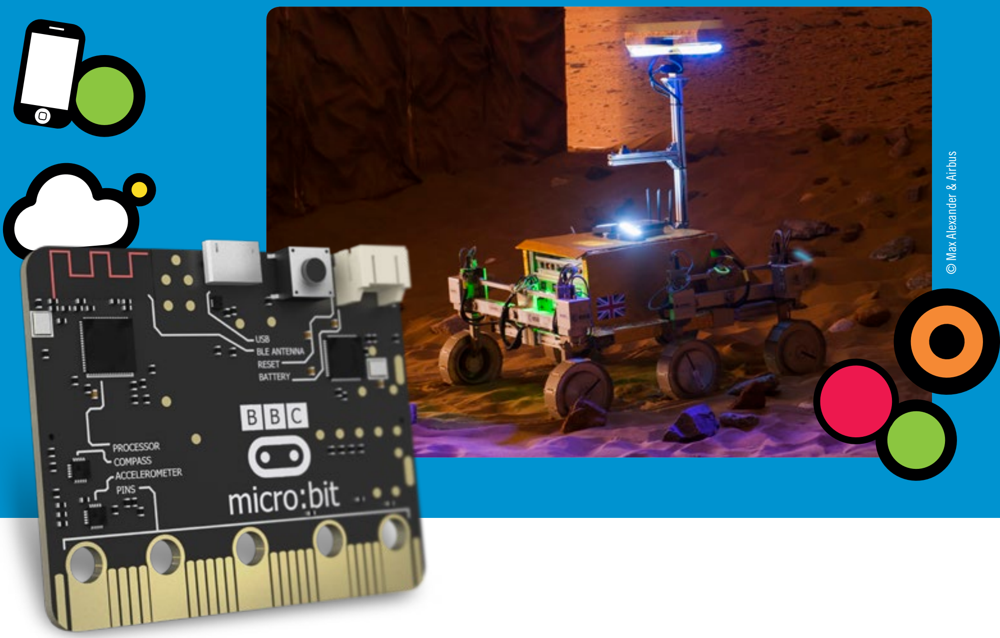
IET Education
The Institution of Engineering and Technology
Faraday

micro:bit



Case study

Acceleration test

AIRBUS DEFENCE & SPACE

Abbie Hutty
Spacecraft Structures Engineer,
Airbus Defence and Space

for more case studies visit
www.ietfaraday.org/microbit

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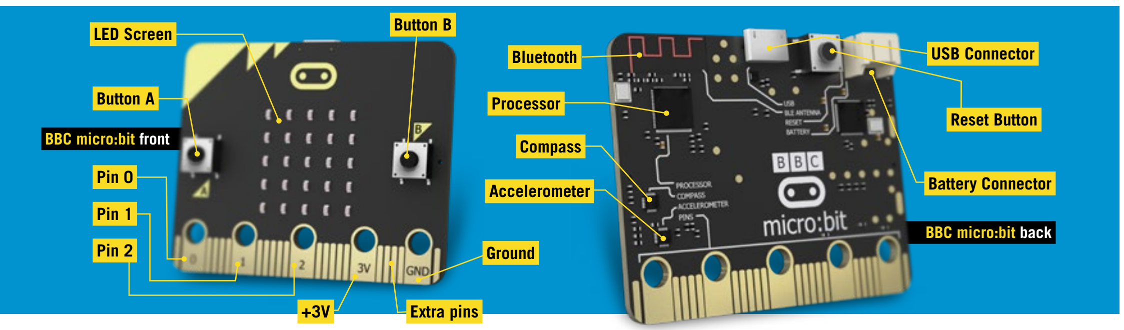
About the BBC micro:bit

The BBC micro:bit is a pocket-sized codeable computer with motion detection, a built-in compass and Bluetooth technology. It is an excellent device to prototype ideas with, because you can try lots of creations really quickly, and keep the ones that work best.

The BBC micro:bit:

- **easy to program**
- **lots of choices of different inputs and outputs**
- **use the on-screen simulator to try your ideas first**
- **easy to change a program once you have written it**
- **connects to other BBC micro:bits, devices, kits, mobile phones, tablets, cameras and everyday objects.**



About this case study

Case studies are useful for learning about practical uses of technology that can improve the day-to-day lives of people. This case study focuses on testing parachute designs to help the ExoMars Rover land on the surface of Mars.

