Science and
Technology
Facilities Council

Science and Engineering Careers Challenge

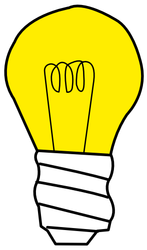
Created by
Kate Winfield
Ryan Smith
Louise McCaul
Chris Parmenter

Introduction

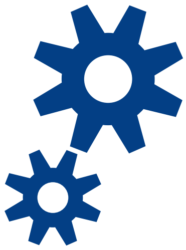
Welcome to the Science and Engineering Careers challenge!

The challenge has been created by members of the graduate scheme from the Science and Technology Facilities Council (STFC) at the Rutherford Appleton Laboratory in Harwell. The challenge is designed to introduce different science and engineering careers found at STFC.

The challenge is split into 6 sections:

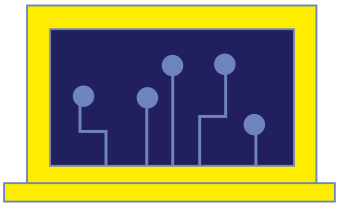


Section 1:
Electronic Engineer

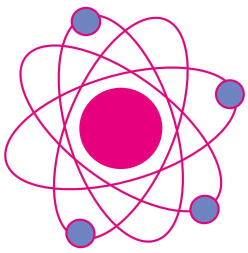


Section 2:
Mechanical Engineer

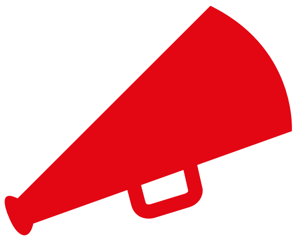
Section 3:
Data Scientist



Section 4:
Software Engineer



Section 5:
Physicist



Section 6:
Science Communication

To complete the challenge we recommend the unit completes one activity from each section, please adapt to suit your needs.

We have included activities for all age groups and there are loads of choices, so don't think you have to do everything! The recommended age groups for each activity are for guidance. Feel free to do whichever activities you think your groups will be comfortable with.

We have also included a separate case studies document of people working in all the six sections.

Once you've finished the challenge, complete the badge order form via the link here, along with the feedback form.

www.smartsurvey.co.uk/s/STFC-CareersChallenge-Orders

Disclaimer
Please note: Adult supervision is required for all activities. The challenge team takes no responsibility for any accidents occurring while completing the challenge. Units are encouraged to complete an additional risk assessment before undertaking the activities.

About STFC

The Science and Technology Facilities Council (STFC) is a world-leading multi-disciplinary science organisation, one of nine Councils within the United Kingdom Research and Innovation (UKRI). STFC's goal is to deliver economic, societal, scientific and international benefits to the UK and its people.

STFC has large-scale scientific facilities in the UK and Europe that are used by more than 3,500 users each year, carrying out more than 2,000 experiments! The facilities provide a range of research techniques using neutrons, muons, lasers and x-rays, as well as high performance computing and complex analysis of large data sets.

STFC works in areas such as particle physics, scientific computing, laser development, space research, and technology addressing some of the most important challenges facing society. These departments include:

RAL Space

RAL Space carries out world-class science research and technology development with involvement in more than 210 spacecraft to date. Working throughout the lifecycle of space missions, RAL Space lead concept studies for future missions, design and build instruments, provide space test and ground-based facilities, operate ground-stations and process and analyse data.

ISIS neutron and muon source

The ISIS neutron and muon source is a world-leading accelerator for research in the physical and life sciences. The suite of neutron and muon instruments give unique insights into the properties of materials on the atomic scale.

Scientific Computing Department (SCD)

The Scientific Computing Department (SCD) manages high performance computing facilities, services and infrastructure, supporting some of the UK's most advanced scientific facilities. This includes creating new computational science software, helping to visualise complex scientific results, or developing the infrastructure that allows us to process huge amounts of data.

Central Laser Facility (CLF)

The Central Laser Facility is one of the world's leading laser facilities; its high power lasers can recreate the conditions inside stars while its small, compact lasers have medical, security and environmental applications.

Technology

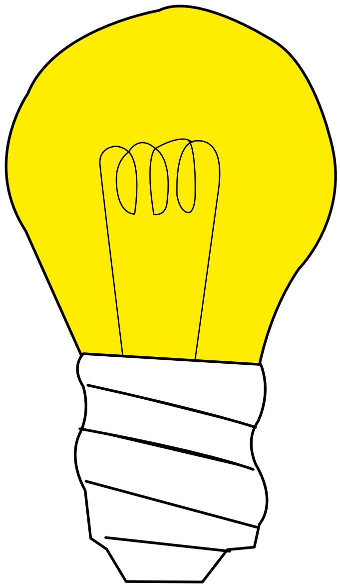
Technology underpins some of the world's leading science experiments. Our technology ranges from the very small - micro/nano-engineering, to the very large – major engineering structures. This includes the Large Hadron Collider, telescopes and much more!

Rutherford Appleton Laboratory in Harwell. One of the sites owned by STFC.

Science and Technology Facilities Council

Table of activities

Section	Activity Name	Target Audience	Related skill builder/ UMA/ interest/activity badges
Electronic Engineer **Page 5**	Lemon Batteries	Brownies, Cubs, Guides, Scouts, Rangers, Explorer Scouts. Can be demonstrated to younger groups.	• Scouts Electronics • Cubs Scientist
	Electronic playdough	All	• Scouts Electronics • Cubs Scientist
	Electronic game	Rainbows, Beavers, Brownies, Cubs	• Scouts Electronics • Lead Stage 2
Mechanical Engineer **Page 14**	Edible rover	All	• Brownie Baking • Brownie Inventing • Innovate Stage 2 • Beavers Builder
	Building a structure	All	• Rainbows Construction • Brownie Inventing • Innovate Stage 5 • Beavers Builder
	Crash proofing	Brownies, Cubs, Guides, Scouts, Rangers, Explorer Scouts	• Brownie Inventing • Beavers Builder
Data Scientist **Page 19**	Rain gauge	Main activity for Rainbows, Beavers, Brownies, Cubs Main activity + extension for Guides, Scouts, Rangers, Explorer Scouts	• UMA Rangers Rain Collector • Scouts Meteorologist • Explorers Science and Technology • Cubs Scientist
	Satellite jigsaw game	All	• UMA Rainbows Story Puzzles • Scouts Astronautics
	Binary bracelets	All	• Innovate Stage 4
Software Engineer **Page 23**	Exact instructions for making a sandwich	All	• Digital Maker Staged • Cubs Communicator
	Coding obstacle course	All	• Innovate Stage 5 • Cubs Communicator
	Coding game	Rainbows, Beavers, Brownies, Cubs	• Cubs Communicator • Lead Stage 2
Physicist **Page 27**	Solar system: • Scale of the Solar System • Weight in the Solar System	All Brownies, Cubs, Guides, Scouts, Rangers, Explorer Scouts.	• UMA Guides Spaced out • UMA Brownies planetary puzzles • Cubs Astronomer • Cubs Scientist • Beavers Space • Scouts Astronomer
	Astrophysics: • Beyond the Solar System – Doppler Spin • Beyond the Solar System – Exoplanets & Aliens	Brownies, Cubs, Guides, Scouts, Rangers, Explorer Scouts. All	• Cubs Scientist • Scouts Scientist • Beavers Space • Scouts Astronomer
	Particle physics - Particle detection game	All	• Cubs Scientist • Scouts Scientist
Science Communication **Page 34**	Drawing a scientist or engineer	Rainbows, Beavers, Brownies, Cubs	• Rainbow Drawing • Live Smart Stage 2 • Brownie Jobs
	Matching job descriptions	All	• Brownie Jobs
	Creating and presenting a poster	Guides, Scouts, Rangers, Explorer Scouts	• Digital Citizen Staged • Cubs Astronomer



Electronic Engineering

Section 1

An electronics engineer designs devices which require electricity to work. This involves combining relatively simple components, such as LEDs, resistors and capacitors, to do more complex things. Every department in STFC has electronic engineers from RAL Space, Technology, ISIS Neutron and Muon Source and lots more!

Lemon batteries

This activity is best suited for those aged 8+. For units below this age range, it is recommended this activity be demonstrated to the young people instead.

In the Imaging Systems Division at RAL Space, electronics engineers design scientific instruments to be used in space; examples include cameras to take pictures of the sun and devices to identify elements in a rock sample from a comet. They do this by designing circuits on a PC, which they then build and test to check they work as expected. In this activity you will create your own circuit using lemons!

What you will need:

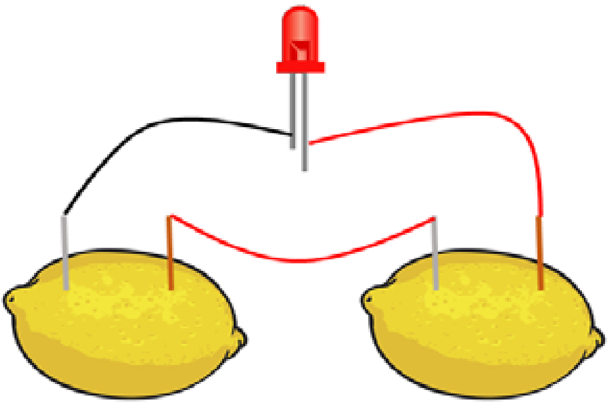
- Lemons (2-3 per pair)
- Sharp knife
- 1 copper object per lemon (e.g. copper wire, coin etc.)
- 1 galvanised washer per lemon
- Crocodile clips & wires (available on Kitronik – e.g. pack of 10 for £2.16)
- 1 LED per pair (available on Kitronik – around £0.18 each)
- *Extension - 1 toggle switch per pair (available on Kitronik - around £0.60 each)*

NOTE: Galvanised means the steel has a thin layer of zinc on its surface. The washer must be galvanised in order for this activity to work. Alternatively, a galvanised nail, screw, bolt, or even a paperclip, should be fine to use.

What to do:

NOTE: Step 1 can be completed in advance, to avoid young people handling sharp objects.

1. Using the sharp knife, cut two slits into a lemon, making sure the inside of the lemon is exposed. Do this for all lemons.
2. Insert a copper object into one slit, and the galvanised washer into the other (shown as brown and grey lines respectively in the diagram below). Again, do this for each lemon.
3. Using crocodile clips and wires, connect the circuit as shown below. The LED should light up! If two similar objects in the lemons are connected, or if the long LED lead is connected to the galvanised washer, the LED will not light.



What's going on?

When the zinc and copper are placed into the citric acid of the lemon, they undergo a chemical reaction – zinc atoms dissolve into the acid and leave free electrons in the metal (this process is called oxidation), while hydrogen ions in the acid react with the copper so it has less free electrons (this process is known as reduction). The difference in electron concentrations between the two metals means a voltage exists between them.

When the batteries are connected to the LED, excess electrons in the zinc now have a path to flow to the copper. The electrons get a "push" to flow from the voltage difference between the zinc and copper. This is known as an electrical current, which lights up the LED.

