Future of flight:

Health monitoring

Royal Academy of Engineering

THIS IS ENGINEERING

TEAM TEMPEST

Introduction

How would you measure how healthy you are? Is it your blood pressure or your heart beat?

When in an aircraft, we have to measure the health of a pilot constantly to make sure that they are safe to operate the plane at speeds so high that you could pass out! Just like the pilot, we also have to make sure that the aircraft is "healthy" and to identify any faults before they happen so that it is safe to fly.

On our future aircraft, we plan to use as much data as possible to help both the pilot and the aircraft to always perform at their best.

Case study

Laura

Aerospace Design Engineer at BAE Systems

I became interested in aeronautical engineering as a young child when I went to the Royal International Air Tattoo, where I got to meet the Red Arrows pilots after watching their spectacular flying display.

I didn't think that I was clever enough at school to be designing jets one day. I was great at subjects like art and graphics and not so great at maths and physics.

I found a creative path into engineering by studying a degree in Product Design. This allowed me to pursue my love of art and graphics as well as learning the basics of design engineering at the same time. This has taught me to never give up on a dream or goal. There is always a way to get where you want to go.

In my job I now get to design parts for the next generation of aircraft using 3D CAD software on a daily basis. The best part of my job is being able to hold a finished part in my hand that started off as a concept inside my head. It is literally bringing my ideas to life.

"Engineering is about working well with people around you, and together you can all come up with new and great ideas that improve the world around us."

The wearable cockpit

The cockpit is the area that the pilot controls the aircraft from.

If you look at cockpits in current aircraft, they have physical displays. If you can imagine a cockpit without a single physical screen in front of you, that, since the launch of Team Tempest, is what their technologists have been working on – the creation of a future cockpit concept based on Augmented and Virtual Reality.

Controls and displays can be tailored to suit every pilot and mission's needs. The virtual cockpit can monitor and alert the pilot and ground control of their health and the aircraft's health.

Time to reflect

- Why is health monitoring of a pilot so important?
- What does a pilot do?
- What does a pilot look like?
- How can an aircraft protect a pilot?

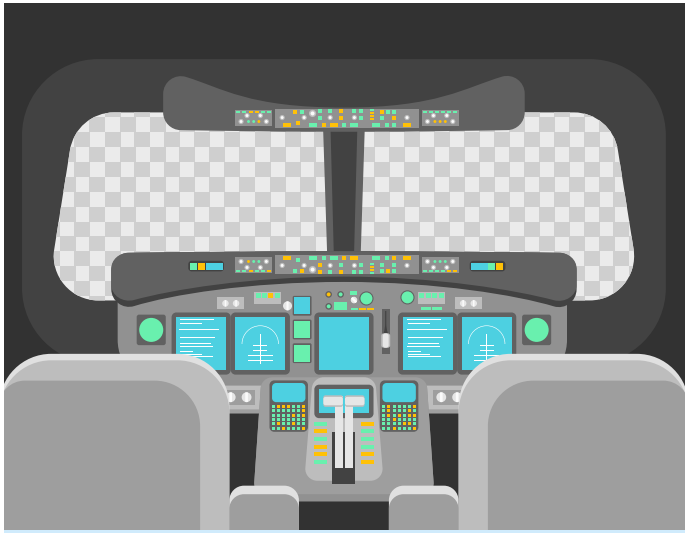
Time to design

- What do you think a virtual cockpit for a pilot would look like?
- What controls would it need to have? Where would they go?
- How would it alert the pilot of any issues? How could the pilot and the cockpit communicate?

Did you know?

In order to keep fighter jets as space efficient as possible, there are no toilets on board the aircraft.

Explore the virtual cockpit for yourself by visiting www.raf.mod.uk/what-we-do/team-tempest/tempest.



Design your own cockpit. What controls are needed? Where would they go?

Think like a pilot

Part of the pilot and Team Tempest's role will be finding ways to efficiently coordinate people in difficult situations.

Being able to logically approach a challenge like this will mean saving time, and as a result, people's lives.

All change!

You need to swap people and medical supplies from two different sides of a road.

People and medical supplies can either slide to an **adjacent** space or **jump over** another item if there is a gap next to them.

- Can you swap the people for the medical supplies?

Try this out in your groups. Arrange seven chairs in a line, with three people sat at one end and three bags at the other end. Swap the people for the bags.

