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SENSUM project, Smart SENSing of landscapes Undergoing hazardous hydrogeomorphic Movement

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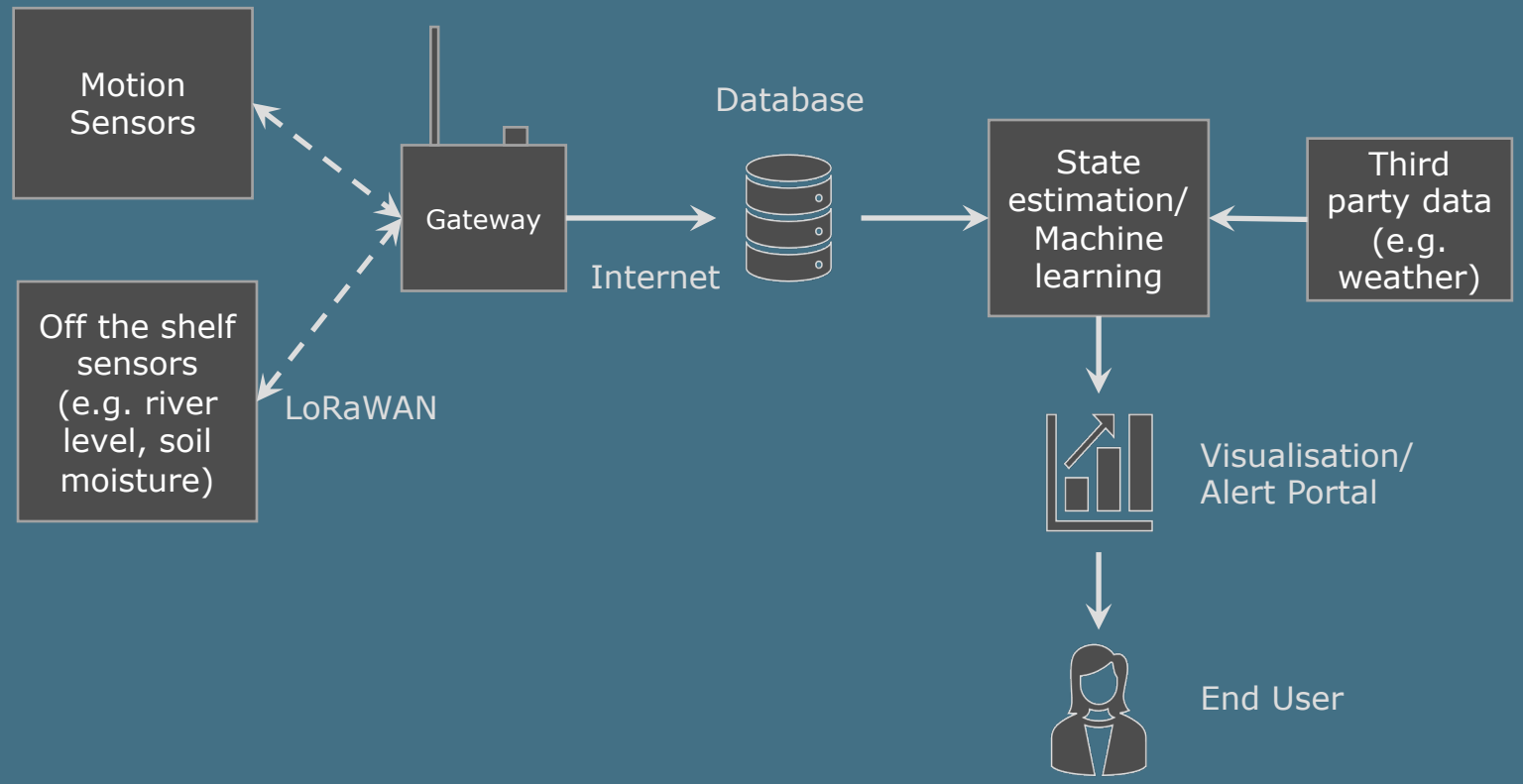
(Very Brief) Background

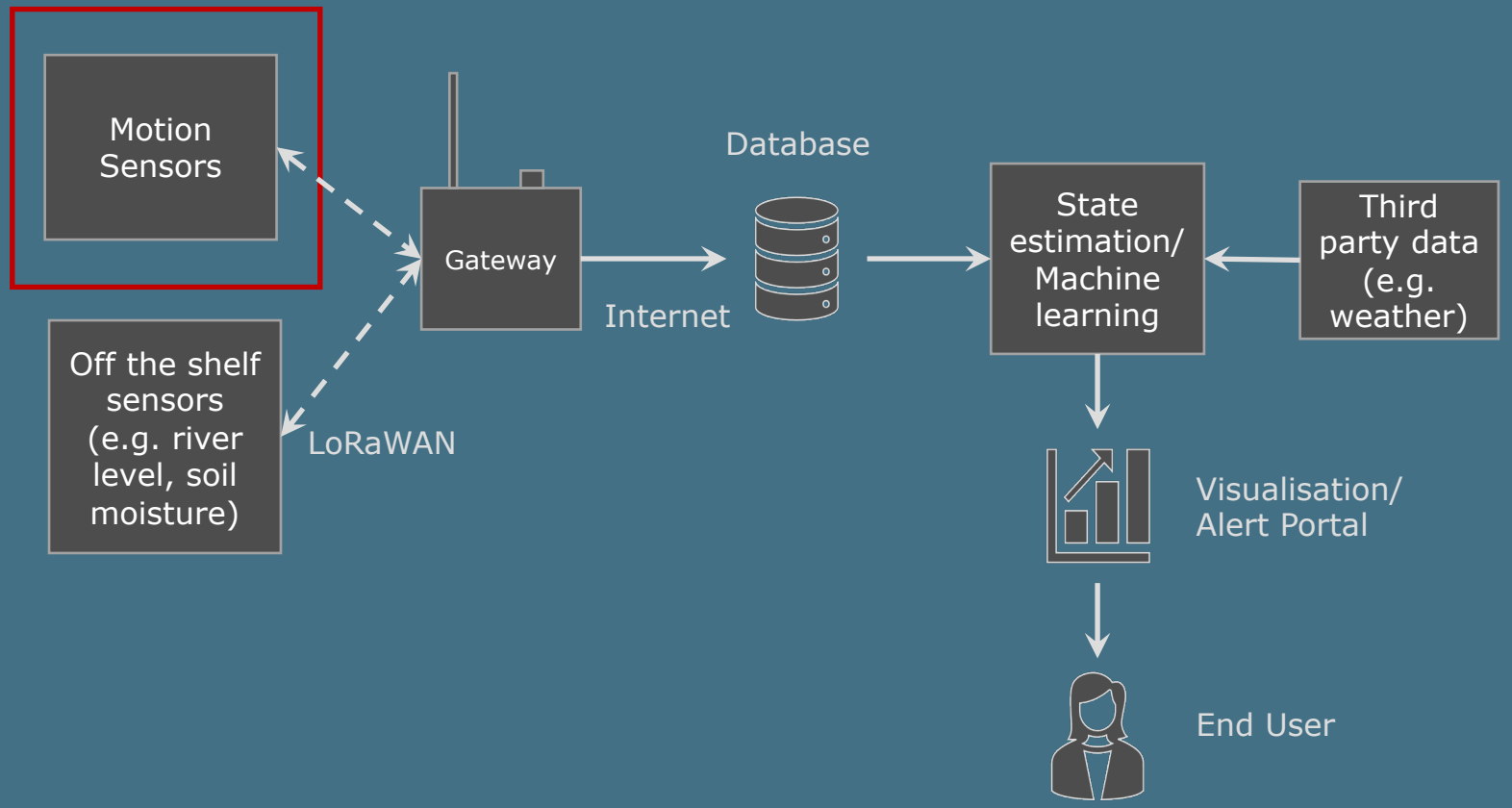
- UKRI-funded partnership
- Until Sept 2023
- Development of embedded motion sensing device/system
- Collect data from landslides and flood-prone sites within boulder/wood debris
- Combined with lab data, improve models of hazardous processes
- Using machine learning, detect hazardous movement in a near real-time early warning system.

