I N S I D E
QUANTUM
TECHNOLOGY

The Future of the Quantum Internet

A Commercialization Perspective

ITU Workshop on Quantum Information Technology for Networks
Shanghai 5-7 June 2019

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About Inside Quantum Technology

- The first company to be entirely dedicated to meeting the strategic information and market analysis needs of the emerging quantum technology industry

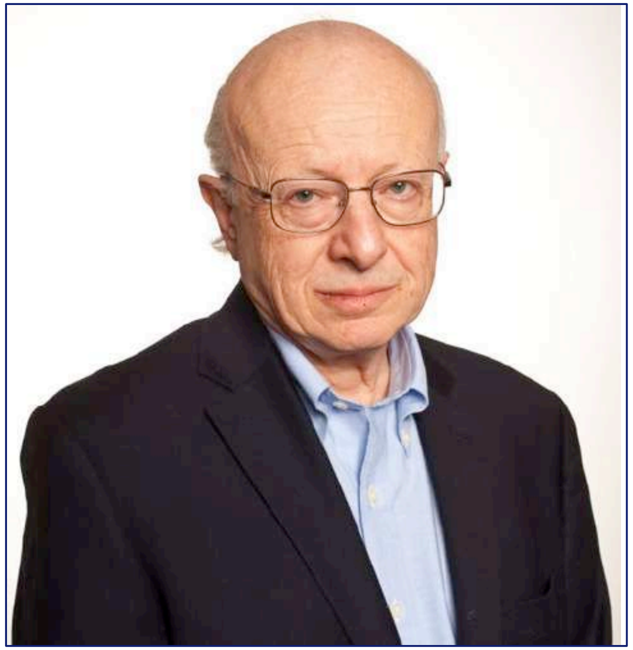
- Our **Industry Analysis Reports** provide insight into the most important revenue opportunities in quantum technology including QKD and the Quantum Internet.

- We also offer **Customized Consulting** providing clients with analysis and forecasts that go beyond what is available in published reports.

- We run two major quantum technology **Conferences** annually in the US and Europe. These conferences offer more than 30 expert speakers from leading organizations and companies

www.insidequantumtechnology.com

Lawrence Gasman



Lawrence Gasman founded Inside Quantum Technology, in 2018 with the backing of 3DR Holdings. He has founded three other industry analysis companies and has authored reports on a wide variety of novel technologies including sensors and telecommunications/data communications.

Lawrence has carried out a wide range of consulting assignments on technology assessment and market sizing and has written numerous articles and books on advanced technology commercialization. He has been a speaker at the Q2B quantum computing conference and will be addressing an International Telecommunications Union meeting on quantum networking later in 2019.

Lawrence holds a bachelor's degree in mathematics from the University of Manchester and advanced degrees from the London School of Economics and the London Business School.

