Task sheet: phase 1

Background
Rotimon is an imaginary island. La Soufriere is its youngest volcano. It last erupted in the 1970s. It is not monitored at the moment.

Recently the volcano has shown some strange signs. Tourists have reported strong sulfur dioxide smells. They have noticed bubbles in the crater lake. Some felt earthquakes when lying down near the top.

The island’s chief minister is worried. She wants the volcano to be monitored.

What to do
Your group is a team of volcanologists. You have £50,000 to monitor the volcano for six months. This money must pay for the monitoring and maintenance of your instruments and your staffing costs.

- Decide where to build your observatory. It must be far from the volcano. Mark this with an X on your map.
- Choose the best monitoring techniques from briefing sheet 1 to monitor the volcano. Cut these out from briefing sheet 2, and use Blu Tack to stick them around the map. Draw lines to show where you will place each instrument (apart from the satellites!)
- Use briefing sheets 1 and 2 to work out how many staff you need and the cost of employing them. Record this in the table on the record sheet.
- Use briefing sheet 2 to calculate the costs of helicopter trips to maintain your instruments. Write this in the table on the record sheet.
Key Stage 4 - Volcano Eruption!

Task sheet: phase 2

Background

There has been a small eruption near the summit. This might have destroyed some of your instruments.

The chief minister is worried there will be a bigger eruption. She may give you extra money to monitor the volcano for one more year. The amount of money depends on how well you predicted the small eruption.

What to do

Stage A

• If you have an instrument that is within 3 km of the summit, throw a dice. If you throw a 1, 2, or 3, the eruption destroyed the instrument. Remove this instrument from your map. If you throw a 4, 5, or 6 the instrument survives. Leave it on the map.
• Repeat for each instrument within 3 km of the summit.

Stage B

Find out how much extra money you have for next year by deciding which statements below apply to you. If you had...

a one more seismometers within 3 km of the summit you detected a strong increase in earthquakes before the eruption. The chief minister agrees that you should expand the monitoring. You have £30,000 extra.

b one or more seismometers within 3 km of the summit, and all your seismometers were within 10 km of the summit, you knew that all the earthquakes were below Soufriere. You have £40,000 extra.

c one or more seismometers within 10 km of the summit, but none within 3 km, you detected some earthquakes before the eruption. You have £10,000 extra.

d four or more cGPS receivers within 3 km you detected changes in the volcano slope shape three days before the eruption. The chief minister believes your argument that this is a valuable monitoring technique. You have £20,000 extra.

e collected satellite radar data you could see changes in ground shape after the eruption. You have £10,000 extra.

f a ground-based UV camera within 5 km of the summit and to its west (left) you did not detect extra sulfur dioxide, since the eruption was at night. But measurements after the eruption showed extra sulfur dioxide. You have £10,000 extra.

g collected satellite UV spectroscopy data you did not detect extra sulfur dioxide, since the eruption was too small. You have no extra money.

Stage C

• Calculate how much extra money you have for next year.
• Use briefing sheet 1 to decide which extra instruments and/or data to buy. You can also replace broken instruments. Cut all these out, and use Blu Tack to stick them next to your map. Draw lines to show where you will place each instrument (apart from the satellites!)
• Use briefing sheets 1 and 2 to work out how many staff you need and their cost, and briefing sheet 1 to calculate the costs of helicopter trips to maintain your instruments. Write these in the tables on the record sheet.

Remember, your money must pay for new instruments and data, and for staff to maintain the instruments and interpret the data, as well as for helicopter maintenance trips.
Task sheet: phase 3

Background

Six months later there has been no change in the nature of activity at the volcano. However, a hurricane hits the island. Much of your monitoring equipment is damaged.

What to do

Stage A

a  Systems that rely on telemetry to transmit data, and all ground-based instruments, have been damaged. Throw a dice to determine the total extent of this damage: throwing a one means your instruments have lost ⅙ of their value; a five means your instruments have lost ⅘ of their value, and so on. Calculate the total cost of replacing or repairing the damaged instruments.

b  The solar panels on some of your instruments are also damaged. Throw a dice to calculate the fraction of solar panels that need replacing: a one means that ⅙ of your solar panels must be replaced. One new solar panel costs £1,000. Calculate the total cost of replacing the damaged solar panels.

c  Estimate the helicopter time required to replace and repair your damaged instruments and solar panels.

d  Use the values calculated in a, b and c to calculate how much money you need to reinstate your monitoring system. Write this on the record sheet.

Stage B

e  A week later, the chief minister tells you that the government has insurance. It can meet 50% of the costs of reinstating your monitoring system. Decide which instruments to replace, or whether to spend the money on different monitoring techniques.

f  Your part-time staff tell you they cannot afford to live on the island. They will leave unless you employ them full-time. Decide what to do about this.

Stage C

g  Two weeks after the hurricane, emergency aid arrives from the United Nations. Your team has an extra £10,000 to develop monitoring capacity. Decide how to spend this unexpected income.
Task sheet: phase 4

Background

One month later there is a major eruption. Did your monitoring techniques work?

What to do

- Calculate the value of your remaining instruments:
  - Everything within 3 km is destroyed
  - Half your instruments within 5 km are destroyed
  - A quarter of your instruments within 10 km are destroyed.

- Find out how much value your monitoring system saved (or not!) by deciding which statement below applies to you:
  a. If you had a working network of 3 or more seismometers and one working GPS station within 5 km and either inSAR or a ground-based UV camera within 5 km to the west (left) of the volcano then you predicted the eruption in advance. You called for an evacuation. You saved lives and £100,000 worth of possessions.
  b. If you had a working network of 3 or more seismometers and either inSAR or a ground-based UV camera within 5 km to the west (left) of the volcano then you could see that things were happening. You called for a partial evacuation. You saved lives and £50,000.
  c. If you had any other system you did not have enough data to call for an evacuation. People died. No money was saved.

