Innovate UK

Results of Competition: Commercialisation of Quantum Technologies FS R3

Competition Code: 1701_FS_EE_QUANTECH3

Total available funding is up to £13m - £9m from Innovate UK with up to £4m from EPSRC

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Cascade Technologies Ltd	QUantum-Enhanced SpecTroscopic molecular detection - QUEST	£211,739	£105,870
Fraunhofer UK Research Ltd		£152,477	£152,477
University of Bristol		£56,360	£56,360

Project description - provided by applicants

Optical instruments are critical in identifying substances and molecules. They are used in a diverse range of applications such as manufacture, pollution monitoring, airport security systems and healthcare diagnostics. Often, molecular species are present in minute amounts, making their measurement difficult. A fundamental limit to sensitivity of such instruments is the presence of noise in the laser light, which hides the very signature fluctuations in the optical signal intensity that enable detection of very minute levels of a given substance. In this project, we will address this by exploiting recent advances in quantum optics - the application of squeezed quantum states of light. In this special form of quantum light, one can choose to sacrifice the purity of characteristics of the light that one is not interested in order to reap gains in others that one is - in our case, characteristics that enable spectroscopy. Such an approach was recently and spectactularly successful in the first steps of helping the next generation of LIGO detectors search deeper into space for astronomical events causing gravitational waves. We will exploit squeezed light for molecular detection with unprecedented sensitivity, thereby enabling detection of far smaller amounts of molecules possible with standard techniques.

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RedWave Labs Ltd	Narrow-linewidth Emission by Enhancement of Diode Lasers for quantum systems NEEDLE	£222,380	£155,666
Fraunhofer UK Research Ltd		£134,583	£134,583
Project description - provided by applicants			
Quantum technologies are poised to reshape the scientific field, but are limited at present by the availability of high-performance, narrow-linewidth laser systems in a compact size, as these laser sub-systems tend to be a major contributor to the size and cost of the final system. In this project we will develop a compact, narrow-linewidth laser system to achieve the performance required for quantum technology applications. This project will aim to address the requirements for use in Rb based quantum sensors with a practical narrow linewidth laser system at 780 nanometers.			

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Optocap Ltd Fraunhofer UK Research Ltd	QUEST - Quantum Entangled Source	£162,157 £130,105	£81,079 £130,105
Project description - provided by applicants			
The possibility to exchange a cryptographic key secured by the laws of quantum physics is rapidly leaving the academic laboratories and entering our everyday life, with commercial devices currently available. These, typically, rely on the propagation of quantum states of light in dedicated optical fibres. However, the unavoidable fibre loss is limiting the maximum distance achievable to roughly a hundred miles. This limitation could be overcome by exploiting satellite quantum communication. Different governments and funding agencies, such as China and the European Space Agency, are currently investigating this possibility. The main component for satellite quantum communication is the source of quantum light. In this project, we want to evaluate the feasibility of a commercial product for the generation of the necessary quantum states of light able to be deployed on a satellite. By combining Optocap's expertise in the packaging of optical components for space applications and Fraunhofer Centre for Applied Photonics know-how in quantum technologies, we aim at defining the route towards the first commercialisation of a source of entangled photons for satellite quantum communication.			

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Teledyne e2v (UK) Ltd	Synchronisation with cold ion trapped ytterbium - SYNCHRONICITY	£259,253	£129,627
NPL Management Ltd		£239,957	£239,957
Project description - provided by applicants			
Precise measurement of time is fundamental to the effective functioning of services we take for granted in modern society. This project is a major step in developing a reliable, widely available timing standard that is one hundred times more stable and accurate than those commercial systems in use today. It will enhance resilience and reliability of energy supply, safety of transport links, data networks and electronic financial transactions. The enhanced performance will enable advances in mobile telecommunications such as transition to a 5G network. The use of GPS for timing signal in these essential systems is widespread but vulnerability to accidental or malicious disruption is an emerging concern. The impact of the loss of power, transportation and communications could easily become catastrophic in the very short term and disrupt our highly interdependent society in the long term. The Royal Academy of Engineering highlighted these issues in their report of 2011 and that message is creating a demand for timing solutions that are not GPS dependent. The precision clock in this project is based on transferring the UK'™s National Physical Laboratory know-how into British industry and creating a technical and economic success for the UK.			