- How many moves does it take to swap them?
- What is the least number of moves you can do this in?

Stretch and challenge

Record what you did (how many jumps and and how many slides).

Extending the emergency

What happens if you have four sets of medical supplies and four people to swap? Five sets of medical supplies and five people?

Can you predict how many moves it will take based on the number of supplies and people?

Stretch and challenge

What happens when the number of medical supplies is different to the number of people?

Use the table to help you record your results.

Teacher note: Using counters will help to extend this task to more people and more supplies.

People \ Medical supplies	1	2	3	4	5	?
1						
2						
3						
4						
5						
?						

Finger on the pulse

Having quick reactions is an important part of Team Tempest training.

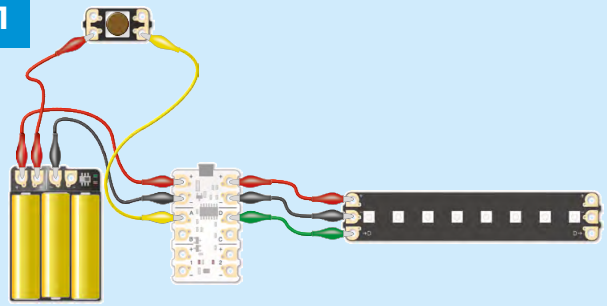
Being able to think fast is important not only for pilots, but those working as part of the flight team. If an emergency happens, they need to be able to react quickly and calmly to keep people safe.

Team Tempest are developing technology to study pilot's behaviour and reaction speed, so ground commanders can be warned if they are tired.

Time to program

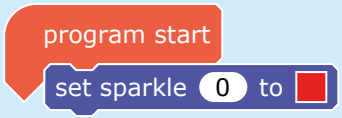
Build and program a game to test your group's reaction times.

1



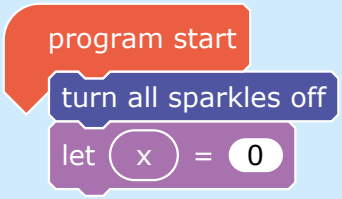
Connect your Crumble, push-switch, battery-pack and Sparkle Baton.

2



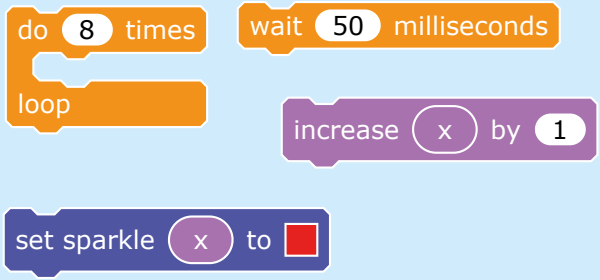
- All programs start with the program start block.
- Test the Sparkles using the 'set sparkle' block.
- Experiment with setting different Sparkles on the chain and changing the colour.

3



- To create our reaction tester, we want the Sparkles to quickly light up in turn.
- Instead of addressing the LEDs manually, we can use a variable x.

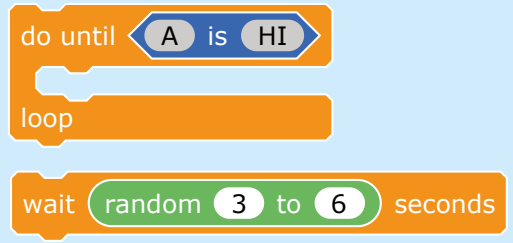
4



Using the blocks shown, add the loop to the above program so that each LED turns on in succession (with 50ms wait between).

This will act as our timer.

5



- Now we want to stop the timer when the button is pressed (connected to pad A).
- We also need to wait a period of time after the 'Run' button is pressed.
- Use the 'random' block to make it difficult to guess when the timer will start.

6

- While this program will appear to work, the 'x' will keep increasing if the button is not pressed.
- To prevent this from happening, we can check both the value of 'x' and 'A' using an 'Or' block.

Can you change the condition in the 'do until' loop?

Stretch and challenge

Make the test automatically restart.

Time to compare

Collect data, either for yourself and/or for your group.

Who has the fastest reaction time in your class? Is there an average reaction time? Do reaction times improve with practice? Do your reaction times change depending on the time of day? Or if you are doing other activities at the same time (for example, can you say the six-times-table)?

Remember the time will change depending on how you have written the program!