Extension

Try adding a toggle switch in the circuit between the LED and a lemon. Can you turn the LED on and off? When the switch is open, the current path is broken so the LED no longer lights up. When the switch is closed, the current path is complete and electrons can once again flow to light up the LED.

An apprentice engineer working on a CNC (computer numerical control machine) to cut out parts.

Science and Technology Facilities Council

Electronic playdough

For this activity you will use conductive and insulative modelling clay/playdough to build a simple and fun electronic circuit. Electronic engineers at STFC design, build, and test electronic circuits that enable, monitor, and control a wide range of activities. At ISIS Neutron and Muon Source electronic engineers have designed sophisticated circuits featuring many components that play a part in accelerating particles up to 80% the speed of light. They often interact with sophisticated software systems therefore it might be a good idea to choose an activity from the software engineering section next, if you haven't done so already.

What you will need:

NOTE: The dough can be made in advance by leaders. Dough is naturally beige in colour and safe to eat. Food colouring can be added to create colourful models.

Conductive Dough:

The high salt content in this dough is what allows it to conduct electricity. Salt is an electrolyte which means when dissolved in a solution it creates a number of free ions that enable current to flow.

- 1½ Cup (355 ml) Flour
- 1 Cup (237 ml) Water
- ¼ Cup (59 ml) Salt
- 3 Tbsp. (44 ml) Cream of Tartar*
- 1 Tbsp. (15 ml) Vegetable Oil
- Choice of food colouring

** 9 Tbsp. (133 mL) of Lemon Juice may be substituted*

Insulative Dough:

The high content of sugar in this dough is what makes it an insulator. Sugar is not an electrolyte therefore it does not assist the flow of current.

- 1½ Cup (355 ml) Flour
- ½ Cup (118 ml) Sugar
- 3 Tbsp. (44ml) Vegetable Oil
- ½ Cup (118 ml) Water
- Choice of food colouring

To build the Models (per group):

- 2 x 5mm Blue LEDs*
- 1 x 4 AA Battery Holder*
- 4 x AA Batteries

**Kitronic is a good option for sourcing electronic components and kits. They stock a 4 x AA covered battery holder with on/off switch and leads at a cost of £0.84 per item when ordering 10 or more (https://www.kitronik.co.uk/2222-4xaa-covered-battery-holder-with-switch-and-leads.html) and 5mm blue diffused LEDs at a cost of £0.11 per LED. (https://www.kitronik.co.uk/3543-blue-5mm-diffused-led-500mcd.html).*

What to do:

To make the conductive dough:

1. Add all ingredients to a medium sized saucepan.
2. Cook over a medium heat, stirring continuously. The mixture will thicken and lumps will begin to form.
3. Continue heating until the mixture comes together to form a ball.
4. Turn the dough out onto a lightly floured surface bearing in mind it will be very hot.
5. Allow the dough to cool. When it is cool enough to touch knead for a few minutes until the desired consistency is formed.
6. Dough can be stored in an airtight container for several weeks. Condensation may form on the inside of the container, this is normal. When using dough that has been in storage make sure to lightly knead before use to refresh its pliable nature.

To make the insulative dough:

1. Mix 1 cup of flour with the sugar and oil.
2. Add water, 1 tbsp at a time, until large sandy lumps form.
3. Turn the lumpy dough out onto a floured work surface and gather together to form a single lump. Feel free to add small amounts of water if needed.
4. Continue to add more water and flour until you have a pliable consistency.
5. Dough can be stored in a sealed container for up to a week. If dough becomes sticky, lightly knead with some flour to restore its pliability.

To assemble your squishy circuits:

Electricity is a form of energy that travels by a flow of electrons. The flow of electrons is called an electric current and an electric current always travels from positive to negative charge via the easiest route. When we design our clay models we need to think about how we can create a low resistance path for our current to flow from the battery through the LEDs and back to the battery. This activity can be done individually or in small groups.

Stage One - Design

Note this part of the activity is suited for older groups Guides/Scouts/Rangers/Explorer Scouts.

1. To prepare for the activity split into small groups and ask each group to match the new terminology below with the correct definition.

1. Conductive	A material which allows current to flow through it easily. Opposite of insulative.
2. Insulative	A material which does not allow current to flow through it easily. Opposite of conductive.
3. Circuit	A closed path where current flows from the positive terminal of a power source to the negative terminal of a power source.
4. Current	The flow of electrons through a conductive material.
5. Voltage	Electrical energy which gives a "push" to make current flow (similar to high and low pressure forcing water through a pipe)
6. Resistance	A property of a material which says how easy a current passes through it e.g. if it is conductive or insulative.
7. LED	A Light Emitting Diode - an electronic component that converts electrical energy to light. These devices have a polarity, where the long leg represents the positive side and the short leg represents the negative side.
8. Battery	A component that converts chemical energy into electrical energy. It can be used as a power source in an electronic circuit. Has polarity.
9. Polarity	A property of an electronic component which means one side is considered positive and the other negative. Such components need to be connected the right way around in a circuit to allow current to flow.

Stage Two - Build

1. Provide groups with modelling clay and instructions to build their models (see Sun, Sentinel and ISIS neutron target station examples below). Also provide LEDs. Remind the group to pay attention when connecting their LEDs.
2. As each group completes building their model, provide them with a battery holder and 3 AA batteries. Remind them that batteries have a polarity and therefore need to be connected a particular way around. For younger groups you could choose to supervise them at this stage and as they connect the battery to their model.

Stage Three - Test and Operation

1. To test their circuit groups need to provide power. A successful attempt will cause the LED to emit light. Depending on the age and ability of your group you can assist them to connect the battery to their model. If the LED does not light up you will need to undergo some debugging. Debugging is when you identify potential 'bugs' or problems in your circuit. A good method for identifying bugs is to work systematically around the loop.

Common bugs include:

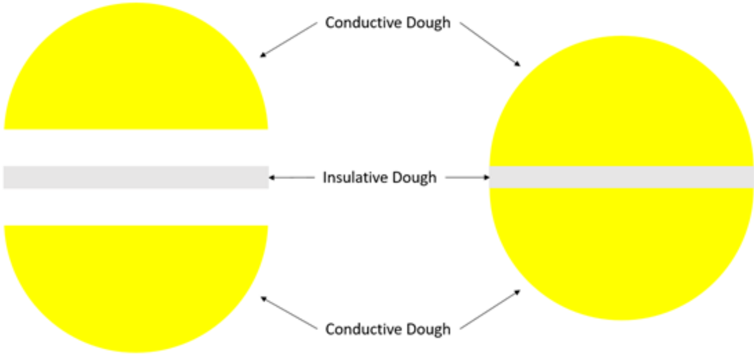
a. Have you used a battery holder with an on/off switch? Have you remembered to switch the battery on? It may seem silly but it is a common mistake.

b. Are the battery leads in the right position and do they have a good connection with the conductive playdough? If the wires are loose they will not close the circuit and so current will not flow. Equally if the wires are connected in the wrong place or touching they could be providing a path for current flow that misses out the LEDs.

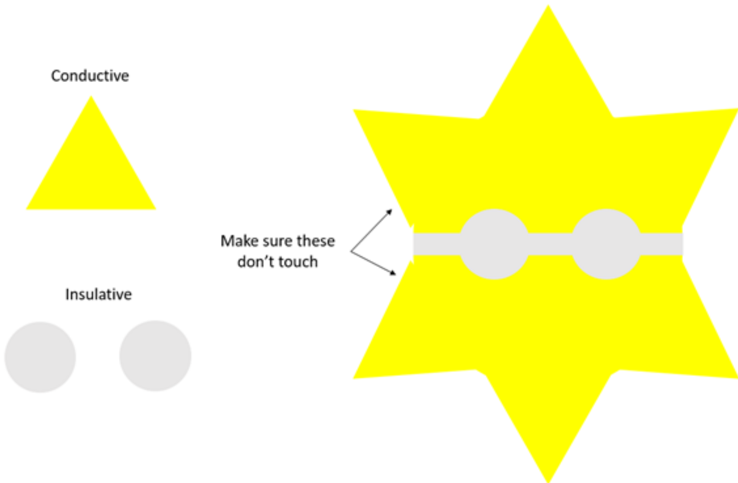
c. Are the LEDs connected the right way around, and are both their legs in separate blocks of conductive dough with an insulator in between? If both legs are in the same piece of conductive dough there will not be enough electrical pressure to encourage the flow of current through the LED.

Sun model

1. Create the face of the Sun by creating two half circles and add a thin white piece of insulating dough in the middle. Then push the two pieces together to make a circle. This will be the face of the Sun.

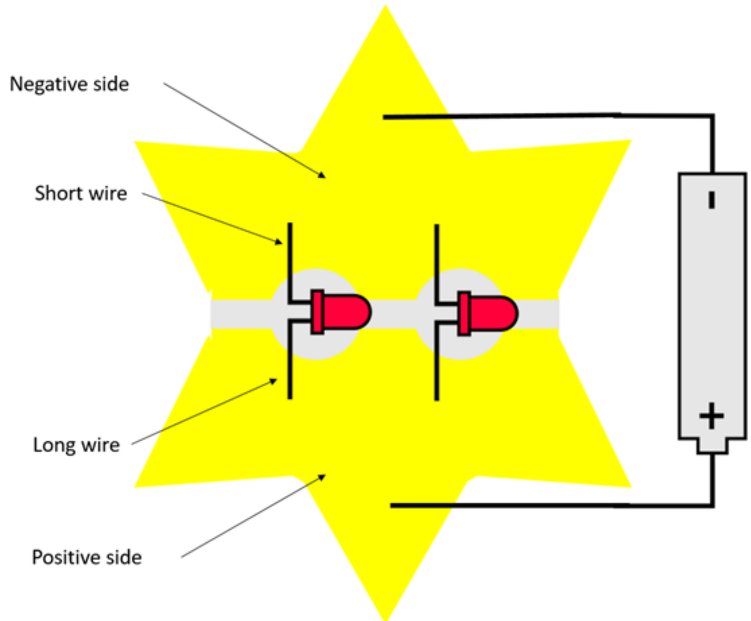


2. Use some of the spare yellow dough to make the spines of the sun to make a star shape. If there is some insulative dough left over you can make some eyes. Make sure the two sides of the yellow don't touch.



3. Take two LEDs, and insert the short sides (look at the length of the wires) into one of the yellow halfs, this is the negative side of the star. Then pierce the long side of the LEDs into the other half of the star, and that becomes the positive half. Then take the battery wires, and put the negate wire (likely black) into the negative side, and the positive wire (likely red) into the positive side.

