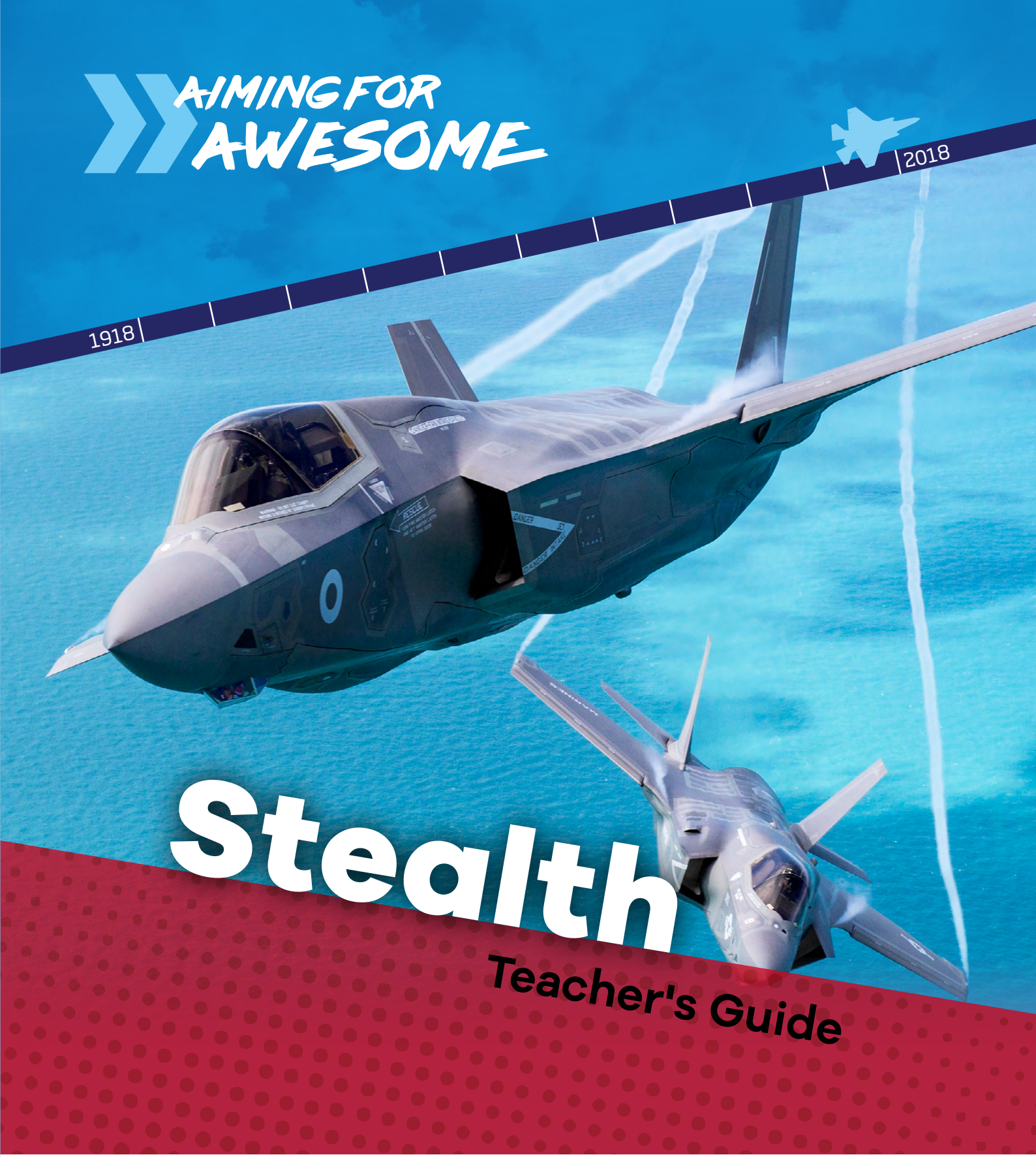
AIMING FOR AWESOME

1918 2018



Stealth

Teacher's Guide

Royal Academy of Engineering

THIS IS ENGINEERING

ROYAL AIR FORCE Youth STEM

The aim of this resource is to give students the opportunity to investigate the impact of science, technology, engineering and mathematics (STEM) on making stealth vehicles.