University of Exeter
University of East Anglia
University of Plymouth
UK Research and Innovation
Natural England
Environment Agency
Dorset Council
AECOM
National Trust

System Architecture

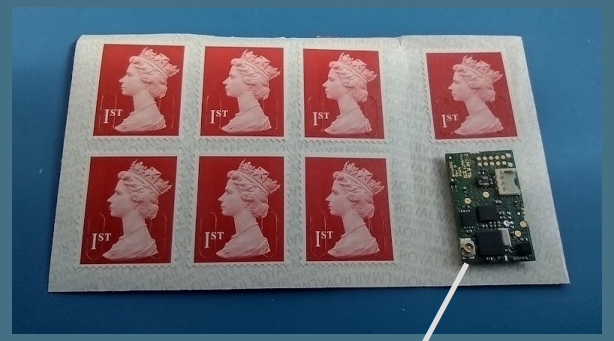


System Architecture



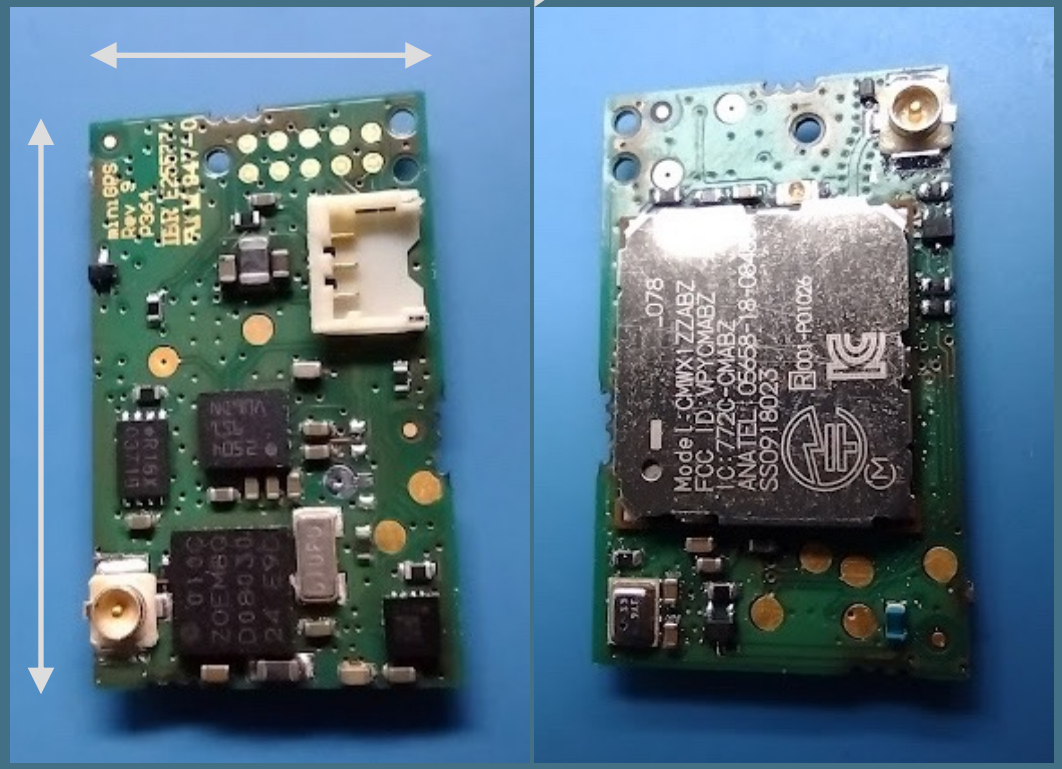
Sensor Features

- MiroMico MiniGPS Tracker
- Postage stamp size (23mm x 14mm x 4mm)
- Low power microcontroller
- Custom firmware
- 2MB flash storage
- LoRa radio transceiver (868MHz and 915MHz)
- Data/configuration OTA or via serial cable
- uBlox GNSS receiver
- 9 axis motion sensor (accelerometers, gyroscopes, magnetometers)
- Configurable up to 16g and 2000dps
- 3 axis triggering accelerometer



