UK
Quantum Technology Hub
Sensors and Timing

Working with industry for a quantum-enabled future

Sensors can be found in our everyday lives, from smart phones and cars to industrial applications in manufacturing, engineering and imaging.

The UK Quantum Technology Hub Sensors and Timing (led by the University of Birmingham) brings together world-leading physics and engineering experts from the Universities of Birmingham, Glasgow, Imperial, Liverpool John Moores, Nottingham, Southampton, Strathclyde and Sussex, NPL and the British Geological Survey to drive commercial exploitation of quantum sensor technology in collaboration with industry.

The Hub's specific areas of focus are magnetometry for healthcare, geophysics, navigation, timing and underpinning technology aimed at reducing the size, weight power and cost of future sensor systems.

What are Quantum Technologies?

Quantum theory is one of the most significant scientific breakthroughs of the 20th century. It has led to the development of some of the most widely used technologies such as the transistor and the laser which are now commonplace. A new generation of quantum sensor technologies is now enabling and driving a new range of previously impossible devices and systems to help build a safer, more efficient future.

Sensing the underground

Researchers are UK Quantum Technology Hub Sensors and Timing are developing the next generation of gravity sensors capable of detecting deep-underground hazards such as sinkholes, mineshafts and landslides faster and more precisely. This means that potential catastrophes can be spotted earlier and averted.

Unknown underground conditions present the largest single risk in infrastructure projects and cause significant delays and cost overruns, potentially costing up to half a percent of the gross domestic product of the country.

Understanding what lies beneath the ground would also help to protect the existing infrastructure and necessitate fewer, less invasive roadworks. If a rail track can be surveyed weekly, landslips could be spotted before it is too late.

This technology allows sensors to penetrate much deeper below ground than current remote sensing tools are able to do, and to make faster measurements of gravity. It opens the possibility of transforming huge sectors and industries, both economically and from a health and safety point of view. Gravity sensors will also make a huge difference to everyday life – meaning clearer roads, due to roadwork interventions, rapid broadband and mobile connections, and even more precise and measurements of droughts, floods and ocean current levels.

Impact:

- Water resource management from space
- Detecting sinkholes, mineshafts and landslides before they occur
- Clearer roads, due to less roadwork intervention

Better detection for a safer airspace

We are all too aware of the congestion caused by so many cars on the road, and the impact on the environment.

An increasing number of cars opens up the possibility of flying taxis, which sound improbable but are actually just a short way from being realised. Already, big companies around the world are launching their first electric air taxis.

As we begin to explore airspace, it will become increasingly important to think about the need for real-time precise situational awareness.

And that is why quantum-enabled radar is needed. Researchers at the UK Quantum Technology Hub Sensors and Timing are developing incredibly accurate quantum clocks, which will provide the necessary oscillator for the radar systems.

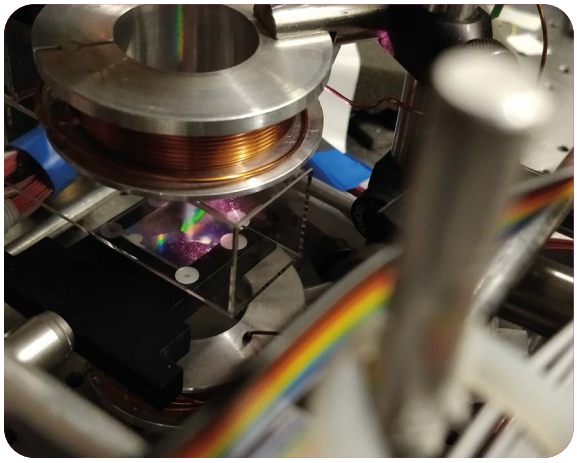
These systems will represent a step-change from current technology, in being able to reduce the noise, to be able to detect small, slow moving objects at much longer distances and in busy, cluttered environments.

Impact:

- Regulated, controlled airspace
- Better detection of unmanned aerial vehicles
- Faster, resilient communications networks

The Hub is focusing on five work streams:

- **Geophysics**
- **Magnetometry for Healthcare**
- **Navigation**
- **Timing**
- **Underpinning Technologies**



Enabling real-time brain imaging

Quantum-enabled brain imaging technology will not only help to further our understanding of what is often considered to be the most complex part of the human body, but will also improve potential for diagnosis and treatment.

Hub researchers are helping to develop a new generation of quantum magnetic sensor systems using Magnetoencephalography (MEG) to reveal the real-time brain.

MEG technology brings what is not possible with other current technologies - it measures magnetic fields generated by electric signals through the brain's network of neurons, and is able to provide real-time high level imaging measured every few milliseconds.

Hub researchers have used Optically Pumped Magnetometers (OPMs) to develop a wearable helmet-style brain scanner, comprising OPMs placed in a 3D-printed head-cast. Unlike current technologies, patients do not have to remain still during brain imaging, particularly suitable for children and those suffering from behavioural disorders such as ADHD. The scanner can be placed directly onto the head, closer to the brain, greatly enhancing the detection signal.

Impact:

- Enabling better understanding of cognitive brain conditions and neurological disorders

Facilitating independent and safer navigation

Often termed as the 'invisible utility', our reliance on Global Navigation Satellite System (GNSS) is often underestimated.

Many, if not all of the services comprising our UK national infrastructure – transport, telecommunications, emergency services – are heavily reliant on satellite systems for their operations.

According to the Satellite-derived time and position: Blackett review (2018), "all GNSS receivers are vulnerable to natural and man-made interference." This single point of failure system is detrimental to services dependent on these systems.

Hub researchers are working together to develop a quantum inertial navigation system. This navigation system is not dependant on external satellite signals.

A recently funded Hub project also aims to transform an existing gravity gradiometer developed by Hub scientists into a hybrid instrument that will extend the Hub's map-matching navigation technology.

Independent navigation capabilities has applications across the transport sector. Researchers are currently exploring the possibility of identifying problems with rail tracks through the use of an on-board navigation system.

Impact:

- Resilient, independent and GPS free navigation for car, rail and maritime transport

Developing lightweight, cost-effective technology

Reducing the size, weight, cost and power of quantum sensor technology is essential in realising a quantum-enabled future.

Researchers have been working hard since the Hub's inception in 2014 to strike the perfect balance between designing compact, robust technology which still retains the necessary accuracy and sensitivity.

The Hub's underpinning technology development is now advancing through to commercialisation.

Advantages of using quantum imaging:

- Portable, easy to use sensor technology able to be used in many different environments and challenging weather conditions

Contact us

We have many different collaboration opportunities available to those interested in working with us.

To discuss this in more detail, please contact:

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www.quantumsensors.org/collaborations

The Hub, which has over 150 projects valued at approximately £140 million, is keen to collaborate with industry companies to further advance quantum sensor technologies.

The UK Quantum Technology Hub Sensors and Timing is part of the National Quantum Technologies Programme (NQTP), which was established in 2014 and has EPSRC, IUK, STFC, MOD, NPL, BEIS, and GCHQ as partners.

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