Student	Time	What is happening?

Monitoring stress

It is important that pilots can operate under high stress.

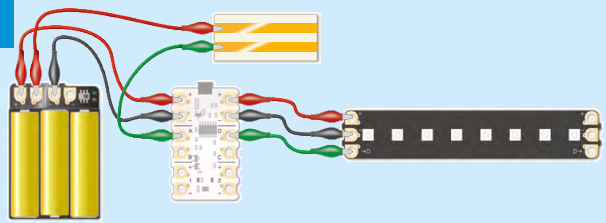
During training, the team are put in difficult situations to check that they are still able to navigate and operate an aircraft.

Data about pilot stress levels might also be collected as part of their live health monitoring. This technology could be part of the cockpit or part of clothing.

Share an example of where smart clothing is used today.

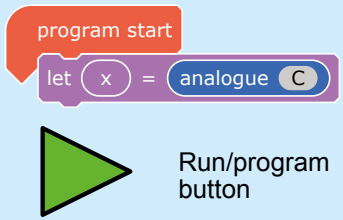
Time to program

1



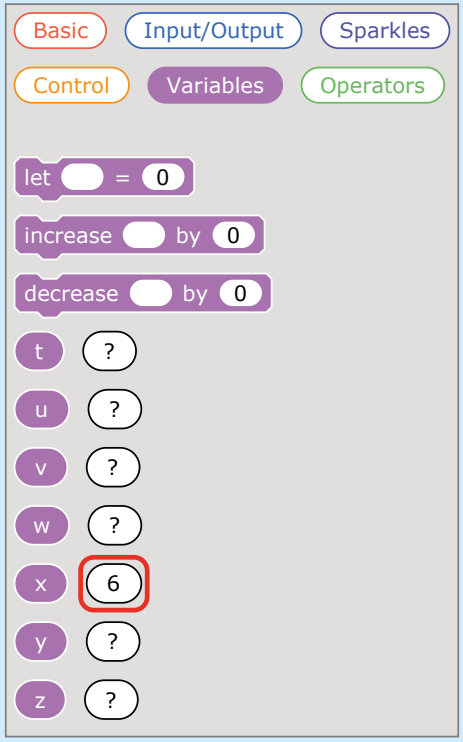
Connect your Crumble, pair of conductive tracks, battery-pack and Sparkle Baton.

2



- To begin with, we want to set a variable (x) to the analogue value on pad C (where our 'stress tester' is connected).
- Press the 'program/run button', and you can see how much electricity can flow across our tester.
- 0, there's no connection, and 255, an unbroken connection – electricity can flow freely.

3



In the variables tab, you can see the current value of x. In this program, the value will only update when the run button is clicked.

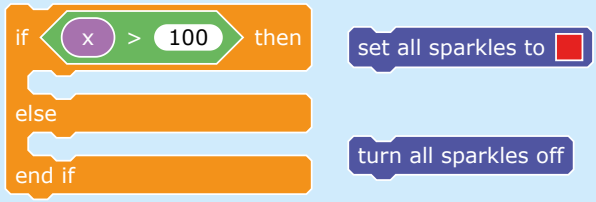
4

Use these blocks to make your program read the input every second.

5

We can use the 'more than' block to check if x is above a set value.

6



Use the blocks shown to light the Sparkles if x goes above 100.

You may wish to adjust the set value from 100.

Stretch and challenge

Make the Sparkles flash if x goes too high.

Putting your stress to the test

As part of training for a future aircraft like Tempest, team members might be given several tasks to complete at the same time or be put in situations where they become disorientated to practice keeping their stress levels low and their reactions quick.

Take it in turns to challenge members of your group to complete one of the following two tasks in less than two minutes.

After they have completed the task, check their stress levels and reaction times again.

What do you think should happen?

- Is this what you expect happening, always happening?
- What does this tell you about health monitoring tools that we use?

Time to compare

What are the challenges of collecting data for this activity? When everyone is 'not stressed', are the readings the same?

Do you think it is a reliable indicator of stress on its own?

What else could you use to get a more confident reading of stress levels?

Challenge one – countdown

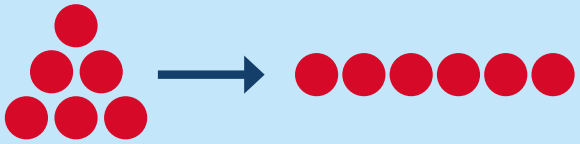
25	9	4	7	1	8

Using the number cards available and the four standard operations (add, subtract, divide and multiply) to make the target number. Each number can only be used once, but not all number cards need to be used.

