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Place Your Bets:

Creating a Quantum Technology Strategy for Defense Firms

Evan Rolfe

Quantum technologies may be in their nascence, but strategies regarding their potential use cases within defense and intelligence are not. Firms in these industries should carefully investigate how quantum computing, communication, and cascade lasers can affect their business—then invest accordingly before it's too late.

Place Your Bets:

Creating a Quantum Technology Strategy for Defense Firms

There is no greater fear in a technology-driven industry than missing a paradigm shift. Within the defense industry, quantum computing and communication are beginning to stoke those concerns. Growing awareness about the potential for game-changing breakthroughs in the computational and national security space, and beyond, means it is time for aerospace and defense companies to begin putting together quantum computing strategies that address how to proactively respond to the new technology given their capability sets and business models.

The arrival of a major new technology – especially one that is nascent and poorly understood – can lead to bad strategy. Firms often rush to make reactive investments that do not build on capabilities, satisfy customer requirements, or position the company for market leadership. Alternatively, other firms adopt a "wait-and-see" approach, leaving them in the dust as the technology reaches maturity. However, these traps can be avoided through a researched, measured approach.

Firms should develop an understanding of how quantum technologies could advance their particular industry, identify the most efficient and cost-effective way to leverage these advancements, and develop a path to market that prioritizes customer requirements, rather than technology.

One key consideration defense (and other) firms must keep in mind is that "quantum technology" is actually a group of multiple, distinct sets of technology with little developmental overlap. Although quantum computing, quantum communication, and quantum cascade lasers all rely on advances in quantum mechanics, advancements in one will do little to advance another. Firms must determine which technology possesses the most market potential before developing an investment case.

Quantum Computing: Revolutionary Processing Speed

Potential Market Disruption	LOW — HIGH

Quantum computers process complex data exponentially faster than conventional computers, offering an advantage processing problems such as "brute-force" computations. Unlike a conventional computer that processes bits, which are data stored as a 1 or a 0, a quantum computer uses quantum bits, or qubits. Qubits can be 0, 1, or in both states simultaneously (called a "superposition"). Qubits can also be entangled with one another, meaning that they express correlation with one another.

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These features are key to quantum computing's speed advantage.

Although there are various use cases for quantum computing, the best applications will reflect both a company's existing business lines and their longer-term growth strategies. Quantum computing has the potential to benefit both, and given the potential investment required, the notion of return on investment is an important one to consider. Among the most likely applications, the following hold the greatest promise to the defense industry.

Quantum Encryption and Communication: Ultra-Secure

Potential Market Disruption	LOW — HIGH

Although distinct from quantum computing, quantum communications may offer some of the most intriguing opportunities for the defense sector. Quantum communication is actually a collection of a number of potential

Industry Applications		
DECRYPTION	This has the most potential to cause the greatest disruption in the national security and corporate realm. Paradoxically, it is rarely discussed, which is testament to the threat to status quo technologies and systems. This is all the more reason to have a quantum strategy that takes this into consideration.	Signals Intelligence
MACHINE LEARNING	Machine learning includes the development and application of algorithms that learn from large amounts of example data and make predictions or decisions. Quantum computers show promise for improved machine learning capabilities due to their abilities to quickly work with large amounts of data, and can even develop algorithms that can then be run on conventional computers or remotely deployed on devices like autonomous unmanned aerial vehicles that can employ quantum-computer-developed models during their operations.	Sensor Processing Pattern & Object Recognition Autonomous Systems
ENGINEERING & MODELING	Quantum-enabled engineering design and modeling systems used to design new aircraft, ships or other hardware will be able to crunch through engineering simulations much faster due to the ability of qubits to quickly work with large amounts of data. This could potentially lead to improvements in the engineering design process, improving time to market. Similarly, quantum computing may hold promise for software verification and validation, testing complex systems for errors.	Software Verification & Validation Engineering Design

technologies. The most developed is quantum key distribution (QKD), in which key distributions are effectively encoded in qubits to secure data so that the receiving party can identify whether the information has been compromised en route. QKD has been in development since the 1980s, with systems in place at DARPA and Los Alamos, four existing commercial providers, and development programs across many leading telecommunications providers. Conventional encryption relies on prime number factorization problems that are too time consuming for most computers to crack. Although conventional encryption (public key cryptography) can be broken by increasingly more powerful computers (and, potentially, quantum computers), QKD is secured by fundamental laws of quantum physics, such that if the key is intercepted or compromised, the intended recipient is immediately aware. Other more theoretical quantum communications concepts focus on using entangled qubits to transmit information.

