Innovate UK

UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME

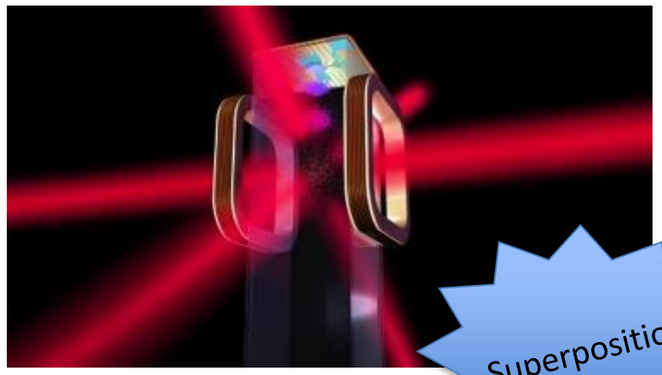
EPSRC Engineering and Physical Sciences Research Council

Exploring the commercial applications of quantum technologies

Richard Murray
Lead Technologist Emerging Technologies and industries

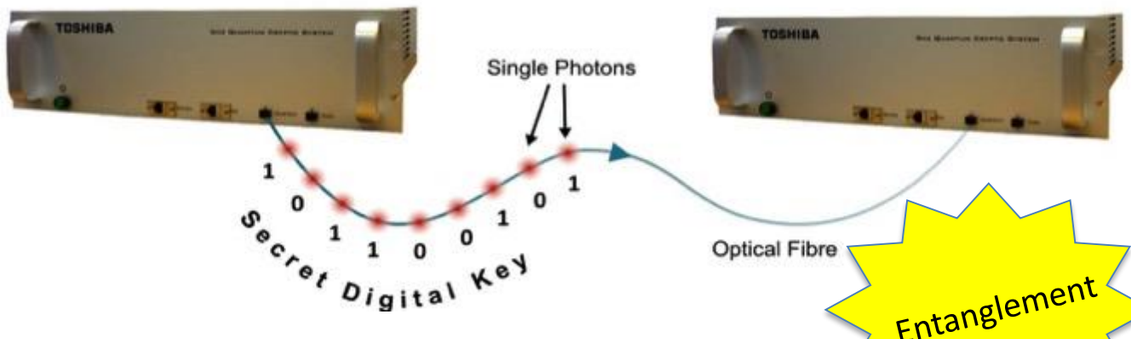
What are the uses of quantum?

Quantum Sensors and Timing



Superposition

Quantum Communications



Entanglement

Quantum Imaging

Entanglement

Quantum Computers

Superposition

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Could a 'quantum compass' replace GPS? British military develops system to navigate WITHOUT using satellites

The Telegraph

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Google's new quantum computer is '100 million times faster than your PC'

Google and Nasa have been working on a lightning-fast quantum computer that is 3,600 times faster than a supercomputer at solving complex problems

Quantum computers

A little bit, better

The Economist

After decades languishing in the laboratory, quantum computers are attracting commercial interest

