addition to the spaceport team, some of the children will take on the role of space experts such as astronaut Tim Peake and the part of interviewers from local radio and television, asking visitors for comments on proceedings!

Plenary

End the lesson by reading together the suggested script for a Launch day celebration provided in the Appendix. During the reading, emphasise again the variety of jobs and the opportunities offered by a new UK spaceport. Explain that the special event they will be holding in school will be a celebration of UK achievement. Alternatively, teachers may wish to have the children compose the script in a separate session.

Note: The plan for the assembly and the launch script is a suggestion and teachers are encouraged to be creative and use their own and the children's ideas. The children might compose dialogue and an introduction about spaceports, demonstrate some of their spaceport-related activities or include mock interviews with space experts. Space-themed music and poetry would enhance the event.

Extension and further activities

The children could work in groups to compose introductions, additional activities or dialogue and assign play roles for the celebration /assembly launch event.

Whom would they invite to a UK spaceport launch event and why? Plan a guest list of valued visitors they would like to invite such as parents and school governors.

Can they think of any other jobs that might be needed at a UK spaceport?

Write letters to the local radio or television or newspaper to advertise the event.

Choose space-themed music and design props and scenery if required.

Cross curricular links

The activity provides opportunities for further research and practical investigations in several areas of the curriculum, including:

English: speaking and listening skills, presenting to different audiences, writing creatively and for different purposes.

Art: Designing invitations to the celebration event.

Computing/Technology: Recording videos and spoken interviews.

Music: Listening to the signal transmitted by the first Sputnik satellite. Composing musical rhythms. Listening to space-themed music.

Useful website links

Launch of ESA's solar orbiter satellite from Florida. Quite a long video but contains interesting information for teachers and children, featuring a presenter who narrates the action.
https://www.esa.int/ESA_Multimedia/Videos/2020/02/Solar_Orbiter_launch_replay

Solar orbiter launch preparation highlights:
https://www.esa.int/ESA_Multimedia/Videos/2020/02/Solar_Orbiter_launch_highlights

Space X launch: https://www.youtube.com/watch?v=4Rm_GEFPJnw

Appendix

Launch Day! script for a celebration assembly or play.

Introduction: Welcome everyone to our assembly. Today we are thinking about the opening of the UK's first spaceport and the launch of the first satellite from UK soil.

The children would like to explain what a spaceport is, share with you some of their science work, why a new spaceport is great news for the UK and describe some of the jobs it can provide. Then we will be joining the launch team to find out how the successful launch of a UK satellite needs skill, team work and cooperation.

Speaker 1: What is a spaceport? Rockets carry satellites (and sometimes humans) into orbit around Earth. Satellites help us to do lots of important things such as finding our way or forecasting the weather. Lots of countries around the world are launching rockets from special sites called spaceports. Soon the UK will be building spaceports to launch rockets carrying satellites! UK spaceports will launch rockets vertically or horizontally along a runway, just like planes! It will be very exciting!

Speaker 2: What is a satellite?

Usually, when we talk about satellites, we mean machines that are built and launched into space to orbit Earth.

We have been learning about the different kinds of satellites and the exciting science work they do

Speaker 3: The UK designs and makes lots of satellites and our new UK spaceport will be launching satellites into polar orbits around the Earth. This means the satellites will be travelling around the Earth passing over the North and South poles.

Speaker 4: Modern satellites are complicated. Some are used for GPS navigation, whilst others are used for communication, for TV or phone calls. Others can track planets or stars in far off galaxies, helping scientists to better understand the universe; these space satellites work better than Earth based telescopes as they are positioned above the clouds and dust in the atmosphere. Satellite images of the Earth are vital in helping us to avoid disasters or forecast the weather.

Speaker 5: Satellites come in many shapes and sizes. Here is a model satellite that we made. They consist usually of four main parts:

(*Describe the different parts on the model satellite*).

- a power system which may be solar, battery or nuclear ; solar panels make power by turning sunlight into electricity.
- antennae to transmit and receive information.
- a system for controlling the height of the satellite.
- a 'payload' comprising scientific instruments such as cameras, telescopes, particle detectors or sensors to collect information.

Speaker 6: Real satellites have to be tough to withstand the vibration during a rocket launch. We tested our models to see whether they are strong. (*Show the vibration test of the model by shaking it inside a box).*

Speaker 7: Launching satellites: We learned how a rocket carrying a satellite needs fuel to help it to overcome the force of gravity to reach space. Rockets need boosters to give them some extra push. They often have two boosters as well as the main engine.

Speaker 8: Rocket fuel: We asked the question: Do rockets with more boosters use fuel more quickly? We investigated this by using a model. We used water for fuel and compared the rate of fuel used. (*Demonstrate the timing of water representing fuel in a container passing through a lid with one, two, three or four holes*).

