Case study
Fatigue test

LAING O'ROURKE

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www.ietfaraday.org/microbit

Contents

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.**

LED Screen
Button B
Bluetooth
Button A
Processor
USB Connector
BBC micro:bit front
Compass
Reset Button
Pin 0
Accelerometer
Battery Connector
Pin 1
Pin 2
BBC micro:bit back
Ground
+3V
Extra pins

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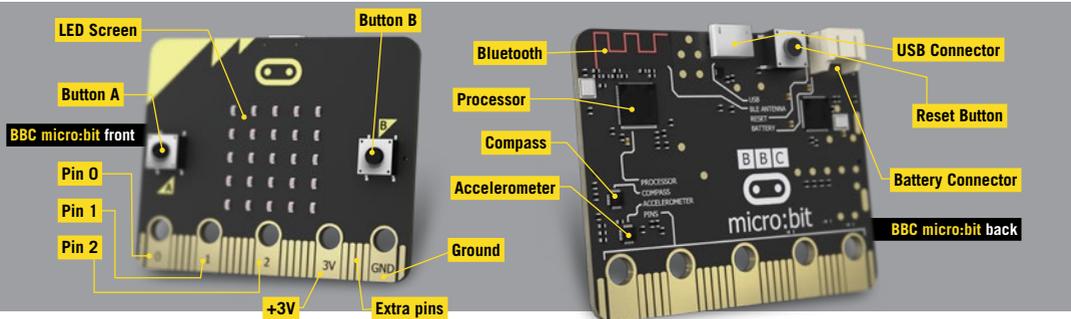
# About this case study

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 how to test the fatigue levels of machine operators.

In this case study you will learn:

- **why safety is important on construction sites**
- **how reaction time can be used to measure alertness of operators**
- **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
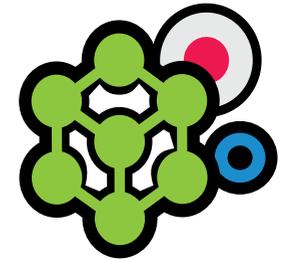
Andrew Ellwood
Mechanical Project Engineer, Laing O'Rourke's Engineering Excellence Group

Andrew comes from a manufacturing sector background, and joined Laing O'Rourke manufacturing operations five years ago. He is now a Chartered Mechanical Engineer and recently led innovation and continuous improvement on the Stafford Area Improvement Programme on the West Coast Main Line railway route.

Andrew Ellwood

"Fatigue management is a constant challenge on construction projects, where large machinery must be operated for long shifts."

About fatigue management

It's very difficult to assess how tired a machine driver is, because the role is inherently solitary and symptoms vary from driver to driver. The consequences of getting it wrong can include major accidents involving the workers on the ground around the machines.

We are going to explore how the fatigue levels of machine operators can be assessed and managed:

Working patterns

- Machine operators can work for long shifts, sometimes up to 12 hours.
- There are regulations for maximum working times without a break, but measures of alertness can be more important to assess.
- Unplanned overtime can arise at short notice, for instance following equipment breakdowns. As a result, it is often hard to know if the driver is too tired to continue working safely.

Risk assessment

- A company will perform a risk assessment to identify possible causes of danger.
- A risk assessment includes the risk, the likelihood of it happening and the possible consequences that would need to be avoided.
- Each identified risk also includes methods that can be used to minimise its chances of occurring. Measuring fatigue or alertness is a good way to minimise many risks.

Measuring fatigue or alertness

- When operators get tired, they respond more slowly to reaction tests. A computer can measure their time to respond and give them a score.
- Tired operators also find it hard to think and make quick decisions. A reaction test that makes them look at a screen and make some kind of decision will put them under more pressure, and is a much better test overall.

Avoiding learned behaviour

- Operators that take the test regularly may learn the answers, and the tests will be less effective. A certain amount of randomness is needed to prevent learned behaviour affecting the accuracy of the test.

Scoring and advice

- Via research, the best threshold score is identified and programmed into the device.
- The operators score is assessed against this threshold.
- A simple piece of advice is given to the operator based on whether they meet the threshold or not – back to work, or take a rest.

The problem

To measure fatigue, we need to:

1. **test operators at regular intervals**
2. **check the reaction time to some simple tests**
3. **decide what an acceptable score is for safe machine operation.**

The prototype runs 10 timed tests on the operators, to assess how alert they are. Each test takes a random amount of time. The BBC micro:bit measures how long it takes for the operator to respond and whether they responded correctly or not.

There are two random tests that are chosen from: (1) a button press (2) a shake.

The economic costs due to injuries and ill health in 2013/2014 were estimated as:

- employers: £2.8 billion
- employees: £8.2 billion
- government: £3.4 billion.

The solution

micro:bit

Inputs
Button press to start, button press or shake to respond.

Processing
Timer between each test, random time and random test, looped 10 times. Counts correct and wrong answers.

