THE JET AGE AND HELICOPTERS

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HISTORY OF MODERN AIRCRAFT TECHNOLOGY AND THE RAF

The historical information here explores some of the basic technical information about aircraft and how they have affected events and how events have affected aircraft. There are two key focuses: the jet age (development of the fighter jet) and the impact of the helicopter. Anyone using this information is advised to watch the film *Jet Age and Helicopters* carefully to understand some of the technical information.

EARLY AIRCRAFT

The Industrial Revolution introduced huge technological and scientific changes to many people, especially those living in Europe and the Americas. The development of engines and the use of man-made power, such as steam, made a significant difference to industrial output and to travel. One of the earliest types of engine invented was the early piston engine.

THE PISTON ENGINE

In piston engines, a crankshaft allowed for the rapid rotation of a shaft via a rod mounted on a moving plug. With a propeller mounted at the end of the shaft, the engine could power an airplane. Sheathed inside a cylinder, it could power the engine of a train or automobile.

EARLY INVENTORS

Credit for inventing history's first piston engine goes to French physicist Denis Papin, who published his design for a piston steam engine in 1690. The basic design evolved by the early eighteenth century: Thomas Newcomen of England and James Watt of Scotland improved upon Papin's innovation by adding a boiler and steam condenser to the cylinder, further enhancing performance.

ADVANCEMENTS

After the inventions of James Watt and Thomas Newcomen in the early eighteenth century, a number of variations of the piston engine started to appear in the industrial sphere. The atmospheric engine, steam engine, Stirling engine and internal combustion engine emerged by the nineteenth century, subsequently providing power for trains and automobiles. In the present day, the internal combustion engine powers motor vehicles.

https://sciencing.com/history-piston-engine-5038824.html

The development of the steam engine enabled massive distances to be covered by rail and sea. However, steam engines were often heavy and not as suited for small vehicles; those developing the early use of cars and aircraft continued to use piston engines, as they could provide a lot of power but were also small and light in comparison to the steam versions.

The Wright brothers made the first successful flight in 1903, with Alberto Santos-Dumont successfully completing the first powered flight (using an engine) in 1906. After that, aircraft and flying became an area of technological focus and development. To understand the principles of flight, see the technical drawing 'Taking off and moving through the air'.

The use of the piston engine enabled the aircraft to fly successfully, albeit over a limited range. Early aircraft were biplanes; this was because the materials available for aircraft construction were not strong enough and also light enough to withstand flight. In biplanes, two sets of wings provide strength to the aircraft. Most of the planes could only carry the pilot and possibly a co-pilot/passenger. Aircraft were limited in how far they could travel due to their size and engines. They also had open cockpits, so pilots and flying were limited by the weather and visibility.

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The Sopwith Camel was typical of the type of aircraft used in the First World War. It was a biplane made out of fabric-covered wooden surfaces.

Its fuel tank was located at the rear of the aircraft, which made the position of its centre of mass vary significantly with changing fuel load, earning it a reputation as being difficult to fly.

The role of aircraft during the First World War was given an enormous push; they went from being simply eyes in the air to intelligence-gathers, communications lynchpins, and attackers and defenders. Following the war, in the 1920s and '30s, aircraft competitions that pushed the physical capabilities of aircraft and experimented with better designs were popular and often sponsored by the RAF and the new engine companies.

By the Second World War, the piston engines had been refined, developed and given an increased sophistication that went way beyond the early engines. These advanced piston engines were able to provide a lot more power to the aircraft, enabling them to carry far heavier loads and cover much further distances. Developments in design and metals meant that many aircraft now had a metal skeleton, although much of the outer covering was not metal. Aeroplanes began to have two fixed wings, and the old biplane design was slowly abandoned. However, the engine capabilities still resulted in limitations to how high or fast the aircraft could fly.

During the Second World War, the aircraft – as well as the pilots – of the RAF became well known to many on the ground. The Battle of Britain meant that many people could spot a Spitfire or a Hawker Hurricane as they flew overhead. Further, the power and size of the Lancaster Bombers, as well as their deadly cargo, became a symbol of force for the Allies and horror for the Germans.

Both the Spitfire and the Hurricane were powerful aircraft with good manoeuvrability – ideal for the dogfights that they were now required to perform to stop the Nazi Luftwaffe (air force) from dominating Britain's skies. They seemed a millions miles from their counterparts of the First World War; nonetheless, all sides still wanted aircraft that were stronger, faster and able to carry more.