14 mm

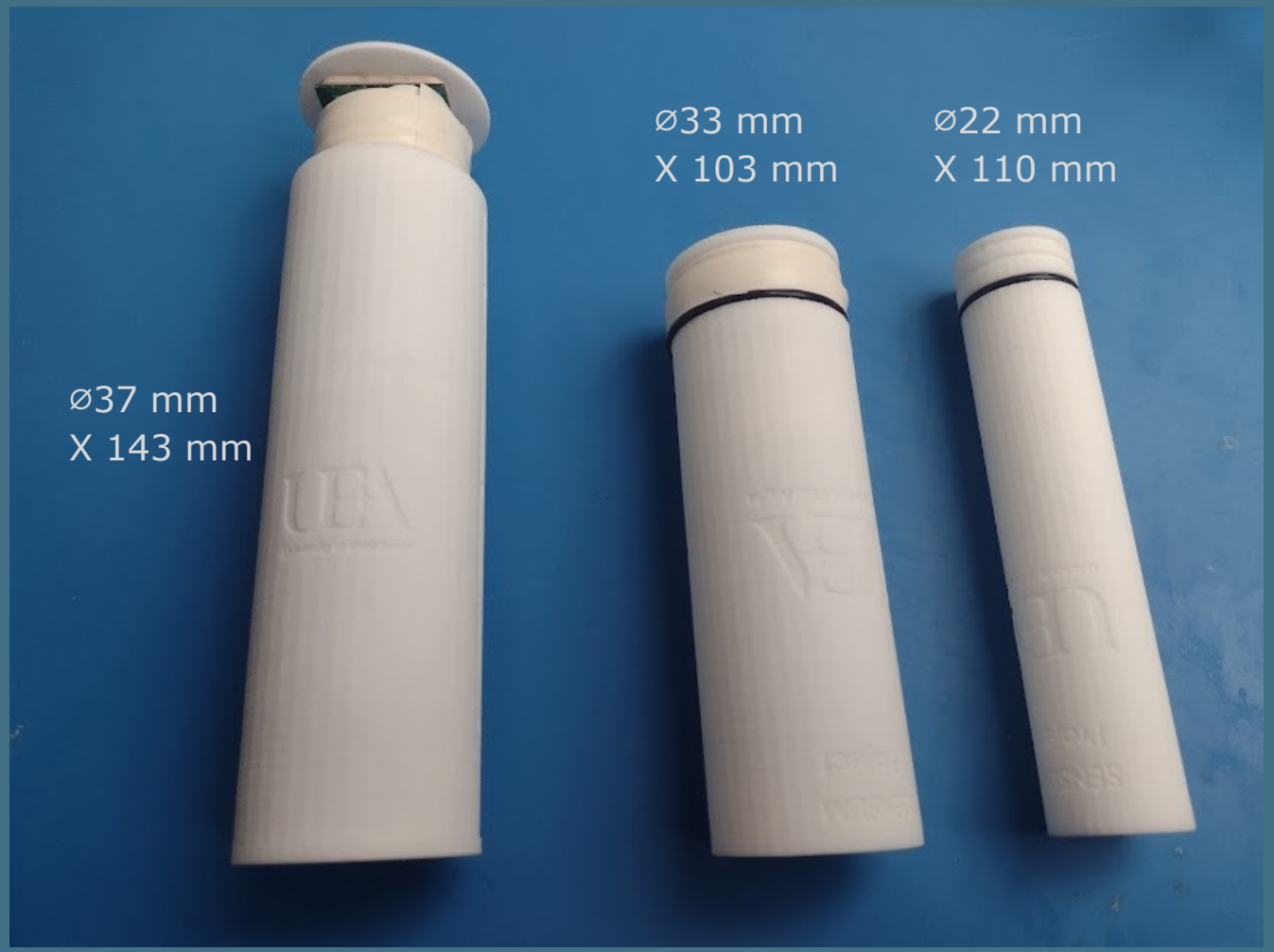
23 mm



Top Bottom

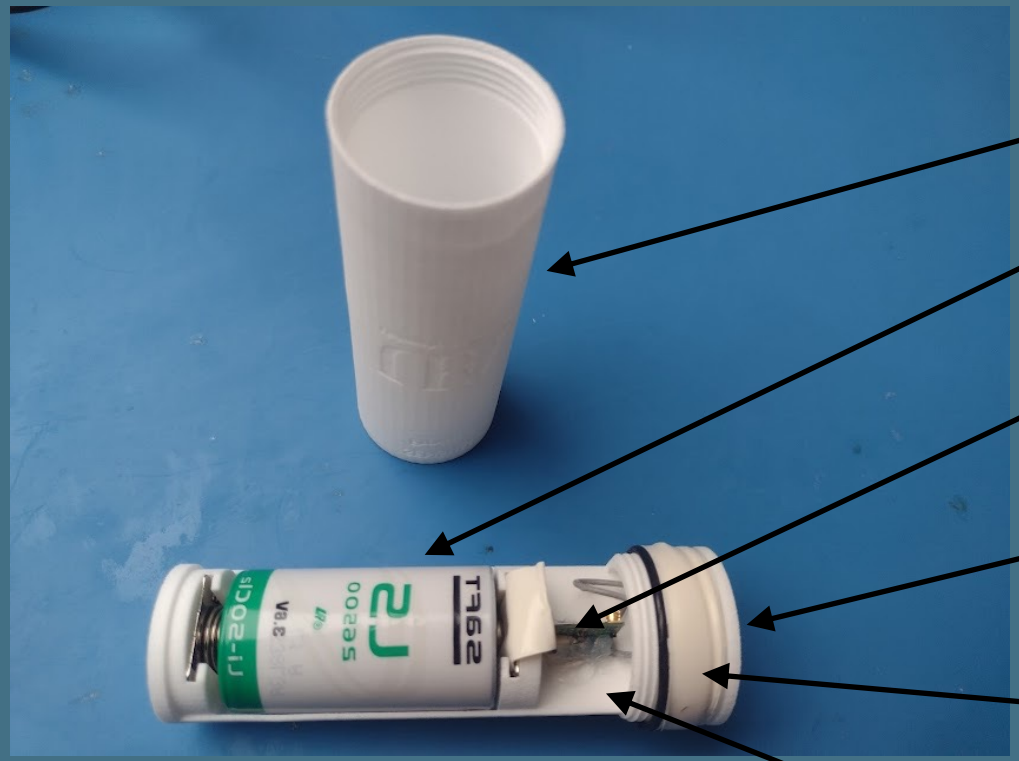
Sensor Enclosures

- Custom-designed
- 3D printed in nylon
- Water resistant
- Reusable (replace battery)
- 3 sizes
- Battery life (representative):
  - D cell – 12 months
  - C cell – 7 months
  - AA cell – 2.5 months