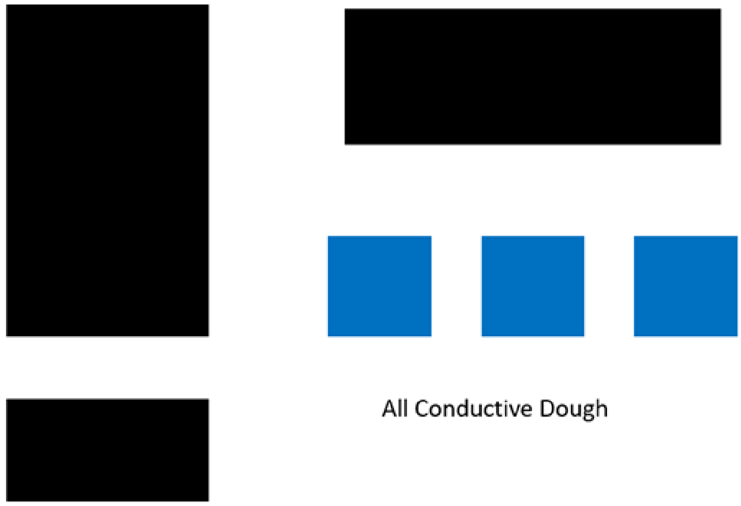
4. The LEDs should light up! If they don't, check the LEDs are the right way round, or put the battery and LED wires closer to each other. Discuss what happens when you move the wires closer/further away from each other?



Science and Technology Facilities Council

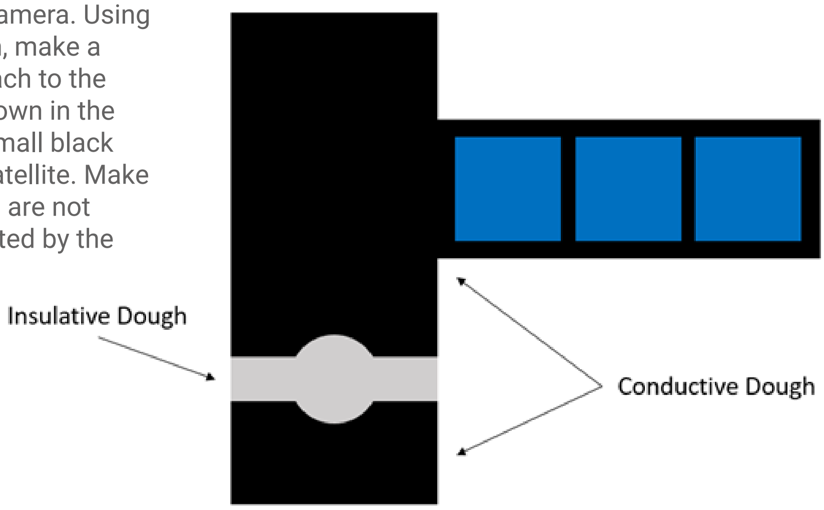
Sentinel 3 satellite model

1. Out of conductive dough, create one large black rectangle, one medium size black rectangle and one small black rectangle, similar to the ones shown below. Also out of conductive blue dough, create 3 small squares, which will become solar panels.



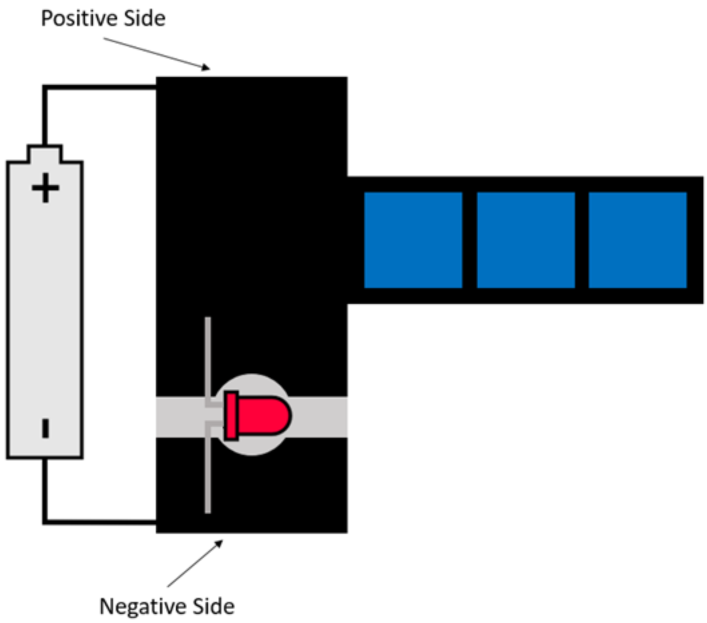
2. Next we will create the solar panels that power the instruments on the satellite. Using the blue dough add three squares on top on the black rectangle, and attach it all to the big rectangle.

3. Next we will create the camera. Using the grey insulative dough, make a small grey circle and attach to the bottom of the box, as shown in the diagram. Then add the small black box on the base of the satellite. Make sure the two black boxes are not touching, and are separated by the grey insulative dough.



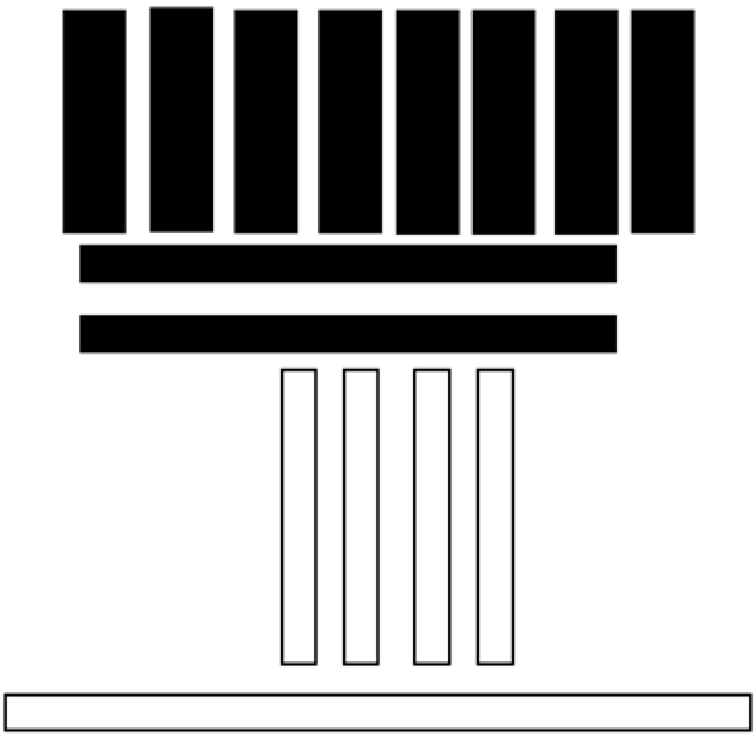
Science and
Technology
Facilities Council

4. Insert the short leg (negative) of the LED into the smaller box of the satellite, this is where the black battery wire will be connected. Be sure to place the longer LED leg into the larger satellite box. This is also where the red wire from the battery holder will be inserted.



ISIS neutron source target station model

1. To create the target station first create 8 small black rectangles, 2 long black rectangles, 4 white small rectangles, 1 long white rectangles as seen in the diagram. White is the insulating dough.



2. Combine 2 short black rectangles with a white short rectangle to form the 4 instruments.

3. Combine the 2 long black rectangles with the long white rectangle. This is the ISIS target station.

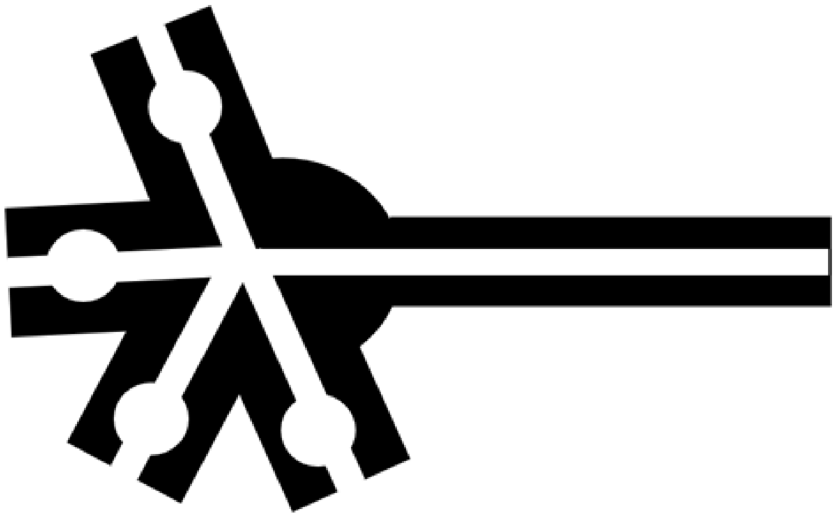
Science and Technology Facilities Council

4. Combine all together to form the image left.

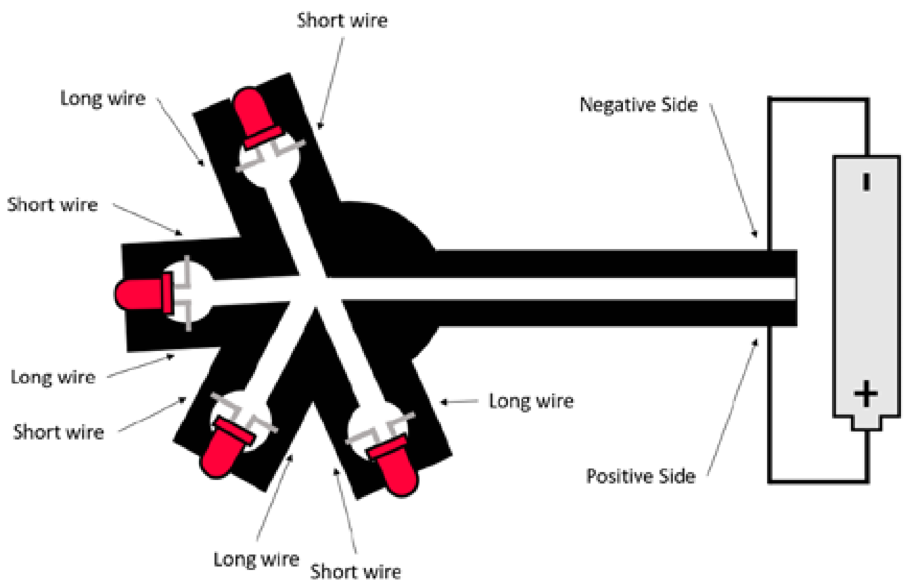
5. With the white insulating dough create a line along the targets and 4 circles for the instruments.

6. Create 4 white circles to form the targets and attach to the instruments, make sure they are connected to the white dough.

7. Insert the short leg of the LED into the instruments. Be sure to place the longer LED leg into the target station. This is also where the red wire from the battery holder will be inserted.



8. Last, attach the battery holder to the target station. Insert the red wire into the target station and the black wire into the instruments. Turn on the battery holder to light up the instruments. You may need to use a much more powerful battery (such as a 9V or 12V). You can always put lots of AA batteries together.



Electronic game

To build a circuit you need a power source such as a battery, components such as switches (turn on/off), LEDs (light), buzzers (sound), motors (movement) and connections such as wires.