The Hawker Hurricane was a new type of aircraft and the RAF's first main departure from biplanes for its fighter aircraft. It was first discussed in 1933 and went into production in 1935. By the start of the Second World War, the Hurricane was the main fighter aircraft across the RAF. It was the first aircraft used to shoot down a German aircraft in October 1939.

The Hurricane had an advanced Rolls Royce piston engine and was known as the 'workhorse' of the RAF fighter command, because of its reliability. Hurricanes were easier to repair than the more famous Spitfire, making them popular with the ground crew. They made up the largest number of fighter aircraft used by the British during the Battle of Britain.

Over 14,000 Hurricanes served during the Second World War.

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FRANK WHITTLE AND THE JET ENGINE

Frank Whittle was the son of a mechanic and had a fascination with engines and aircraft. Born in 1907, he watched the fast development of aircraft as he was growing up. On his third attempt to join the RAF, he became an apprentice (his two earlier rejections were due to his not meeting the height requirement) and qualified as a Pilot Officer in 1928.

Very early on, he recognised that if aircraft were to fly at high altitudes, a new type of engine would be required to replace piston engines. He began work on his own designs and, in 1929, he patented (registered) a design for an encased gas turbine engine, although they were not actually made.

The RAF approved the formation of Whittle's own company – Power Jets Ltd – in 1935. With additional financial backing, Whittle and the RAF began to construct and test the new jet engine design. The first design was unsuccessful; despite this, Whittle pushed on. In 1939, the Second World War had started and the Air Ministry was distracted by other priorities; nonetheless, further finance was agreed. In 1941, the new engine was at the testing stage, and the first successful flight with Whittle's jet engine was made in May of the same year.

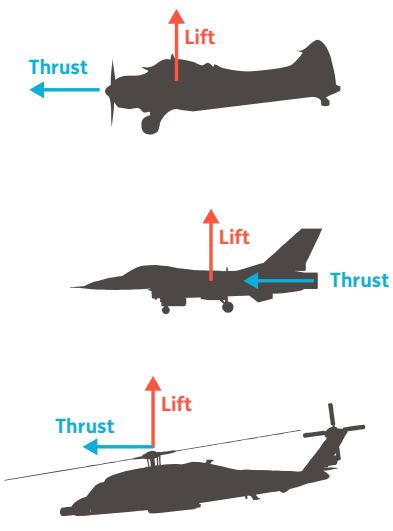
The Americans heard about the programme and asked for Whittle and his team to go to the USA. Working with the US company General Electric on further engine tests, they began construction of the new jet aircrafts using the Whittle's engines, leading to the 1942 American XP-59A Airacomet. Back in the UK, due to the demands of the Second World War, the British Meteor jet didn't become operational until 1944.

At the same time as Whittle was coming up with his early idea, so were other inventors. Germany started to use jet engines in 1939 in some of its aircraft, although many of the engines were difficult to handle and prone to accidents, making the pilots nervous and therefore less likely to take risks. Indeed, Germany's Hans von Ohain was the designer of the first operational turbojet long before Whittle's engine got going – but Whittle had patented his design first, thus making him the father of the jet engine.

Both the German designs and Whittle's demonstrated that jets would be the way forward. Combined with a better understanding of aircraft materials, new aircraft were now being built that could travel much further distances than the previous aircraft. However, one of the main advantages of the jet was its speed.

TAKING OFF AND MOVING THROUGH THE AIR

All aircraft propulsion systems use the same principle: they push air in one direction to create a force (thrust) in the opposite direction.



Propellers are like fans in reverse. They have spinning blades connected to a piston engine (similar to those found in cars) that push air backwards to create a forward force.

Jet engines also push air backwards, but work in a different way to propellers. They can produce more thrust because they heat and compress the air so that it is pushed backwards at a higher speed.

The force required to lift the aircraft into the air is created by airflow around the wings. A fixed wing aircraft can only take off when the air is moving quickly around the wings. They need runways to reach take-off speed.

A helicopter can take off vertically because it has the propeller (called a rotor) mounted on its top, which pushes air downwards to produces an upward force. The rotor needs a much more complex design than a propeller because the blades need to be hinged so that they can move independently of each other to allow the pilot to be able to provide both lift and thrust using just the rotor.

