

The Quantum Challenge and Opportunity

Dr Paul Martin

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Innovate, Collaborate, Trust



Defence



Medical & Healthcare



Security



Smart Sensors

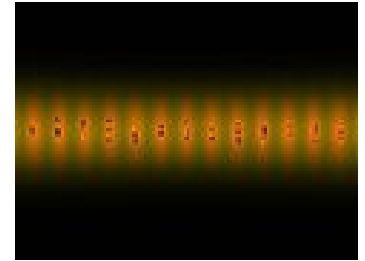
Quantum

- Hands up those who consider themselves part of the Quantum community and have been coming to events like this for 18 months
- Those with hands up now take your hands down and sit on them
- From everyone else, how soon will Quantum products be in the market to buy?
- 3, 5, 10, 20, years

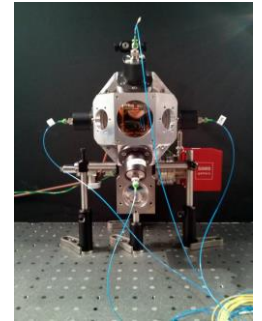
QUANTUM TECHNOLOGIES

Quantum Technologies - Technologies

- Clocks
 - Variety of types with different characteristics
 - Orders of magnitude smaller, greater stability
- Sensing
 - Gyros, Accelerometers, Magnetometers, Gravimeters/Gradiometers
 - Imaging, Single photon detectors
- Communications
 - Quantum Key Distribution, Tx and Rx of Quantum information (Qubits)
- Quantum Computing



Source: NIST Yb ion clock



Source: Birmingham University MOT

Quantum Technologies - Applications

- Timing

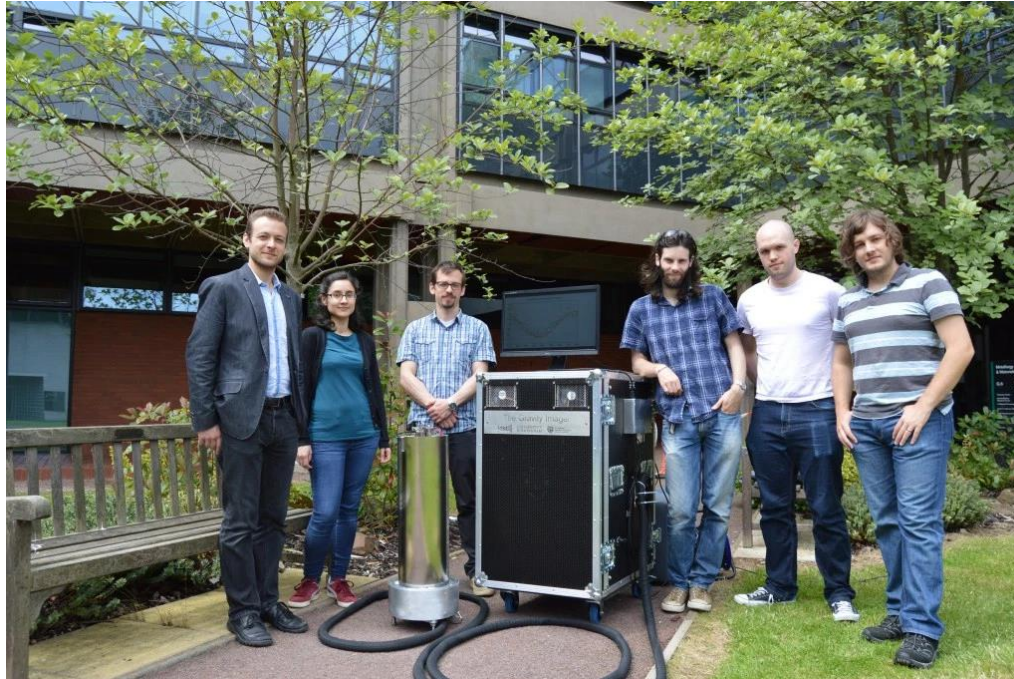


- Rubidium clock
 - Power consumption 10-25W
 - Size 125 x 86 x 25mm
 - Weight 434g



- Chip Scale Atomic Clock (Microsemi CSAC)
 - Power Consumption <120mW
 - Size 41 x 35 x 11mm
 - Weight 35g