What you will need:

A clear space

What to do:

1. One member of the group is the engineer, who will call out the commands. Everyone else should stand in the centre of the space, ready to respond to the commands with the appropriate action.
2. Everyone should practise the engineer commands:
   - Battery: stand still and straight, no moving otherwise you are out
   - Switch: stand and crouch movement (on/off)
   - Light: star jumps
   - Motor: movement of arms up and down in circles
   - Connections (number): Get into lines holding hands
   - Circuit: to make a circuit there must be 4 people with one battery, switch, light and motor all connected together.
3. Play the game and the last person to do the action or who does the wrong action is out.
4. The game continues until there is only one person left – the winner.

Electrical engineer working on ALMA (Atacama Large Millimetre Array). Big radio telescope.

Mechanical Engineering

Section 2

A mechanical engineer designs systems where moving components and/or supportive structures are required. They can be involved in thermodynamics (heat), fluid dynamics and energy components. Every department in STFC has mechanical engineers from RAL Space, Technology, ISIS Neutron and Muon Source and lots more!

Science and
Technology
Facilities Council

Edible Rover

A rover is a space exploration vehicle designed to move across the surface of a planet or asteroids, to find out information and to take samples. They can collect dust, rocks, and even take pictures. They are very useful for exploring the solar system. In RAL Space, mechanical engineers work to ensure spacecraft instruments, such as cameras, are designed and built to survive the demanding conditions placed upon them during launch and operation in space. In this activity you will create your own edible spacecraft. Please note leaders may want to bake before this activity.

What will you need:

- Food (can be adapted)
    - Oreos
    - Kit Kats
    - Candy bars
    - Strawberry laces
    - Marshmallows
    - Jelly beans
    - Icing
    - Wafer cookies
    - Biscuits
    - Ginger bread
- Cocktail sticks x 8 for each group
- Straws x 2 for each group
- Plates

What to do:

1. Start the activity by asking the group 'Why does it take so long to develop and send a rover to Mars?'
    - Rovers are very complicated machines
    - It is very expensive to send missions to Mars
    - There are several steps that must occur
2. Now ask the group 'What parts does a rover need?'
    - Body - protection
    - Brain - computer that processes information, makes it move, controls temperature, heaters and insulators
    - Arm - to pick up samples
    - Wheels - rover movement
    - Energy source - solar panels and batteries
    - Communications - data sent back to Earth
    - Camera - to take photos
3. In small groups draw a design for your rover. Think about the materials that are available and decide what is best. Engineers often have a lot of constraints but at the same time a lot of possibilities. For Guides/Scouts/Rangers/Explorer Scouts ask your group to cost out the rover parts using the ingredients. Assign parts a cost, and then come up with a budget. Engineers have to set a budget for making instruments by costing out parts. (Note the leaders will have to write down the cost of the ingredients).
4. Construct your rover in your groups. Think about how things fit together and the strongest way of making the parts.
5. Evaluate your rover. This is a design review.
    - What works?
    - What does not work?
    - How would you improve it?

Mechanical engineer working on a robot.

Crash-proofing in the real world

Mechanical engineers often have to think about what will happen to the thing they have designed when somebody bumps into it, drops it, or crashes it. Sometimes we have to design things to be dropped or crashed! Cars are a great example of something that could be in an accident, and often are. Designers of cars make them in a way that means that the people inside are much safer and less likely to be hurt. Equally here at RAL Space our mechanical engineers have to make things that deal with sudden shocks. Imagine something that needs to be launched to another planet: it will shake a lot during the rocket launch and then it will be slowed down by the parachute during landing, but as soon as it hits the ground it will need to be strong enough so that it doesn't smash to pieces! Mechanical engineers need to decide what materials they should use to make their product as safe as possible.

What will you need:

- Something breakable, but quite light, examples include:
  - Eggs (this can get messy)
  - Teacakes (less messy, and they can be eaten!)
- Random materials such as plastics, cardboard and paper.
  - Can link it in with the Conservationist Scouting badge, linked with recycling.
- Materials to attach parts together such as:
  - Tape (many types they can try)
  - Glue
  - Blue tack

What to do:

1. Start the activity by asking the group 'What sort of things need to survive a drop from a height, or an accidental crash? Does the vehicle need to survive or just the stuff inside?'
   - Humans landing on the Moon
   - Landers on Mars (carrying scientific instruments)
   - Dropping aid in remote areas with no runways
   - A car or lorry on a road
   - A plane

Mechanical engineer working on SLSTR (Sea Land Surface Temperature Radiometer).

2. The task is to take one of the scenarios that they came up with and see if they can devise a way to solve the problem using recycled materials. Pick one of the following or create something similar, and then afterwards share how it went:
   - **Mars Lander** - The challenge is to drop your spacecraft from a height (depending on how high you can drop it from safely) and for the scientific instrument inside to survive (this is the breakable item). This is what they have to think about when landing spacecraft on Mars. They use parachutes and rockets now but originally they surrounded the outside with big balloons, and it bounced along safely.
   - **Protecting a car** - Using some sort of model car or lorry, or anything you have to hand, preferably remote controlled (but this is not essential) the task is to stop the person inside (the breakable item) from breaking when it crashes into a wall. This is usually by creating some sort of bumper. Most cars now will have areas that crumple when in a collision, and engineers have to choose the right materials and shape so that this happens in the way we want.
   - **Plane crashing** - This challenge is twofold, firstly to make a glider big enough to go a set distance (maybe 10m) while holding a breakable item, and also for the breakable item to survive when landing (or crashing depending on the design). Engineers who design planes need to make sure that the plane survives the landing, and that all the people inside are safe and not injured.
3. In groups discuss what did not work?
   - How would you improve it?
   - Discuss it with the rest of the group.
   - Could they think of any more applications for this type of technology?

Building a structure

At the Space Engineering and Technology Division at RAL Space, mechanical engineers design protective housings for sensitive scientific instruments and a way of attaching them to a satellite. In addition, they analyse and test their designs to check if they will survive forces they will experience on the spacecraft e.g. during launch. In this activity you will be testing your own structures!

What you will need:

- Pack of spaghetti
- Things to attach them together, examples are:
  - Tape
  - Marshmallows
  - Midget gems
  - Blue tack
- Ruler or measurement tape
- Bowl and weights (could be anything, like pasta)
- Weighing scales
- Watch or clock

What to do (Cubs/Brownies and Scouts/Guides):

1. Ask the group to think of examples when a structure is needed that can hold up something heavy. Examples to help them along would be:
   a. A bridge
   b. A crane
   c. A building
   d. A water tower
   e. Streetlights

2. Now ask the group what features would make the structures more stable, and able to hold up more weight. They could mention a few of these features:
   a. The structure is made using only triangles.
   b. Much wider base than the top. The Eiffel tower is a good example.
   c. More support at the base as this holds the most weight.

3. In small groups they get given a set amount of 20 strands of spaghetti and a small amount of the connecting material, 10 marshmallows/1m of tape is a reasonable amount. The challenge is to first make the tallest tower possible that can stand up on its own for at least 10 seconds. They have 10 minutes to make the structures.
   a. Once the 10 minutes is up the leaders need to use the ruler or measuring tape to measure the height from the base to the top of the structure, once it has lasted 10 seconds freestanding. Note down the heights, and get them to note it down as well.

4. In the same groups, give each group a bowl with a set amount of weights in it (roughly 250g is a good amount), and a new set of materials. The challenge is to make the tower as high as possible but still hold the weight of the bowl and weights on top or inside the tower. As before the structure must last 10 seconds freestanding and they have 10 minutes to make the structure.
   a. Once the 10 minutes is up the leaders need to use the ruler or measuring tape to measure the height from the base to the top of the bowl, once it has lasted 10 seconds freestanding. Note down the heights, and get them to note it down as well.

5. In the same groups the teams now have the freedom of deciding how much weight they want their structure to hold. The challenge is to make a structure that holds the weight they choose at the highest possible height. They want to gain as many points as they can using the following calculation:

   0.1 x weights (in grams) x height (in cm)

   As before it must last 10 seconds freestanding and they have 10 minutes to complete the challenge.
   a. Once the 10 minutes is up the leaders need to use the ruler or measuring tape to measure the height from the base to the top of the bowl, once it has lasted 10 seconds freestanding. Also weigh the bowl with the weights. Note down the heights and weights and appropriate scores, and get them to note it down as well.

6. Get the groups to join together in a circle and discuss what went well and what went badly. Did they learn anything between the challenges, such as how to get it to hold more weight? Was it easier to make a small tower that can hold a heavy weight or a tall one with little weight?

Mechanical engineer working on MIRI which is part of the James Webb Telescope.

What to do (Beavers and Rainbows):

1. Ask the group to think of examples when you need to hold up something heavy. Examples to help them along would be:
    a. A bridge
    b. A crane
    c. A building
    d. A water tower
    e. Streetlights

    Pictures of cranes and buildings are very helpful. We have found large cranes and the London Eye are good examples as they have obvious triangles in their structure.
2. Organise the young people into small groups, preferably with an adult to help. Pass out a small pile of spaghetti and the building materials to each group. Get the young people to come up with ways to fasten the spaghetti and building materials together.
3. Give the group 15 minutes to build a structure as high as they can. Materials like marshmallow tend to melt and become very sticky once used in crafts like this.
4. Measure how tall the structures are in relation to the young people. Do they reach their knee, or waist?
5. Gather everyone together and discuss what went well, and what went badly. If they were to do the challenge again, what would they do differently?

Data Scientist

Section 3

Data is growing all the time, every single second, in every work sector from crime to science, health and business. A data scientist solves complex problems in the storage and handling of data for the long term preservation, turning raw data into meaningful information. This requires computer programming, artificial intelligence, machine learning and statistical tools.

The Centre for Environmental Data Analysis (CEDA) is based in the RAL Space department at STFC and holds over 250 million files of atmospheric and Earth observation data. That is 14PB of data equivalent to 14000000 GB or the size of seven rhinos! (If 1GB = 1 gram). You would need over 27,000 smartphones (e.g. iPhone 11 Pro) to store that much data! This data is all stored on our supercomputer called JASMIN.

CEDA's data scientists provide data management support for the atmospheric and Earth observation academic research communities. This data can then be used in weather forecasts and climate models.

JASMIN computing cluster.

Rain gauge

A rain gauge is used to measure the amount of rain that has fallen in a certain period of time. CEDA collects these measurements from the scientists, which are then used in climate models and forecasts.

What you will need:

- An empty plastic bottle (2 litre drink bottle) for each young member
- Scissors
- Jelly (3 or 4 cubes made up as directed on packet – this is not essential)
- Sticky tape
- Ruler
- Paper
- Pencil

What to do:

1. Cut around the plastic bottle about two thirds of the way up.
2. Note this is optional. Your bottle needs a flat bottom to be able to measure the rainfall properly. Pour a few centimetres of jelly into the bottle and allow it to set to create a flat bottom.
3. Turn the top part of the bottle upside down and place it inside the bottom part - fix it in place using the tape.
4. Make a scale in centimetres on a piece of tape, using a ruler, and fix it to the side of your bottle.
5. Find a place outside to put your rain gauge. It must be open and away from trees.
6. Dig a hole and bury your rain gauge so that the top is sticking out of the ground. This will stop the rain gauge from blowing down on windy days.
7. Check the rain gauge every day at the same time, measure the amount of rain collected, and empty the bottle.
8. Write down the amount of rain collected in a table.