Jun 20th 2015 | From the print edition

Timekeeper

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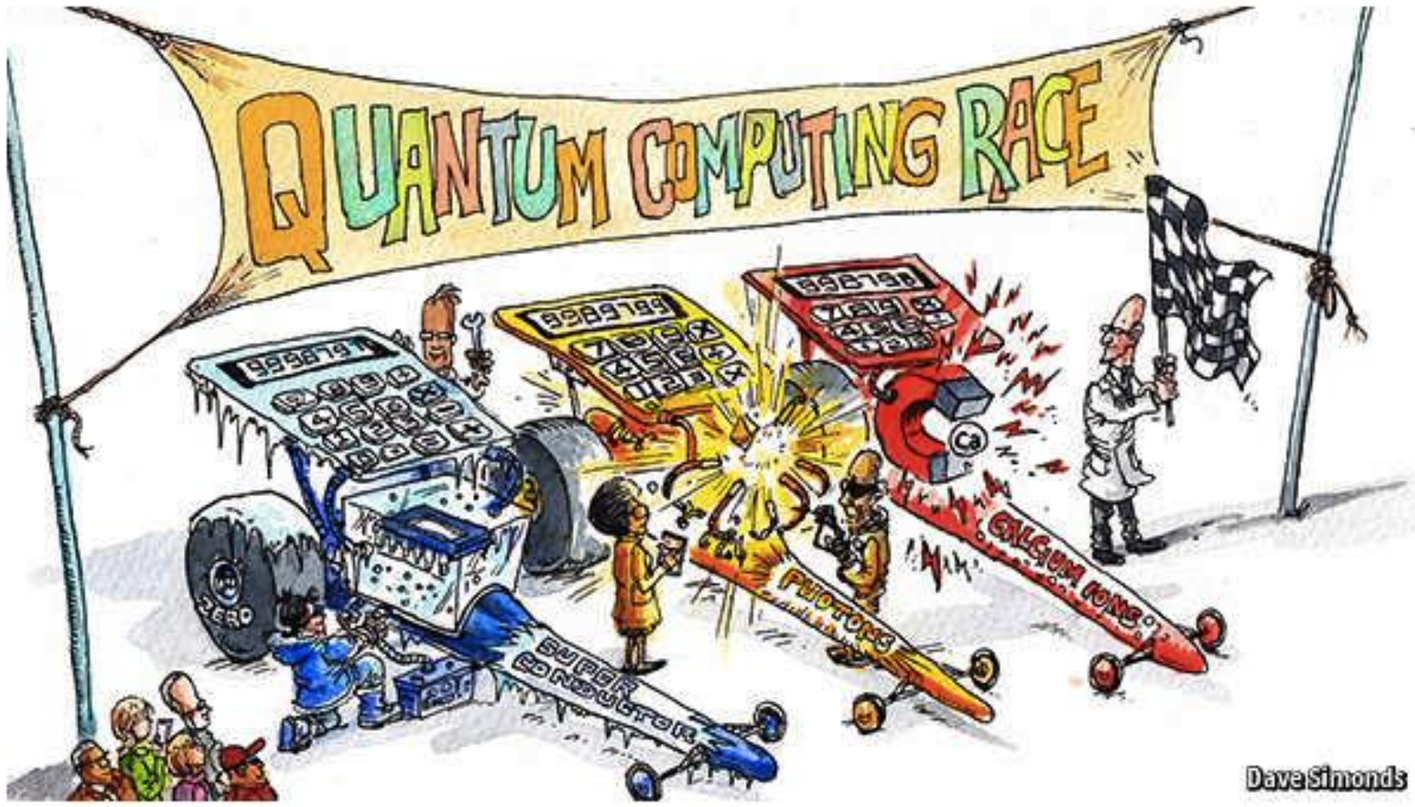


THE TIMES

News

27

How the Earth's magnetic field could put an end to roadworks

Tom Whipple Science Editor

There are two reliable ways to map the position of pipes and electricity cables before major construction work starts. The first — favoured by councils throughout Britain — is to take a pneumatic drill to the road or pavement and have a look below.

The second is to suspend a supercooled atom above the ground, drop it in a vacuum, monitor its progress with a laser and measure the minuscule fluctuations in the Earth's magnetic field caused by underground pipes.

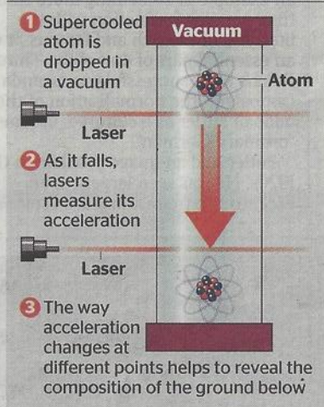
British scientists are hoping to convince councils of the advantages of the atomic technique over the dig-it-up-and-have-a-look method by developing a portable "gravimeter", so sensitive that it can measure changes in gravity to nine decimal places.

"Less than 50 per cent of urban infrastructure is noted down on maps," Kai Bongs, from Birmingham University, said. "That's why people dig when they put down new constructions — they don't want to drill into a gas line."

He said the savings by using a gravimeter and not having to dig could amount to billions of pounds a year.

The key is to measure gravity accurately enough. For a force that determines the motion of the heavens, gravity is extremely weak. Although everything with mass exerts gravity, objects generally have to be the size of a planet

Measuring gravity



before you notice it. But by harnessing sophisticated quantum mechanical techniques, Professor Bongs, working with the National Physical Laboratory in southwest London, believes that they are close to developing their gravimeter into something portable that can spot tiny changes in density to "see" below the ground — all by observing the behaviour of individual atoms.

Normally atoms whizz around at hundreds of miles an hour, Professor Bongs said, but by using laser cooling physicists are able to control them. "We can get hold of them in space, isolate them in a vacuum and use them," he said. Gravity can then be measured by seeing its effect on a single atom, and if the ground is slightly less dense, items such as a pipe will show up.

The problem with a device that sensitive is that it is difficult to ensure that what you are measuring is gravity. When the scientists tested the device, near Stonehenge, they found mysterious regular oscillations. Eventually they realised it was waves hitting the beach 30 miles away.

The solution is to have two different "clouds" of atoms a distance apart, using the paired readings to cancel out non-gravitational effects. Then, by moving the device over the ground you can map what is underneath it in ways that are not possible with radar or electromagnetic devices.

"With radar it depends very much on ground conditions. If it is wet you can't penetrate very far. For things that are not conducting, like plastic pipes, you also don't get a large electromagnetic signal," he said. Even in good conditions, neither technique can look very deep.