Quantum Technologies - Applications



University of Birmingham gravity sensor (with permission)

Quantum Technologies - Applications

- Timing references
 - Defence/Security – provides timing during denial of GNSS signals, enables novel sensing techniques
 - Industry/society – Financial trading, cellular communications, power distribution, IOT synchronisation, new economy where knowing position has commercial value (eg vehicle insurance, precision advertising)
 - European reliance on GPS amounts to €390Bn (source RAE, 2011)
 - Technology is fundamental and UK is developing sovereign capability

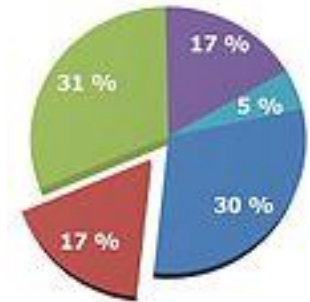


Quantum Technologies - Applications

- Precision Motion Measurement and Navigation
 - Currently GNSS provides precision motion measurement and navigation for many aspects of society.
 - What if GNSS is not available – naturally eg in-building or undersea or jammed?
 - Inertial navigation platforms are required to measure motion from a fixed point
 - INS platform has gyros, accelerometers, timing (and other sensors)
 - Accuracy without GPS circa 1nm/24 hrs (source DSTL)
 - Quantum INS expected to deliver circa 1000x improvement (source DSTL)
 - Defence/Security – navigation without reliance on GNSS signals
 - Industry/society – reduced reliance on GNSS, increase in precision over time
 - Oil/gas exploration, autonomous vehicle reliability (land, sea, air)

Quantum Applications - Disruption

- Each application provides an opportunity for market disruption
 - Orders of magnitude improvement in performance
 - Orders of magnitude reduction in size
 - Orders of magnitude reduction in power consumption
- QT applications have the potential for significant market disruption
- How can the UK win global market share?

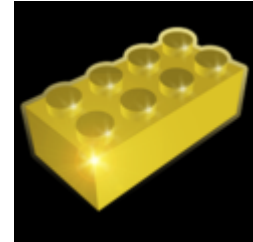


MARKET/DEVELOPMENT/POLITICAL TIMING

Market Timing

- First a definition
 - Product Type A – a component which is used with other components to construct a system

 - Product Type B – a system of components integrated together providing functionality for a market requirement