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Teledyne e2v (UK) Ltd	GRAM - Gravity for Rivers, Agriculture and Mines	£199,346	£99,673
RSK Environment Ltd		£148,656	£74,328
RSK ADAS Ltd		£24,738	£12,369
The Coal Authority		£10,225	£10,225
Canal & River Trust		£19,847	£19,847
University of Birmingham		£156,105	£156,105
Cranfield University		£38,971	£38,971

Project description - provided by applicants
The coming gravity sensors based on Quantum Technologies (QT) have the potential to disrupt existing surveying practices through dramatically improved measurement sensitivities. GRAM is a collaboration between Teledyne e2v, RSK, the Canal & River Trust, the Coal Authority, Cranfield University and the University of Birmingham (UoB) to establish the Quantum Technology (QT) gravity sensor market opportunities against assessment of current geophysical technologies to determine soil compaction for precision agriculture, detection of water levels in disused mines and mineshafts and canal & river embankment leak detection. GRAM will baseline the capabilities of existing sensor technologies in the sectors identified, provide technical specification and performance requirements to the manufacturers of prototype and commercial QT gravity sensors and establish a market pull from the end users of the information generated by the sensors. Moreover, it will provide a market sizing and market penetration assessment to determine the size of the potential markets, analyse the competitors and determine the cost brackets for each of the three applications together with expected survey methodologies.

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RSK Environment Ltd	Quantum Technology Potential for Railway Infrastructure (QT-PRI)	£116,443	£58,222
Network Rail Infrastructure Limited		£26,274	£26,274
Atkins Limited		£30,037	£15,019
University of Birmingham		£118,517	£118,517

Project description - provided by applicants

QT-PRI is a collaboration between RSK, Atkins, Network Rail and the University of Birmingham (UoB) to establish the Quantum Technology (QT) gravity sensor market opportunities against assessment of current geophysical technologies to detect and assess the condition of assets buried below the railway network, in particular drains, as well as water flow through the railway earthworks. There are over 190,000 railway earthworks and over 6000km buried assets. The incomplete asset inventory significantly limits the development of a framework to allow proactive condition assessment thereby maximising the limited resources and keeping the rail network operational. Currently, geophysical sensors are commercially used to detect the location of the ducts and pipes in roads and with limited success on the railways, but are rarely used to detect the asset condition or the condition of the parent asset (earthwork) itself. QT-PRI will open up a new market for QT gravity sensors by: 1) Assessing in detail the capability and limitations of QT gravity sensors benchmarked against current geophysical sensors for the railway environment; 2) Increasing the marketplace for the sensors by engagement with the client base, excellent dissemination activities, and practical field demonstrations.

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Unitive Design and Anaysis Ltd University of Bristol	Commercial Feasibility for Sub-Shot Noise Quantum Technology Sensing and Imaging	£45,980 £16,472	£32,186 £13,178
Project description - provided by applicants			
Unitive Design and Analysis are conducting a market Feasibility Study together with the University of Bristol to establish industry requirements for Quantum Enhanced Imaging technology. QLS is a Quantum Light Source capable of beating the shot noise limit and as such is enormously exciting for industries which rely on ultimate precision for measurement and monitoring. This study will analyse the commercial potential for this technological innovation which could lead to a first to market commercial enhanced imaging product. Current state of the art imaging accepts photon shot noise as a necessary limitation and so QLS has the potential to deliver disruptive, innovative imaging solutions to many industry sectors.			

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QinetiQ Group PLC	Evaluation and Demonstration of Gravity Gradiometers	£132,227	£66,114
Imperial College London		£90,559	£90,559
University of Oxford		£39,919	£39,919
Project description - provided by applicants			
QinetiQ Ltd, Imperial College and Oxford University will jointly investigate the use of novel gravity gradiometers to detect buried objects such as pipes, tunnels and sinkholes. We will model the gravitational field of a range of buried targets, and investigate methods to mitigate noise and clutter. We will determine what type of objects are detectable, at what range, and develop some outline Concepts of Operation. We will investigate the applicability of a range of sensors, both high performance quantum devices based on "cold atom fountains" and lower-cost MEMS-based devices, configured as gravity gradiometers, and compare them to the performance of commercially available sensors. We will build a single-axis gravity gradiometer based on two existing gravimeters, and use this to validate our models with through short field trials to demonstrate the detection of a buried object.			