Curriculum links

England

Activity	Key Stage	Subject	National Curriculum
Time to investigate one	KS2	*Science*	**Light:** use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye.
Time to investigate two	KS2	*Science*	**Light:** use the idea that light travels in straight lines to explain why shadows have the same shape as the objects that cast them.
Time to think	KS2	*Science*	**Light:** use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye.
Time to investigate one	KS3	*Science*	**Light waves:** colours and the different frequencies of light, white light and prisms.
Time to investigate two	KS3	*Science*	**Experimental skills and investigations.**
Time to think	KS3	*Science*	**Light waves:** the transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface.

Scotland

Activity	Subject	Topic	Experiences and outcomes
Time to investigate one	*Sciences*	Vibration and waves	SCN 2-11b
Time to investigate two	*Sciences*	Vibration and waves	SCN 2-11b
Time to think	*Sciences*	Vibration and waves	SCN 2-11b

Wales

Activity	Key Stage	Subject	National Curriculum
Time to investigate one	KS2	*Science*	**How things work:** how light travels and how it can be used.
Time to investigate two	KS2	*Science*	**How things work:** how light travels and how it can be used. **Skills:** communication. **Skills:** enquiry.
Time to think	KS2	*Science*	**How things work:** how light travels and how it can be used.
Time to investigate two	KS3	*Science*	**Skills:** communication. **Skills:** enquiry.

Northern Ireland

Activity	Key Stage	Subject	National Curriculum
Time to investigate one	KS2	*The world around us*	**Strand 2:** Movement and energy: the causes and effect of energy, forces and movement.
Time to investigate two	KS2	*The world around us*	**Strand 2:** Movement and energy: the causes and effect of energy, forces and movement.
Time to think	KS2	*The world around us*	**Strand 2:** Movement and energy: the causes and effect of energy, forces and movement.

Preparation

- Ensure all materials and equipment needed are available well in advance of the session. See the resource list below for essential materials and components.
- A full risk assessment should be conducted prior to the session.
- This session is expected to last 60 minutes.
- Ensure technology is available to project the relevant video materials.

This resource has been linked to the Engineering Habits of Mind (EHoM). For more information about the EHoM please see the information sheet provided or www.raeng.org.uk/ltbae.

Resource list

For this activity, you will need the following per student:

- Coloured filters
- Torch
- Aircraft cut outs
- Squared or graph paper

Lightning

Stealth is the ability to evade detection by radar, infrared sensors or emission interception.

Stealth provides greater survivability, and makes it easier for aircraft to operate in contested areas without being detected.

The Lightning aircraft was designed to be hard to detect.

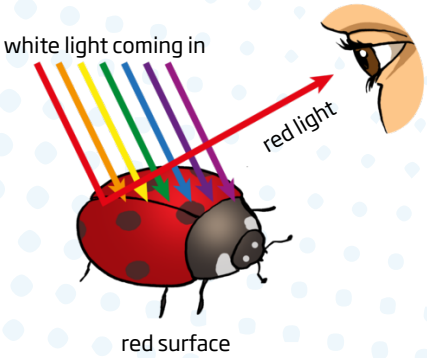
Engineers used a combination of the aircraft's shape and stealthy, radar-absorbent materials to make it a very-low-observable aircraft.

The Lightning is a single-seat, single-engine supersonic jet and has the most advanced computers and networking abilities of any aircraft so far.

The F-35B has short take-off and vertical landing (STOVL) capabilities, meaning it can hover.