This means, he hopes, that by making a cheap portable device there could be applications even more important than stopping your road getting dug up — from finding pockets of oil left in wells to monitoring magma flows to predict the scale of volcanic eruptions.

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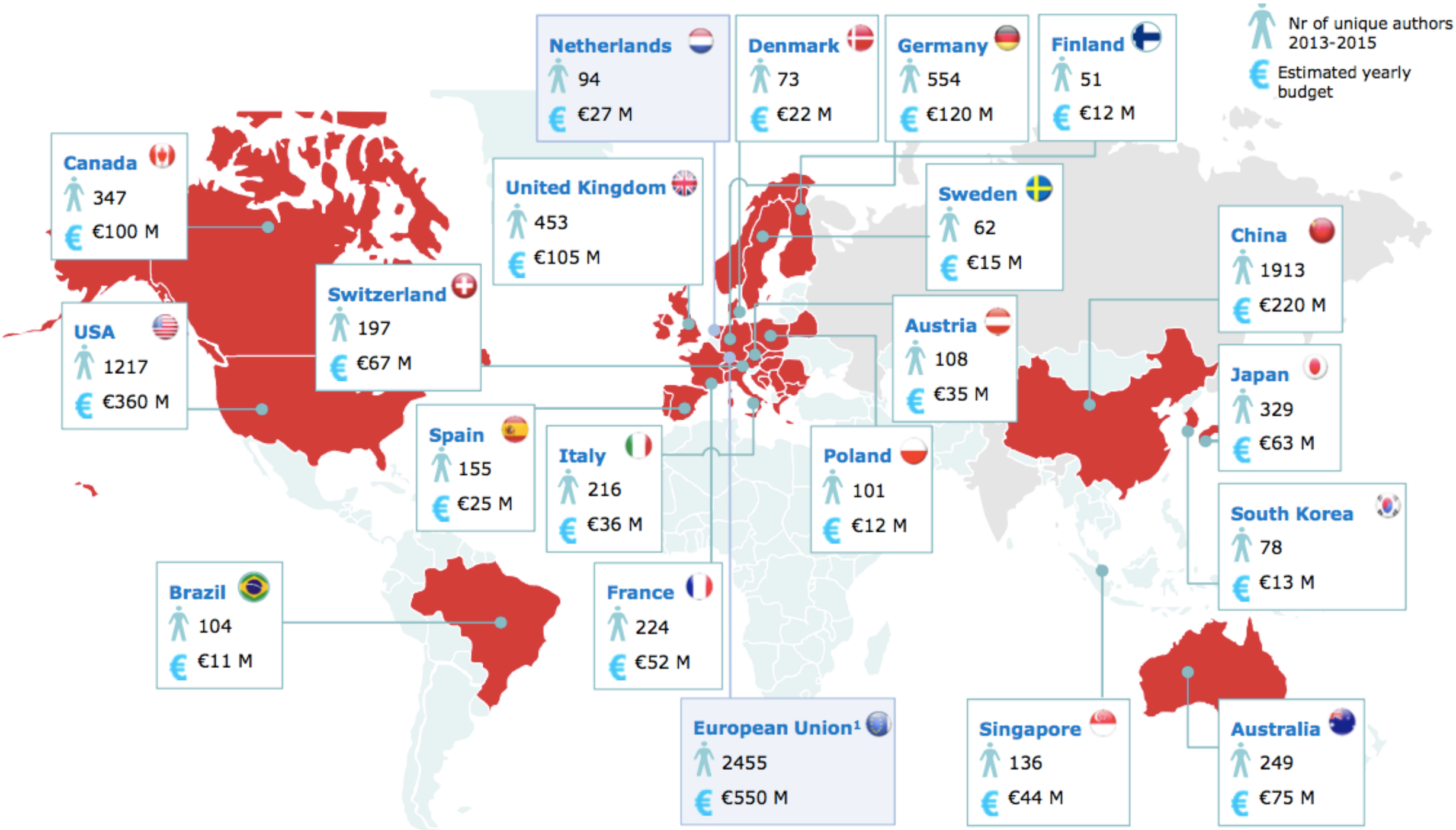
Worldwide quantum technologies activities