In this case study you will learn:

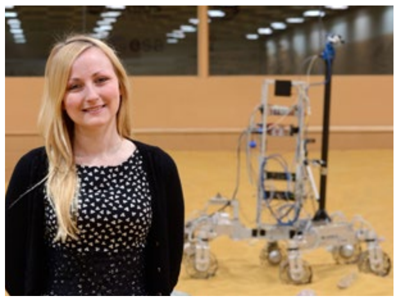
- **why parachutes are important for safe spacecraft landing**
- **how an accelerometer can be used to assess parachute effectiveness**
- **how the BBC micro:bit can be used to quickly prototype a new idea**
- **what the code looks like, and how it works.**

Meet the author

Abbie Hutty

Spacecraft Structures Engineer, Airbus Defence and Space

Abbie is currently working as Lead Structures Engineer for the ExoMars Rover Project, Europe's first Rover mission to Mars.



Abbie Hutty

"We need to make sure our parachute design will get the ExoMars Rover, which is quite fragile, in one piece to the surface."

About parachute design

The ExoMars Rover has to land on the surface of Mars, via parachute and survive the impact of landing on the Mars surface. Parachutes are designed using a combination of design calculations and Earth-based tests.

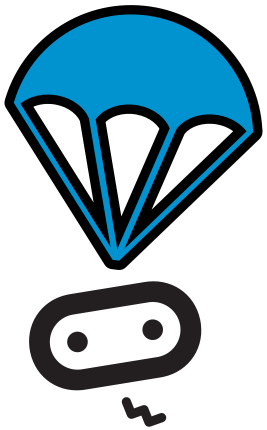
We are going to explore how different parachute designs can be assessed.

- The ExoMars Rover will launch in 2020, and will take 6 months to make its journey to the red planet.
- A huge amount of engineering effort has gone into the design of the craft and the mission. Thorough testing is vital, to ensure that the craft is not damaged or lost. A significant base of future scientific results and discoveries could otherwise be put at risk.
- In March 2016, a craft called Schiaparelli was launched. Let's look a bit more closely at the descent sequence, to understand the sheer magnitude of some of the numbers that make a safe landing on the surface of Mars possible:
  - The parachute deploys in less than a second at 11km above the surface, while the craft is traveling at 1,700 kilometres per hour.
  - Two minutes later, the craft should have decelerated to a speed of 240 kilometres per hour and will now be 1.2km above the surface.
  - The parachute is jettisoned, and thrusters are fired for the remaining 30 seconds, with the craft travelling at 10 kilometres per hour when it hits the surface.

Terminology

velocity – measured in metres per second (m/s) - how much distance is travelled in one second of time.

acceleration/deceleration – rate of change of velocity in metres per second per second (m/s/s) - how much does the velocity (m/s) change by, in one second.



The problem

To measure the effectiveness of a parachute design, we need to:

1. **time how long the descent takes**
2. **measure the maximum acceleration in each of three axes**
3. **measure whether the craft flips upside down or not**
4. **measure how much the craft spins around.**

The ExoMars Rover weighs in at 310kg, and its lander weighs 827kg.

Our prototype uses the on-board compass to measure how much the craft spins. This compass works by measuring the Earth's magnetic field.

Other measurement techniques will be required on Mars.

However, spacecraft engineers test their designs on Earth, so it is okay to use the compass as part of this test equipment.

It is very important to choose carefully the landing site for the spacecraft in order to minimise other causes of damage on touch-down.

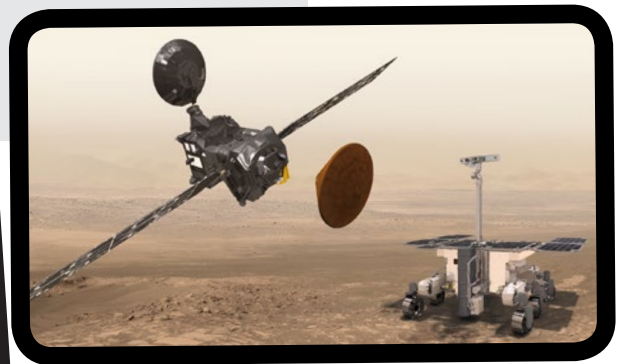
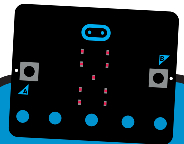


Photo: ESA/ATG medialab

The solution

Inputs
Button to start, accelerometer and compass.

