Gravity sensors see underground

A UK collaboration is learning to see deep underground, using quantum technology to detect minuscule variations in the force of gravity. Among other things this could make roadworks faster and more efficient by revealing pipes and hidden hazards.

- Gravity can probe deeper than radar and other sensors
- Each reading takes seconds, rather than the minutes required by existing technology
- Quantum gravimeters will have a profound impact on civil engineering, defence, agriculture and many other fields

Engineers already have ways to peer beneath the ground, for example using radar and electrical measurements. But these all give a dim view, revealing only relatively large and shallow objects. They would miss a one-metre pipeline if it were buried more than two or three metres down, for example.

Gravity sensors have the potential to see much deeper, by detecting the tiny variations in Earth's gravitational field created by buried objects or cavities. Existing gravity sensors take several minutes to filter out the effect of local vibrations, making surveys too slow and expensive for most purposes, but quantum sensors can do better.

A collaboration between the University of Birmingham, RSK Group and Teledyne e2v is developing a series of quantum gravity sensors based on cold atoms. As the atoms fall under gravity, their speed can be measured with extreme precision using a laser. Rather than simply measuring gravity at one point, these devices use two clouds of cold atoms to measure the difference in gravity between two points. This drastically cuts down the effect of vibration, enabling measurements to be made much more quickly – potentially in no more than a second. It should also mean engineers can scan the ground from a moving vehicle, impossible with existing tech. For example they could be mounted on trains to perform constant track inspections.

Of the three Gravity Imager devices being developed at Birmingham, one is already running; another will be more sensitive, and the third will be small and light enough to fly on a drone. A parallel programme led by RSK is developing a commercial prototype, Gravity Pioneer.

This work has been largely prompted by the research undertaken at the UK National Quantum Technology Hub for Sensors and Metrology, particularly the Gravity Imager, REVEAL and SIGMA projects, and is funded by UKRI through the National Quantum Technologies Programme (NQTP) and by Dstl.

Over the next few years, quantum gravimeters will benefit from the breadth of the NQTP, as new lasers being developed at the Quantum Technology Hub will help to reduce the size and cost of these devices. Another advantage of the National Programme is its open culture of knowledge sharing, says Michael Holynski, PI of the Birmingham Pioneer team. "One of the main benefits is the good connections to industry and end users. It's easy to meet and talk to people like RSK, to find out what problems we need to target."

Gravity Pioneer partners:

- RSK Group
- Teledyne e2v
- Fraunhofer UK
- Altran
- Geomatrix Earth Science
- Magnetic Shields
- UniKLasers
- Silicon Microgravity
- Optocap
- QinetiQ
- University of Birmingham
- University of Southampton