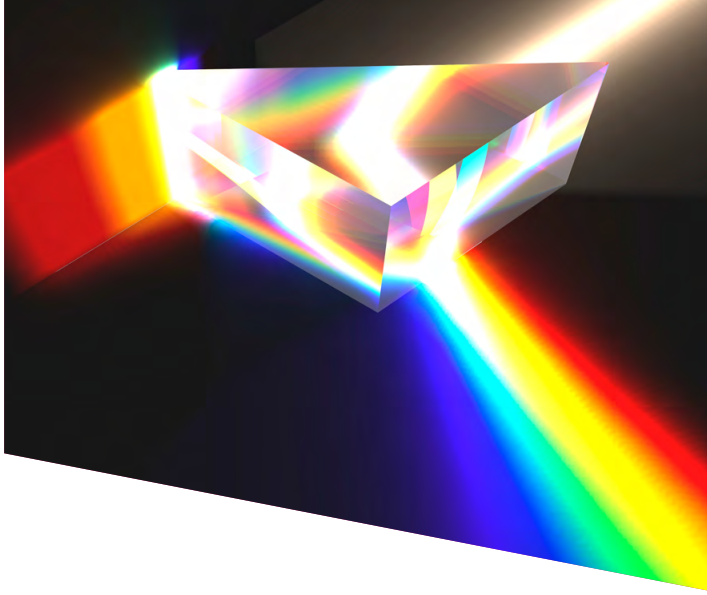
Camouflage

Objects reflect different colours of light. The colours that are not reflected are absorbed. This ladybird is red, because it reflects red light.



Some animals can use this to camouflage themselves. Most chameleons change colour as social signalling or a reaction to external temperatures. However, some chameleons can change their colour to camouflage themselves.

Aircraft can also be coloured to camouflage. For example, until 1941, the top of Royal Air Force (RAF) fighter aircraft were painted in dark green and brown to blend in with the ground, and sky colours underneath to avoid being seen from the ground. However, aircraft were lost and pilots reported that the colours used made their fighters conspicuously darker than the sky.



TIME TO INVESTIGATE – 1

How are different colours made?

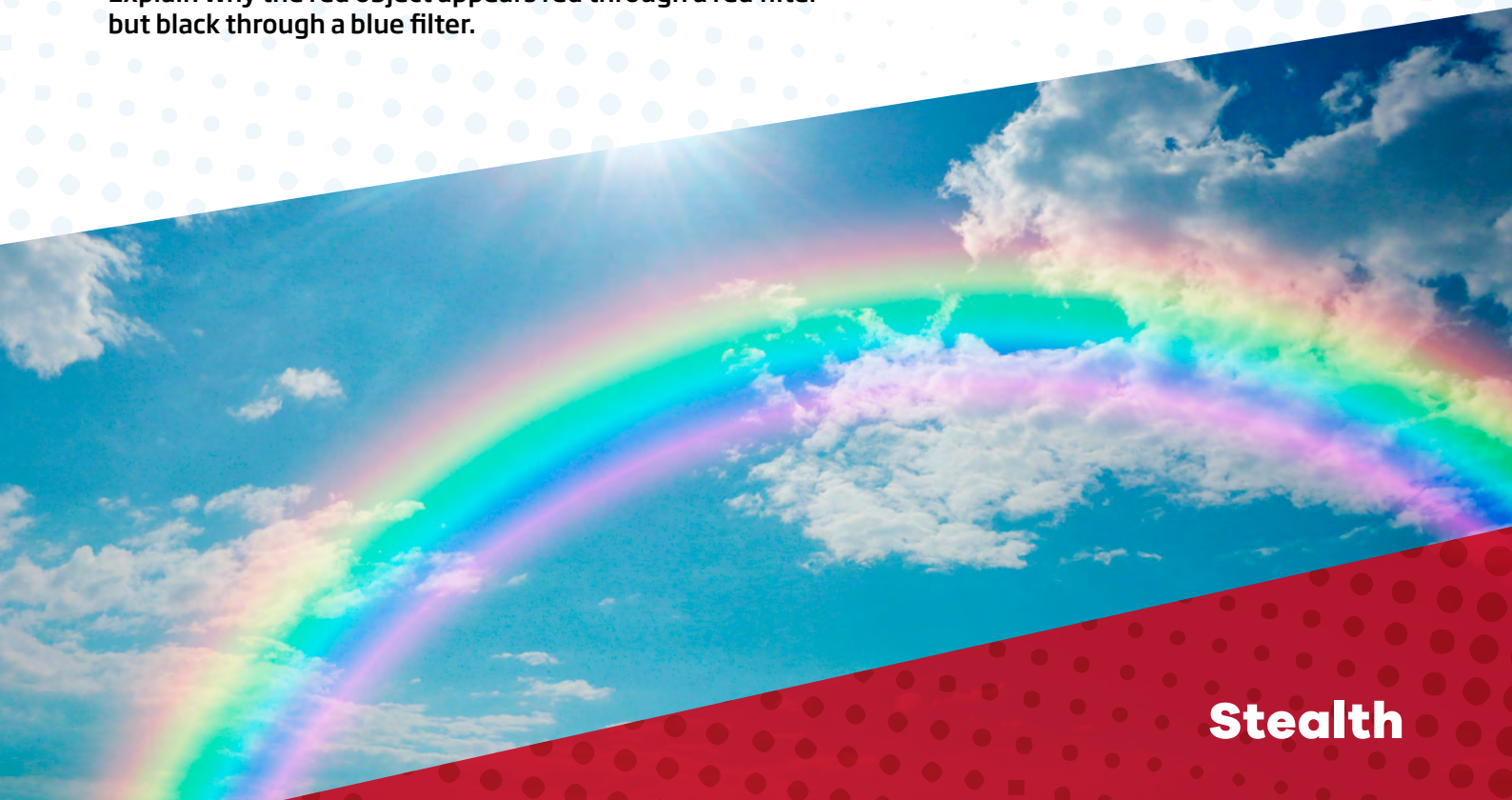
White light is made up from the colours of the rainbow.