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THE JET ENGINE AIRCRAFT

The Allies and the Axis powers had all developed jet engine fighter aircraft by the end of the Second World War. By the end of the 1940s, the US forces had developed a jet engine bomber, and the rest of the world began to follow. The light bomber English Electric Canberra was put into service by the RAF in 1951.

In the civilian world, the British Overseas Airways Corporation (BOAC, a forerunner of British Airways) flew from London to Johannesburg as the first commercial jet service in 1952, with the de Havilland Comet jetliner. The aircraft had a number of crashes, which helped to pave the way for the more successful Boeing 707 in 1958. In the space of a few decades, military and commercial journeys had gone from taking months at sea to only hours in the air.

In the 1950s, the UK developed the V bombers – the Vickers Valiant, the Avro Vulcan and the Handley Page Victor. They were large jet engine bombers that demonstrated the UK's independent capability as well as its role as a key player in NATO. The V aircraft proved that the UK was not totally reliant on the United States for large aircraft. In 1956, the Valiant was used in the UK's involvement in the Suez Crisis.

Although the jet bombers were advanced for their time, their internal instruments were fairly basic, and the cockpit controls were not that different from many found in the aircraft of the Second World War. By the 1980s, the V bombers were being wound down, when in fact they were about to face one of their greatest challenges – the Falklands War of 1982 (to find out more, look at the activity and film on Long Range Missions and Operation Black Buck).

The next generation of jet aircraft introduced more advanced instruments as well as engines. Increasingly, aircraft became computerised. The modern Tornado jet took over from the Vulcan in the 1980s. It was developed for high-speed roles, as well as reconnaissance and ground attack. It was used in conflict zones in the Gulf War, Iraq and Afghanistan.

New versions of aircraft are being explored and developed all the time, but only certain versions will ever go into production; however, even the development stages will cost millions of pounds. Each new jet aircraft – such as the currently used Typhoon – costs £70 million to produce.

Aircraft are now designed for multiple roles – reconnaissance, attack, defence, speed, manoeuvrability, the ability to carry modern weapons and so on. As the Tornado is being phased out for the RAF, the main aircraft used are the Typhoon and the F-35B Lightning.

AVRO VULCAN

The Avro Vulcan was introduced by the RAF in 1956 and had a distinct V-shaped design. The design of the Vulcan was very advanced for its time, utilising advanced aerodynamics that helped to influence later air technology and design, such as Concorde (the first commercial aeroplane to fly faster than the speed of sound). The Vulcan was an important aircraft in the V Force. The V Force was part of the UK and NATO's nuclear deterrent against the Soviet Union during the Cold War until 1969.

In 1969, the UK switched to submarines to carry its nuclear weapons. The Vulcans then had their paint colour scheme changed, from white to green and grey camouflage, which indicated that it was to be used in low-level attack rather than high-level.

Vulcans stopped being produced in 1965, making those used in the Falklands War around 20 years old. The Vulcan was withdrawn from operational service on 31 March 1984.

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THE TYPHOON

The Typhoon FGR.Mk 4 is a highly capable and extremely agile fourth-generation multi-role combat aircraft, capable of being deployed for the full spectrum of air operations, including air policing, peace support and high-intensity conflict. Initially deployed in the air-to-air role as the Typhoon F.Mk 2, the aircraft now has a potent, precision multi-role capability as the FGR4. The pilot performs many essential functions through the aircraft's hands-on throttle and stick (HOTAS) interface which, combined with an advanced cockpit and the Helmet Equipment Assembly (HEA), renders Typhoon superbly equipped for all aspects of air operations.

Although Typhoon has flown precision attack missions in all its combat deployments to date, its most essential role remains the provision of quick reaction alert (QRA) for UK and Falkland Islands airspace. Detachments have also reinforced NATO air defence in the Baltic and Black Sea regions.

https://www.raf.mod.uk/aircraft/typhoon-fgr4/

What this means is that the Typhoon is currently the UK and most of Europe's most sophisticated modern jet fighter. It is one of the most advanced aircraft used by air forces in the world today.

F-35B LIGHTNING

The F-35B Lightning fifth-generation combat aircraft will operate alongside the Typhoon. Lightning is a multi-role machine capable of conducting missions including air-to-surface, electronic warfare, intelligence gathering and air-to-air simultaneously.

The aircraft combines advanced sensors and mission systems with low observable technology, or 'stealth', which enables it to operate undetected in hostile airspace. Its integrated sensors, sensor fusion and data linking provide the pilot with unprecedented situational awareness. The pilot is able to share information gathered by the jet with other platforms using secure data links, and/or use the information to employ weapons or electronic means.

