Royal Academy of Engineering

THIS IS ENGINEERING

DRONES: FRIEND OR FOE?

What is a drone?

This resource is designed as an introduction to the uses of drones.

WHAT IS A DRONE?

Whole colonies of bees are dying all over the world, and this is causing concern as there is a risk of crops not being pollinated. Engineers at Harvard University have developed a RoboBee to autonomously fertilise crops

To find out more about the RoboBees visit the Harvard website: tinyURL.com/robobee1

Introduction

When you hear or read the word 'drone' you can be forgiven for thinking about an Unmanned Aerial Vehicle (UAV) used by the military. However there is more to unmanned vehicles than just war.

1. Types of drone

Unmanned vehicles can be autonomous, remotely controlled by a pilot, or somewhere in between. An autonomous vehicle is one which can operates completely unaided and without human interaction.

Unmanned vehicles can be designed to travel across any terrain unreachable or dangerous to a human, which allows us to explore more and previously unreachable areas of the world, and even beyond. Unmanned vehicles have been used to research the deepest depths of the oceans and the furthest reaches of the solar system.

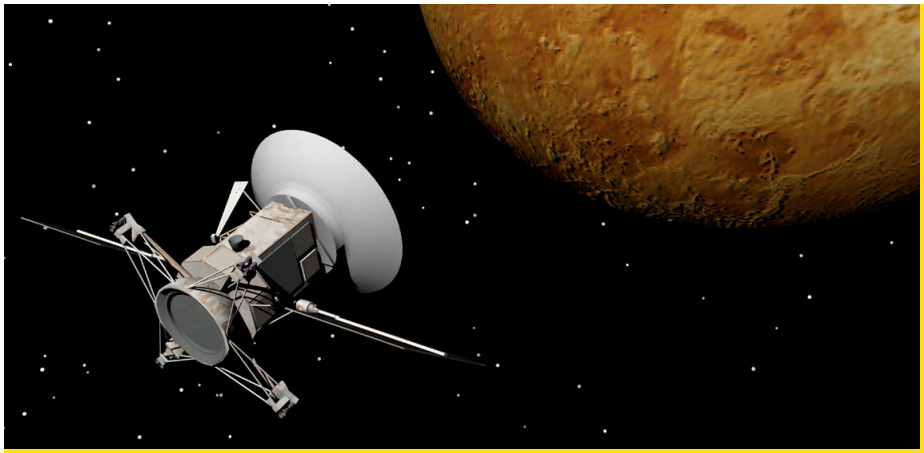
Aerial drone used for video and photo production

Activity 1 – Discussion

Some drones are referred to as *unmanned vehicles* when others are *autonomous vehicles*.

What do you think are the differences between 'autonomous vehicles' and 'unmanned vehicles'? Can a vehicle ever be truly autonomous?

- Use the pictures on pages 1 and 2 to brainstorm some of the current uses of drones.
- Can you think of any new ways in which we could use unmanned or autonomous vehicles?



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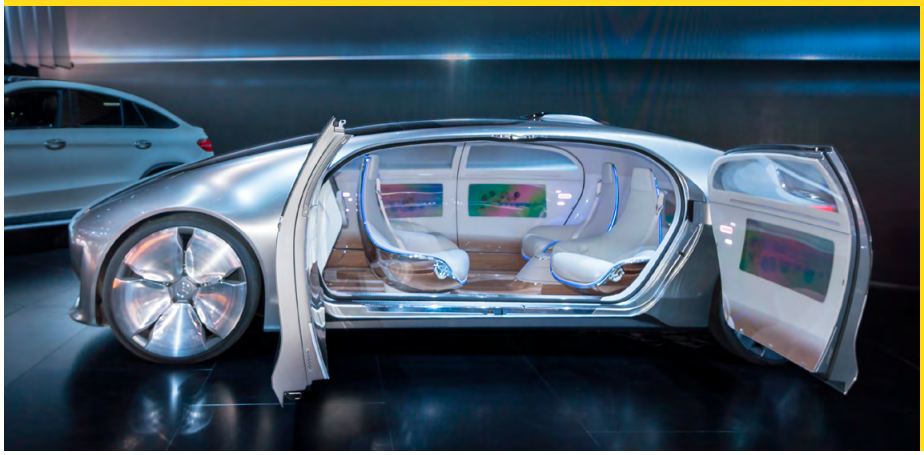

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Examples of drones used in space, sea air and on land

Top: Space probe

Middle: Unmanned submarine

Bottom: Driverless car

2. Communication with your drone

It is important to communicate effectively with your drone to avoid disastrous collisions. If you are in control of your drone remotely, you need to be able to communicate how to move in its environment to keep the drone, and others, safe.