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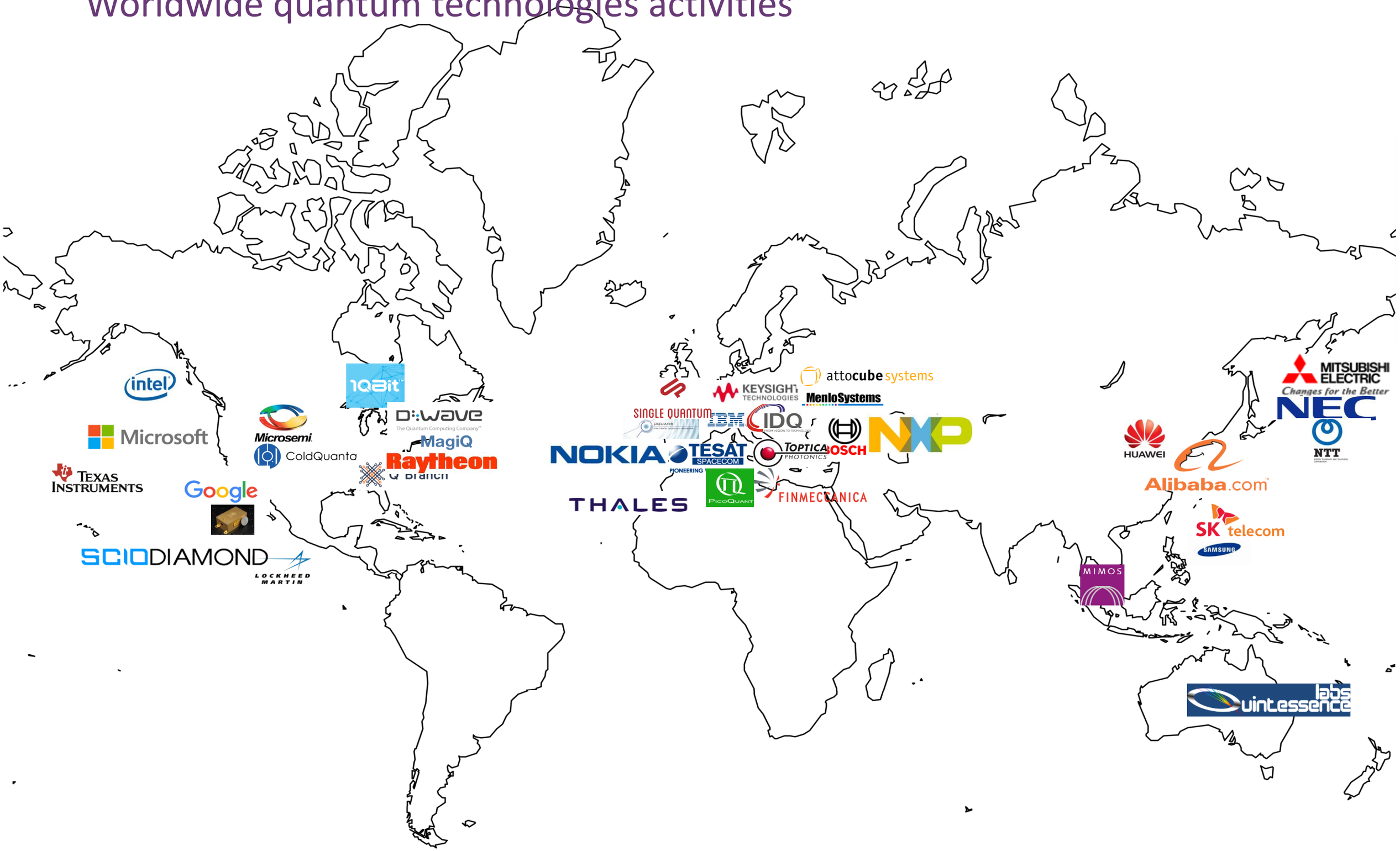
Worldwide quantum technologies activities



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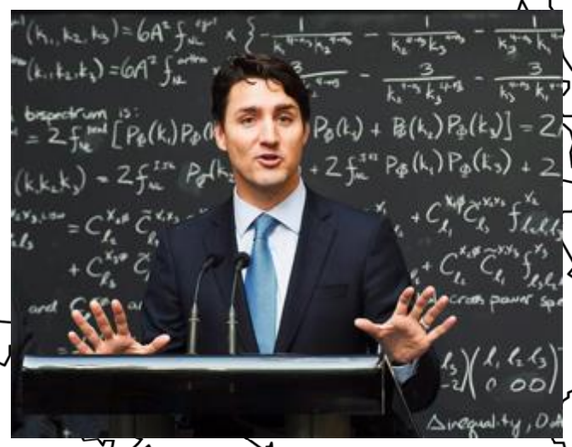
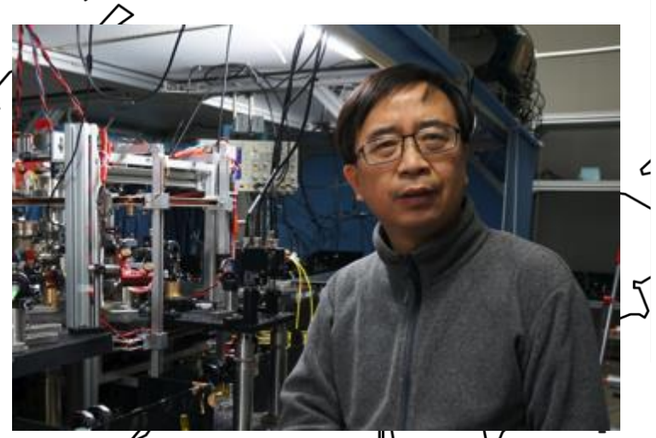
Worldwide quantum technologies activities



UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME



DARPA

CQT Centre for Quantum Technologies

The business case

- A £300 million programme with £50 million for Innovation
- **Long term** - A 5 year programme with a 10 year vision.
- **Wealth creation**- Delivering new devices and new businesses from world leading UK research
- **Joined up**- Industry, academia and public bodies working together to create opportunities for UK wealth creation.