D cell C cell AA cell

Sensor Enclosures



C cell

Desiccant

Lid

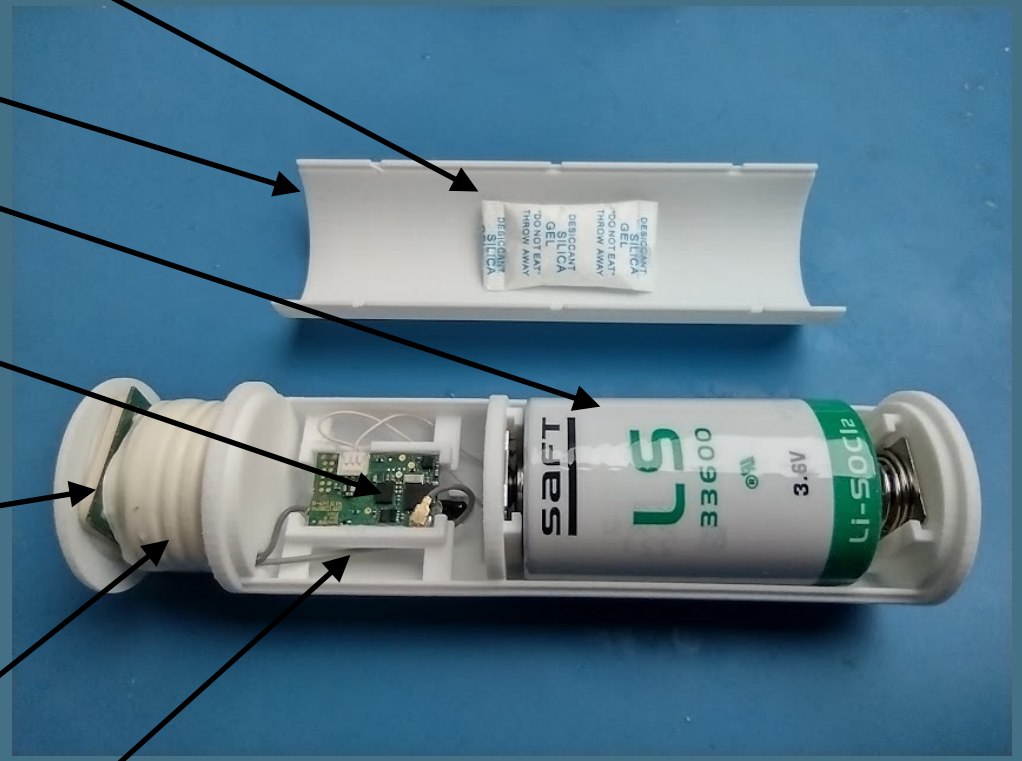
Battery

Sensor board

GNSS antenna

LoRa whip antenna

RFID capsule



D cell

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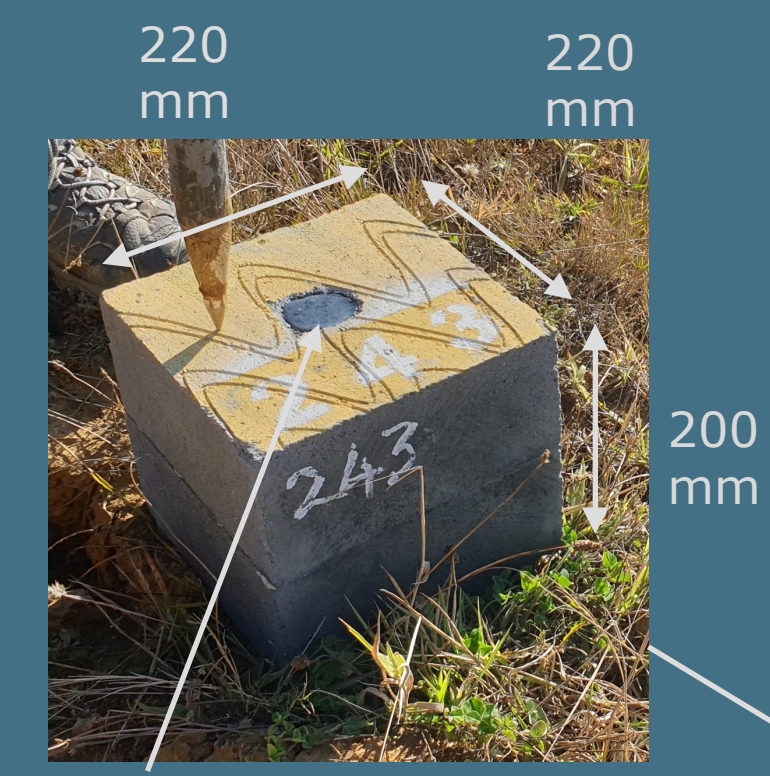
Slide Cube

- Artificial boulder
- Aerated concrete
- Sensor sealed in hole with resin
- Installed of ~20 each at:
  - The Spittles, Lyme Regis (Oct 21)
  - Compton Bay, Isle of Wight (Oct 21)
  - Harmalière landslide, France (Dec 21)

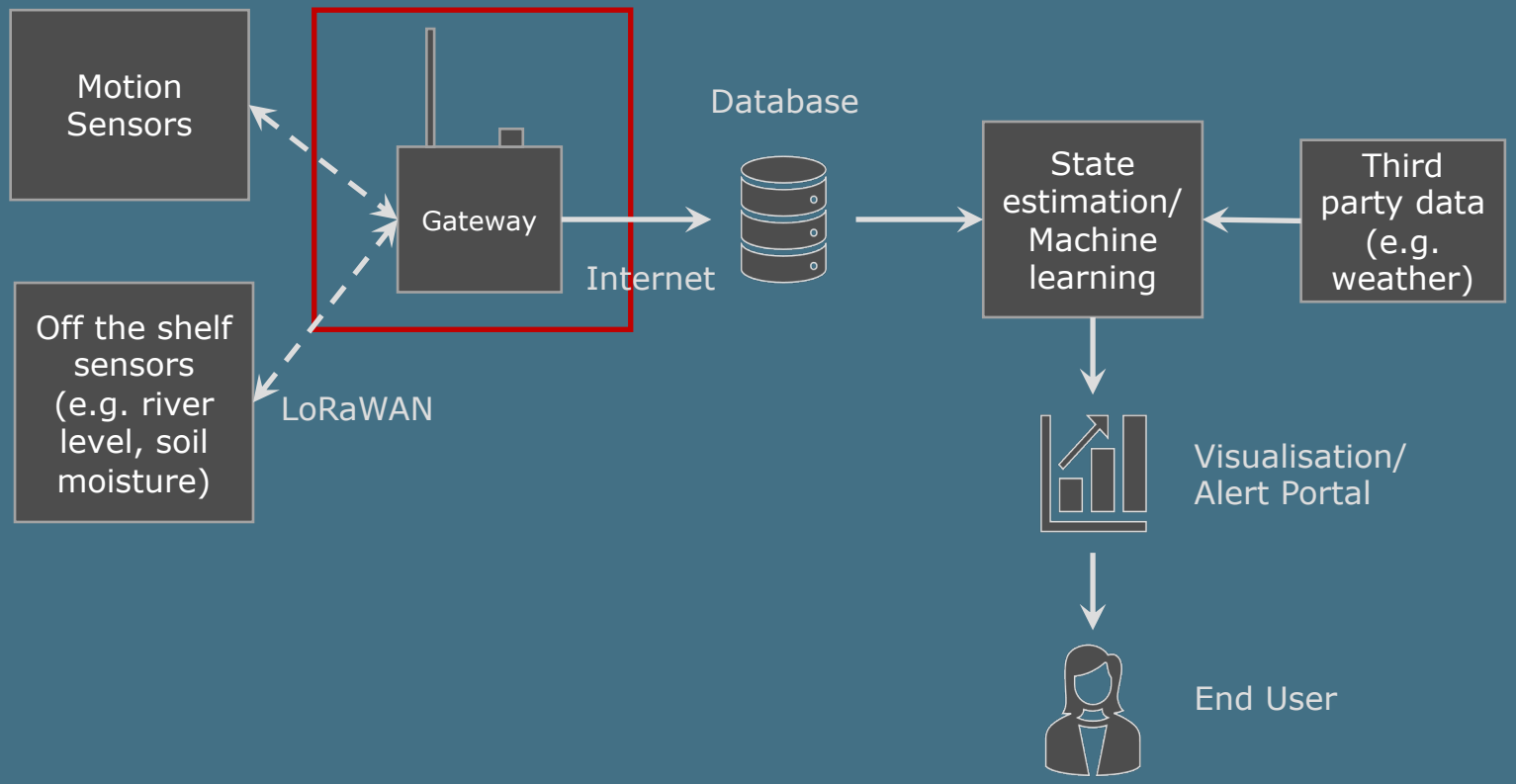
Advantages over natural boulders

- Always available!
- Lighter (6kg)
- Same size, mass, density, shape for more consistent dynamics
- Improved visibility from UAV
- Easier RTK survey