Extension

1. Draw your data on a graph. (Remember to think about how you present your data e.g. what type of graph are you going to use, what information do you need to include e.g. title, axis labels, location of rain gauge).
2. Compare your data to another person or the rest of the group. Are the rainfall measurements similar or different? And why do you think that?
3. Make a table with everyone's results in. Think about how you would present the data to someone who does not know your data? What information do you need to include to be able to use the data in the future?

Note: There is no correct answer!

Satellite jigsaw game

Satellites can look at the whole Earth all the time, and can give us lots of important information about our own planet. Satellites are used to forecast the weather, study changing land use, and show us how cities are growing. From space, we can also see many natural and man-made events, such as floods and forest fires, changes in ice cover, rising sea levels and air pollution. CEDA holds large volumes of these images.

What you will need:

- Printed satellite pictures (see appendix)
- Scissors

What to do:

1. Cut the pictures into at least 6 jigsaw pieces (they can be any shape).
2. Spread them across the room.
3. Split the group up into teams.
4. The teams then race to complete as many jigsaw puzzles as possible. Each person can only collect/return one piece of the puzzle at a time.
5. Once all the pictures have been completed think about:
   a. What do the pictures show?
   b. What might the picture tell us?
   c. How can this information be used?

Sentinel 3 satellite (European Space Agency).

Binary bracelets

Binary data is a number system that uses 0s and 1s. Binary digits can be grouped together into bytes. A lot of data now comes to CEDA in a binary format as it reduces the file size, taking up less room in the archive. It is numerically represented by a combination of zeros and ones. This data is all stored on our supercomputer called JASMIN.

What you will need:

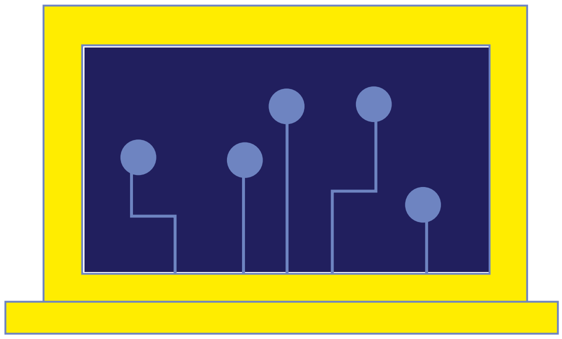
- 3 different coloured beads
- String
- Scissors
- Binary chart

What to do:

1. Assign a separate colour for 0, 1, and spaces.
2. Cut some string for a bracelet or necklace.
3. Using the binary chart below create your name and add the beads to the string. Include a space between the letters.
4. Knot into a bracelet or necklace or even a keyring.

Data scientists working in CEDA.

A	0001	J	01010	S	10011
B	00010	K	01011	T	10100
C	00011	L	01100	U	10101
D	00100	M	01101	V	10110
E	00101	N	01110	W	10111
F	00110	O	01111	X	11000
G	00111	P	10000	Y	11001
H	01000	Q	10001	Z	11010
I	01001	R	10010		



Software Engineering

Section 4

A software engineer solves complex problems by writing code for a computer to run, developing new technologies. Every department in STFC has software engineers from RAL Space, Scientific Computing Department (SCD), Technology, ISIS Neutron and Muon Source and lots more!

Exact instructions for making a sandwich

Giving clear, concise instructions to a computer is important, as it will only do what you tell it to do! The leaders may want to wear an apron as this activity can get messy!

What you will need:

- 3 loaves of sliced bread
- Several butter knifes
- 1 jar of jam
- 1 jar of peanut butter (or use another item if there are allergies!)
- Plate
- Paper
- Pens

What to do:

1. Set up a table where the leader will sit displaying all the equipment
2. Split the unit into groups of 3 or 4, and assign them to a spot in the hall/room.
3. Ask the groups if they know how to make a peanut butter and jam sandwich? Would they teach you how?
4. Hand out paper and pencils and ask each group to write down their instructions for making a peanut butter and jam sandwich.
5. Have them pass the instructions to you when they are done.
6. Take a minute to look through the instructions, look for unclear commands, these are the ones you will want to act out.
7. Read the first instructions out loud, and do EXACTLY what it says. For example, if it says “put the peanut butter on the bread”, you can literally put the jar of peanut butter on the bag of bread. There was no instruction to open the bread or the jar of peanut butter, no instruction to use the knife in any way, etc. The more literal you are by doing exactly what the instructions say, the funnier the activity will be and the more likely you are to get your point across about the importance of clear instructions.
8. Get the groups to redo their instructions until a sandwich is made.
9. Ask the unit why they think it is important to give clear, concise instructions?

Software engineer working on code in CEDA.

Coding obstacle course

Software engineers use programming languages to create their code such as Python, Java and lots more! A programming language is a set of rules that tell you how code should be written and formatted. In this activity you will use programming statements to complete the obstacle course. Giving clear, concise instructions to a computer is important, as it will only do what you tell it to do!

What you will need:

- Slips of paper with the following instructions
  - Move forward one space
  - Move backwards one space
  - If
  - Else
  - While
  - For
  - Drop
  - Grab
  - Squat
  - Body rotate
- Equipment for an obstacle course
  - Chairs
  - Rope
  - Balls
  - Bean bags
  - Table
  - Hoops

What to do:

1. Set up an obstacle course that can be completed in around 10 minutes. Arrange it to suit your equipment.
2. Begin by asking the following questions:

   What is computer programming?
   - Computer programming is a way of giving computers instructions about what they should do next. These instructions are known as code, and computer programmers write code to solve problems or perform a task.
   - Coding is like writing a recipe for cooking; you have to specify the ingredients, the amount of each ingredient and the exact steps to combine and cook the ingredients to make the meal you want.

   Why do computers need to be programmed?
   - A computer will do exactly what it is programmed because it can't think for itself.
3. Get into partners.

Software engineer working on the JASMIN infrastructure.

4. Explain to the group that the task is to complete the obstacle course only by using the commands on the slips of paper. The conditions for the commands are as follows (x is equivalent to a person);
   - 'If' : Makes the group either complete an action or not complete an action e.g. If x has one bean bag, move forward one space
   - 'Else': When the 'If' statement was not completed do something else e.g. If a ball is next to me move forwards one space, else move backwards one space.
   - 'For': For repetitive actions e.g. for x at the ball station drop the ball 10 times.
   - 'While': Continue an activity until a threshold or event has reached e.g. While x is standing still, jump 5 times.
   - 'Drop' : Drop an object
   - 'Grab' : Grab an object
   - 'Squat' : X can squat
   - 'Body rotate': X can rotate body by a specified number of degrees and direction (left/right)
5. Complete the obstacle course only using the commands on the slips of paper. You may want to stagger the pairs or start them on a different part of the course.
6. If other commands are used they must start again.

Science and Technology Facilities Council

Coding game

Software engineers use a programming language to create their code, with languages such as Python, Java and lots more! A programming language is a set of rules that tell you how code should be written and formatted, and your code then tells the computer what to do. A computer can't think for itself, so the programmer has to tell it everything it has to do, and what everything means. In this activity you will use programming statements to play a game.

What you will need:

- A clear space

What to do:

1. One child is the Programmer and everyone else is a Computer.
2. The Programmer stands in front of the Computers and gives them commands:

   "If I ____ (fill in the blank), Then you _____ (fill in the blank)."

   For example, the Programmer can give the command "If I turn in a circle, Then you turn in a circle." Or they can give challenging instructions like "If I touch my nose, Then you touch your toes."
3. Choose a number of commands that the programmer will say (like the examples above), and what the computer must do as a result.

   The programmer then just says "If I ____, then you…" and the computers must remember what that command means. If any of the computers get it wrong, this is an error, and they are out.
4. Continue until you have a winner, and then they become the new programmer, and you can keep the same commands, or make some new ones!

Physicist

Section 5

Physicists study how everything works, from the smallest parts that everything is made of, to the largest galaxies in the universe. Physicists create theories and test them with experiments. Lots of the work at STFC helps physicists and other scientists do experiments; the ISIS neutron and muon source, the Diamond Light Source, and the Central Laser Facility all help physicists look inside materials, to find out what they're made of!

Solar System: Scale of the Solar System

Scientists at STFC study everything in the solar system and beyond, from planets and moons, to galaxies and asteroids. Studying the universe is sometimes quite difficult, as the things you study are so far away. This activity will give you an idea of the scale of our solar system and some of the ways we study things that are so far away.

What you will need:

- Toilet paper (optional)
- Paper
- Pens
- Clay (optional)
- String
- Map of local area
- Calculator (for extension activity)

In our solar system, we often measure distances in **Astronomical Units (AU)**, where 1 AU is the average distance between the Earth and the Sun (as the planets' orbits are not quite circular), equal to 1.5 x 10^8 km, that's 150,000,000 km! Using the distances to all the planets, we can make a scale to understand just how vast our solar system is, for example, if you were the sun, and your friend stood 1 m away they would be the Earth, but another friend would have to stand 30 m away to represent Neptune!

In this challenge you will demonstrate the scale of the solar system, there are some examples below of how you could do this:

- Using a roll of toilet paper and the table below (Rainbows, Brownies, Beavers, Cubs)
- Plan a scale and route around your local area/ campsite (Brownies, Guides, Rangers, Cubs, Scouts, Explorer Scouts)
- Make and measure your own scale on a piece of string (Guides, Rangers, Scouts, Explorer Scouts)
- Make a plot and scale on a map of your local area (Guides, Rangers, Scouts, Explorer Scouts)

To add to the model, you could print out/draw/make out of modelling clay all of the planets.

Think about how long it takes you to travel somewhere in a car/plane, and how fast you go in a car/plane, and compare that to how far it is to our closest planet, and to the edge of the solar system – the solar system is huge! And this is only a tiny part of the universe that we study!

Planet	Distance from the sun	Cumulative loo roll	Additional loo roll
Mercury	0.4 AU	½ a sheet	½ sheet
Venus	0.7 AU	¾ of a sheet	+ ¼ sheet
Earth	1 AU	1 sheet	+ ¼ sheet
Mars	1.5 AU	1.5 sheets	+ ½ sheet
Jupiter	5.2 AU	5 sheets	+ 3.5 sheets
Saturn	9.5 AU	9.5 sheets	+ 4.5 sheets
Uranus	19 AU	19 sheets	+ 9.5 sheets
Neptune	30 AU	30 sheets	+ 21 sheets

Extension activity for older Guides/Rangers/Scouts/Explorer Scouts (calculators advised):

Scientists and engineers often send spacecraft and rovers to explore other planets, the distances above are the average distances from the Sun to each planet, but all the planets are orbiting the sun at different speeds.

Can you work out the minimum and maximum distance between the Earth and Mars for example?

Try drawing a picture of the orbits of the Earth and Mars to help you.

When we send satellites and rovers to other planets, we want to be able to communicate with them to receive our data and make sure they are in the right place. However, information can only travel at the speed of light, 3×10^8 ms^{-1}, or 300,000,000 metres per second.

