Innovate UK

Results of Competition: Commercialisation of Quantum Technologies CRD R3
Competition Code: 1701_CRD_EE_QUANTECH3

Total available funding is up to £13m - £9m from Innovate UK with up to £4m from EPSRC (across CRD and FS streams)

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
Toshiba Research Europe Limited	Embedded Quantum Technologies for Information Protection (EQUIP)	£855,991	£427,996
Royal Holloway & Bedford New College		£154,561	£154,561
Bay Photonics Limited		£163,150	£114,205
NPL Management Ltd		£200,070	£200,070
British Telecommunications Public Limited		£275,592	£137,796

Project description - provided by applicants

The quantum theory elaborated in the 20th century revolutionised the way we describe the world at the atomic scale. It told us that phenomena and measurements made on single particles can be completely unpredictable. Recently it has been realised that these effects could be very useful for generating the random numbers and secret keys that are needed in the cryptographic applications that protect IT systems and networks. This project is developing chip-based technologies for generating random numbers and keys and integrating them into demonstrator systems for secure communications. As these devices can be manufactured cheaply in large numbers, it will allow us to take these innovative new quantum technologies out of the lab and into everyday life.

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Toshiba Research Europe Ltd	Fibre Wavelength Quantum Networks (FQ-Net)	£437,525	£218,763
University of Sheffield		£99,859	£99,859
University of Cambridge		£99,996	£99,996

Project description - provided by applicants

Quantum communications provides a way to guarantee security of encrypted data transmissions across networks, based on fundamental physical laws. Unlike conventional cryptography, quantum communications are immune to future advances in computing power and mathematics, making quantum communication networks an important part of keeping our most precious and private data safe in the information age. This project aims to address a missing piece of the solution, and build and demonstrate a low error quantum network node compatible with established point-to-point link quantum encryption systems. This is vital to extend the utility of dedicated links to flexible networks, and the quantum internet. Our approach will be based on development of newly emerging semiconductor telecom quantum LED technology, which shares roots with conventional opto-electronics. Our research plan will develop enhanced LED designs that will revolutionise performance, including high frequency operation. Finally, we will begin field testing of our systems, distributing quantum-entangled LED light over installed optical fibre infrastructure.

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M Squared Lasers Limited	MCLAREN: Miniaturised Cold Atom Gravimeter for Space Applications	£504,474	£302,684
ColdQuanta UK Ltd		£365,610	£255,927
STFC - Laboratories		£669,946	£669,946
University of St Andrews		£202,234	£202,234
Clyde Space Limited		£29,839	£17,903
Magnetic Shields Limited		£150,284	£105,199

Project description - provided by applicants
The project aims to develop a compact cold atom gravimeter and identify routes to development for a space-deployable system. Space-based high precision gravimetry as offered by cold atom approaches is an emerging key enabling technology for a range of markets dependent on Earth observation. Furthermore gravimetry has a broad number of terrestrial applications from underground surveying to locating oil and mineral deposits. Although the levels of precision of cold atom gravimetry have been demonstrated, in comparison to current gravimeters the most prominent drawback is the systems size weight and power (SWaP) characteristics. SWaP requirements are seen as the key roadblock in the wider adoption of cold atom gravimeters, despite having a multitude of advantages over existing solutions. This project brings together routes to miniaturised, compact and space deployable subsystems to yield a compact cold atom gravimeter demonstrator. In 2016 flooding caused £1.6bn of damage, and accurate flood prediction could have avoided some of these costs and associated stress of losing homes. Accurate location of underground infrastructure could reduce traffic congestion that costs the UK £4.6bn per year.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Photon Force Limited	Low noise, high-throughput, time-resolved single-photon sensor for quantum applications	£380,111	£266,078
Heriot Watt University		£165,102	£165,102
Fraunhofer UK Research Limited		£129,111	£129,111

Project description - provided by applicants

Quantum technology will revolutionize science, computing, communication, medical diagnosis and treatment, security, defence, and consumer goods. Fundamentally, the development and proliferation of quantum technologies into everyday life depend on the availability of sensors capable of time-resolved recording of individual energy quanta. Photon Force has partnered with Heriot Watt University (Edinburgh) and Fraunhofer UK (Glasgow) to create a single-photon sensitive fibre-coupled light detector which can detect and time 0.5 billion individual photons per second with 55 picosecond time precision. The sensor could help physicists advance their research, firefighters see through smoke, improve the resolution and speed of medical imaging, or provide secure optical communication links.