Processing
Time descent, measure maximum acceleration in x,y,z, measure amount of spin and number of total flips.



Outputs
Maximum X,Y,Z, number of spins, number of flips.

User
Deploy parachute, read out readings at end of descent.

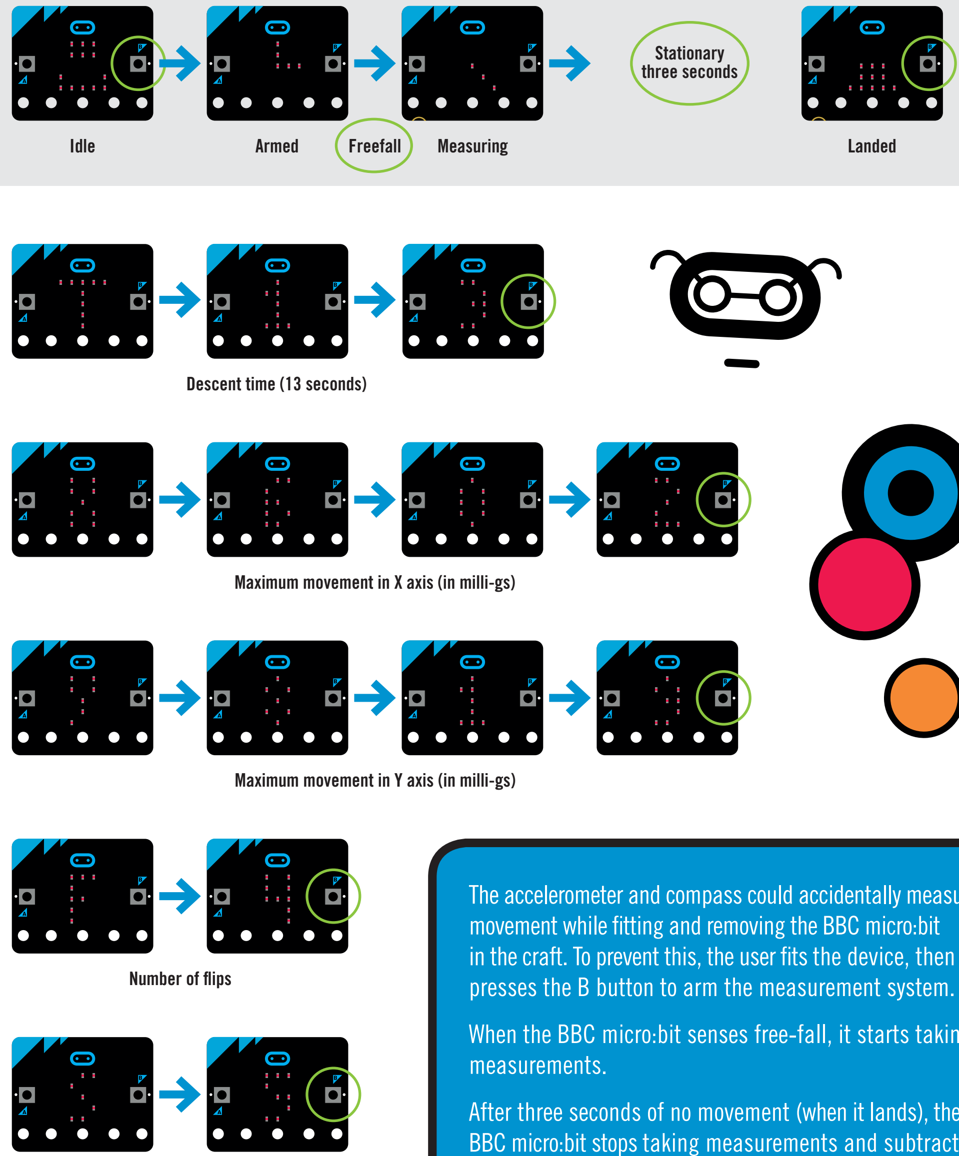
Using the product

- The measurement device is fitted into the craft.
- The B button is pressed to arm the measurement system.
- The craft is sealed, and dropped from a height. Free-fall starts the measurement system.
- When it lands and senses no movement for three seconds, the measurement system stops. Then, the user reads out the readings by pressing the B button to cycle through each of the different values.