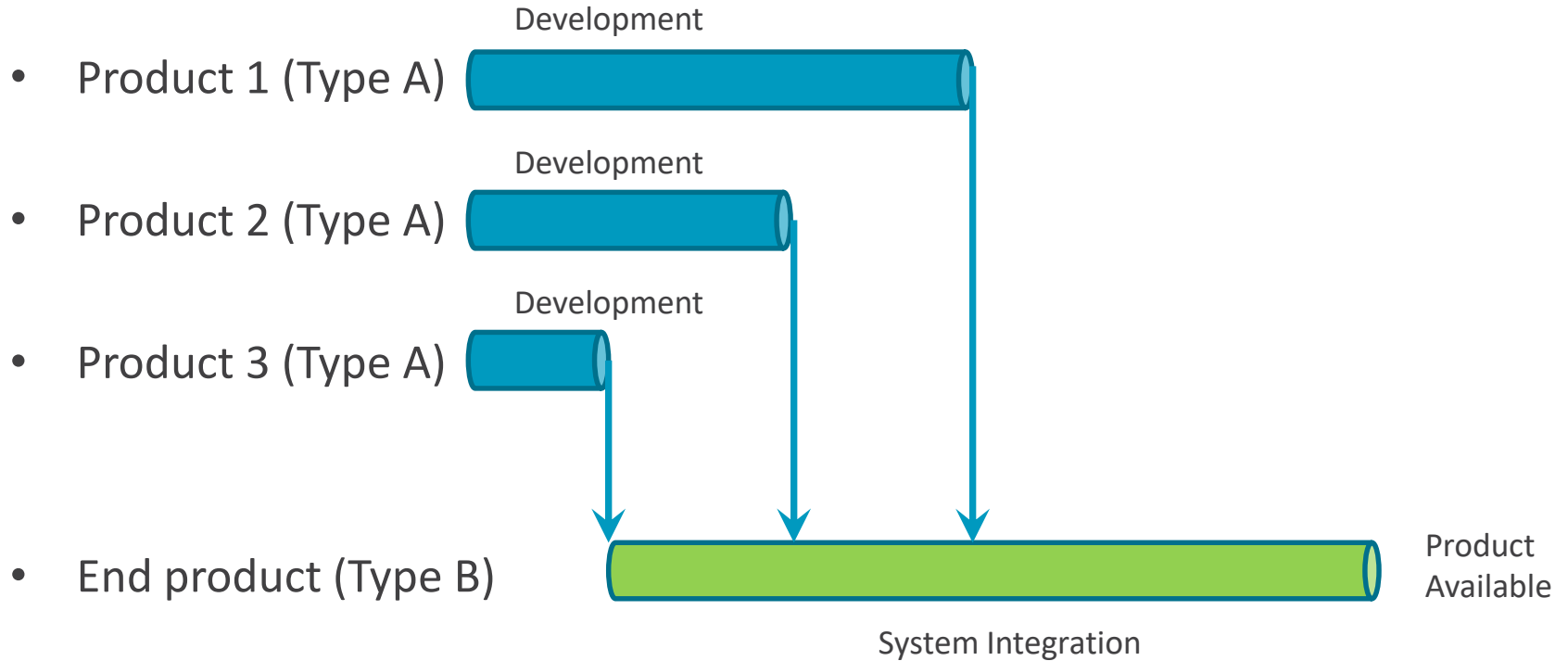


Market Timing

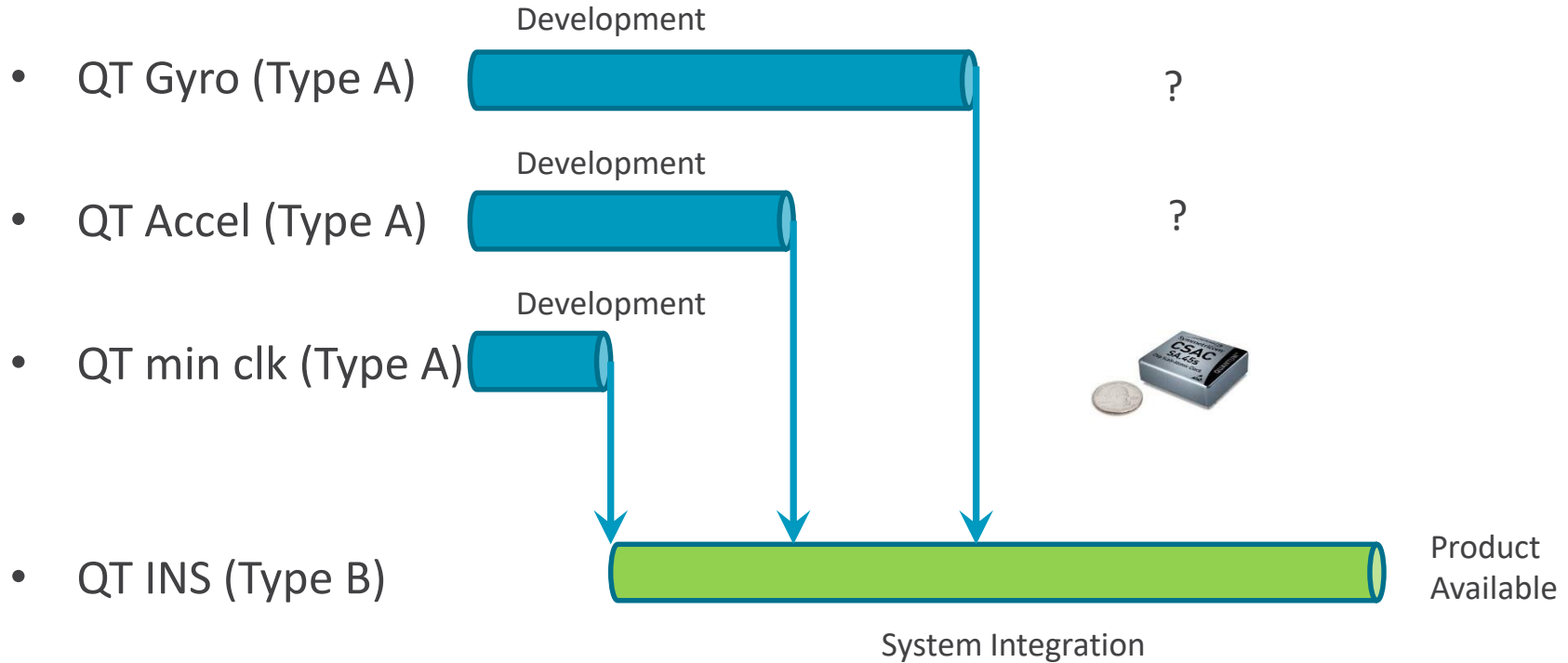
- Customers for Type A product
 - System Integrators
 - Research community (QT research, RTOs, Tier 1 defence)
 - Volumes shipped from SIs : Research are (ultimately) 1,000,000s:1
- Customers for Type B product
 - Defence, Security, Industry, Society