Activity 2 – Being a drone

In pairs, decide who will play the part of a drone. The task is to get the drone to the target avoiding any collisions.

The person acting as the drone will be blindfolded and can only respond to compass bearings. Your teacher will give each team a different starting point and target.

Remember that when giving bearings, the angle should be three figures and taken from north, for example east is 090° and west is 270°.

After you have tried driving controlling a drone, discuss the following questions:

- How easy was it to communicate with your drone?
- Did the distance between the pilot and drone affect the communications?
- How easy was it to avoid collisions with other drones?

Now think how you could improve the instructions for controlling the person acting as a drone and test it again – how was it better?

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Left: Medical drone used to deliver first aid

Right: Military drone

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3. Friend or foe?

The idea of using drones for military purposes has been around for over a hundred years and they have some devastating consequences. In 1849, during the Siege of Venice, Austria launched unmanned balloons which floated over Venice carrying bombs. The balloons were not as successful as the Austrians hoped. One eyewitness account describes a balloon as being blown by a sudden southeast wind, speeding over the city and as a result the bombs were dropped on the besiegers. Find out more here: **tinyurl.com/veniceballoon**

You can find a timeline of military drones here: **tinyurl.com/uavtimeline**

However, new, and more friendly, ways to use drones or autonomous vehicles are arising every day. For example, the Delft University of Technology in the Netherlands has designed a defibrillator drone to provide assistance to cardiac arrest patients faster than an ambulance could. Find out more here: **tinyurl.com/drones4good**

Activity 3 – Discussion

Design a solution to one of the following scenarios, using drone technology:

- There has been a plane crash in the mountains.
- A city in the desert has been devastated by war.
- Poachers are killing lions in Mozambique to sell as bushmeat.
- A cargo ship has been sunk in the middle of the ocean.

Remember you will need to consider:

- What are the problems you face?
- What type of drone could you use to help solve the problems you have identified?
- How will it be operated?
- What are the ethical and legal issues?
- What are the safety issues?

Present your groups solution to the rest of the class.

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Thinking like engineers

NOTES FOR TEACHERS

This introductory session is aimed at getting the students to think about what a drone is and how they can be used.

Before you start, you could show your students the first drone music video, created by the University of Pennsylvania's General Robotics, Automation, Sensing and Perception (GRASP) Laboratory group: **tinyurl.com/musicaldrone**

Working in groups

Students should be encouraged to complete all of the activities in groups.

Activity 1

A misconception that students may have is that autonomous and unmanned can be used interchangeably to mean the same thing.

A fully autonomous vehicle is any vehicle that is capable of driving completely unaided for the entire journey without any human interaction. An unmanned vehicle, however, refers to any vehicle without a body inside driving it. This could, for example, be a vehicle driven by a remote pilot via radio communication.

There are also levels of autonomy, for example, parking assistance or cruise control. For a vehicle to be truly autonomous, it would have to be able to think for itself. You may like to discuss artificial intelligence with your students.

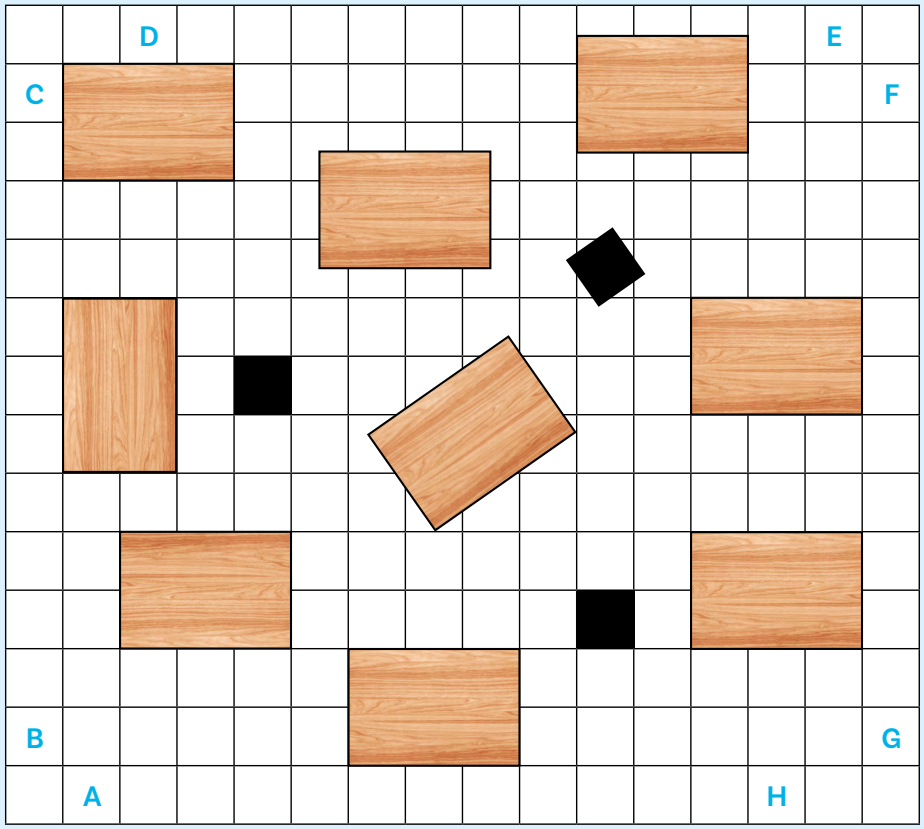
The word drone tends to refer to unmanned aviation vehicles (UAV); however there are a number of other unmanned vehicles that can travel in or on almost any medium. Below are some examples of space, air, land and sea unmanned vehicles:

