QUANTUM TECHNOLOGY FOR BUSINESS

It's about business opportunities, not quantum mechanics

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IT'S ABOUT BUSINESS OPPORTUNITIES, NOT QUANTUM MECHANICS

Governments worldwide anticipate benefits to society, industry and academia of next generation quantum technologies. They're investing heavily in both research and bringing the tech to market. It's a race that will bring big money to the winners.

The combination of UK academic excellence and the Government investing £400 million has positioned the UK as a world leader in next generation quantum technologies (QT). The challenge we now face is matching these exciting, disruptive technologies with opportunities to benefit both business and society.

It's often said academics can adapt QT to meet business problems but don't know them in detail, while industry has plenty of challenges but doesn't know how next generation QT could help. The applications are there and the technology is maturing, there just needs to be a vision to accelerate QT out of university laboratories.

WHAT ARE NEXT-GEN QUANTUM TECHNOLOGIES?

Quantum, like cyber and IoT, is a broad group of technologies that will unlock enormous opportunity. The defining characteristic of QT is the ability to manipulate unique properties of atoms. This enables a wide range of applications, from more accurate ways of sensing the environment to revolutionising computing.

Applications using quantum principles have been embedded in society for at least 50 years, from the circuits that make mobile phones possible to nuclear power. But next generation quantum technologies exploit the principles of superposition and entanglement – something Einstein called "spooky action at a distance."

As with many technologies, it's not necessary to understand the inner workings of quantum to understand how it can be harnessed to create new business opportunity. For example, we don't need to know how a semiconductor works when we use a mobile phone or laptop.

Next generation QT systems typically use existing technologies, such as fibre-optics, integrated circuits and power supplies, and precise mechanical engineering to achieve new functions. These new applications can be grouped into four areas:

1. Precision navigation and timing
   (such as gravity navigation and atomic clocks)
2. Motion and imaging sensors
   (such as accelerometers and single photon detectors)
3. Securing communications
   (such as quantum key distribution)
4. Computing
   (such as new ways of parallel calculation)

Technologies from the first two groups could be widely available within three to five years, while QT based on the other two groups ranges in likely availability from a few years to a decade.

At PA, for example, our Global Innovation and Technology Centre is working with an international business on precision navigation using QT. Our expertise working with business and developing disruptive technologies means we can create the product specifications and estimate the complexity and cost of creating the quantum solution. This means our client can fully understand the investment case and produce the results they want.

WHAT DOES QUANTUM TECHNOLOGY DO THAT'S DISRUPTIVE?

Grouping the technology in the way we have shows QT has many 'standard' applications. So, the question is, what does it do that's disruptive? In most areas, it's down to big improvements rather than new functions.

1. Reduced size, weight and power consumption
2. Lower cost
3. Higher accuracy
4. Faster results

Any organisation that relies on traditional digital technologies will be affected by QT development, so they need to think about the position they'll take.

They can decide QT will be a truly disruptive force and devise a strategy to exploit the opportunity. Or they could explore the emerging QT relevant to them and decide it needs further development before it will fit their strategy, choosing to wait and see what happens. Finally, they could decide QT won't disrupt their market and ignore it.

Ignoring it altogether would be naive. While a company might not see their industry as being at risk of disruption, QT will eventually permeate into everyday lives, making it important for all businesses to explore its impact.

HOW QUANTUM TECHNOLOGY COULD DISRUPT AN INDUSTRY

To highlight this threat, let's look at one established technology-based industry – Global Navigation Satellite Systems (GNSS).

Precision navigation and timing is embedded in our lives through GNSS such as GPS, Galileo, GLONASS, BeiDou and NAVIC. A 2017 report by the Global Navigation Satellite Systems Agency put global revenues from GNSS devices at €94.8 billion a year.[1]

These systems are used for a wide range of applications across personal and professional lives, including navigation, cellular communications timing synchronisation and stock market time stamps.

But GNSS signals are very weak and easily lost. They have patchy availability in buildings and are hampered by 'urban canyons' in built-up areas. Plus, signals can be easily jammed or worse, spoofed. That gives QT a truly disruptive opportunity.

1 www.gsa.europa.eu/system/files/reports/gnss_mr_2017.pdf

1. Precision timing

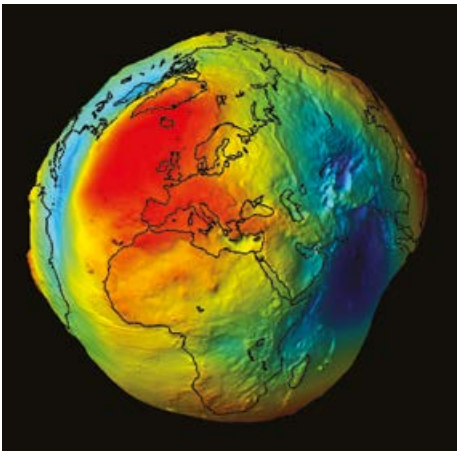
Where GNSS signals are used for precision timing, a high-performance QT clock can act as a backup for when the signal is unavailable. These clocks are much smaller, lighter, and more power efficient than existing atomic clocks. One QT clock, the Chip Scale Atomic Clock (CSAC), is already available from Microsemi (Microchip) in the USA and others are in development in the UK.