- Add up and record the value of your instruments and savings.

www.oxfordsparks.net/volcano

Task sheet: phase 4

Background

Six months later there is a major eruption. Did your monitoring techniques work?

What to do

- Calculate the value of your remaining instruments:
  - Everything within 3 km is destroyed
  - Half your instruments within 5 km are destroyed
  - A quarter of your instruments within 10 km are destroyed.

- Find out how much value your monitoring system saved (or not!) by deciding which statement below applies to you:
  a. If you had a working network of 3 or more seismometers and one working GPS station within 5 km and either inSAR or a ground-based UV camera within 5 km to the west (left) of the volcano then you predicted the eruption in advance. You called for an evacuation. You saved lives and £100,000 worth of possessions.
  b. If you had a working network of 3 or more seismometers and either inSAR or a ground-based UV camera within 5 km to the west (left) of the volcano then you could see that things were happening. You called for a partial evacuation. You saved lives and £50,000.
  c. If you had any other system you did not have enough data to call for an evacuation. People died. No money was saved.

- Add up and record the value of your instruments and savings.
Before a volcano erupts, magma rises through the crust and may start to fill a magma chamber. The ground surface above a volcano may change shape. Detecting moving magma helps predict eruptions.

Rising magma releases dissolved gases, for example sulfur dioxide. Detecting extra sulfur dioxide in the air near a volcano helps predict eruptions.

The instruments in the table detect moving magma or sulfur dioxide gas.

<table>
<thead>
<tr>
<th>Monitoring technique</th>
<th>What it detects</th>
<th>Other information</th>
<th>Staffing</th>
<th>Costs</th>
</tr>
</thead>
</table>
| **Seismometer**      | Seismic energy from earthquakes, explosions, ocean waves, and so on. | • You need three or more to locate local earthquakes.  
• Powered by a car battery trickle-charged with a solar panel.  
• Can be buried.  
• Data transmitted by mobile phone, Wi-Fi, or telemetry. Telemetry involves the automatic recording of readings from an instrument and their transmission by radio signals. | Scientist to interpret data, 2.5 days/week | £10,000 per seismometer |
| **Continuous global positioning system (cGPS)** | Measures the daily averaged position of a GPS receiver. | • Each instrument gives a single location, so 4-6 instruments are needed to give adequate coverage.  
• Receivers must have a good view of a clear sky.  
• Powered by a car battery trickle-charged with a solar panel.  
• Precise to within a few millimetres.  
• Data transmitted by mobile phone, Wi-Fi, or telemetry. | Scientist to interpret data, 2.5 days/week | £10,000 per receiver |
| **Satellite radar data (inSAR)** | Wide-scale changes in the shape of the ground. | • Limit of detection on the ground is an area of about 30 m × 30 m.  
• Images produced every 11 days for the whole island.  
• There is just one working satellite that collects this data. | Scientist to interpret images, 1.0 day/week | £5,000 per year £10,000 for all past images |
| **Ground-based UV cameras** | Sulfur dioxide gas given out by the volcano. | • Images require UV light source (the sun), so produced in daylight only.  
• Instruments must be downwind of the volcano.  
• Powered by a car battery trickle-charged with a solar panel.  
• Fairly large uncertainties in data, so need several instruments. | Scientist to interpret data, 1.0 day/week | £5,000 per instrument |
| **Satellite UV spectroscopy** | Sulfur dioxide gas emitted by the volcano. | • Images produced every day for the whole island.  
• The current satellite (Ozone Monitoring Instrument, OMI) can only detects gas that is 6 km or more above sea level. | Scientist to interpret images, 0.5 day/week | free |
### Key Stage 4 - Volcano Eruption!

**Briefing sheet [2] Instruments and staffing**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cost</th>
<th>Description</th>
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<tbody>
<tr>
<td>One seismometer</td>
<td>£10,000</td>
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</tr>
<tr>
<td>One cGPS monitoring system</td>
<td>£10,000</td>
<td></td>
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<tr>
<td>One year of inSAR data</td>
<td>£5,000</td>
<td></td>
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<tr>
<td>One ground-based UV camera</td>
<td>£5,000</td>
<td></td>
</tr>
<tr>
<td>Satellite UV spectroscopy data</td>
<td>free</td>
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**Staffing and maintenance**

The base station needs staff. Each person costs £10,000 per year (full time, but they can work part time):

- A director (1.5 days/week) to manage staff, and to liaise with government and media.
- A technical officer. One full time person can maintain up to 10 instruments.
- Scientists to interpret data. The director can do this for the rest of his or her time.

Instruments with car batteries need helicopter support unless they are within 1 km of a road or track.

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The volcano is called La Soufriere. The circles around the volcano are of 3 km radius, 5 km radius, and 10 km radius.
## Record sheet

### Phase one

<table>
<thead>
<tr>
<th>Staff role</th>
<th>Cost (£)</th>
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**Helicopter trips**

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<th>Number of hours</th>
<th>Cost (£)</th>
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### Phase two

**Extra funds available: £______**

<table>
<thead>
<tr>
<th>Staff role</th>
<th>Cost (£)</th>
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**Phase three**

**Funds needed to reinstate monitoring system: £______**

**Extra funds available: £10,000**

### Phase four

**Savings: £______**

**Value of instruments: £______**

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<th>Cost (£)</th>
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