A coloured filter allows some colours to pass through and absorbs the others. For example, a red filter transmits red light only and absorbs all the others, whereas a blue filter will absorb all colours except blue.

The primary colours of light are red, green and blue. View a red, green and blue coloured object through the different filters.

Object colour	Filter colour	Observation
Red	Red	
	Green	
	Blue	
Green	Red	
	Green	
	Blue	
Blue	Red	
	Green	
	Blue	

Explain why the red object appears red through a red filter but black through a blue filter.



STRETCH AND CHALLENGE

Use the filters to work out how to make the secondary colours of light.

Object colour	Filter colour	Observation
Yellow	Red	
	Green	
	Blue	
Cyan	Red	
	Green	
	Blue	
Magenta	Red	
	Green	
	Blue	

Yellow is made of red and green light.

Cyan is made of green and blue light.

Magenta is made of red and blue light.

Guidance provided to STEM activity leader

Before the students conduct this activity, you could demonstrate dispersion, or splitting white light into the constituent colours.

Use a ray box to shine a single beam of white light into a triangular prism. The prism will split the light into the spectrum of colours. The prism does this because the different colours of light have different wavelengths, which means they are refracted by different amounts. This is how a rainbow is made. Droplets of rain act as a prism and refract the light from the Sun.

Radar detection

Radar can also be used to detect aircraft.

A bistatic radar system has a transmitter and receiver separated by a distance, whereas a monostatic radar has the transmitter and receiver in the same place.

There are many different methods to detect aircraft using bistatic radar, one of which is forward scatter radar. The forward scatter radar technique uses bistatic radars to emit a radar that hits the object and is blocked from the receiver, much like how a shadow is formed. Forward scatter radar is useful because it is not effected by stealth coatings.

TIME TO INVESTIGATE – 2

The size and shape of an aircraft is also important to consider to avoid it being detected.

Shine a torch on the cut-outs of the RAF aircraft through the ages. What do you notice about the area of the shadows?