Securing electronic communications with QKD could render today's encryption obsolete. A quantum system would be resistant to conventional hacking measures, as well as the use of quantum computing for decryption. Demand would come from both government customers, as well as high-end commercial users seeking to protect their data. Indeed, gaining a foothold in this market could be key to developing a communications security strategy for the next few decades.

QCLs fit in a larger spectroscopic technology portfolio, far from the encryption and computing world.

Quantum Cascade Lasers: Improved Sensor Accuracy

Potential Market Disruption	LOW — HIGH

The third "quantum" technology is a quantum cascade laser, which has very little to do with quantum computing or quantum communication. Quantum cascade lasers (QCLs) are a type of semiconductor laser that utilizes quantum wells containing electrons in lasing states. QCLs have a variety of potential real-world applications, such as gas and explosive detection, imaging, and countermeasures. They also could be used for a number of environmental applications, as well as potentially cruise control and collision avoidance radar, and medical diagnostic equipment. However, QCLs do not utilize entanglement, superpositions, or any of the aspects of quantum information theory common to quantum computing or communication. Their inclusion in the field of "quantum technology" is a red herring of sorts. QCLs fit in a larger spectroscopic technology portfolio, far from the encryption and computing world.

Devising a Quantum Technology Strategy

As with any new advancement, defense companies should start by working toward a technical and commercial understanding of the technology. This can inform an assessment of the most promising approaches for a given application or portfolio. Moreover, investment needs to be paired with a thorough understanding of which technologies are most relevant to a company's business model – if at all. A tactical aircraft manufacturer will have different needs than an intelligence analytics firm, and will want to approach quantum technology accordingly. As with any business strategy, the potential disruptive aspects of next-generation computing should not be underestimated. Nor should the importance of knowing when not to invest, as will be the case for some defense firms.

Understanding the technology is one thing, but thoroughly comprehending how it fits with market opportunities at federal and private-sector customers is another. This analysis should be based on credible use cases, a rational assessment of internal investment opportunities in quantum technologies and a strategic approach toward preparing for game-changing technologies. For some firms, quantum technology will not be a good fit for their current and even future business models. For these firms, monitoring technological evolution and adaptation is likely enough.

Firms that choose to become involved in quantum technologies must stake out strategic paths to market. This involves figuring out where a firm wants to enter in the value chain. Just as every company that uses a conventional computer does not design and build that device, a company getting involved in quantum computing does not need to develop its own hardware. Algorithm development may ultimately be more important for a defense company in ensuring that it has a competitive advantage over competitors in developing quantum computing use cases (e.g. superior engineering modeling or intelligence analysis software). Hardware could be accessed through a partnership or purchased from a provider (either as a system or per use).

This strategic and technical analysis need not be abstract. In fact, defense firms regularly assess

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technology markets for exactly where they want to focus their investment efforts and business development resources. Quantum computing's potential does require certain shifts in those approaches, but this potentially groundbreaking technology should not induce corporate paralysis or management confusion.

Change is Coming – Ready?

Within the next ten to fifteen years, quantum computing and communication will have the ability to revolutionize many industries, including the defense sector. For executives and boards of directors sizing up the potential impact, the natural instinct might be to reflexively invest in a disruptive technology as a defensive strategy against being passed by a once-in-a-lifetime innovation or outmaneuvered by a rival. Yet doing so without a sound strategy could be even more harmful than doing nothing at all if a company charges into markets where it is inherently disadvantaged. Quantum technology may be able to do many things in the coming years, but it cannot overcome bad corporate strategy.

A smart quantum strategy involves deciding how these technologies will influence core markets and strengths while potentially using major disruptions to a firm's advantage. For some companies, it may be a major investment to position as a leader in the market. For others it might be forming a partnership or even monitoring the market to see how industry adapts. Careful analysis to determine when and how to enter the market is key to making a decision that will position a company for the future, as opposed to investing unwisely out of fear of disruptive technology.

About the Author

Evan Rolfe is an Associate at Avascent, where he manages market research and strategic support efforts for clients working in governmental and related markets. Evan has conducted projects in a number of industries, although his past work has focused on new technology development and implementation; architecture, engineering, and construction; expeditionary logistics; and oil, gas, and mining. Functionally, much of his work deals with strategic alignment and expansion efforts into commercial and international markets. His recent efforts have included thesis validation for quantum computing and oil and gas technologies, strategic realignment and market research for engineering and environmental firms, and a portfolio evaluation for an R&D focused company.

Prior to joining Avascent, he was an associate editor at the Brown Journal of World Affairs and a research assistant at the Instituto de Cuestiones Internacionales y Política Exterior (INCIPE) in Madrid. Evan holds a B.A. in international relations and economics from Brown University. Evan speaks Spanish and is a member of the Society of American Military Engineers.

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