Slide cube

System Architecture



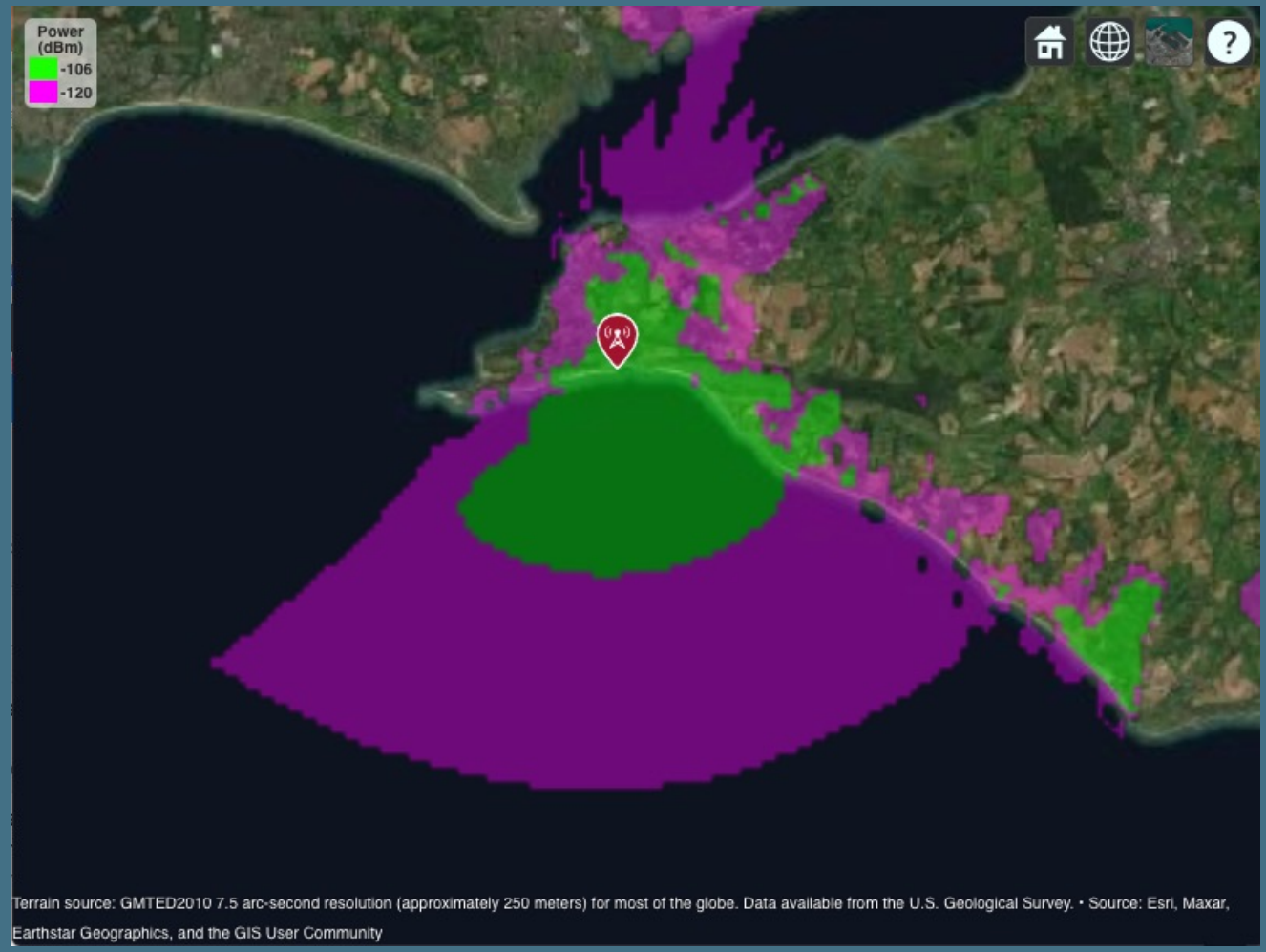
LoRaWAN communication

Why use LoRaWAN for a Wireless Sensor Network?

- Low power chirp spread spectrum (CSS)
- Range up to 20km
- Uses unlicensed frequencies
- No per device cost
- Not dependent on cellular network (gateway may be)
- Coverage planning aids gateway placement accounting for terrain (Longley-Rice radio propagation model)
- Some open community networks

BUT

- Only suitable for low bandwidth



Gateway Installation

Custom-built gateways developed give more installation flexibility than off-the-shelf gateways alone.

- Mounting options
  - Wall
  - Pole
  - Ground/roof
- Off-grid solar
- Direct mains powered
- Main powered with ~12 hour battery backup

Solar powered gateway

Build cost ~£600+VAT (€700)

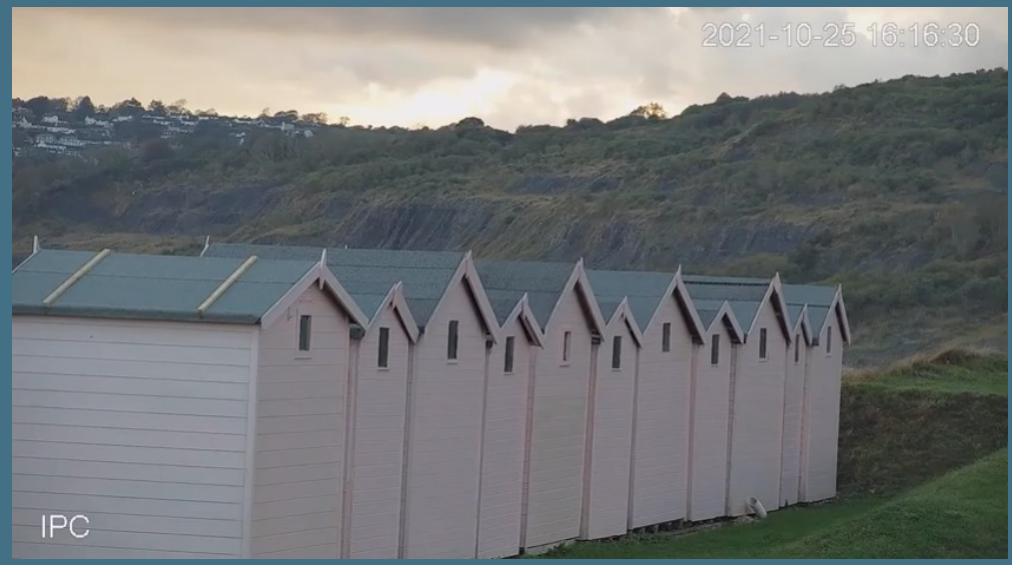
Cellular camera

- 1080p camera
- Shares gateway cellular connection
- Live streaming
- Time lapse
- Zoom control