Write a method to investigate how the shadow changes for each of the cut-outs.

To make sure the experiment is reproducible you need to control all the variables, except the independent and dependant variable. The independent variable is what you change each time, in this case the aircraft shape, and the dependent variable is what you measure, in this case the area of the shadow.

What variables are you keeping the same each time?

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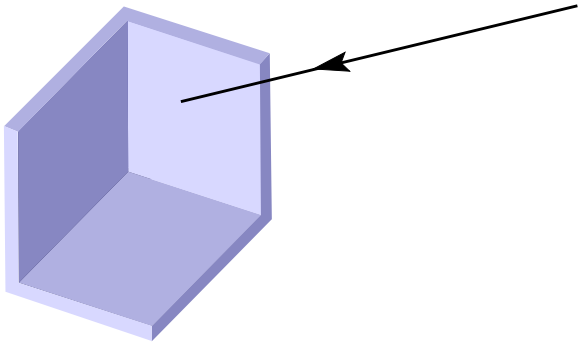
Use the table below to record your results.

Aircraft	Area of shadow cm²

Which aircraft is the best for avoiding forward scatter radar detection?

The backscatter technique uses the reflection of radar to detect and aircraft.



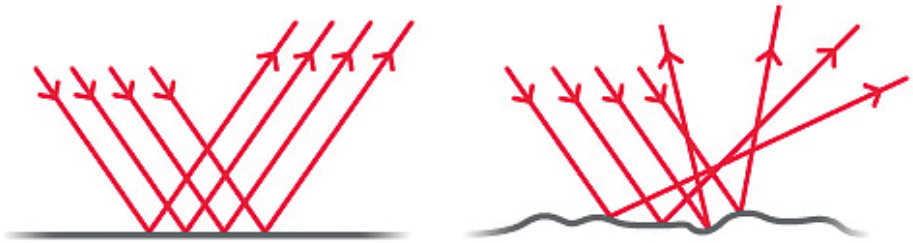
TIME TO THINK

What do you think you will see if you look into the corner cube, or retroreflector?

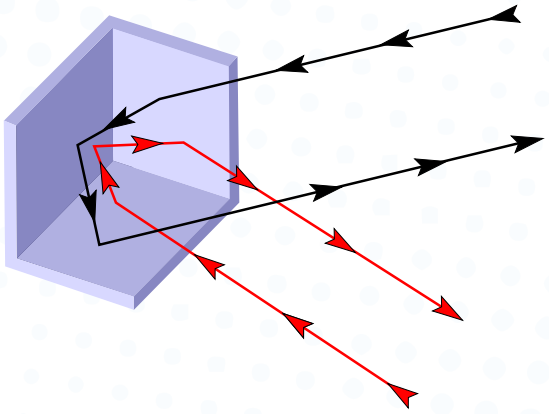
Do you think it will be different if you look at the vertex from the other side?

TIME TO DEMONSTRATE

Explain that light travels in straight lines and is reflected by shiny surfaces. We can see objects because light is reflected off them and into the eye. When light is reflected by a smooth shiny surface, the light is all reflected in one direction and we see a normal image, just like a mirror. When light is reflected by a rough surface, the light is reflected in all directions; this is called diffuse scattering. It explains why you can see a clear image of yourself in a shiny flat mirror, but not in a dull rough wall.



With the retroreflector cube, no matter which angle the light hits the mirror, it is always reflected off each side and directly back to the source.



With the introduction of new detection technologies, aircraft skin is now designed to scatter light and radar to stop aircraft being detected in this way.

Stealth

Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

What we do

Talent & diversity

We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

Innovation

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

Policy & engagement

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.

ROYAL AIR FORCE Youth STEM

The RAF Youth STEM programme is designed to engage and inspire young people by building their interest in engineering and technical career pathways.

From cyber specialists to aerospace, aviation, electronics, and mechanical disciplines, the RAF is committed to widening participation in STEM, extending opportunities to all, and encouraging greater diversity in this critical area of national skills shortages.

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