Convert your minimum and maximum distances between the Earth and Mars into metres (1 AU = 1.5×10^{11} m = 150,000,000,000 m), then work out the minimum and maximum time it would take for a signal to travel between the two – we call this the communication lag. (Remember speed = distance/time).

How long would it take for a message to be sent from the satellite around Mars, to mission control on Earth, and then a reply sent and received again by the satellite?

Think about what difficulties this presents for sending and operating spacecraft and rovers to Mars.

Answers:

Minimum distance between Earth and Mars = 1.5 AU – 1 AU = 0.5 AU

Maximum distance between Earth and Mars = 1.5 AU + 1 AU = 2.5 AU

Minimum communication lag = $\frac{(0.5\times(1.5\times10^{11})}{(3\times10^{8})}$ =250 seconds = 4.2 minutes

Maximum communication lag = $\frac{(2.5\times(1.5\times10^{11})}{(3\times10^{8})}$ =1250 seconds = 20.8 minutes

Time for a message to be sent and a reply to be received is twice the communication lag plus any time to understand the message and compose a response.

Difficulties for operating spacecraft and rovers at Mars (suggestions);

- No real time control is possible – all navigation/driving must be pre-programmed or semi-autonomous
- It takes a long time to react to an unexpected problem
- All information about location/speed etc. will be out of date by the time you receive it
- If/when we send people to Mars they will be unable to directly talk to Mission Control

Solar System: Weight in the Solar System

What you will need:

- Set of scales (up to 3 kg)
- A number of containers of varying sizes (with lids is helpful for reducing mess potential)
- Something to weigh out (sand, flour, rice etc.)
- Funnel (if using bottles)
- Calculator (for extension activity)

Each planet in our solar system is a different size, both in how big they are and in how much mass they contain. Your mass (the amount of stuff you're made up of) doesn't change depending on where you are, but your weight, which is gravity acting on your mass, does. The strength of gravity on a planet depends on its mass, so the bigger planets have stronger gravity. Try to put the planets in order of their mass (higher mass = stronger gravity, so from the table below, Jupiter is the most massive planet, and Mercury and Mars are the smallest).

You can weigh out different amounts of sugar/flour/rice etc. into bottles/containers to simulate how much lighter or heavier 100 g or 1 kg feels on different planets, and the moon, using the table below. Have a go lifting up 2 containers, either one in each hand, or consecutively to feel the change.

The Apollo astronauts who walked on the Moon had to learn how to do their jobs in lower gravity; have a think about what things would be different, and what difficulties they would present? How about working and living on Mars? Use the containers of Earth, Moon & Mars gravity comparisons to help you.

Planet	Gravity (ms^{-2})	Relative weights for 100 g (g)	Relative weights for 1 kg (g)
Mercury	3.7	37.8	378
Venus	8.9	90.7	907
Earth	9.8	100	1000
Moon	1.6	16.3	163
Mars	3.7	37.7	377
Jupiter	23.1	236	2360
Saturn	9	91.6	916
Uranus	8.7	88.9	889
Neptune	11	112.2	1122

Extension activity for older Guides/Scouts and Rangers/Explorer Scouts (calculators advised)

Calculate your weight on different planets -> weight (Nms^{-2}) = mass (kg) x gravity (ms^{-2}).

Mass is how much stuff you are made up of, measured in kilograms, whereas weight is what you experience when gravity acts on your mass, and is measured in Newton metres per second per second (Nms^{-2}), and this can change depending on your local gravity.

For example, if your mass is 60 kg, then your weight on Earth is 60 x 9.8 = 588 Nms^{-2}, but on the moon your weight would be 60 x 1.6 = 96 Nms^{-2}, so you would feel much lighter!

Science and Technology Facilities Council

Astrophysics – beyond the Solar System: Exoplanets & Aliens

Over the past few decades astronomers have been able to detect planets orbiting other stars, and for some of these, by looking at the light coming from them, we can tell what their atmospheres are made up of and whether they are likely to be able to support life.

What you will need:

- Paper
- Pens
- Imagination!

Think about what is important for life on our planet (some suggestions below), then in groups design your own planet and alien species. For younger groups a design is sufficient, for older groups they can also consider the points below. Once complete, present to the rest of the group.

Important things for life on Earth:

- Temperature - distance from the sun and greenhouse effect in the atmosphere maintains the planet as not too hot/cold
- Water - high percentage surface coverage - most life as we know it depends on availability of liquid water
- Oxygen - animals and plants use oxygen in respiration to produce energy
- Radiation protection - the Earth's magnetic field and atmosphere protect the Earth from harmful solar radiation

Extension activity for older Guides/Scouts, and Rangers/Explorers:

Thinking about life on other planets is one thing, but how about humans leaving Earth to live on another planet/moon? Colonies on the Moon or Mars have been talked about for years, but what would it take to make this a reality? Considering the same factors for supporting life as above (and any more you can think of), do some research into how you could support long term human settlement on the Moon or Mars, and design a plan, over a number of decades if needed, of how you would achieve your settlement. You could think about experiments that would need to be done beforehand, and smaller missions to be used as proof of concept. You can then present ideas to the group, who will act as the international human exploration committee, to vote on the best idea to be funded and implemented.

Meteorological data coming through our radio telescope in Chilbolton.

Astrophysics – beyond the Solar System: Doppler Spin

The Earth spins on its axis, this is what gives us night and day. The Sun also spins on its axis, as do all stars and planets and galaxies, but how do we know this for stars that are light years away? And how can we measure how fast they're spinning by just looking at the light coming from them? We use the Doppler Effect, and we can observe the same effect with sound.

What you will need:

- String
- Egg timer or similar (something smaller that makes a noise)

What to do:

1. Attach your egg timer (or similar) securely to the end of the string.
2. Test that it stays securely attached when you swing the timer on the string.
3. Ask the group 'Can you make the sound that a police car, ambulance or fire engine makes when it goes past?'

It starts off higher pitched when it's coming towards you, then gets lower as it drives away from you. This is because sound, like light, is a wave, with peaks and troughs. A wave is described by its wavelength (the distance between two peaks) and its frequency (how many peaks in a certain length). When the ambulance is moving towards you the parts of the sound wave of the siren get squashed closer together, decreasing the wavelength; this increases the frequency, which for sound means that the pitch gets higher. The opposite happens when the ambulance is moving away from you; the parts of the sound wave get stretched out, increasing the wavelength, decreasing the frequency, and the pitch decreases.

The same idea works for light, except that instead of being able to hear the different pitches we see different colours of light (because the wavelength and frequency determine the colour of the light). We can measure the wavelength of light we see coming from distant stars and we can measure the light coming from different sides of the star. If these wavelengths are different, i.e. one is longer than the other, we know that the star is rotating and we can work out how fast by comparing the difference in wavelengths.

This can be demonstrated with the egg timer (or similar) on the end of the string.

Swing this in a circle above your head and see what you can hear, try swinging it at different speeds and note how the sound changes. The faster you spin, the higher the pitch of the sound will be. You should be able to tell when the timer is being spun faster with your eyes shut, just by the sound.

Note: Please stand well away from each other!

Instrument scientist working on ALMA instrument.

Particle Physics: Particle detection game

Everything in the known universe is made up of particles. There are lots of different types and particle physicists working at STFC design theories and experiments to detect particles using particle accelerators, like the one at CERN in Switzerland.

Most things in the universe are made of the most common particles; protons, neutrons and electrons, but there are a whole host of other particles that scientists try to produce by smashing other particles together and seeing what the interaction produces.

What you will need:

- Selection of small objects of different shapes (bits of lego, blob of blu-tac, pipe cleaners, beads etc.)
- Small sheet/large piece of flipchart paper (possibly several)
- Small ball (bouncy ball size)
- Paint (optional)

The aim of this game is to 'detect' the 'particle' without directly looking at it, by instead using another 'particle'. First of all the group should have a look and feel of all the small objects - these are the 'particles' we want to detect - you can make up names for them if you like. Then the leader should place one object underneath the sheet or paper, then the group must 'detect' which particle it is using the small ball. This is done by rolling the ball across the sheet/paper and watching how it changes direction when it rolls near/past the 'particle' under the sheet. To work best, the ball should be rolled reasonably slowly. In order to see the path that the ball takes more easily, the ball can be dipped in paint before starting. The group then has to figure out which of the items is under the sheet, based on how the ball's path changed as it rolled near it. Repeat for a number of different objects.

Particle physicists use predictions from theories about the energies (sizes) of new particles, and then they look for them by colliding known particles together and seeing if they detect anything from the collision that looks like one of the theorised particles. Though quite often they are unable to directly detect the new particle, and rely on what happens when other particles interact with them. This is like using the ball, and the path it takes near the unknown particle to detect which particle is underneath the sheet.

Physicist working on lasers to measure atoms.

Science Communication

Section 6

Science communicators are important in telling the world about the research, science and engineering that STFC do, making it easy to understand. Science communication involves a range of ways to do this such as; social media, writing news stories/magazine articles, TV documentaries, talking to governmental departments, activity days and many more!

In STFC, science communicators aim to inspire, inform and engage the public in the research, science and engineering that takes place across the organisation. One of their goals is to encourage the next generation to take up careers in STEM fields, and demonstrate how people from all backgrounds can become scientists – in fact the more diverse the better!

Science and Technology Facilities Council

Drawing a scientist or engineer

Science requires the recording of data to seek insights and patterns. An example of recording data could be drawing. There are many perceptions young people have of scientists and engineers. This activity explores these perceptions and shows the importance of communicating science.

What you will need:

- Paper
- Pens
- Examples of scientists and engineers in the appendix

What to do:

1. Get the young people to draw what they think a scientist or engineer looks like.
2. Have a quick discussion amongst the group. Are there any stereotypes? E.g. gender, clothing etc.
3. Show them the examples of scientists and engineers in the case study document.
4. Have a quick discussion and ask the group:
    - What did you learn about the scientist by viewing their image and reading their bio?
    - What questions are you left wondering?
    - Could you see yourselves working in STEM?
    - Do you think it is important to communicate science?
    - A diverse team with people from different backgrounds produces better results and a higher quality of scientific research. Why do you think this is?

STFC public engagement stargazing event.

Matching job descriptions

A lot of schools are encouraging young people to go into science and engineering jobs, but these are big areas with many different types of scientists and engineers. In STFC there are many science and engineering jobs including Electronic engineer, Mechanical engineer, Data scientist, Software engineer, Physicist, Communication/impact officer and many more! This activity will explore how much you know about what Scientists and Engineers do.

What you need:

- Scissors
- Cut out printed table of jobs

What to do:

1. Ask the group 'What do you think scientists and engineers do?'
2. Ask the group 'Do you know any engineering or scientist jobs?'
3. Cut out the table opposite with jobs.
4. See if the group can match the job descriptions to the job name.
5. Ask the group 'Are any of these jobs are of interest?', 'Could you see yourselves doing any of these jobs?'
6. Ask the group 'What skills are needed for each job?', 'Which of these skills do you already have?'