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Advanced Hall Sensors Limited	Microstructural characterisation using Quantum enabled BARKhausen noise Analysis	£169,855	£118,899
TWI Limited		£155,930	£155,930
The Compound Semiconductor Centre Limited		£117,125	£70,275
Microsemi Semiconductor Limited		£45,270	£22,635

Project description - provided by applicants
Awaiting Public Project Summary

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Airbus Group Limited	Q-DOS light: Quantum key distribution for Drones with Optimal Size, weight and power	£170,105	£85,052
KETS Quantum Security Limited		£553,214	£387,250
ID Quantique Limited		£164,172	£114,920
University of Bristol		£200,955	£200,955
University of Oxford		£199,694	£199,694

Project description - provided by applicants

Unmanned Aerial Vehicles (UAVs) have seen a huge increase in commercial uptake in recent years, but their applications have been limited, in part by the inability to securely communicate sensitive data back to the ground. Current encryption methods are becoming increasingly insecure due to advances in computing capability. Project Q-DOS light (Quantum key distribution for Drones with Optimal Size weight and power), led by Airbus, will solve this rapidly growing problem by delivering a low-weight, high-speed free-space optical communication system with highly secure quantum encryption and eavesdropping detection. The system will be demonstrated in flight using a small drone (under 7kg) communicating with a ground-station and will therefore have to use novel, integrated, quantum devices in order to meet challenging Size, Weight and Power (SWaP) requirements. Once proven, this technology will become an essential building block of secure communication payloads for future aircraft and spacecraft systems.

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M Squared Lasers Limited	SLATE: Strontium Lattice for Commercial Optical Clocks	£386,338	£231,803
University of Birmingham		£327,950	£327,950

Project description - provided by applicants
Precision timing plays a vital role in the economy, from enabling satellite-free navigation to protecting the integrity of electronic financial trading. The current state-of-the-art commercial timing systems use microwave frequency atomic clocks, but commercial optical frequency atomic clocks are expected to be available within the next 4 years, promising a 100x improvement or better over current technology. This will enable submarine navigation to improve from 2 km accuracy over a 24 hr period to 100 m accuracy over several months. It will also prevent millions of pounds in losses due to timing errors in the financial sector. In this project, M Squared Lasers, together with the University of Birmingham, will design and build the core components of a commercial atomic clock based on the strontium atom. As forerunners in this field of new quantum technology development, we will develop compact vacuum chambers, stable laser sources, and robust electronics packages that will facilitate wider adoption of a new precision timing state-of-the-art.

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ID Quantique Limited	Single Photon Range Imaging for Natural Gas Sensing SPRINGS	£570,784	£399,549
QLM Technology Limited		£428,230	£299,761
Sky-Futures Partners Limited		£159,636	£111,745
University of Bristol		£175,280	£175,280

Project description - provided by applicants

Gas sensing is a growing market, with Oil & Gas leak detection alone expected to grow to $3.4Bn in 2022. Natural gas leaks cost companies $30Bn per year, the ability to detect these leaks is limited by the characteristics of existing technologies. The SPRINGS project sets out to develop a quantum-inspired laser radar (LIDAR) capable of detecting the lowest concentration of natural gas leaks required by the industry out to a 200 metres operational distance. This brings a 10-fold sensitivity improvement over our closest competitor and enables fast scanning and imaging. It is lightweight and low-power and unlocks new applications for Oil & Gas and waste management industries, and it delivers an unprecedented 30 miles per hour surveying speed. To ensure long-term leadership, we will also develop a quantum-enhanced prototype, taking us to mid-IR wavelengths, for a further 10-fold performance gain. This opens up the possibility for other gas species and unlocks applications such as Oil & Gas exploration and remote detection of explosives.