The F-35B's short take-off and vertical landing (STOVL) capability allows it to operate from the new 'Queen Elizabeth'-class aircraft carriers and the vessels of allied nations, as well as short airstrips.
https://www.raf.mod.uk/aircraft/f-35b-lightning/

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NEW AIRCRAFT: HELICOPTERS

Helicopters as an idea have been around for centuries, but they started being experimented with in a realistic way in the 1930s. The idea is that just as winged aircraft use propellers that push the aircraft forward (whether they are on the front of an aircraft or encased in an engine), a helicopter uses a propeller to push it upwards. Helicopters then have a small rotor or propeller on the back tail, which helps to keep the aircraft balanced. Just like early aeroplanes, the first types of helicopters were limited in what they could do

The advantage of helicopters is that they don't need large areas to land or take off. Instead, they can either hover over an area, including water, to winch people or goods up or down, or they can land in small areas that are otherwise difficult to reach. At the start of the Second World War, basic light helicopters were being used.

Helicopters first displayed their worth during the Korean War (1950–53), when fighting in the mountains made it difficult to get supplies to troops and, in particular, to get injured servicemen out. Helicopters were used to get the injured servicemen straight from the battlefield to the hospital units (MASH – Mobile Army Surgical Hospital) in a short amount of time – journeys that would have taken hours by road.

It was possible to land a helicopter in a small area, unlike fixed-wing aircraft that needed a landing strip. This meant that injured soldiers could be strapped to the helicopters in specially designed pods and transported to hospitals in under an hour. Helicopters are also able to hover above the scene of an accident, allowing the injured to be winched up under the aircraft for speedy removal. These advantages also made the helicopters susceptible to attack, but their advantages outweighed the dangers for many.

During the Korean War, a seriously wounded soldier who arrived at a Mobile Army Surgical Hospital (MASH unit) had a 97% chance of survival after treatment, as long as he was transported there as quickly as possible.

Following the Korean War, using helicopters was quickly adopted by other countries, in particular the UK with the RAF. Helicopter design and technology was still quite simple in the early days – helicopters were small and light.

Their size made their ability to land in difficult places easier, but it also made them vulnerable to attack and to accidents. Helicopters were not necessarily very robust – the designers soon set about trying to change that. The piston engines were upgraded to gas turbine engines and the aerodynamics began to be properly explored.

What followed was the development of more powerful rotors and sophisticated systems. To get an aircraft to hover while remaining stable is actually quite difficult, but essential if a helicopter is to fulfil the roles it is needed for – especially rescue.

While the challenge for fixed-wing aircraft had been speed with manoeuvrability, for helicopters it was power, strength and stability alongside versatility.

Helicopter technology has advanced incredibly over the last 70 years. They are now used for a large range of roles in the military and in the civilian environment. Their versatility is essential to many aeromedical evacuation roles (see the film and materials on medicine and aeromedical evacuation). The RAF is considered one of the leading providers of military aeromedical evacuation for troops and civilian support in the world, partly due to its adapted Chinook (see below) and helicopter capabilities.

THE WESTLAND WESSEX AND WESTLAND SEA KING

The Wessex was a turbine-powered development of the American Sikorsky S58. The initial production version was for the Royal Navy but in the early 1960s the RAF required a powerful general-purpose helicopter capable of troop-carrying, air ambulance and ground attack roles. Sources include **https://www.rafmuseum.org.uk/research/collections/westland-wessex-hcc4/**

The Wessex was developed to create the Westland Sea King, which was capable of operating in rough weather conditions and across stormy seas. This took on the RAF's Search and Rescue Force and adopted the now famous yellow colour.

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AIR, SEA AND MOUNTAIN RESCUE

When the RAF was created in 1918, it took over the responsibilities of the Royal Flying Corps (RFC) and the Royal Naval Air Service (RNAS).

One of these responsibilities was the protection and support of British coastal areas through the RAF Marine Branch. Over time and after two World Wars, this responsibility became the RAF Air Sea Rescue and then the RAF Search and Rescue Force (SARF or SAR Force), created in 1986. The final version came when the Force decided to rely entirely on helicopters for its rescue mission, demonstrating the strength and resilience of the aircraft.