Space	Air
■ Space probes like Voyager ■ Mars and Lunar rovers	■ Military drones ■ Flying doctors ■ Toys ■ Spy cameras ■ Solar powered drones that can broadcast mobile broadband to less economically developed countries (LEDCs).
Land	**Sea**
■ Self-driving cars ■ Self-driving trains ■ Military Multifunctional Utility/Logistics and Equipment (MULE)	■ SpaceX's spaceport drone ship ■ Unmanned underwater vehicles (UUVs) that can be used for various applications, for example Remus, a submarine that clears underwater mines or searching for black boxes from crashed aircraft.

Activity 2

You will need to set up the room with obstacles for this activity beforehand. A suggested layout is provided on page 6. It is recommended that a large room such as a sports hall should be used for this activity. Tables and chairs could be used as the obstacles. A brief risk assessment should also be conducted.

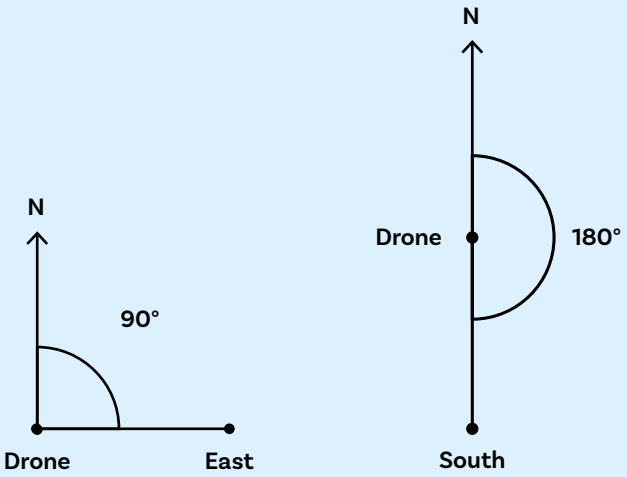
Students should work in pairs as drone and pilot. Depending on the group, you might like to pre-select pairs and roles or allow the students to choose someone they feel comfortable working with. Blindfold the drone so you are sure they cannot see. Assign each pair with a start position and a target position. The positions are suggested to maximise the chance of collision between drones. This is to get students thinking about how to communicate effectively in order to avoid the collisions. You could also create your own layout depending on room and class size.