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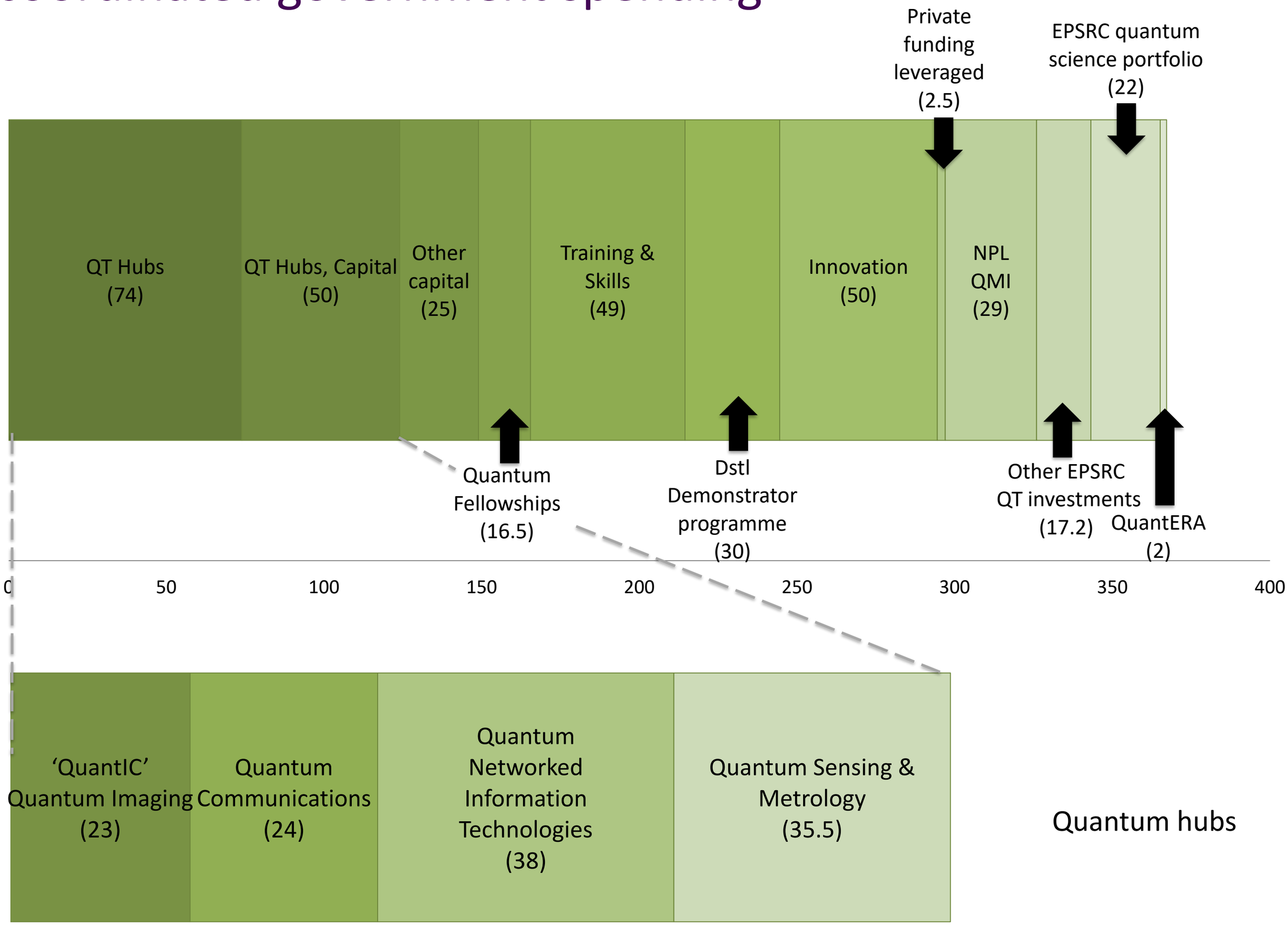
The need for public intervention