INSIDE QUANTUM TECHNOLOGY

Technical Differences Between Quantum Networks and Classical Digital Networks

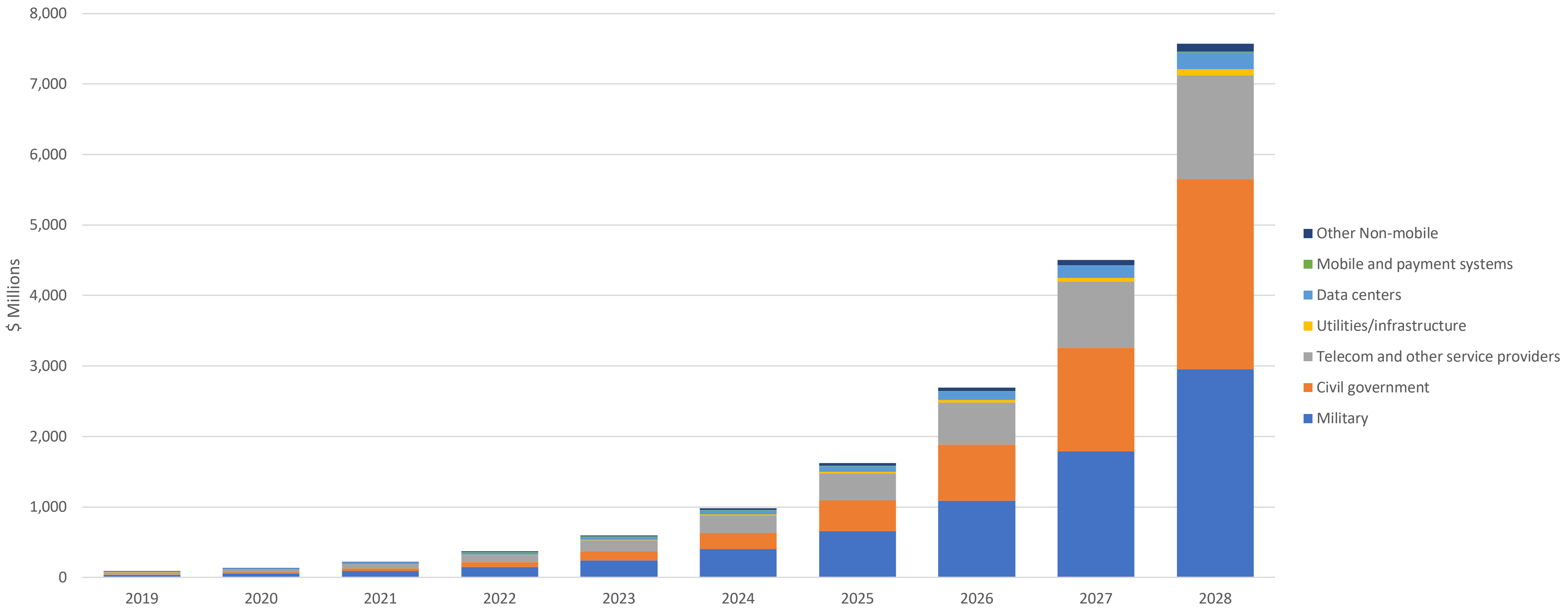
	Classical Digital Networks	Quantum Networks
Information units	Bits. A platform for IT since the 1970s. Inherently robust	Qubits. Inherently non-robust. That's why quantum technology is so powerful. Entanglement over networks
Transport networks	Radio, satellite, fiber -- all mature	Satellite and fiber widely used, but the latter is distance limited. Quantum wireless for payment emerging?
Increasing signaling strength	Amplification technology is mature and has been important enabler for for geographical growth of digital fiber networks	Amplification in quantum networks is impossible because of no-cloning. Quantum repeaters are the answer, but how do we build them and when? Trusted nodes will have to do for now
Standards	Mature. Change driven by data rates	Standards emerging. Multi-point networks especially challenging

Applications on the Quantum Internet: Life Beyond QKD?

- **QKD networks.** A killer app for the quantum Internet? Happening now.
- **Research networks.** This is how new networking technologies always begin. About to happen
- **Quantum computer networks.** Qubit nets. Remember how digital computers needed. 5-10 years
- **Quantum secure networks for mobile payment.** Anti-hacking measures can pay for themselves. 5-10 years

QKD Currently dominates . . .

Markets for QKD Systems by End User ($ Millions)



Quantum Internet Roadmap and Options

Technology at Experimental Level	Network Type	Transmission	Architecture	Key limitations	Applications
Current	Trusted Node	Satellite and metro/regional fiber	Point-to-point	Trusted node must be secured. Carrier can access keys	Simple QKD Encryption
In three years, experimentally	Simple repeater	Satellite and metro/regional fiber. Carries quantum states	Initially point-to-point then multipoint	QKD applications with keys that are genuinely secret – no carrier access	
In four years	Quantum repeater enables entan-glement sharing	Satellite but trending towards fiber, including long-haul	Multipoint	No storage of quantum states	Advanced QKD, secure payment, Q computer networks
In six to ten years	Quantum repeaters with memory	Predominantly fiber	Multipoint	Unknown territory in terms of costs and demand	Quantum clouds for quantum computing and quantum IoT

Quantum Repeater Options

Repeater Scheme	Description
Single sequential quantum repeater	A memory is placed between Alice and Bob. It attempts to generate an entangled pair. After that the entangled particles are sent to Alice and then to Bob. The memory performs a Bell measurement on the two quantum states it is holding. Using the result of that measurement, Alice and Bob can generate 1 shared bit of information.
Single photon	Alice and Bob each have memories. They prepare an entangled electron-photon pair. While the electron qubit is stored, the photons are simultaneously sent to a beam-splitter and two detectors at the mid-point. When only one of the detectors clicks, Alice and Bob can prepare 1 shared bit of information.
Single photon with additional detection setup	A mix of the previous two schemes. The single-photon protocol is run between Alice and a repeater. Only Alice performs measurements on its stored electron. The repeater attempts to generate entanglement between its memory and Bob.
Single photon over two links	Another combination of the first two schemes. The repeater is placed between Alice and Bob and tries to generate entanglement with their quantum memories using the single-photon scheme twice separately.

Missing Parts

- Proven applications
  - Beyond QKD
- Support from supply side
  - Equipment manufacturers and carriers
- Repeaters and memories
- Standards
- Policy issues
  - Defense
  - International networks

Thank you!