The rescue capabilities were all developed for military use in the first instance, in particular the rescue of pilots or sailors adrift at sea due to combat (ship attacked or ejection from aircraft). The role of rescuing and assisting civilians was to be a secondary role. However, over time, civilian assistance became far more a part of the SARF responsibilities than anything military. RAF personnel became adept at rescuing civilians from mountain areas, the sea and flooded areas, as well as some emergencies overland.

In 2015, SARF was disbanded; the air and sea rescue responsibility was handed over to a civilian organisation (although many of the staff are former RAF SARF personnel). The RAF are still responsible for mountain rescue. This is due to the fact that, in addition to having expertise in helicopter rescue and getting to people in difficult areas, they also have specialist trained teams of mountaineers that can assist in those areas.

MODERN WAR ZONES

In the last few decades, the RAF has developed helicopter squadrons (units of organisation in the RAF) for a variety of roles. These roles include international military roles and peacekeeping activities.

BOSNIA – 1990s

In the early 1990s, the country of Yugoslavia began to break apart into separate nations, starting with Slovenia. As more of the Yugoslavian territories declared independence, civil war broke out. In some cases, the war descended into ethnic cleansing and genocide. The international community became involved and, in 1992, the United Nations authorised a UN Protection Force (UNPROFOR) to try to establish peace in the region.

In the winter of 1995, the peacekeeping mission in Bosnia (formally a part of Yugoslavia) was handed over to NATO's Implementation Force (IFOR).

Britain had troops in Bosnia from the UN participation and the NATO role, lasting until 2002. The military role included ground troops for peacekeeping patrols, the Royal Engineers to help in the rebuilding of the country after the fighting, the Royal Navy to patrol the sea and support those on the mainland, and the RAF. The RAF's roles included maintaining a peacekeeping presence, assisting in the movement of troops and supplies, and supporting other military operations.

One of the RAF's contributions was 28 Squadron – a Puma helicopter squadron. They were stationed in the region due to the ability of the Puma helicopters to get around the mountainous area in often difficult weather conditions, and where many of the roads had been badly damaged by the fighting in the civil war. They were able to deliver medical support, equipment and supplies, as well as provide a visible presence that could get around with relative speed.

The stationing of a helicopter squadron was viewed as less threatening than a jet fighter or bomber squadron, and this helped enormously with the peacekeeping and development role of the British military in the former Yugoslavia.

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TODAY

Helicopters play a fundamental role for troop movements and supplies and an essential role in medical evacuation (see the film *Aeromedical evacuation*). Chinook aircraft, with their two blades, are incredibly technically advanced and are able to fly into remote and difficult areas that would be impossible to reach by road while carrying heavy loads.

The Chinook and the Puma helicopters are sophisticated aircraft that are a vital component of the RAF today.

ABOUT THE PUMA HELICOPTER

The Puma has gone through a number of designs and is now the HC.Mk 2 medium support helicopter with a digital cockpit. The aircraft is used in a variety of combat roles, including the tactical movement of troops, weapons, ammunition and stores on the battlefield, as well as the extraction of casualties and in response to medical emergencies on the frontline. It is also employed during non-combatant evacuations, and humanitarian and disaster relief operations.

The aircraft is capable of carrying 16 passengers, 12 fully equipped troops or up to 2 tonnes of freight, the latter moved as internal cargo or underslung, or a mix of the two. It can also be fitted with up to six stretchers for operations in the casualty evacuation or medical emergency response team role.

The Puma HC.Mk 2 is capable of operating in harsh environments, lifting troops, supplies and humanitarian

aid wherever needed, especially under hot-and-high conditions. The aircraft can be prepared for transport by C-17 in just four hours, flown across the globe, and be rebuilt and returned to flying just as quickly at the destination, making it a highly mobile, deployable battlefield support helicopter.

https://www.raf.mod.uk/aircraft/puma-hc2/

THE CHINOOK

The Chinook is an extremely capable and highly versatile support helicopter that can be operated from land or sea bases into a range of diverse environments, from the Arctic to the desert or jungle. The aircraft may be armed and is fitted with a suite of self-defence equipment allowing it to operate across the battlespace. Chinooks are primarily used for trooping, resupply and battlefield casualty evacuation (casevac).

With its triple-hook external load system, internal cargo winch, roller conveyor fit and large reserves of power, the aircraft can lift a wide variety of complex underslung or internal freight, including vehicles. It can carry up to 55 troops or up to approximately 10 tonnes of mixed cargo.