Skill sets

Electronic engineer:
Technology, Problem-solving, Maths, Design, Time planning

Mechanical engineer:
Problem-solving, Creativity, Design, Writing, Team work, Communication

Data Scientist:
Computing, Curiosity, Presenting, Team work, Communication, Problem-solving

Software engineer:
Computing, Problem-solving, Multitasking, Attention to detail

Physicist:
Problem-solving, Science, Maths, Curiosity, Writing, Communication

Science Communicator:
Story-telling, Interacting with people, Organisation, Team work, Writing, Presenting, Design, Adapting communication, Leadership

Electronic engineer	**Mechanical engineer**	**Data scientist**
Software engineer	**Science communicator**	**Physicist**
Solves complex problems in the storage and handling of data for long term preservation, turning raw data into meaningful information.	Creates and proves (or disproves) scientific theories through experiments, especially in the field of physics.	Designs systems where moving components and/ or supportive structures are required.
Promotes the importance of the work of scientists and engineers to the public and encourages people to pursue a career in STEM.	Develops programs to automatically complete easy tasks, or to help solve complex problems.	Designs devices to do useful things, which require electricity to work.

Science and Technology Facilities Council

Creating and presenting a poster

A large part of a science communicator's job is to create new activities and resources, which help them inform the public about the work of scientists and engineers around them. In this activity, you will create a poster on scientific topics of interest to the young people and present to the rest of the group. Suggested topics, along with questions and statistics to consider, are provided.

What you will need:

- Paper (A3 preferred)
- Felt tip pens
- Suggested topics, questions to consider, see below

OR

- A PC for each individual/group who will create a poster, with suitable software e.g. MS publisher, MS PowerPoint etc.
- Suggested topics, questions to consider, see below

What to do:

1. If necessary, split into smaller groups who will work to create their own poster. This activity could also be done individually if preferred. Have each group choose a topic of interest, as long as it has a scientific background.
2. Ask the groups to create a poster, which is eye-catching and contains all the important information. Whilst creating the posters, the young people should also think about how they'd like to present their poster. Their key messages need to be clear and engaging.
3. When all groups are ready, reconvene everybody and have each group take it in turns to present their poster (and allow for any Q+A!).

Here are some suggested topics for the activity.

Also provided are questions and statistics to consider when making arguments. (Note these will be added later).

- How can YOU help stop climate change?
- Is funding space exploration worthwhile?
- Should vaccinations be compulsory for children?
- Nuclear fusion – latest research, limitations and potential benefits.
- What are the benefits and risks of Artificial Intelligence?

Careers

If your group has enjoyed these activities, maybe they would like to consider their next steps. We offer many opportunities for real-life experiences:

Work experience

We offer one or two week work experience placements to over 100 Year 10, 11, 12 and 13 students each year, applications usually close 31 December.

Apprenticeships

STFC has over 20 years' experience in providing engineering apprenticeships and provides an excellent training ground to equip individuals with the relevant skills and experience for their chosen career in either mechanical, electrical or electronic engineering. We offer a competitive salary that increases annually, 4 years supervised training, additional core skills development and the opportunity to undertake overseas placements. We also offer 4 year computing apprenticeships where apprentices work towards a BSc (Hons) Digital and Technology Solutions Degree.

Summer placements

We offer a variety of summer placements, usually lasting 8-12 weeks that can be completed during a university degree.

Industrial placements

We offer a variety of industrial placements lasting up to a year that can be completed during a university degree.

Graduates

Graduate programme which students can apply to join on completion of their degree studies. This helps build/enhance necessary workplace skills and bridges the gap between full time education and employment.

All the information and opportunities at STFC can be found on the careers website: www.stfccareers.co.uk/careers/

Acknowledgements

This pack was created by Kate Winfield (Project Manager), Ryan Smith, Louise McCaul and Chris Parmenter, who are graduates at STFC RAL Space, with the aid of other staff across site, especially including the RAL Public Engagement Team, the RAL Space Comms & Outreach Team and Sarah Beardsley.

We would like to give thanks to our funders; the STFC graduate scheme and the STFC SPARK awards, as well as advice received from Girlguiding Oxfordshire and Oxfordshire Scouting, and our team of proofreaders.

About the team

Kate Winfield

Kate is an Environmental Data Scientist in the Centre for Environmental Data Analysis (CEDA) in RAL Space, where she is responsible for gathering atmospheric and earth observation data from scientists and archiving the data on the JASMIN supercomputer. Kate joined STFC as a graduate in 2017 following a Physical Geography degree at Coventry University and a placement year at CEDA. Kate is a Brownie Leader (Brown Owl) in Oxfordshire and has been in Girlguiding since the age of 7.

Ryan Smith

Ryan is an electronic engineer in the Imaging Systems Division of RAL Space, where he is responsible for designing laser control systems for quantum technologies, as well as building and testing circuit boards before they are

put on spacecraft. Ryan Joined STFC in 2018 with a Masters in Robotics from Plymouth University. Ryan is a Section leader for his local scout group in Didcot, and has been a part of scouting since he was a Beaver at age 6.

Louise McCaul

Louise is a Project Manager in the Imaging Systems Division of RAL Space, involved in projects producing camera electronics for science instruments on spacecraft. Louise joined STFC graduate scheme in 2018 after completing an MPhys in Theoretical Physics from the University of St Andrews. Louise is a Brownies Leader in Training (Barn Owl) in Oxfordshire.