Spaceport Launch

Narrator: Now I think it's time to join the BBC who are over at the spaceport, to meet the launch team and find out what is happening.

Interviewer from BBC: Welcome to all those who have joined us this morning here at the UK's first Spaceport to celebrate a momentous day for all of the UK. I have the Spaceport Director with me who I am sure will wish to say a few words.

Spaceport Director: Yes, Good Morning. As UK Spaceport Director I am delighted to welcome you to the opening of the UK's new spaceport and the first launch of a satellite from the UK. We are thrilled to celebrate this exciting event! I would like to thank all the people who have worked so hard to make this possible.

Interviewer: There certainly are a large number of people who make up the team here and maybe we could meet some of them to learn what they have done to lead up to this launch?

Spaceport Director: Certainly. The spaceport has created job opportunities not only for local people but for scientists and engineers across the UK. My team will explain the different jobs we have here and all the preparations made so far for this satellite launch.

Rocket propulsion specialist: Hello. I am a **Rocket propulsion specialist** and my job is about getting rockets up in the air. I work on engines of all kinds. I tested the rocket boosters.

Fuel delivery driver: I delivered the fuel that was used to fill the rocket's main engine and the rocket boosters.

Satellite engineer: I am a satellite engineer and I design satellites of all shapes and sizes. I have tested and checked the satellite and all its electrical connections.

Driver 1: I drove the container holding the satellite to the fuel filling area and to the Final Assembly building to be loaded onto the rocket.

Logistics Manager: My job as a Logistics manager involves lots of maths. I worked out how to fit the satellite inside the upper part of the rocket.

Satellite engineer: When the satellite was inside the upper part of the rocket I gave it a final check and then the fuel was piped in.

Rocket systems engineer: A rocket is very complicated. My job as a rocket systems engineer is all about making sure that the different parts of the rocket work well together. I checked that the upper part of the rocket was perfectly attached to the lower part.

Driver 2 I drove the vehicle that pulled the rocket along on a platform to the launch pad. The rocket was then put into position ready for launch.

Interviewer I would now like you to meet some of the other important people who make up the spaceport family.

Visitor Centre Manager: Good morning. I manage our visitor centre. Visitors are important to the spaceport. Families can come to see a launch, buy a souvenir in the shop or take a tour around the space museum. They can also enjoy a delicious lunch in the restaurant.

Chef: I really enjoy planning the menus for all our staff and visitors.

Interviewer: Let's have a chat to one of the visitors here today. Have you travelled far today? What do you think of the spaceport?

Local visitor: It's absolutely fantastic. We are so excited to be able to be here at the viewing gallery to watch the launch. We live locally and we are lucky to have this facility so close.

Flight Director: Hello again everyone. I am contacting Air traffic control to pause all aircraft over the spaceport prior to rocket launch.

Air traffic control: I work in our air traffic control tower and my role is to check all flights and cancel any planes for the launch day. We make sure the skies above the launch pad are free from air traffic.

Flight Director: I am now going to speak to the team at the weather station to check the weather conditions and that the launcher and satellite are ready. I can then give the go ahead to start the launch.

Meteorologist: As a meteorologist, I study the weather patterns to make certain it is not too windy for launching. I am glad to report it is a fine day here at the weather station with clear skies and a gentle breeze. Conditions are perfect for the launch.

Spaceport Director: I have received a message from the Health and Safety manager at the launch pad and I am happy to report it is safe to prepare for launch. Does our propulsion engineer agree?

Propulsion engineer: Yes. All clear. I am now giving the okay for the computer to start the pumping of the liquid oxygen and liquid hydrogen into the rocket engine through big pipes.

Health and safety manager: I have made sure lots of water is poured onto the launch pad to cool the area and reduce the noise made by the engines.

Operations Director: Start the launch sequence please.

Narrator*: Lights on the control board turn green.*

The rocket engines are switched on.

(Run the video of ESA's launch of Ariane V rocket. Start the countdown timer. Final countdown starts and all the children join in).

Narrator: We have lift-off!

Operations Director: The rocket is at 75km and the boosters are separating from the rocket before falling into the sea. The final stage of the rocket has ignited and all is going perfectly. Our satellite is on its way.

Operations Director: The mission has been successfully completed. Well done everyone! *Applause*

Interviewer: We are now going over to our BBC studios where we have astronaut Tim Peake waiting to give his comments on the launch. Hello Tim. Thank you for joining us today.

Tim Peake: Hello everyone. I am delighted to be with you. This has been a great celebration of a wonderful event that shows the best of UK science and engineering. I hope that by seeing just how many interesting jobs have been created at our first spaceport, many more young people will be inspired to take up a space-related career, maybe in science or engineering.

Spaceport Director: I would like to thank the UK Space Agency for supporting the development of our spaceport, spaceport team for all their hard work and all of our visitors for coming today.