We're using the BBC micro:bit's accelerometer and compass to work out how much acceleration and how much spin our Rover experiences with each version of the parachute.

Start here

Program flowchart



The accelerometer and compass could accidentally measure movement while fitting and removing the BBC micro:bit in the craft. To prevent this, the user fits the device, then presses the B button to arm the measurement system.

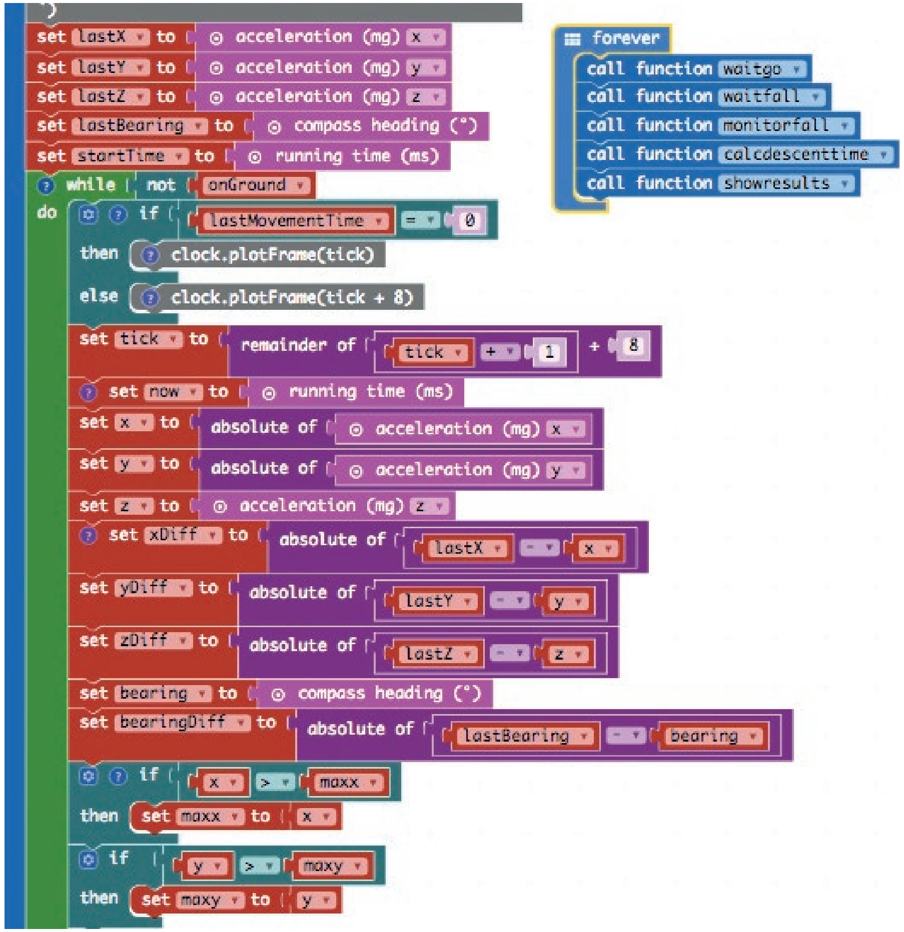
When the BBC micro:bit senses free-fall, it starts taking measurements.

After three seconds of no movement (when it lands), the BBC micro:bit stops taking measurements and subtracts three seconds from the descent time.

Code listing

When free-fall is detected, the device starts taking measurements.

Here is part of the code listing for the parachute measurement system. Compare it against the flowchart on the previous page and see if you can spot where this code slots into our flowchart.



