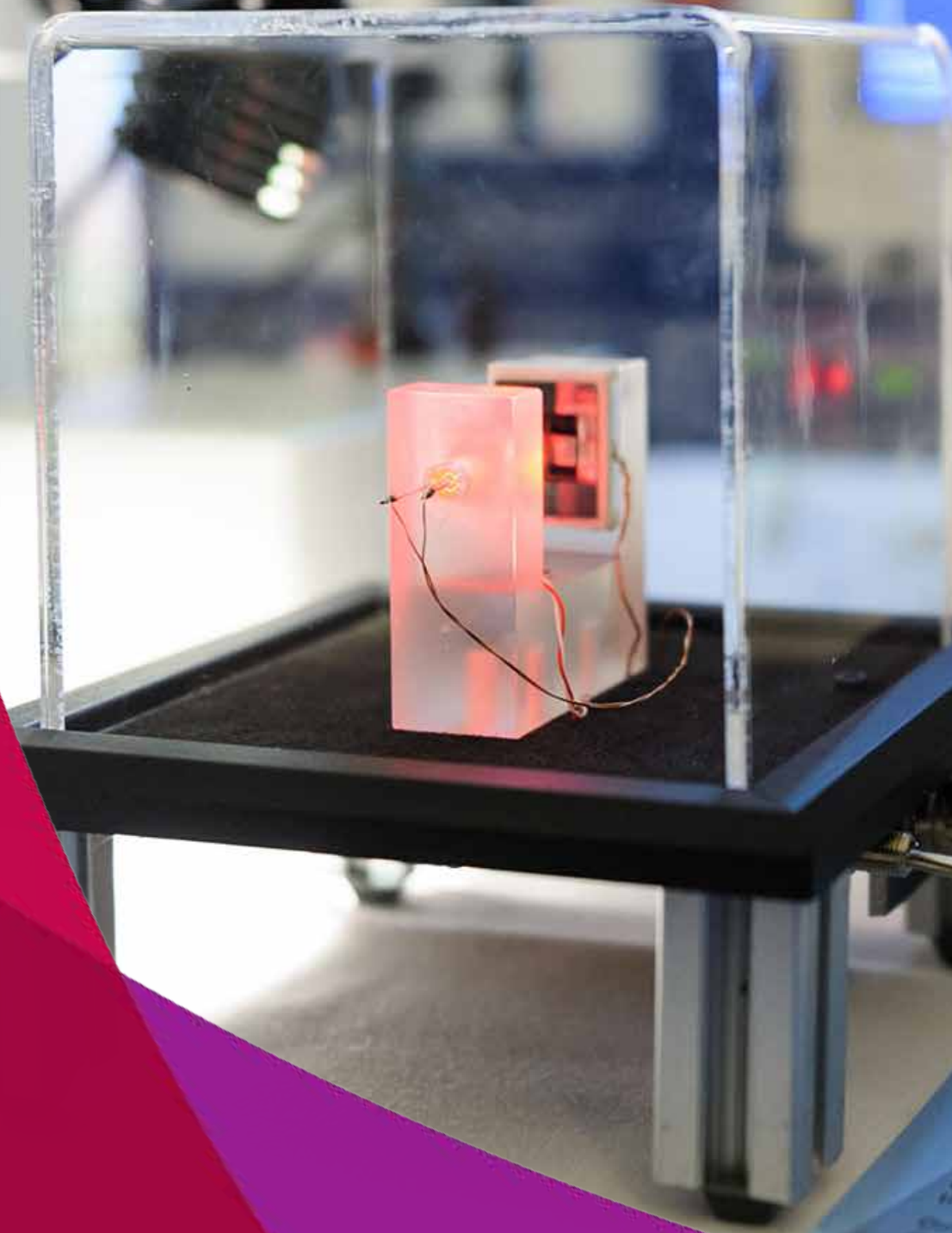




**QUANTIC**

The UK Quantum Technology Hub  
in Quantum Enhanced Imaging



**Wee-g :  
an ultra-sensitive gravity imager**

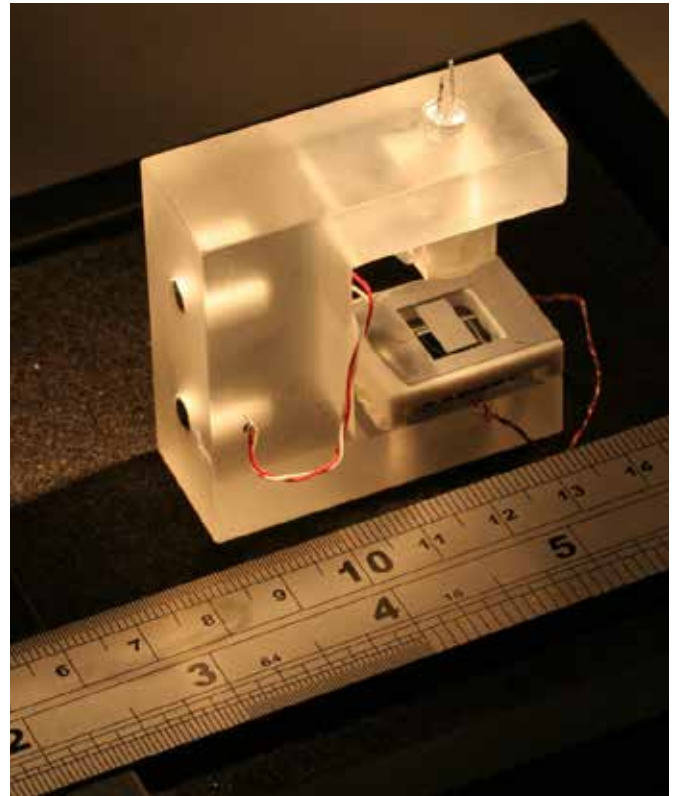
Researchers at QuantIC have developed Wee-g, a compact, ultra-stable Micro Electro Mechanical Systems (MEMS) based accelerometer capable of measuring tiny changes in the gravitational field. Wee-g has sufficient sensitivity to measure the Earth tides; elastic deformations of the Earth which result in changes of gravity 300 billionths of the local gravitational acceleration. Using optical readout for high sensitivity and excellent stability, Wee-g offers small form factor and the best sensitivity-size ratio of any current gravity sensor and has generated significant industrial interest for commercialisation.

## Bridgeporth

QuantIC is working with Bridgeporth to take Wee-g out of the lab and into the real world. Bridgeporth is a specialist geosciences company operating in the oil and gas exploration, mining and hazard mitigation sectors. Supported by a QuantIC Partnership Resource Fund project, the team has developed its first field deployable prototype of Wee-g. Trials in 2017 have shown the device is capable of monitoring the Bouguer/free air gravity correction while on a hillside. The next stage of trials, in late 2017/2018, will be a side by side comparison with commercial gravimeters.

*“The potential impact of Wee-g on land gravity survey is enormous; the high sensitivity and low cost of the device could transform the current gravity survey market as we know it.”*

- Dr Gary Barnes, Chief Scientist, Bridgeporth



## Clyde Space

Wee-g is also heading out into space with world leading micro-satellite supplier Clyde Space through a 4 year fully funded CENSIS (Innovation Centre for Sensing and Imaging Systems) EngD studentship funded via the CDT-ISM (EPSRC Centre for Doctoral Training in Intelligent Sensing and Measurement).

The aim of the industry project is to explore how QuantIC's Wee-g sensing capabilities could be incorporated into Clyde Space's off-the-shelf CubeSat avionics suite. CubeSats are a type of nano-satellite used for both space research and commercial ventures; one of their defining traits is providing surprisingly high-performance platforms at relatively low cost. The research will focus on the modelling, precision sensing, fabrication and development of miniaturized gravity gradiometer sensors for the attitude control of spacecraft where there is a significant market need for accurate, lightweight, and low power sensor systems in CubeSats. If successful, this will be an opportunity to create a transformative new space-based technology with unrivalled sensitivity.