- Hard drive will add recording feature

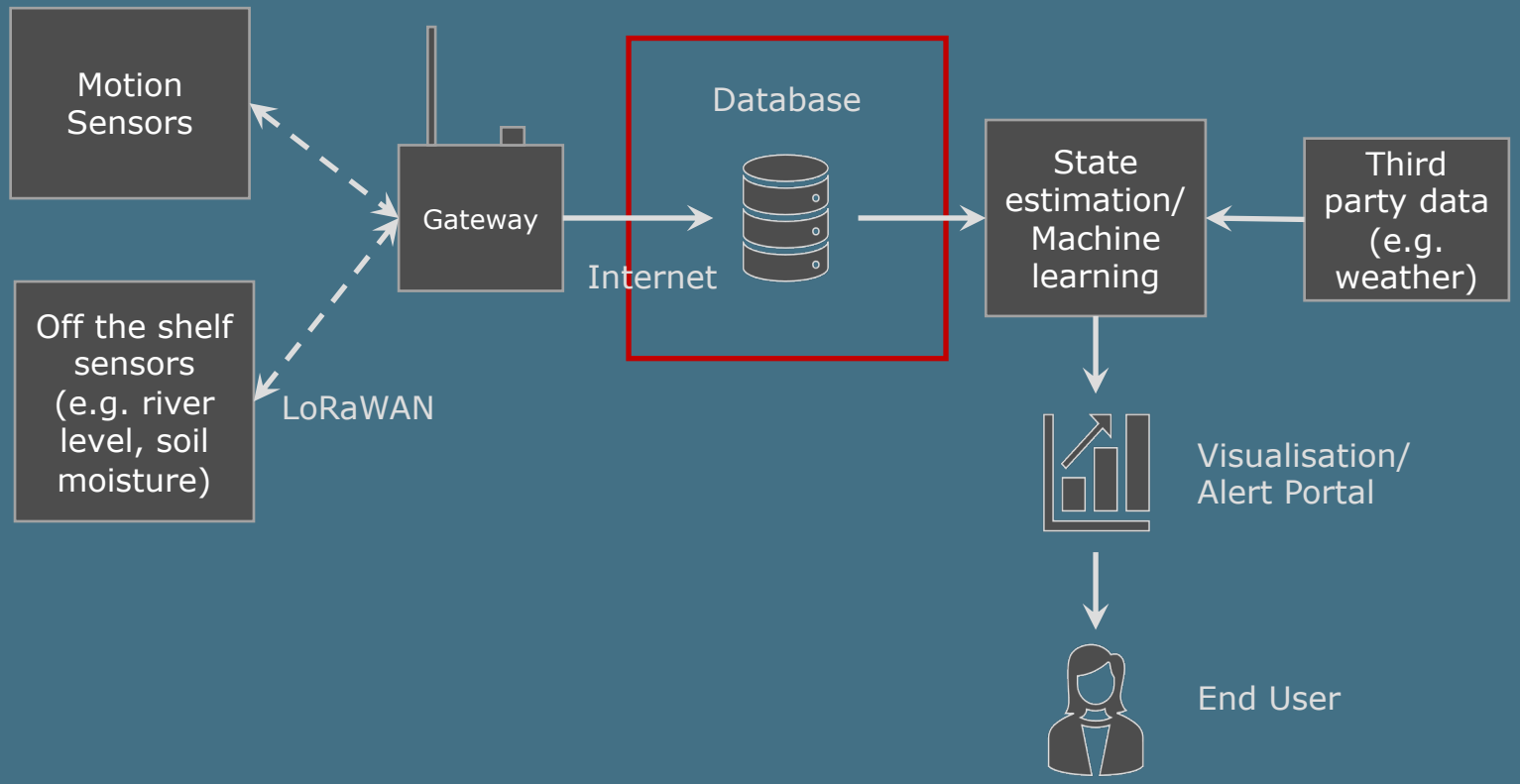
Bullet-style camera

Gateway

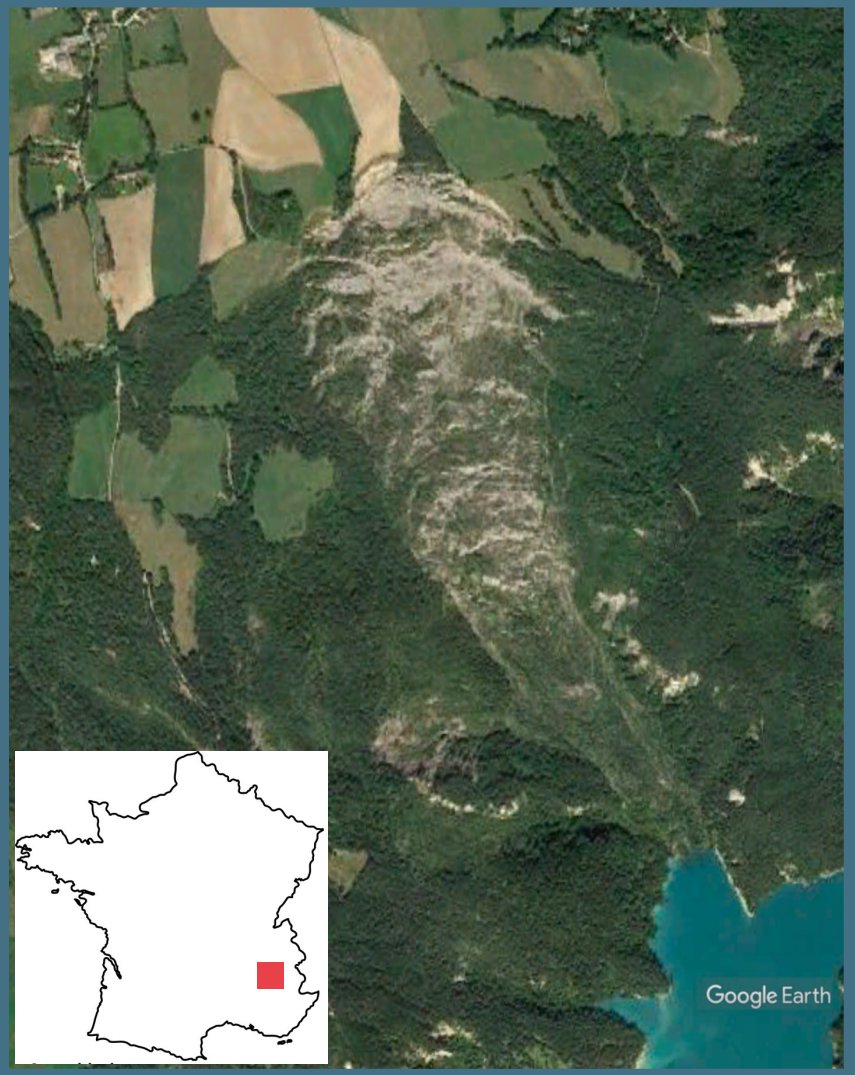


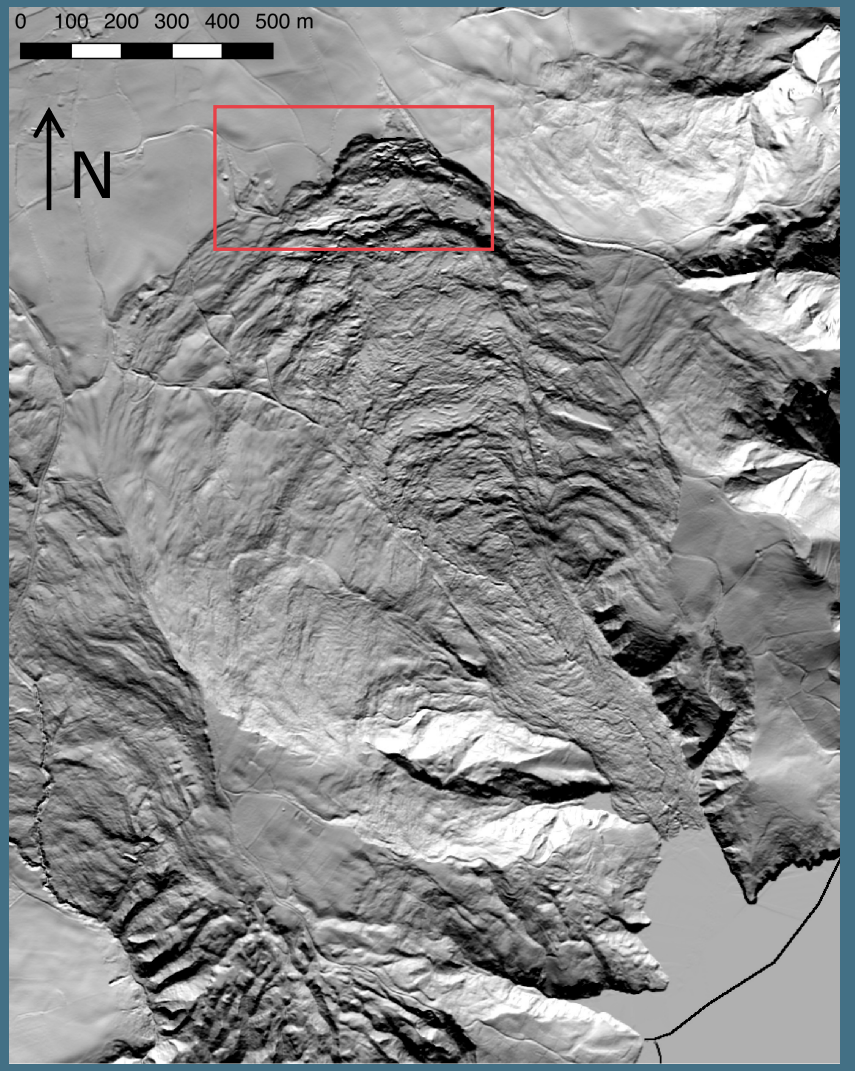
View of The Spittles Landslide from Gateway Camera