The UK quantum tech programme- over £350m of coordinated government spending



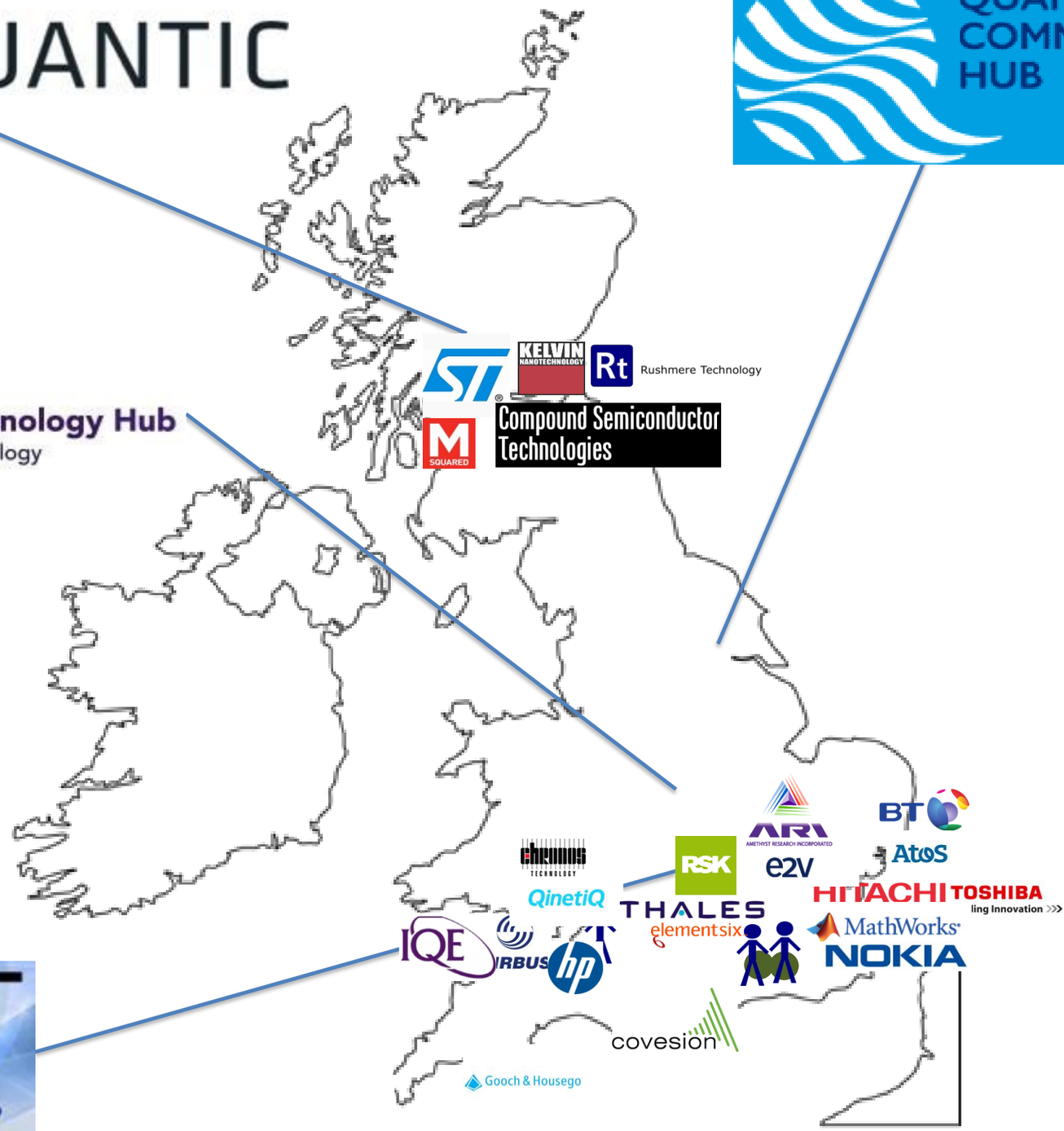
The UK quantum technologies eco-system

QUANTIC

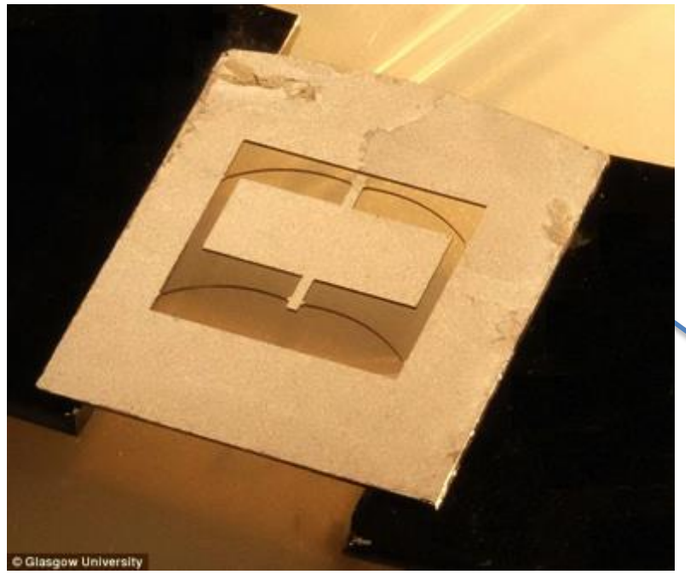
QUANTUM COMMUNICATIONS HUB

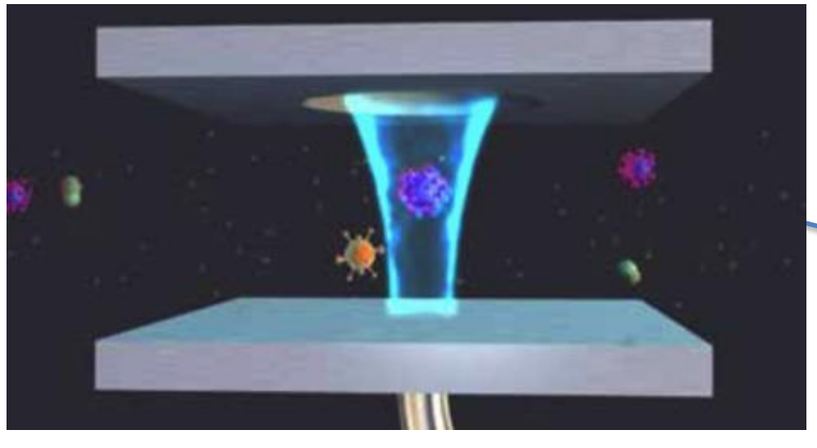
UK National Quantum Technology Hub in Sensors and Metrology

NQIT



The UK quantum technologies eco-system





Ways for companies to engage

Access to finance	▪ £50m innovation fund for company- led projects £50k-£2m, 6-24 months available from Innovate UK ▪ Dstl demonstrator programme
Access to capabilities	▪ NPL Quantum Metrology Institute for standardisation and measurement ▪ Incubation space available at the quantum hubs ▪ Bristol Quantum Enterprise centre gives £50k grants, mentoring and support new companies
Access to Skills	▪ KTN community building events ▪ Companies can put forward projects for the quantum hubs to carry out, using 'partnership resource'. ▪ Companies can support PhDs in the quantum CDTs; work placements available

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[dstl]

EPSRC
Pioneering research and skills

October 2014

1st round of funding

Open competition

36 applications were received

25 projects were funded

£4.7m was committed

March 2016

2nd round of funding

Closed competition, extensions only

16 applications were received

12 projects were funded

£2.1m was committed

M SQUARED

chromis TECHNOLOGY

TMD

TOSHIBA
Leading Innovation

University of Strathclyde

UNIVERSITY OF CAMBRIDGE

UNIVERSITY OF BATH

Durham University

Fraunhofer UK

Gooch & Housego

The University Of Sheffield.

e2v

UNIVERSITY OF BIRMINGHAM

Nokia • Alpha Contract Engineering • University of Oxford • Kelvin Nanotechnology• NPL• Optocat Holdings• Rushmere technologies • TerOpta Oxford Instruments • Lancaster University • Element 6 • Warwick University• RSK group • Cold Quanta • Thales • UCL