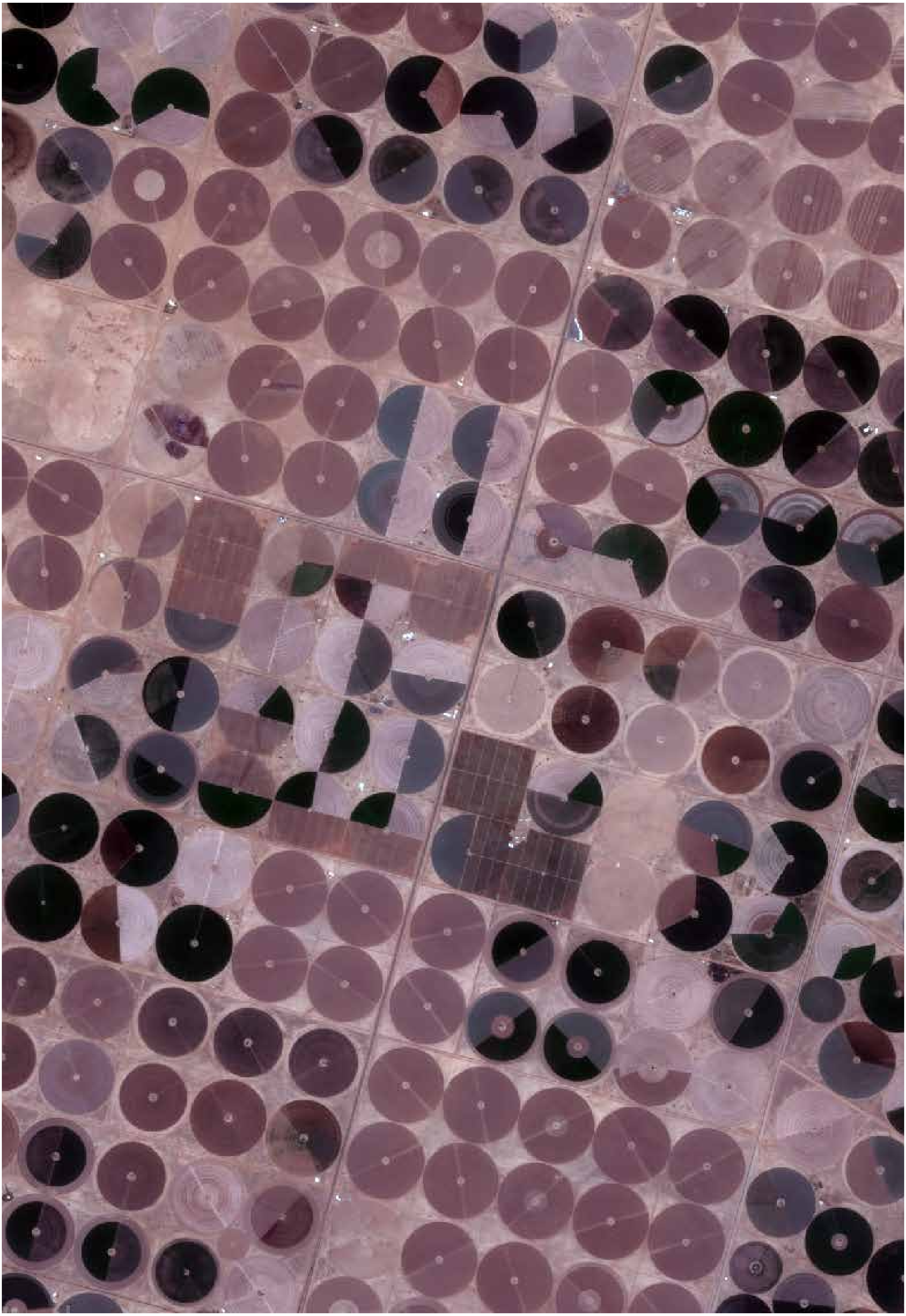
Chris Parmenter

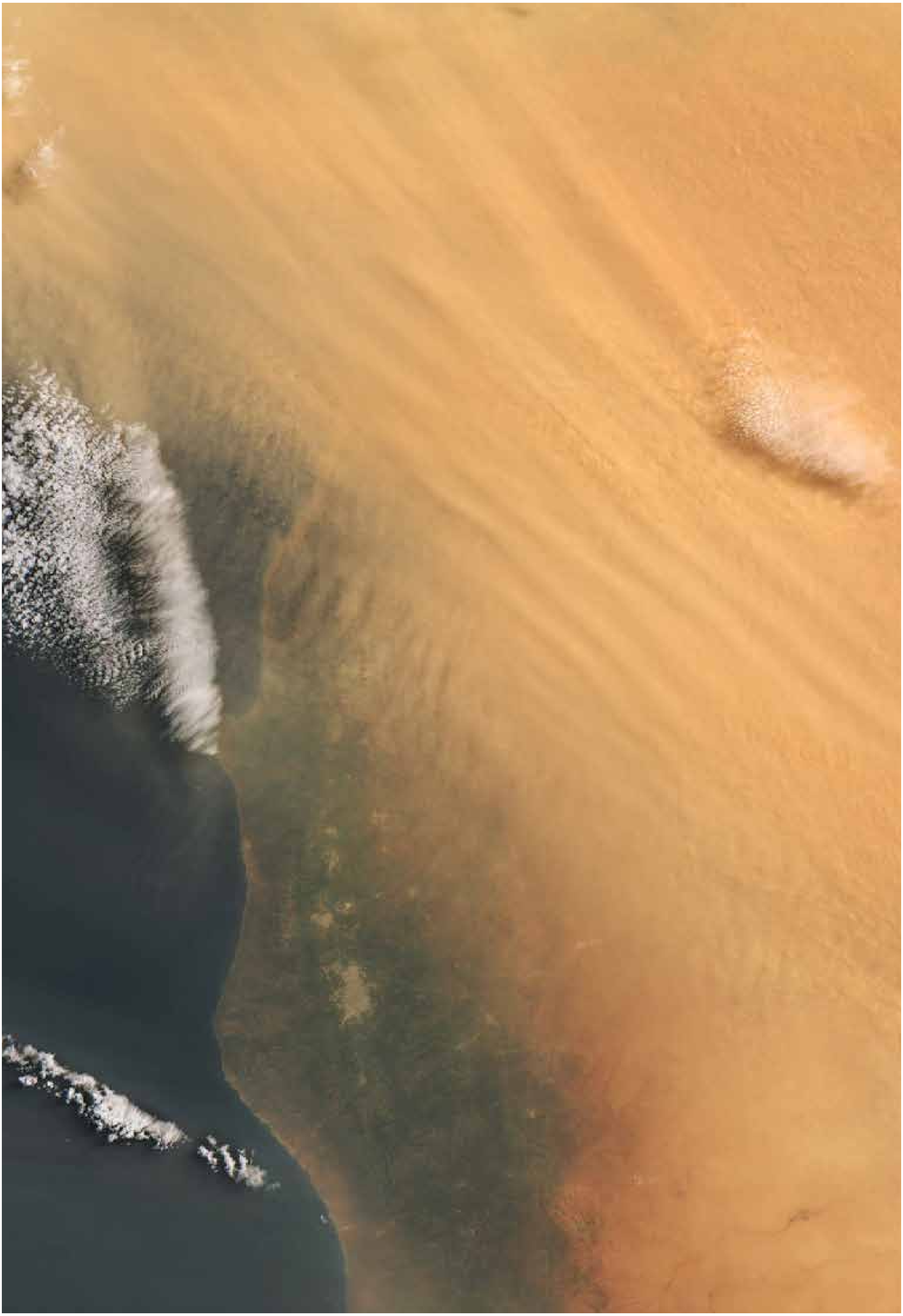
Chris is an Electronics Engineer in the Imaging Systems Division of RAL Space. His main jobs include designing and testing electrical circuits to be used in space missions e.g. for observing the Sun. He joined STFC's graduate scheme in 2017 after completing an MEng in Electrical & Electronic Engineering at Cambridge University. Chris enjoys taking part in a wide range of outreach activities, including STFC & RAL Space events, and volunteers as a STEM ambassador and as a mentor with the Social Mobility Foundation.

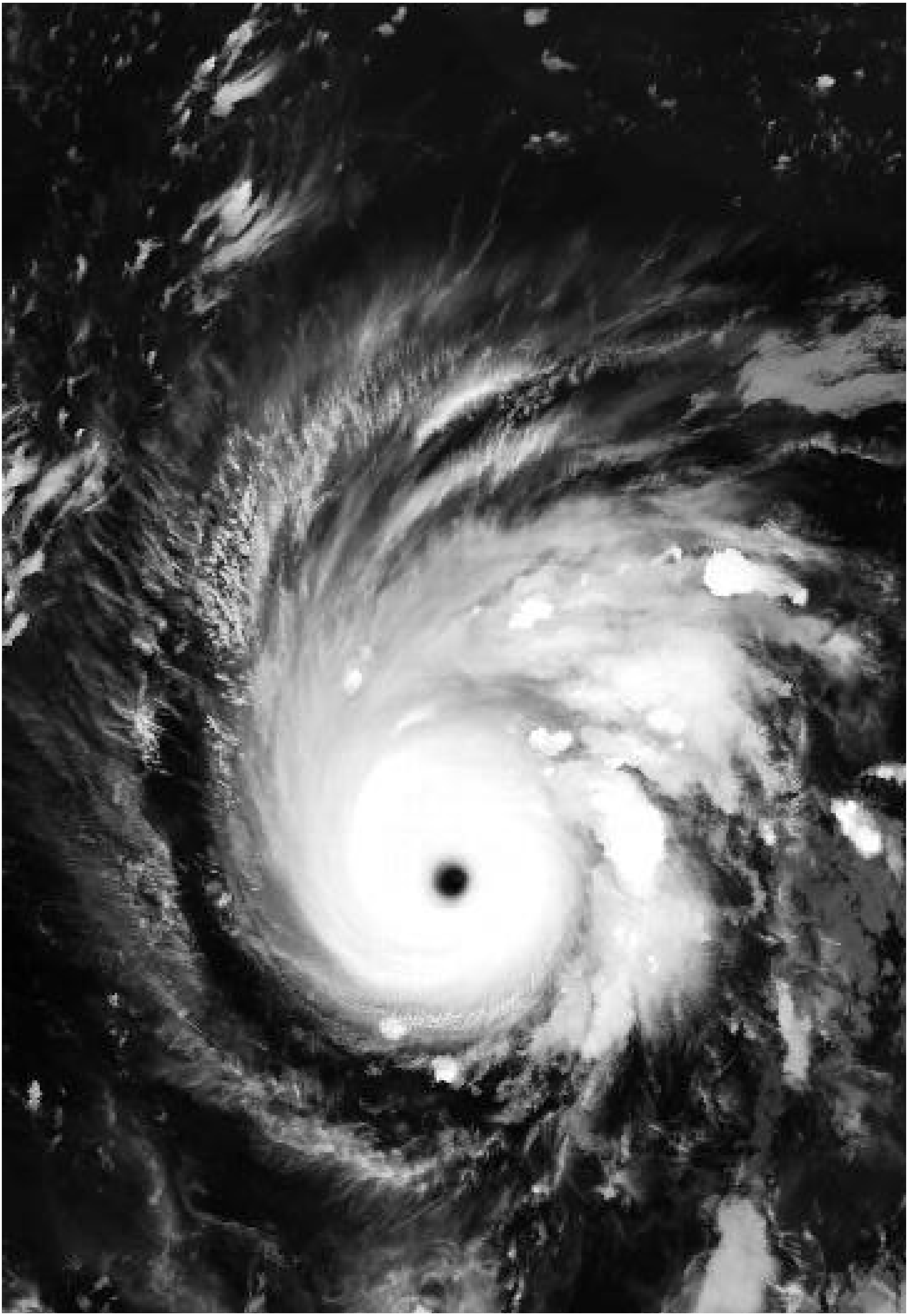
Appendix

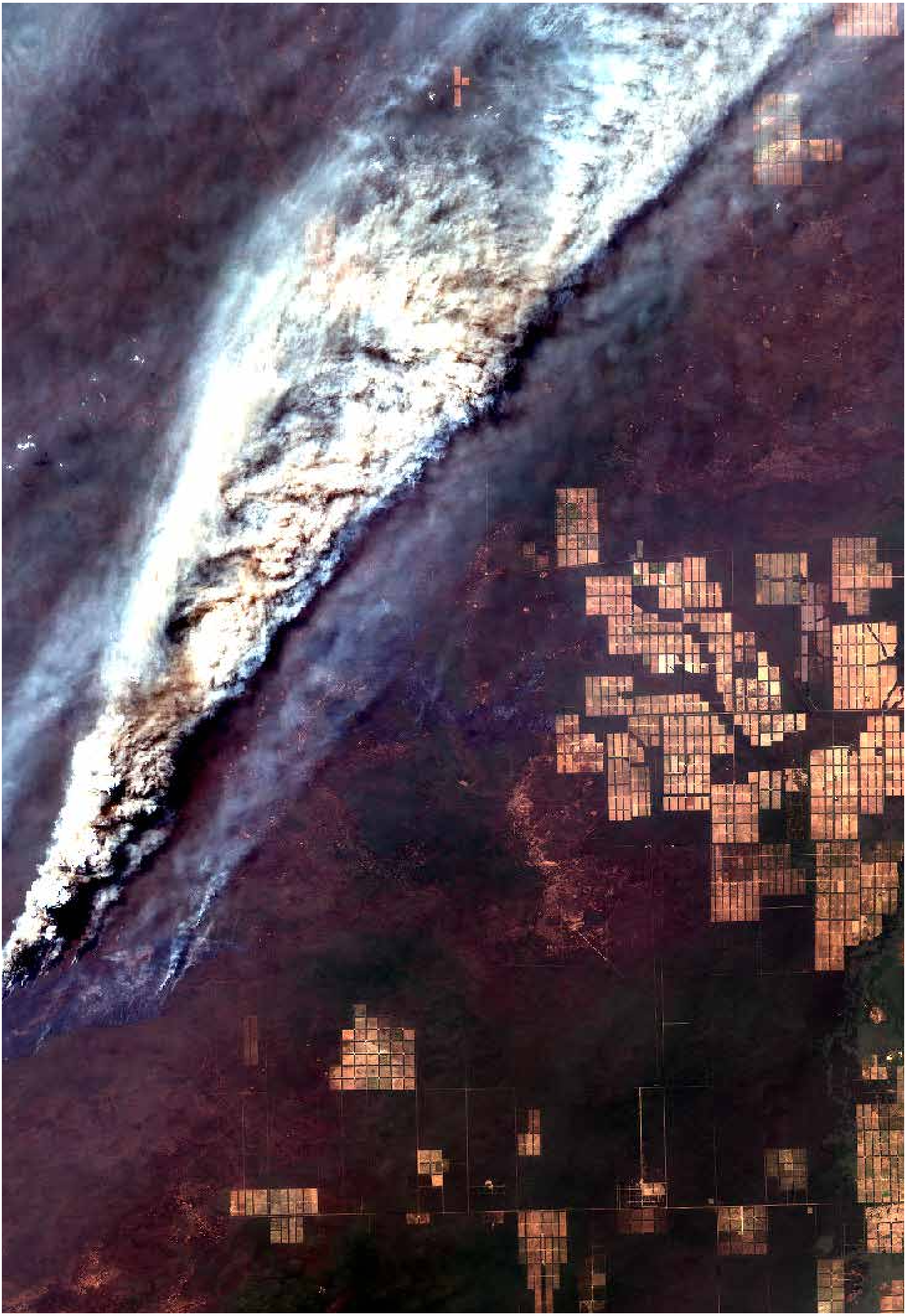
Satellite jigsaw game

Sea Ice	Alaska sea ice taken on 14/05/2018 from Sentinel 2
Wild Fire	Amazon fire taken on 18/08/2019 from Sentinel 2
Man made	Image of the world's longest bridge in China taken in October 2018 from Sentinel 2. This image also shows the transportation of sediment
Hurricane	Hurricane Dorian taken 02/09/2019 from Sentinel 3
Dust	Desert storm in North Africa shows Saharan dust being blown across the Mediterranean Sea taken on 22/03/2013 from Sentinel 2
Volcano	Mount Etna in Italy taken on 13/04/2018 from Sentinel 2. If you look closely you will be able to see gas coming out of the volcano
Rivers	River Thames in London from Sentinel 2
Agriculture	Farming in the desert in Saudi Arabia take on 09/06/2019 from Sentinel 2









The badge design has been expressly approved by Oxfordshire Scouting, Girlguiding and STFC.

Science and Technology Facilities Council