*“The rapid turnaround in mission development and relatively low cost for deployment means that CubeSats are at the forefront of the ‘New Space’ revolution - QuantIC's Wee-g is a perfect example of cutting-edge game changing technology. As award-winning quality innovators Clyde Space believe that the next generation of CubeSat technologies will be quantum based and having access to the Wee-g will ensure we continue to lead the market.”* - Andrew Strain, Chief Engineer, Clyde Space

# QinetiQ

British multinational defence technology company QinetiQ has sponsored an industrial studentship project to explore the use of QuantIC's Wee-g for underwater applications in navigation and object detection. The initial phase of the project will focus on modelling of the sub-sea environment and will assess the performance of the MEMS device as a possible tool for gravity mapping and/or monitoring gravitational gradients due to density anomalies. A later phase will see a field prototype in a submersible vehicle used in a variety of configurations to assess the background noise performance and the acceleration level. The project will also explore the opportunities to recreate gravity maps on the seabed, including the temporal stability of these maps and assessing the signal noise ratio for detection.

*"QinetiQ is delighted to sponsor this studentship. It gives us access to highly novel MEMS-based gravity sensors which could open up new opportunities in maritime autonomy, including for example potential applications in sub-surface navigation, passive obstacle avoidance and sea-bed survey."*

- Dr Gillian Marshall, QinetiQ

# Schlumberger

QuantIC is working with Schlumberger, the world's leading provider of technology to the oil and gas industry, to develop a miniature silicon based interferometer. Miniaturised interferometric sensors have numerous applications in precision sensing and readout of MEMS based devices including accelerometers and gravimeters. This project will see the design and development of a fibre optic interferometer fabricated from silicon with a target sensitivity of better than 1nm over 1Hz timescales, improved robustness and high thermal and mechanical stability which can be incorporated into Wee-g to increase its readout sensitivity. The device will be Deep Reactive Ion Etched (DRIE) in the James Watt Nanofabrication Centre in Glasgow.

*"Schlumberger's leading position in oilfield exploration depends on using leading-edge technology, and that requires working with the best university groups around the world. We are excited to be collaborating with the University of Glasgow in pushing the boundaries on MEMS optical measurements."*

- Ben Jeffreys, Scientific Advisor, Schlumberger Gould Research

# Building a supply chain for future commercialisation

Industrial interest in Wee-g has led to a QuantIC Phase 2 Partnership Resource Fund project with Kelvin Nanotechnology who will develop a robust and repeatable manufacturing process for the MEMS device – an essential step forward for Wee-g’s path to commercialisation. Kelvin Nanotechnology is the commercial arm of the James Watt Nanofabrication Centre and provides a wide range of fabrication services for the semiconductor, quantum technology, photonics, optoelectronic, bioelectronic and nanoelectronic markets.

This project will see the development of 40 MEMS sensors with metal electrodes for capacitive sensing/ feedback control ready for vacuum packaging. They will be made available to collaborators to fully evaluate and identify industrial development opportunities. The devices will be packaged in collaboration with OptoCap, a technology oriented company active in the field of optoelectronics, microelectronics and MEMS packaging design and assembly services, and will be ready for field trials in 2018.



Application area	Detection of Underground Mass Anomalies
Estimated Component Cost	As laboratory demonstrator ~ £5k-10k In volume < £1 k depending on range required
Present Performance Specs	Has sufficient sensitivity to monitor the Earth tides (300µGal) over several days Short-term acceleration sensitivity: 40 µGal/sqrt(Hz) Thermal control: 1mK over several days Field demonstrator: 12 V battery powered system, <5 kg
Latest Publications	Measurement of the Earth tides with a MEMS gravimeter, R. P. Middlemiss, et al., Nature 531, 614–617 2016

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