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Peacock Technology Limited	Feasibility of Magnetocardiography in Livestock (QuBeat)	£184,576	£129,203
Ice Robotics Limited		£42,883	£30,018
University of Strathclyde		£159,733	£159,733
Project description - provided by applicants			
The project will develop an experimental system which will demonstrate the feasibility and effectiveness of atomic magnetometer technology for monitoring the health and welfare of livestock. This is a new approach, made possible by recent advances in the sensitivity of atomic magnetometers. The feasibility of this application will involve tests in a real farm environment.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
QinetiQ Group PLC	Technical and Commercial Feasibility of Quantum Radar and Lidar	£60,736	£30,368
Fraunhofer UK Research Ltd		£55,643	£55,643

Project description - provided by applicants

Radar and its optical counterpart, lidar, are well established and widely used technologies. The first is typically exploited for long-range detection, while lidar, operating at visible to near infrared wavelengths, offers improved resolution yet at a shorter distance. With the recent advances in quantum technologies, we can now investigate the feasibility of using quantum metrology in radar and lidar systems. While proof of principle results show the possibility to exploit quantum detection and illumination (e.g. entangled photons) to increase radar/lidar resolution and sensitivity, it is not clear yet if real systems can actually benefit from these achievements. This study will assess if the available quantum technology is mature enough, or is likely to mature, to increase the performance of radar and lidar with respect to the classical state-of-the-art, or achieve the same performances with reduced size/power consumption? This study will consider the most advanced results for quantum radar/lidar schemes and quantum devices for use in realistic situations. This answer will allow an understanding of whether quantum radar/lidar systems are a valuable commercial development worthy of further investigation and investment by UK companies.

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Added Scientific Limited	OPTAMOT: Optimised Designs for Additively Manufactured Magneto Optical Traps	£225,000	£157,500
University of Nottingham		£101,964	£101,964
University of Sussex		£75,989	£75,989
Project description - provided by applicants			
Quantum devices will have a profound impact on society if they can be made smaller, cheaper and less power intensive; at present they are large pieces of laboratory equipment with few industrial applications due to their size and cost. This project will demonstrate the feasibility of using Additive Manufacturing (AM) to produce components for quantum devices that are commercially viable. Specifically, the project will focus on optimising the design of Magneto Optical Trap (MOT) assemblies, a key component of quantum devices that use ultracold atom clouds; the objective will be to achieve an order-of-magnitude reduction in the size, weight and power compared to current laboratory MOT structures.			

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Plantagenet Systems Limited	Quantum algorithms for optimised planning/scheduling applications	£181,300	£126,910
British Telecommunications PLC		£48,327	£24,163
University College London		£122,061	£116,128
University of Bristol		£49,136	£49,136

Project description - provided by applicants

This project will investigate the technical and business feasibility of exploiting quantum algorithms for optimised planning tasks, in close collaboration with key industry and academic partners. It aims to prove the technical feasibility of enhancing existing artificial intelligence (AI) planning techniques with quantum algorithms, either as fully quantum or hybrid solutions, combining both quantum and conventional computing methods. We will perform experiments to establish benchmarks for enhancing AI planning techniques with early quantum annealing algorithms, and then determine how they might be further enhanced with other universal quantum computing or 'circuit-model' approaches. In addition, this project will perform a market assessment for quantum-enhanced optimised planning solutions and determine the business feasibility of commercialising them for several markets, including telecoms network optimisation, distribution logistics and operational planning. This will help to stimulate wider interest with potential end-users and quantum computing vendors to develop optimisation tools for specific markets, and deliver potential major productivity gains for transport, logistics, energy and finance.

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UNIKLASERS Ltd Fraunhofer UK Research Ltd	Miniature Lasers for Quantum Technologies (MINUSQULE)	£150,136 £149,637	£105,095 £149,637
Project description - provided by applicants			
Quantum technologies are braced to have a similarly wide and ubiquitous social impact that electronics have enjoyed since the invention of the transistor, but to achieve this it will be necessary to miniaturise all the component subsystems, in particular the single-frequency lasers sources needed to manipulate the quantum states of atoms and ions. In this project we will develop ultra-compact solid-state lasers, using an innovative design to extend the wavelength coverage and functionality of microchip lasers. The development of such compact and rugged sources of single-frequency light sources will be instrumental in paving the way for quantum technologies to reach their full potential and make the transition from research labs and large scale installations into industrial and consumer markets.			