See the full program listing by following the links at the end of this booklet.

Quiz

Now that you have worked through this case study booklet and tried the program for yourself, test how much you have remembered with our quiz! You can also look up the answers at the bottom of page 11.

Q How long will the Mars descent take with a parachute deployed?

Q What speed has the craft reached by the time it touches down on the surface of Mars?

Q Why do engineers do Earth-based tests before sending a craft into space?

Q How does the prototype device prevent false readings while being fitted and removed?

Q What might you change about how this program works?

Q What feature might you add to this program to make it even better?

Q Why do you think you might enjoy a career as an engineer?

More information

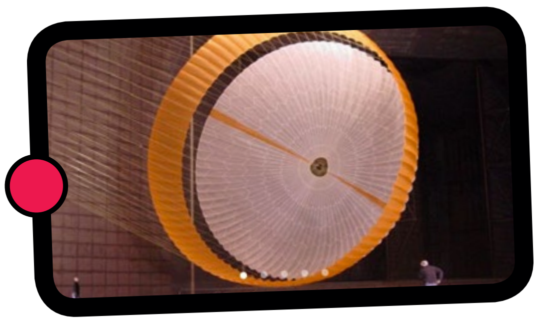
If you want to read more about the topics covered in this case study, why not take a look through some of these suggested websites and additional resources?

Acceleration test

- **Downloadable eBooklet, video and program code**
  https://faraday-secondary.theiet.org/stem-activities/microbit/microbit-case-studies

Information about Mars space exploration

- **ExoMars Rover Programme information**
  www.space-airbusds.com/en/programmes/exomars-l95.html
- **ExoMars Rover fact sheet**
  www.esa.int/Our_Activities/Space_Science/ExoMars/ExoMars_Factsheet
- **Wikipedia page about ExoMars programme**
  https://en.wikipedia.org/wiki/ExoMars
- **Wikipedia page about the ExoMars Rover**
  https://en.wikipedia.org/wiki/ExoMars_(rover)
- **Descent calculations for ExoMars 2016 Schiaparelli**
  http://exploration.esa.int/mars/57464-exomars-2016-schiaparelli-descentsequence
- **Jet propulsion laboratory parachute design activity**
  www.jpl.nasa.gov/edu/teach/activity/parachute-design
- **Airbus Defence and Space**
  www.space-airbusds.com



About IET Faraday

How can I get involved?

The IET Education team will be working on this exciting project in three main areas:

1. **Teaching resources**
   The IET Education team have developed a new suite of resources covering 13 separate topics to help you to introduce the BBC micro:bit to your students. Each of these free resources includes a starter/introduction, main and extension activity as well as video clips to contextualise the information provided. For more information and to view the resources: https://faraday-secondary.theiet.org/resource-pages
2. **Faraday Challenge Days**
   Aimed at Year Eight students in England and their equivalents across the whole of the UK, these off-timetable STEM activity days encourage creativity, team working, problem solving and the application of the technology to real-life situations.
3. **BBC micro:bit classroom poster**
   This poster is free to download or order direct from the IET Education team. It provides a quick look at the individual components of the BBC micro:bit and how you can use it in your classroom.

For more information please visit

www.ietfaraday.org/microbit

or contact **faraday@theiet.org**

Questions and answers

Q. How long will the Mars descent take with a parachute deployed?

P4: The Schiaparelli descent will deploy the parachute 11km above the surface. Two minutes later the craft is 1.2km above the surface and the parachute is jettisoned.

Q. What speed has the craft reached by the time it touches down on the surface of Mars?

P4: 10km/h (10 kilometres per hour).

Q. Why do engineers do Earth-based tests before sending a craft into space?

P4: Parachutes are designed using a combination of design calculations and Earth-based tests. Thorough testing is vital, to ensure that the craft is not damaged or lost. A significant base of future scientific results and discoveries could otherwise be put at risk.

Q. How does the prototype device prevent false readings while being fitted and removed?

P7: The user fits the device to the craft, then presses the B button to arm the measurements system. When the device senses free-fall, it starts taking measurements.

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The Institution of Engineering and Technology (IET)

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Please visit our website for more information:

www.**theiet**.org/education

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