Starting Position	Target
A	E
B	F
C	G
D	H
E	A
F	B
G	C
H	D

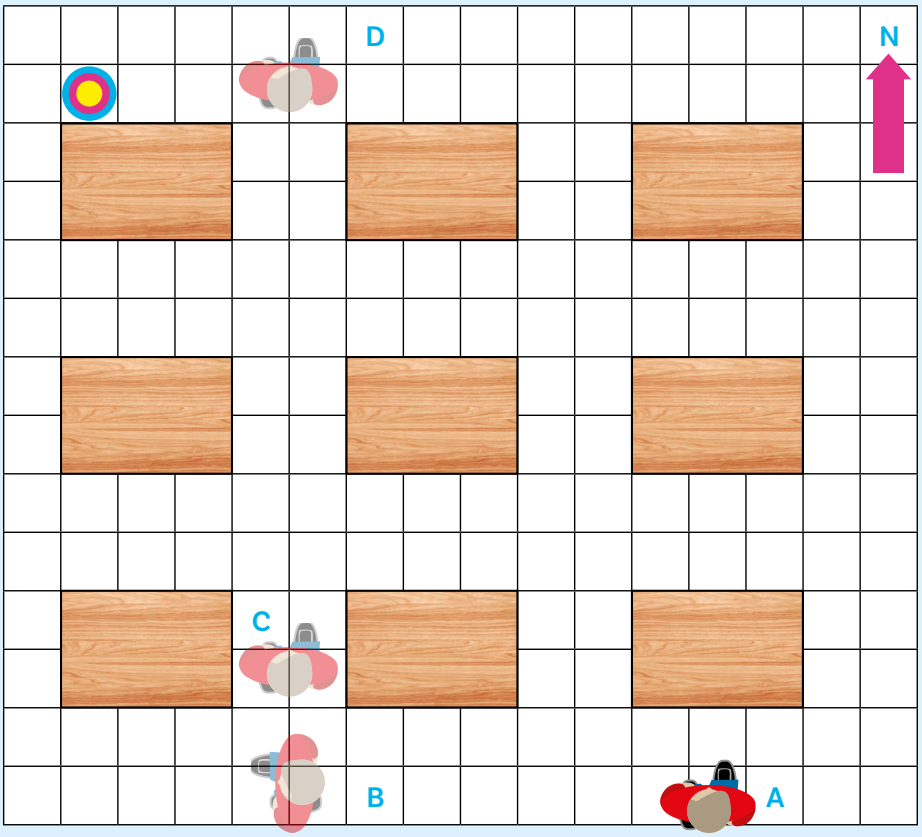
Before you start the activity it may be worth reminding your students that when navigating, the pilot should give their directions as bearings. For this you will need to specify north before you start; it may help to have an N on the wall for the students to refer to.

The pilot must then give three-figure bearings to change the direction of the drone. For example, if the drone was travelling north and the pilot wanted the drone to travel east, the bearing instruction would be "turn 090°", if the pilot then wanted the drone to turn from that direction to travel south, the new bearing would be 180° as bearing are always taken from north.



On the next page is a simple example you could use with your students to show them how the bearings instructions would work.

The student needs to get from their starting point at point A to the target in the top left hand corner of the diagram.



The pilot could give the following instructions as an example:

- Turn to a bearing of 270° and walk forward 7 paces.

The student would then be at point B and need to turn to face north to walk along the path of student C. The pilot would tell the student:

- Turn to 000°

This would allow the student to face north again, as all bearings are given in relation to north.

The instructions would then proceed:

- Walk forward 12 paces
- Turn 270° and walk forward 4 paces

Although this is predominantly a maths and computing activity, you could discuss the science involved in drone communication by looking at wave properties and communication with waves. You could ask your students which wave of the electromagnetic spectrum they would use to communicate with their drone. When drones are in the line of sight of the pilot, radio waves are used. Radio waves are susceptible to interference so are only used for short range.

You could then ask your students to think about what happens when the drone is out of the line of sight, or what happens if all communications are lost. When drones are no longer in the line of sight, communications satellites are used to control the drone. In this case microwaves are used because they have a high enough frequency to pass through the Earth's ionosphere to reach the satellite and again to reach the drone. If satellite communication is lost, some drones are programmed to fly in circles until they can regain signal, and others are programmed to fly back to base.

For more information on how drones are controlled: **tinyurl.com/howdroneswork**

Activity 3

This activity is a good opportunity to look at the wider implications of engineering on the world, as well as getting students to *Think like an Engineer*.

The *Thinking like an Engineer* report offers fresh insights into the ways engineers think. It suggests ways in which the education system might be redesigned to develop engineers more effectively and makes suggestions as to how the wider public might become engaged with these issues.

A summary report can be found:
www.raeng.org.uk/thinkinglikeanengineersummary

Before you start the main discussion activity, you might like to look through the news articles with your students, either by printing them, or on an interactive whiteboard.

Ethical issues

Here are some examples of ethical questions that you might use to prompt your students with:

- Will it affect animals in the environment in any way?
- Will it be intrusive to any local people?

Legal issues

Sometimes you need permission from the Civil Aviation Authority (CAA) to fly a drone in the UK. The rules in the UK are:

- An unmanned aircraft must never be flown beyond the normal unaided "line of sight" of the person operating it – this is generally measured as 500m horizontally or 400m vertically.
- An unmanned aircraft fitted with a camera must always be flown at least 50m distance away from a person, vehicle, building or structure.
- An unmanned aircraft fitted with a camera must not be flown within 150m of a congested area or large group of people, such as a sporting event or concert.
- For commercial purposes, operators must have permission to fly a drone from the CAA.

The rules in other countries may be different.

Safety issues

If your students are struggling with safety issues, you could get them to think about what precautions the need to put in place to avoid collisions, how the weather will affect the drone, or how to protect any human life.

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