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Compound Semiconductor Technologies Global Ltd	Active matrix single-photon technologies on GaAs	£219,348	£153,544
Gas Sensing Solutions Limited		£125,951	£88,166
University of Glasgow		£316,937	£316,937

Project description - provided by applicants

Recent advances in quantum imaging technology have included imaging of light in flight and detection of hidden objects. Such applications relied on arrays of single photon avalanche detectors (SPADs) operating at visible wavelengths. Imaging arrays of SPADs working at infrared wavelengths, not currently available, are highly desirable as they would unlock further applications, and they represent a unique business opportunity. The micro-system technology (MST) group at the University of Glasgow has pioneered mid-wave infrared (MWIR) focal plane arrays (FPAs) based on a monolithic approach, integrating indium antimonide (InSb) photodiodes (PDs) with gallium arsenide (GaAs) MEtal Semiconductor Field Effect Transistors (MESFETs). Compound Semiconductor Technologies Global (CSTG) Ltd, as lead of the project consortium, will take the existing monolithic technology and develop it into a robust process aimed at commercialisation. Meanwhile the consortium, with the University of Glasgow and Gas Sensing Solutions (GSS) Ltd as partners, will investigate the potential of the technology to deliver arrays of avalanche photodetectors (APDs) and SPADs in the short-wave infrared (SWIR) and MWIR spectral range. This technology will have initial applications in optical gas imaging and will represent a unique asset for quantum applications..

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TopGaN Quantum Technologies Limited	GaNAmP	£314,284	£219,999
Helia Photonics Limited		£245,244	£171,671
Fraunhofer UK Research Limited		£310,836	£310,836
University of Birmingham		£59,321	£59,321

Project description - provided by applicants
An integrated GaN laser diode and optical amplifier is developed in GaNAmP to provide a laser source for cold-atom interferometry for optical atomic clocks and quantum sensing applications.

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HighQ Instruments Limited	Nanoparticle and chemical sensors using optical microcavities	£650,368	£455,258
University of Oxford		£429,673	£429,673
Malvern Instruments Limited		£12,000	£0

Project description - provided by applicants

The development of quantum technologies produces high precision instrumentation and components that can benefit a wide range of applications. In this project we use miniature optical resonators, developed for quantum communications and computing, to sense nanoparticles and chemicals. The ability to measure and analyse chemicals and nanoscale particles in fluids is of increasing importance to the modern world. Blood tests, screening for allergens and contaminants in food, developing new medicines for cancer treatment, or measuring air quality in buildings and vehicles are all applications for which high performance sensors are required with sensitivity to minute quantities of material. The '˜quantum'™ resonators offer a step change in performance compared to existing devices. A new spin-out company from the University of Oxford, HighQ Instruments Ltd, is being set up both to develop the sensors and to market resonator components to the quantum technologies and photonics industries. This Innovate UK project will provide support for the construction of the first prototype for a nanoparticle sensor product, and for a parallel R&D programme to advance the technology and develop chemical sensors for a range of applications.

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Kelvin Nanotechnology Limited	gMOT - Magneto optical trap system for cold atom technologies	£276,829	£138,415
TMD Technologies Limited		£206,778	£124,067
University of Strathclyde		£261,153	£261,153
University Of Glasgow		£209,239	£209,239

Project description - provided by applicants

The project aims to deliver a miniature, integrated magneto optical trap (MOT) chamber for use in portable cold atom technologies and markets. Kelvin Nanotechnology, TMD Technologies and the Universities of Strathclyde and Glasgow have teamed up to create a universal miniature cold atom trap device for deployable atomic based quantum technologies that will build on key processes developed by the partners. These processes include diffractive optics design and fabrication, innovative bonding and sealing methods, physics package encapsulation, complex alkali metal vapour filling techniques and performance evaluation methodologies. Integrating these individual technologies into a highly functional and low cost system will enable rigorous testing and qualification by industrial users for deployment in next generation quantum technology systems in a wide variety of applications and markets.

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