Development Timing



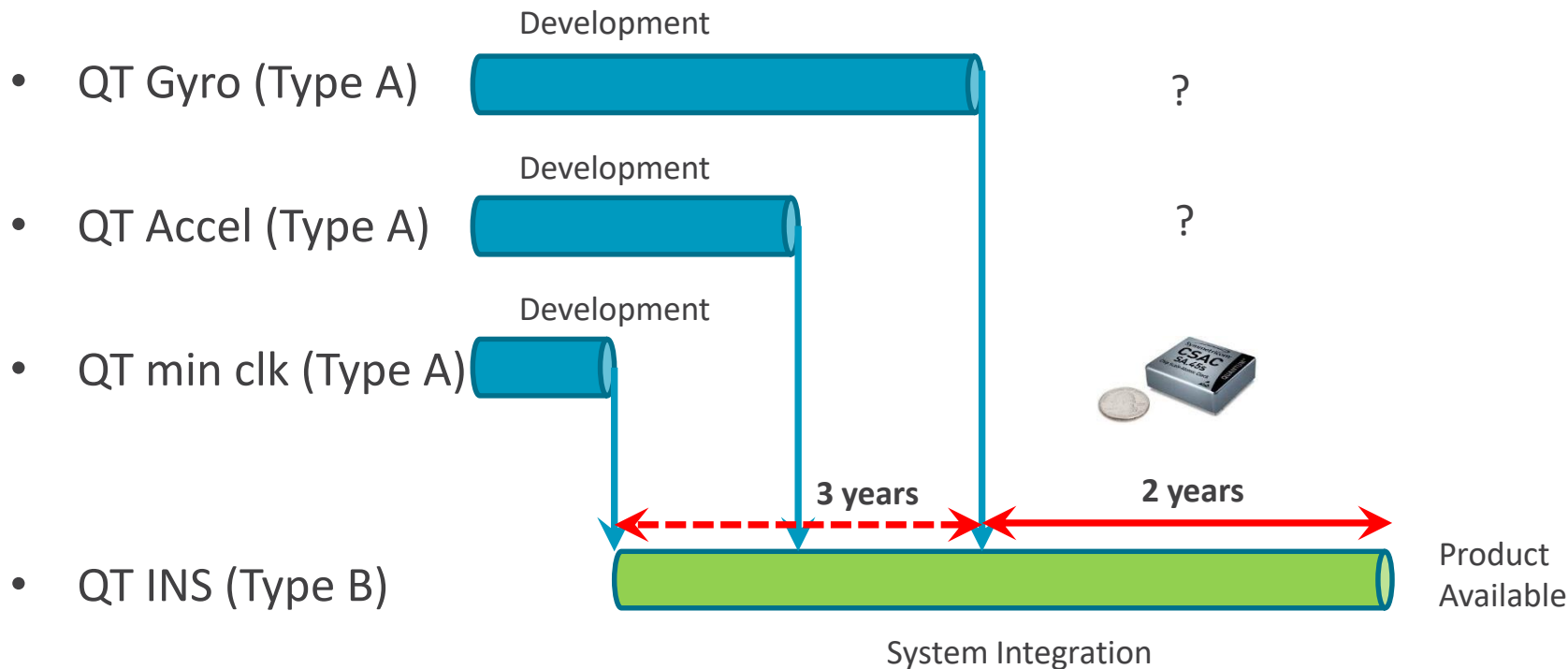
Development Timing – QT INS



Investment Timing

- Who is looking to invest?
 - System Integrators
 - Venture Capital
 - Governments (eg USA, DARPA, SBIR, UK, InnovateUK)
- When?
 - For commercial finance, view so far is commercial returns must start within 5 years
 - Business case for release of Private Venture funds must show this