To generate more countdown numbers, visit Nrich for an interactive version of this game.

Teacher note: change the level of challenge in your stress training activities as you see suitable for your group.

Challenge two – changing formation



Using six identical counters, move from the triangle shape to the line.

Can you do this in seven moves?

Each move consists of sliding a counter to a position in which it touches two other coins.

You cannot lift a counter or use one counter to push another counter.

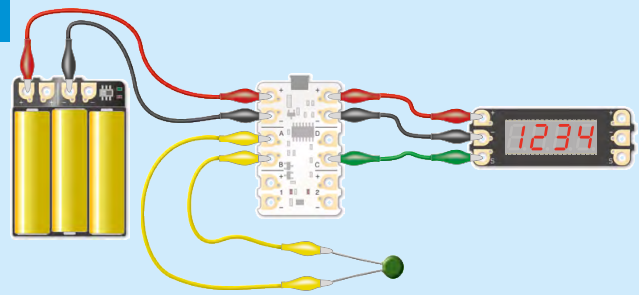
Temperature check

Monitoring temperature is an extremely important part of aviation, and even more important as we develop flight technology.

The temperature inside an aircraft needs to be kept warm as the outside temperature can drop to -40°C, and recording the temperature of the engine is important to ensure it does not overheat (temperatures can reach over 1,700°C) and it stays healthy.

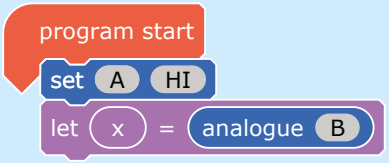
Time to program

1



Connect your Crumble, battery-pack, the thermistor and Digits Smart Crumb.

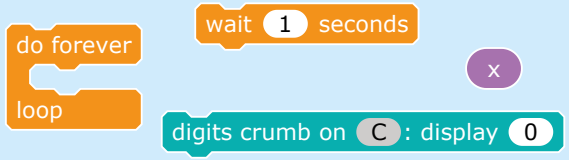
2



To get accurate readings, we will connect the thermistor to A and B. A will be set HI and we can read the analogue value from B.

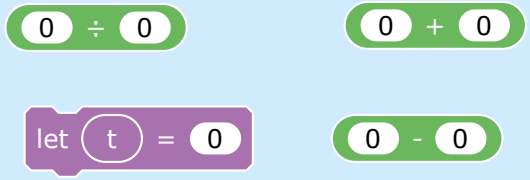
This program will read the value once when run.

3



Use the blocks shown to read the analogue value from B and display it on the Digits Smart Crumb every second.

4



At 25°C analogue B will read approximately 128.

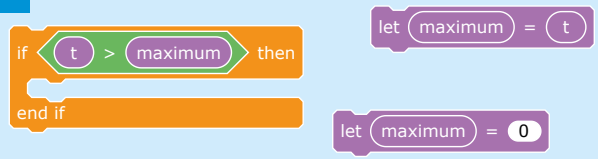
For every 1°C above 25°C, the analogue value will increase by 3 (and decrease by 3 every degree below).

Use the mathematical operators to covert the analogue value to temperature in degrees Celsius and display it on the Digits Smart Crumb.

Hint: analogue ≈ (3 x temperature) + 53

Maximum temperature warning

5



Can you adapt your program to show the maximum temperature that has occurred since it was run?

What is the temperature?

Using the formulae, convert between the analogue and temperature in degrees Celsius.

°C	Analogue
50°C	
-10°C	
	80
	53

The analogue values are between 0 and 255. What is the minimum and maximum temperature readings you could get in degrees Celsius?

Pilot training

Part of a pilot's training includes regular exercise.

Members of Team Tempest will ensure that they have the optimum amount of food and supplies to sustain them while they are training and an awareness of how much energy they will need.

A pilot is planning a number of short training rides leading up to a long ride between Lands End and John O'Groats.

Time to train

They are preparing for a short training ride.

- How much energy will they use during this ride?
- What on the road snacks will they need to take to minimise the amount of calories they lose?
- Which combination of snacks could they take to minimise the weight?