System Architecture

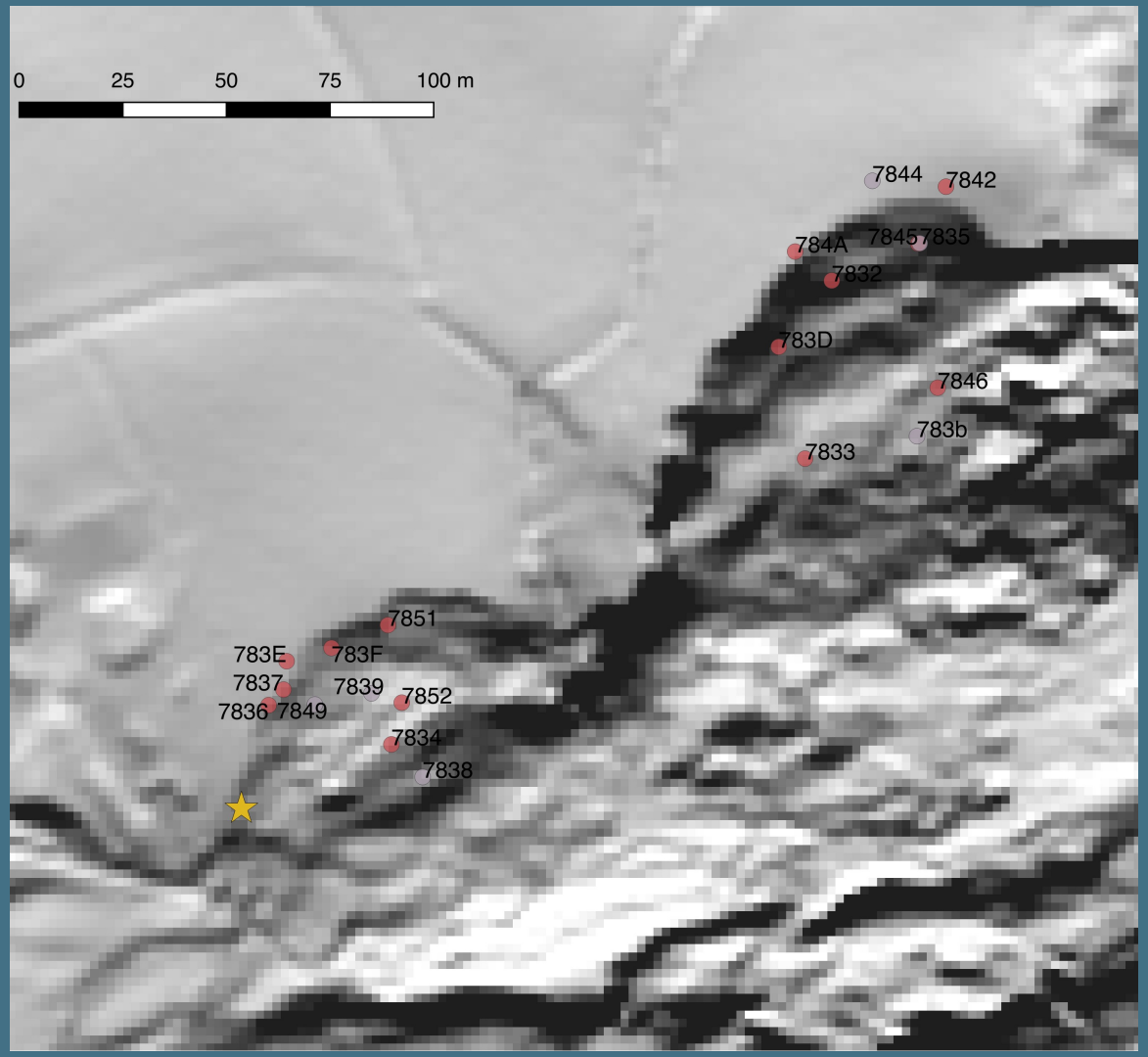


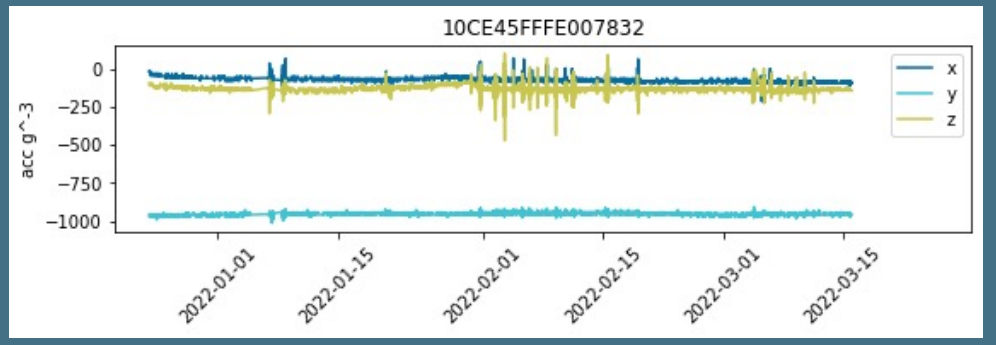
Harmalière Landslide

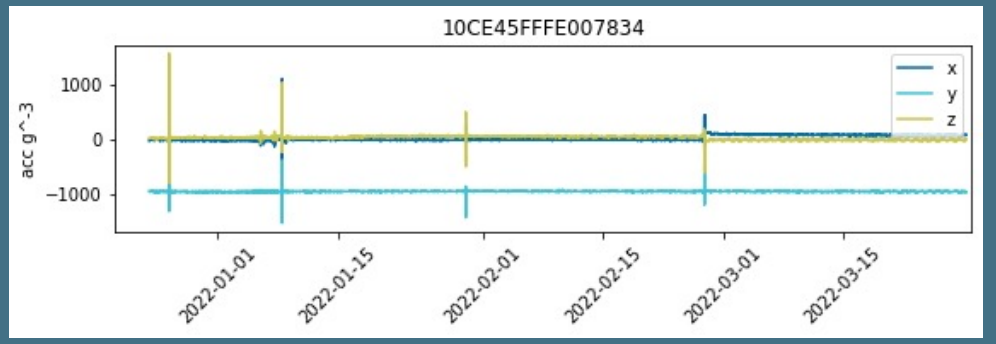


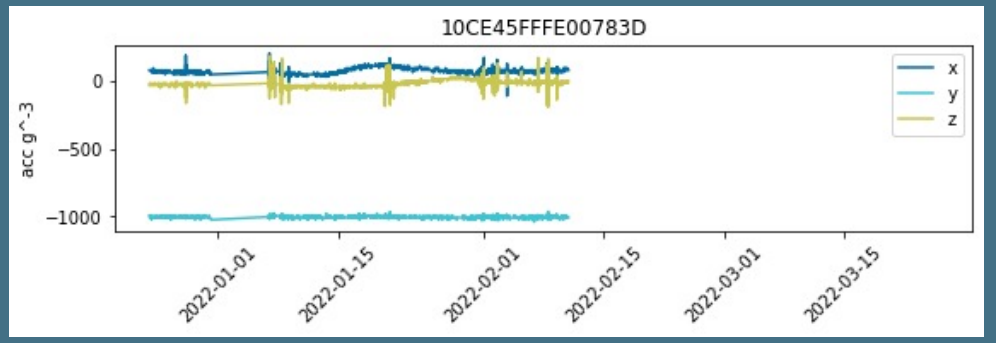


Harmalière: Preliminary Data









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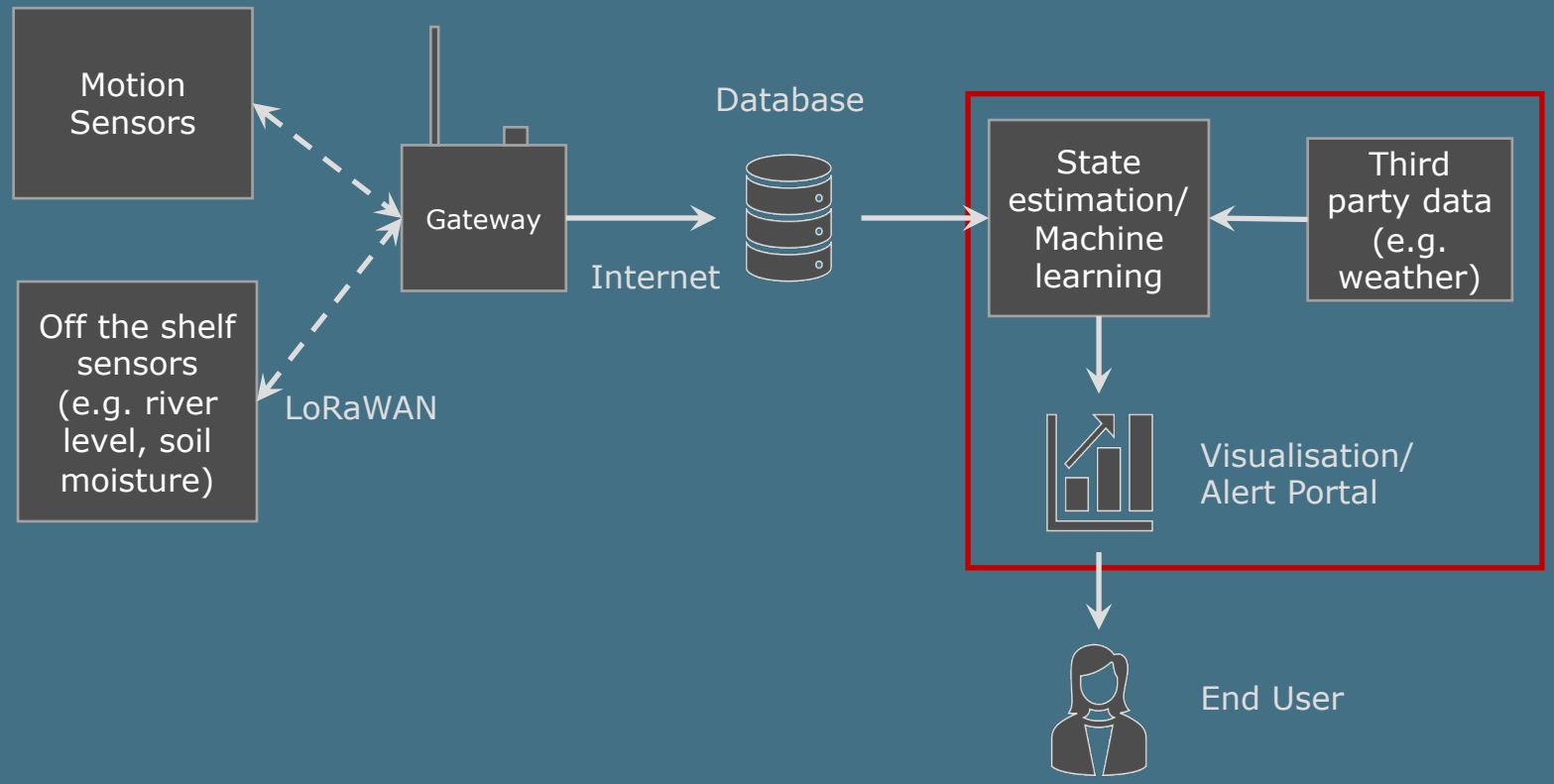
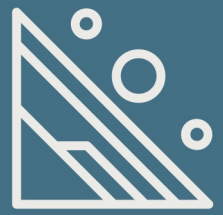


Data visualisation/alerting



What can the data tell us?

- Timing of motion events between sensors, and wrt. events in the environment.
- Rotation/orientation
- Motion type
- Magnitude of accelerations experienced (particularly cyclic).
- Coarse position

SENSUM online portal

- Work on this is underway
- Will provide near real-time dashboards for incoming time series data
- Alerting (e.g. email) will be available based on thresholds/calculations for data or derived data.

Next priorities

- Installation in Nepal (Dini et al. 2021)
- Reinstallation at Lyme Regis and Isle of Wight for winter
- State estimation/machine learning (Wilson et al. 2013)
- Low latency speed/energy measure (Dewhirst et al. 2016)
- IMU calibration

Dini, B., Bennett, G.L., Franco, A., Whitworth, M.R., Cook, K.L., Senn, A. and Reynolds, J.M., 2021. Development of smart boulders to monitor mass movements via the Internet of Things: a pilot study in Nepal. *Earth Surface Dynamics*, *9*(2), pp.295-315.

Wilson, A.M., Lowe, J.C., Roskilly, K., Hudson, P.E., Golabek, K.A. and McNutt, J.W., 2013. Locomotion dynamics of hunting in wild cheetahs. *Nature*, *498*(7453), pp.185-189.

Dewhirst, O.P., Evans, H.K., Roskilly, K., Harvey, R.J., Hubel, T.Y. and Wilson, A.M., 2016. Improving the accuracy of estimates of animal path and travel distance using GPS drift-corrected dead reckoning. *Ecology and evolution*, *6*(17), pp.6210-6222.

Thank you!

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https://sensum.ac.uk

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UNIVERSITY OF PLYMOUTH