Development Timing – QT INS

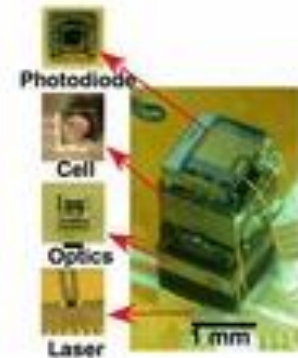


Possible Political Timing for funding

- 2013-2018 QT First phase UK Government funding
- 2015 UK Election
- 2016/17 QT Community lobby for additional funding
- Mid-term review 2017
 - Ministers ask “When will the products be ready?”
- 2018 Second phase 5 year funding announced

Elsewhere

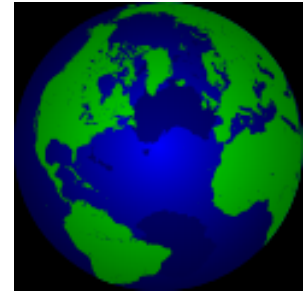
- USA (related to clocks and navigation)
 - 2002/3 DARPA invested in the CSAC through four phases to initial product available 2011
 - 2014 - DARPA awards Chip-Scale Combinatorial Atomic Navigator (C-SCAN) project to Northrop Grumman (\$12.4M for first 12 months extendable)
 - 2016 - DARPA announces Atomic Clocks for Enhanced Stability (ACES) \$50M



THE CHALLENGES

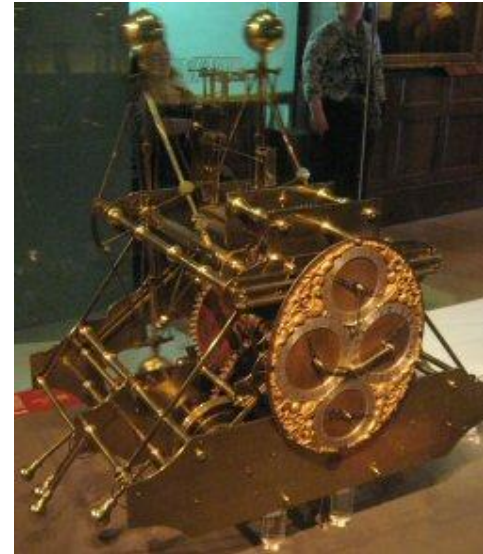
Challenges

- Philosophical
 - Very few occasions when technology offers orders of magnitude improvement across many applications and marketplaces
 - Ambition is high - globally
 - Delivery is down to the detail
 - It is a race to become first to market and successful
- Technology
 - Working today in university laboratories
 - Challenges are
 - Rapidly mature Type A building block technologies
 - Begin systems integration for Type B products in target companies



Challenges

- Timescale
 - Find a way to accelerate Type A product development to match 5 year investment window
 - Ensure the political timescale and agenda is accommodated to secure phase 2 funding
- Funding
 - Type B product companies are sat on their hands
 - Internal funding is difficult to secure
 - Government funding does not at the moment enable significant matched investment



ACCELERATION

Opportunities for Acceleration

- Plug the funding gap
 - Current rules limit UK government contribution to significantly less than costs
 - DARPA/SBIR competitions provide 100% cost coverage plus an additional 7% fee which can be taken as profit
 - Adopting SBIR type funding rules will allow early engagement of System Integrators
 - This speeds early entry to market
- Avoid the “Quantum” distraction
 - A new technology has allowed the introduction of new types of
 - Gyroscopes, accelerometers, gravimeters
 - Timing sources
 - Imaging
 - Secure communications
 - Which are orders of magnitude more sensitive, smaller, more power efficient

Opportunities for Acceleration

- Accelerate knowledge spreading
 - Every engineer currently designing in “traditional” technologies needs to become aware that a new generation is coming which will allow truly disruptive new applications



Summary

- Introduced the potential of new technologies based on QT
- Discussed development, commercial and political timescales
- Looked at the challenges
- Provided some thoughts on acceleration

THANK YOU