Secondary roles include search and rescue (SAR), and supporting a wide variety of specialist tasks.

In addition to its traditional war fighting roles, the Chinook's lifting capability is held at readiness under the National Resilience commitment to respond to emergencies in the UK; in recent years these have included resupplying snowbound farmers in Northern Ireland and moving tons of aggregate to help reconstruct flood defences damaged by winter storms.

https://www.raf.mod.uk/aircraft/chinook/

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USING THIS INFORMATION

This historical information can be combined with the introductory film and resources from the resource section for exploring some creative ideas in a school club or informal club, or for a more curriculum-based lesson.

Below are some ideas and enquiry questions that these materials could support.

In addition to the historical information above, case studies and extra information are available in the resource section of this website. These include biographies and aircraft technology case studies.

KEY QUESTIONS FOR EXPLORATION IN ANY SETTING:

- Why did Whittle want to develop a new type of engine?
- Why did early aircraft use piston engines rather than steam?
- What are the names of the modern jets?
- Why are helicopters suited for sea rescue?
- Why are helicopters important for support in mountainous regions?

HOW TO USE THIS MATERIAL IN A HISTORY CLUB OR LUNCHTIME/ AFTER-SCHOOL/INFORMAL CLUB

These ideas are suitable for a mixture of age groups and abilities. They can also be used with the interactive map on this website to begin a local history investigation concerning the RAF.

SHOW THE FILM: *JET AGE AND HELICOPTERS.*

PROVIDE THE HISTORICAL INFORMATION OR READ IT TO STUDENTS.

Key question:

Ask the students to explain the importance of aircraft development by creating one of the following:

(you might want to use some of the questions from the box to get them thinking):

- A timeline poster of aircraft development.
- A newspaper story for their school/group newsletter on the role of the RAF in pushing aircraft technology forward.
- A display for the school/class/group noticeboard of key aircraft.
- A cartoon series about aircraft development.

Extension: Find out about other technology developed by the RAF that is used in the civilian world.

Now use this information to start investigating the local history of an airbase near you – this can be done starting with the interactive map. What type of aircraft was based there? Over the course of the last century, over 1,500 airbases or places have been used by the RAF, so even if you don't live near to one now, there will have been one nearby at some point.

Find out about the base. Identify what other information or understanding of an historical period is needed to tell the story of that base.

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LESSONS IN SUPPORT OF THE CURRICULUM AND/OR EXAMINATIONS

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GUIDANCE ON HOW THIS MATERIAL COULD BE USED IN A LESSON ABOUT:

1. Britain in the World Since 1945
2. The Technology of Warfare

1. BRITAIN IN THE WORLD SINCE 1945

Ages 11 years and above

The information gathered here could be used with existing lessons on Britain since 1945 or as a single lesson or half lesson based on the model outline below. It is advised to use the historical and factual resources in close combination with the film.

Key suggested enquiry question:

What difference did engine design make to aircraft technology?

Show the film: *Jet age and helicopters*

Provide the historical information or read it to students.

Show the film a second time with pauses and ask the students to make notes on the engine information.

Working in groups, provide students with the information 'Taking off and moving through the air'.

Ask them to create a mind map of how engines developed during the twentieth century and how this affected aircraft. They should put flight at the middle of their map.

The students should present their findings.

Discuss the following statement: Military needs for aircraft did not affect civilian aircraft. Ask students to explain their arguments for or against the statement.

Finish with a discussion on what they have learnt.

Extension: Find out about RAF aeromedical evacuation and what it does for the civilian world.

2. THE TECHNOLOGY OF WARFARE

Ages 14 years and above

This lesson can be used in conjunction with other material on the technology of warfare in the twentieth century. Combined with the activity on the 'Origins of the RAF', this lesson could be a detailed exploration of aircraft technology and roles. Finally, if the information above is used with the film, it should increase a student's knowledge of the relationship between technology and military developments.

Key suggested question:

How has aircraft development affected RAF roles?

(You may want to answer this question using the resources from the other activities so that it becomes an in-depth investigation.)

Show the film once through without pausing. Show it for a second time with regular pauses and ask the students to make notes of the information in the film.

Using the factual resources above and the film, ask students to work in groups to create a timeline of key aircraft technology, identifying the key turning points that have affected RAF capabilities.

Ask students to outline what they think the roles of the RAF are in 2018 from the information they have available.

Extension: Investigate an RAF base near you and find out what it does and has done over time.