Outputs
A different screen depending on whether the operator needs to take a rest or go back to work.
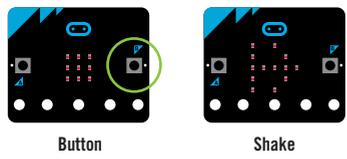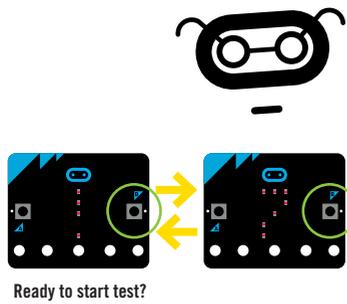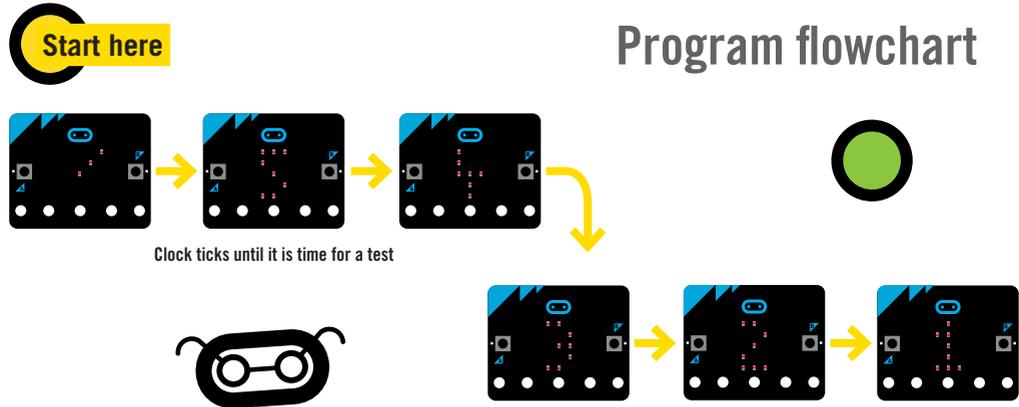
User
Takes 10 random tests, then reads the advice off of the screen.

Using the product

- After a timer runs out, the operator is prompted to press a button to start the test.
- They wait for one of two images to appear and either shake or press the button.
- After 10 tests are performed, a score is calculated.
- If the score is high enough, the user is informed to go back to work.
- If it is too low, they are advised to take a break.
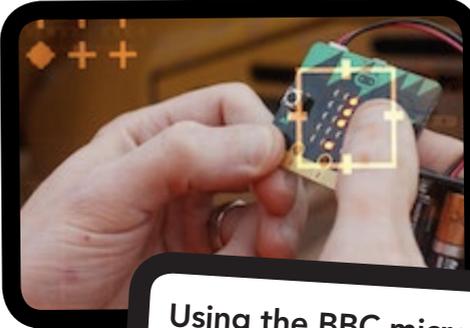
Using the BBC micro:bit, we've created a reaction time test for drivers to assess whether they need to have a break, or whether they are ok to continue working.

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Program flowchart

Start here

Clock ticks until it is time for a test

Random numbers are used to vary the delay between each test and also to select one of two possible outcomes.

This way, every test is different and the operators cannot guess the outcomes.

They have to concentrate, and if they are feeling tired, they are likely to get a lower score.

Ready to start test?

Button   Shake

Outcomes

Rest   Back to work
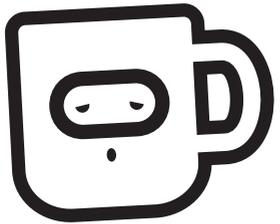
Code listing

Here is the code listing for part of the fatigue test. Compare it against the flowchart on the previous page and see if you identify which parts of the flowchart it relates to.

Note how random numbers are used in the code, to prevent operators cheating due to 'learned behaviour'.

```
forever
  call function wait_6Hours ▾
  call function runtest ▾
  call function wait_2Hours ▾
  call function runtest ▾
  call function wait_2Hours ▾
  call function runtest ▾
```

```
function runtest
  set score ▾ to    0
  call function timeForTest ▾
  call function waitstart ▾
  repeat  10  times
  do  call function busyscreen ▾
      call function showoutcome ▾
      call function measureresponse ▾
      call function updatescore ▾
  call function showscore ▾
  if (    score ▾  < ▾  threshold ▾
  then  call function takeabreak ▾
  else  call function backtowork ▾
```

```
function showoutcome
  set outcome ▾ to (    pick random 0 to   1
  if (    outcome ▾  = ▾  0
  then  ▦ show leds
  ...
  else  ▦ show leds
  ...
```

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

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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 What are the potential consequences of accidents on site?

Q How long might operators work in one shift?

Q How is the alertness of the operator tested with the BBC micro:bit?

Q How does the code try to prevent operators from cheating the test?

Q How many tests does the fatigue tester run each time?

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?

Fatigue test

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

Information

- **Managing fatigue risks**

  www.hse.gov.uk/humanfactors/topics/fatigue.htm

- **Cost of accidents to businesses and employees**

  www.hse.gov.uk/statistics/cost.htm

- **Health and Safety Executive – risk assessments**

  www.hse.gov.uk/simple-health-safety/manage.htm

- **Sample risk assessments**

  www.hse.gov.uk/risk/casestudies

- **PERCLOS measure of alertness in drivers**

  http://ntl.bts.gov/lib/10000/10100/10114/tb98-006.pdf

- **Alertometer – the mobile phone app for workers**

  www.alertometer.com/

- **Psychomotor Vigilance Task (PVT)**

  https://en.wikipedia.org/wiki/Psychomotor_vigilance_task

- **PVT testing in space**

  https://spinoff.nasa.gov/Spinoff2013/hm_1.html

- **Laing O'Rourke**

  www.laingorourke.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 is the alertness of the operator tested with the BBC micro:bit?

P5:   There are 10 timed tests, each takes a random amount of time. The BBC micro:bit measures how long it takes for the operator to respond, and whether they respond correctly or not.

Q.   How does the code try to prevent operators from cheating the test?

P6:   There are 10 random tests in each run of the program.

P7:   Random numbers are used to vary the delay between each test and also to select one of two possible outcomes. This prevents operators cheating due to learned behaviour.

Q.   How many tests does the fatigue tester run each time?

Q.   What are the potential consequences of accidents on site?

P4:   The consequences of getting it wrong can include major accidents involving the workers on the ground around the machines.

Q.   How long might operators work in one shift?

P4:   Machine operators can work for long shifts, sometimes up to 12 hours.

Faraday

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www.**theiet**.org/education

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