After their training rides, pilots will cycle from Lands End to John O'Groats

- How many days will it take to complete the trip?
- How much energy would they use each day?

Stretch and challenge

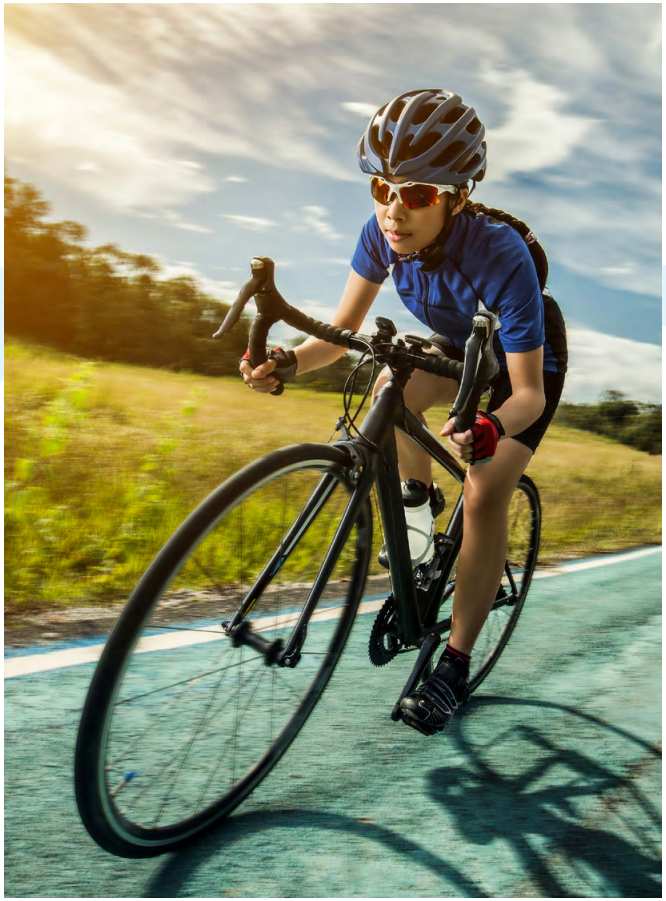
Together with their meals, can pilots in training consume enough calories each day so that they don't lose any weight?

Using the nutrition and training cards shown on the support sheet, work in small groups to tackle the problems above.

Divide the cards equally between you in the group. Each person in the group is in charge of the information on their card.

Teacher note: hand out the cards to each member of the group so each person is responsible for the information given on their cards. Adapt the questions and change the cards use to change the level of difficulty.

This activity is an adaptation of the 'Nutrition and cycling' activity from NRICH.



Calorie deficit

The difference between the calories used during a cycle ride and the calories consumed before and during the ride.

Nutrition and training cards

1 kcal ≈ 4 kJ 1 mile ≈ 1.6 km	A really big meal contains about 1,000 kcal	A big meal contains about 800 kcal	Pilots do not want to consume more than 250 kcal an hour on rides of less than five hours	A pilot uses 100 kJ of energy to cycle 1 km (in addition to normal energy use)
Pilots can use bottle holders which can carry up to three 1-litre water/ drinks bottles	A banana contains 120 kcal and weighs about 120g	Cycling jerseys worn have eight pockets	Each pocket in a cycling jersey can hold 1 banana, 1 energy bar, 3 energy gels or 2 cereal bars	Pilots like to eat a big meal before a short training ride. The energy is released during the ride
An average day, pilots will not do more than seven hours of cycling	Pilots can only eat what is in their pockets while on the road	500ml of energy drink contains 190 kcal	A pack of energy gel contains 110 kcal and weighs 42 g	An energy bar contains 220 kcal and weighs 65g
On average, a pilot will cycle at 14 mph on rides that take more than one day	While training on long rides, pilots do not like to consume more than 350 kcal an hour	On a ride that takes several days, a pilot eats three really big meals a day	Pilots drink about 500 ml of fluids per hour of cycling	The distance from Land's End to John O'Groats is 1,407 km
On average, a pilot will cycle at 9 mph on rides that take less than one day	A typical short training ride is two hours long	On the road, pilots can stop to refill their bottles once every two hours.	An average adult man who does a moderate amount of physical activity needs about 2,500 kcal per day	An average adult woman who does a moderate amount of physical activity needs approx. 2,000 kcal per day

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