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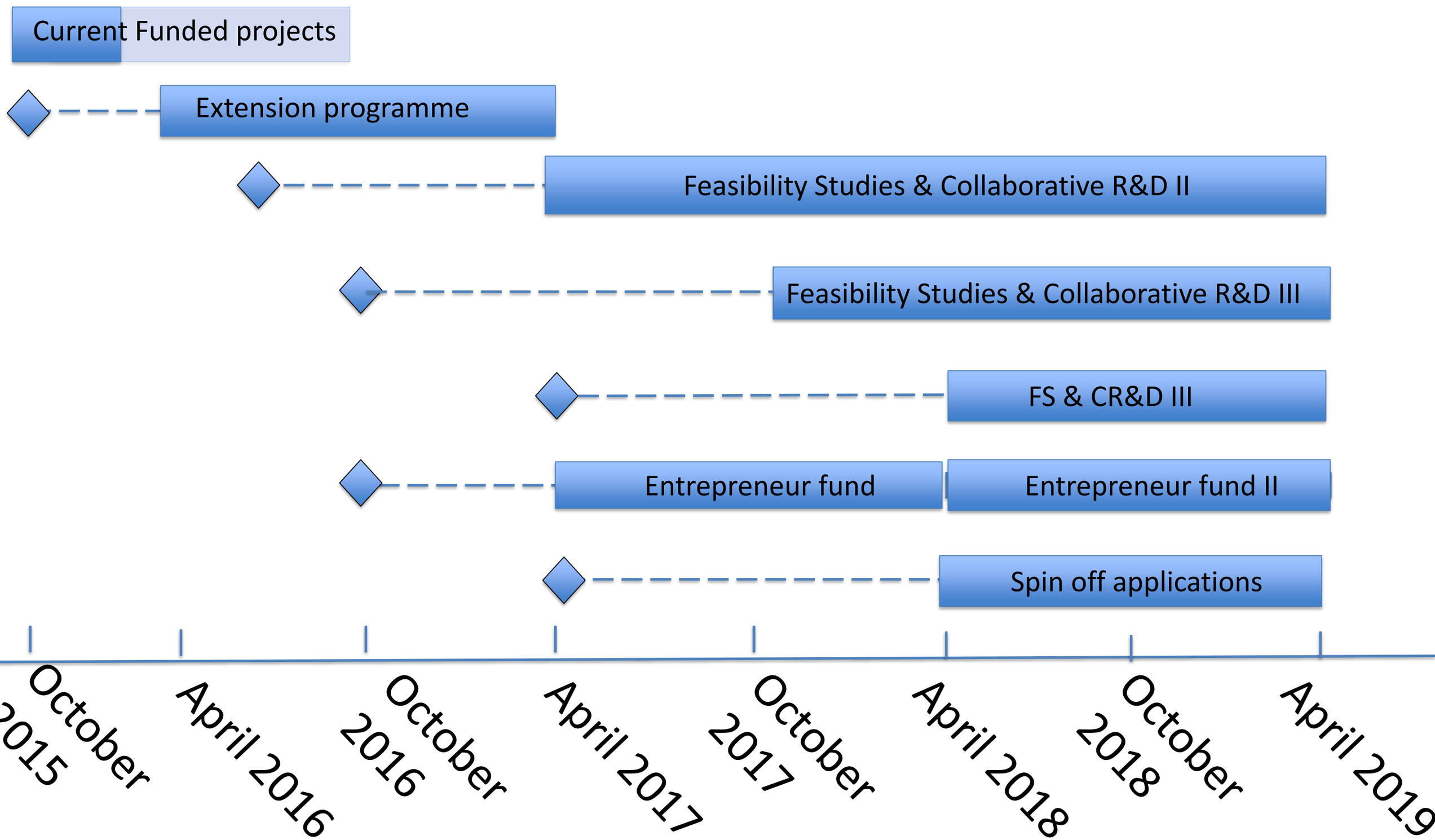
Competition plans



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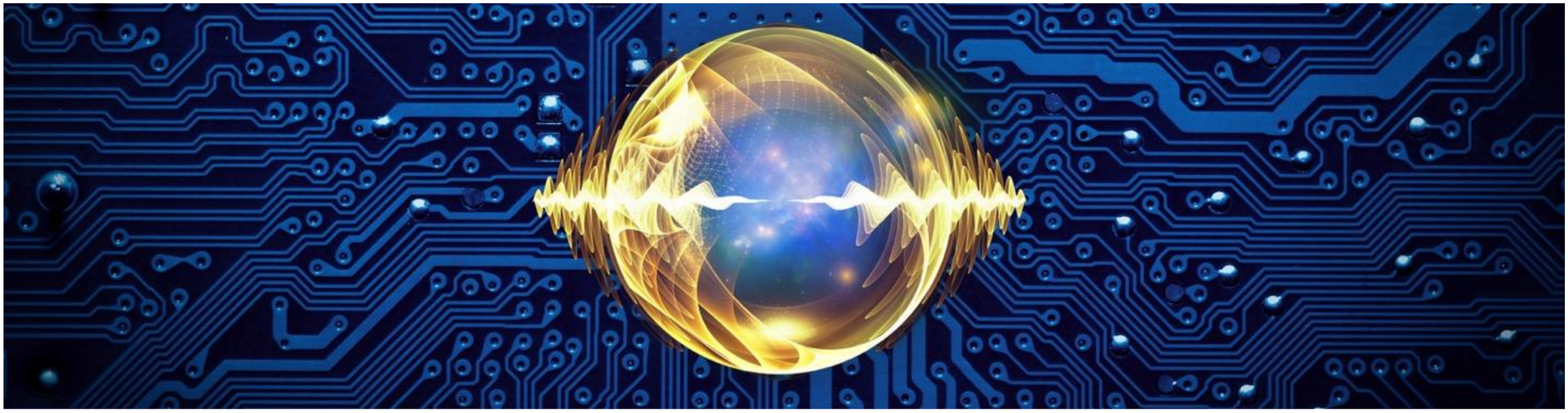
‘Feasibility Studies’

- Total pot: £3m IUK + £3m EPSRC
- £50k - £400k projects
- Up to 12 months
  - Earlier stage devices
  - Components
  - Marketing studies

‘Collaborative R&D’

- Total pot: £6m IUK + £6m EPSRC
- £500k - £2m projects
- Additional +10% top up available for capital spend
- Up to 24 months
  - Connect the supply chain
  - Include an end user
  - Deliver a demonstrator



A date for your diary

Quantum technologies showcase- QEII centre, London - 3rd November

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Thank you

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