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Gooch and Housego (Torquay) Ltd	Establishing the Need - Finding the future market for UK photon sources	£54,681	£27,341
University of Bristol		£27,565	£27,565
Milner Strategic Marketing Ltd		£37,758	£26,431

Project description - provided by applicants

A number of unique and disruptive quantum based technologies are emerging from the UK Quantum Technologies (QT) Programme hubs. The applications for these devices span a diverse range of sectors making it difficult to clearly definine product roadmaps and it is difficult for large companies wishing to commercialise QT to see where a start-up, spin out, SME or large company may fit into their supply chain. Gooch and Housego (GH) with the Quantum Technology Enterprise Centre (QTEC) and Milner Strategic Marketing (MSM) would like to perform a six-month market research study for photon sources currently utilised or under development within the UK programme. QTEC will catalogue the photon sources developed by the hub academics and coordinate with respective business development teams. MSM will conduct the primary market research study with industry input which will be used by GH to establish clear product roadmaps and categorize opportunities with regard to opportunity size and timescale. This approach will inform members of the UK programme on how and when supply chains can be established for photon sources. This approach may be applied to other aspects of the QT programme.

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TopGaN Quantum Technologies Ltd	MagGaN: Magnesium-clock frequency-stabalised GaN-diode lasers	£224,689	£157,282
Fraunhofer UK Research Ltd		£208,715	£208,715
Project description - provided by applicants			
Optical clocks offer superior performance (e.g. >100 times greater accuracy) over alternative atomic clock technologies. They are required in satellite free navagation, timing signals for financial trading as well as scientific research amongst many other potential applications. However, existing optical clocks are large, complex & expensive and have not so far met the needs of these markets, one of the reasons is the lack of suitable laser sources for field deployment. In this project we will develop underpinning subsystems of optical clocks, frequency-stabilised laser systems, using GaN external cavity diode lasers.			

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Unitive Design and Analysis Ltd	Diagnostic Brain Imaging Using Room Temperature Quantum Technology Sensors	£40,240	£28,168
University of Nottingham		£15,792	£15,792
Project description - provided by applicants			
Magnetoencephalography(MEG) is a way of imaging the brain that is non-invasive, safe and most often conducted on an out-patient basis. Although mainly used today for research and for pre-surgical imaging, there is a growing interest in MEG as a diagnostic tool for Mental Health issues which are an increasing concern both in terms of numbers of people affected and in the need for earlier diagnosis. Today's MEG devices are bulky, expensive, difficult to manufacture devices which limits their availability - there are approx 10 in specialist centres in the UK. Unitive Design & Analysis together with the University of Nottingham are conducting a feasibility study into the viability of introducing a newly designed MEG device based on Quantum Technology which would be smaller, simpler, more flexible, cheaper to manufacture, and could radically increase the number of imaging facilities at point-of-care locations across the country, giving significantly more access points for patients (children and adults) and providing additional material for research to aid potential earlier diagnosis.			

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VeriVin Ltd	Quantum Enhanced Sensing of Trace Compounds in Sealed Containers	£159,528	£111,670
University Of Oxford		£128,454	£128,454
Project description - provided by applicants			
In collaboration with the University of Oxford, VeriVin is exploring the usefulness of Quantum-Enhanced Sensing Techniques to investigate the chemical decomposition of complex liquids in sealed containers. The anticipated technique is a-priory non-invasive and is expected to be sensitive at the single-molecule level. As a first commercial application, the partners plan to develop a method and eventually a stand-alone device that is capable of generating a molecular fingerprint of beverages, such as wine and beer, without opening the bottle.			

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Avanti Communications Ltd University Of Birmingham	Space Debris Quantum Imaging Service	£396,636 £100,782	£198,318 £80,626
Project description - provided by applicants			
Satellites provide essential and extremely reliable services related to communication, broadcasting, and earth observation. The increasing presence of debris orbiting the earth, the result of the ever expanding space activities and explorations, is threatening the security of satellites and the reliability of the services they provide. Debris colliding with a satellite can be enough to damage it or put it out of service. As a result, there is a growing need for improved detection of the debris moving close to satellite orbits and their exact trajectories, so that collision-avoiding manoeuvres can be performed in time. This project is a feasibility study in to the use of quantum imaging to improve the identification of space debris with the objective of evaluating whether a service offering improved accuracy can be provided on a commercially viable basis to satellite operators.			

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