Development stage – Available now

2. Inertial navigation

Before GPS was operational in 1978, precision navigation was achieved using inertial navigation systems, where the movement of the vehicle is measured and used to calculate the location relative to the starting point. The accuracy of such a system is governed by the drift of the motion sensors, which is limited by their physical properties. QT sensors should have substantially lower drift than classical sensors, making them accurate to within hundreds of metres rather than tens of miles.

Development stage – Proof of concept shown in labs, ready for industry acceleration



Geoid. *The Geoid is also known as "Potsdam Gravity Potato"*

Source: ESA and GOCE

3. Gravity navigation

Whether navigating with GNSS, inertial sensors or a paper map, there's a risk of errors. Combining systems can mitigate these errors, but QT has the potential to add a whole new layer.

Gravity differs from place to place. A recent satellite mission measured the variation of gravity around Earth, producing the "Potsdam Gravity Potato" (Left). With high-resolution gravity measurements, a map can be created similar to a satellite image. Real-time QT gravity measurements could then let a vehicle navigate by analysing the level of force.

Development stage – Disruptive, QT gravity measurements work today, gravity navigation works in theory but needs investment

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These three possibilities show the potential of QT, from simply improving size, weight and power efficiency, through bettering an existing application, to disrupting the core of an industry.

More work is needed to join business opportunities with technology developments. Academia and business need to focus on working together to accelerate the latest innovations out of university laboratories and into the real world.

HOW TO PLAN QUANTUM TECHNOLOGY INVESTMENT

As with any new technology, any company considering using QT must carefully consider the costs and benefits. In the case of fully-developed technology, like a precision QT atomic clock, this can be based on equivalent traditional technologies.

The detail here is important as the product specification of the new device must be understood so an accurate comparison can be made. Once this has been established, the investment case can be constructed on a practical comparison, for example comparing size, weight, power efficiency, performance and cost.

The two tables below provide a structure for assessing the opportunity of QT and its risks, and form the foundations of a business plan.

Table 1: Checklist for market assessment

	CLASSICAL	QT-BASED	WEIGHTING (1)	IMPORTANCE (2)	DISRUPTION LEVEL
Size	1	0.1	2	20	Disruption may be enough to create a new market
Weight	500g	50g	2	20	Disruption may be enough to create a new market
Power	20W	120mW	4	668	Substantial disruption, is very likely to create a new market and/or have substantial impact on current market
Cost	1	1	1	1	Not a strong driver
Performance	10	10	4	4	Not a strong driver
Total (3)				714	Substantial disruption potential

Source: PA Consulting Group

1: Weighting gives the importance to the market of the particular parameter

2: Importance is the multiple of weighting and QT advantage (could also be disadvantage)

3: Total could be due to one parameter, e.g. 100 times reduction in power consumption.

Table 1 helps measure the disruptive potential of QT against the classical alternative. The calculation considers the level of improvement that QT could bring. The higher the total number, the greater the potential for disruption. In practice, the performance of the comparable technologies will be broken down into more defined areas as the improvement is assessed in detail. It's then important to ensure the weighting factors are considered carefully to balance the assessment.

Table 2: Risk assessment

	CLASSICAL	QT-BASED	WEIGHTING	IMPORTANCE	RISK COMMENT
Performance meets specification	1	5	4	16	Very high risk as performance is not yet demonstrated
Mean time between Failure is evidenced	1	5	4	16	Very high risk as MTBF is in the early stages of discovery for QT
Technology price viable in market	1	4	4	12	Price for QT can be justified in the market. Market studies can be commissioned to support
Technology meets cost target	1	4	2	6	QT technology costs can be predicted
Warranty position is known	1	5	3	12	Risk of product failure in service results in warranty claims
Performance is maintained over lifetime	4	5	4	4	Risk that the performance benefit is maintained in the market application
Total Risk				66	

Note: 1 = Low, 5 = High

Source: PA Consulting Group

Table 2 helps manage a risk assessment, comparing QT with the classical alternative. As the classical technologies are assumed to be well understood, this table emphasises the differences and highlights the overall risk of adopting a new technology.

COLLABORATION IS KEY

To start taking advantage of the huge potential of QT that we've discussed here, the new technology has to be matched with current business problems. This will involve hard work to devise applications for the new technology and generate product specifications that highlight how QT compares to classical technologies. But the hard work will let businesses seize a significant opportunity as the word quantum is put to one side and the focus is put on the business application.

PAUL MARTIN

PA expert in
Quantum Technologies

+44 1763 261222

paul.martin@paconsulting.com

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Corporate headquarters

10 Bressenden Place
London SW1E 5DN
United Kingdom
+44 20 7730 9000

paconsulting.com

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