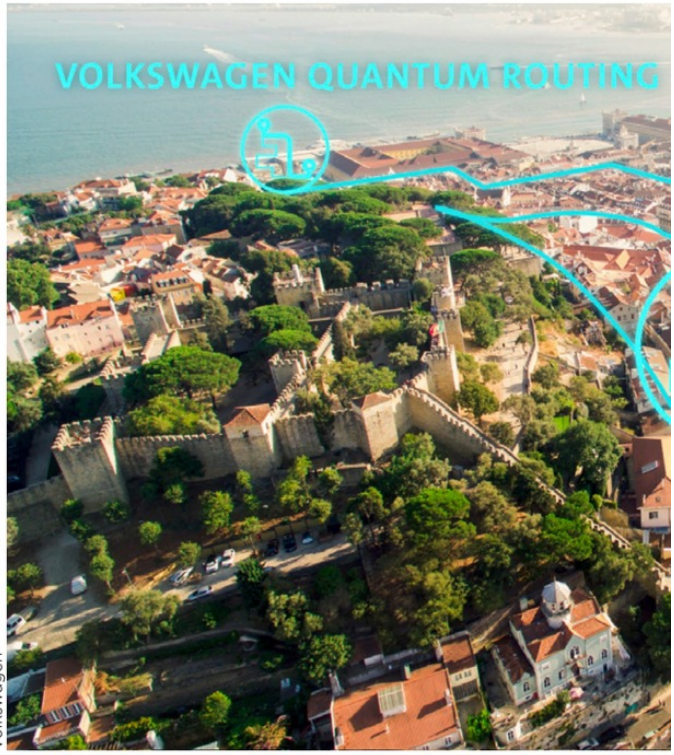
TECH FOCUS: **QUANTUM COMPUTING**

Though current quantum computers are too small to outperform usual (classical) computers for practical applications, they are believed to be capable of solving certain computational problems, such as integer factorization, substantially faster than classical computers.

"It is time to place quantum computing in our strategic plans."

-Ales Alajbegovic

IN THIS SECTION



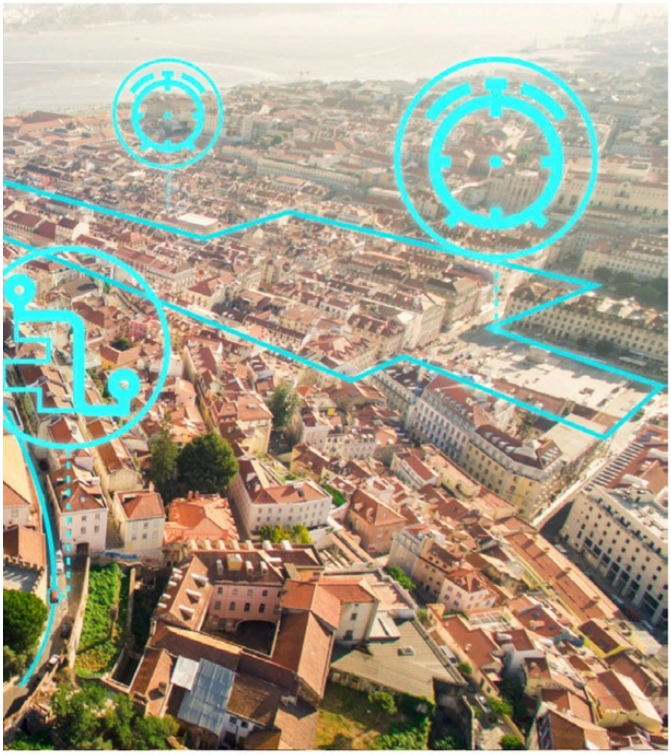
Volkswagen

Volkswagen is exploring the possibility of using quantum computers

QUBITS AND COMPUTING: THAN SCIEN

ABOUT THE AUTHOR

Ales Alajbegovic, Ph.D., wrote this article for *Update*. He is Chief Executive Officer of Four Elements Technologies. He spent his career developing and deploying Virtual Twin solutions for the world's largest automotive OEMs. He is a 16-year SAE Member.



in the optimization of road traffic.

QUANTUM "MORE CE FICTION"

It suddenly appears that the news about quantum computing is everywhere. The number of companies working on quantum computers is running into dozens. There are already several solutions available for testing on Amazon Cloud.

The overall investment in these companies has reached $15B since 2010. This progress is hard to be ignored. We have come very far since I first heard Richard Feynman's ideas about quantum computing during my undergraduate studies in physics. At that time, they sounded more fictional than the science fiction books I was reading. I touched on it again during my time at General Dynamics in the early 2000s when my colleague was applying for research grants on quantum computing. At that time it was clear that there was much more to quantum computing than science fiction; however, I never expected the rapid progress since. So, how did we come to this point and where are we heading?

The basic motivation behind quantum computing is two-fold. First, we are approaching the limit of how small classical integrated circuits can be manufactured. Further reduction in size leads towards the physics governed by quantum mechanics. Second, there is a class of problems which are not suitable for traditional integrated circuits. Phenomena where quantum mechanics dominates are very difficult for them. These are critical for the design of complex molecules and drugs. For this and other problems listed below, quantum computing really represents an ideal solution (Analytics Insight):

- Quantum encryption
- Simulation of quantum systems

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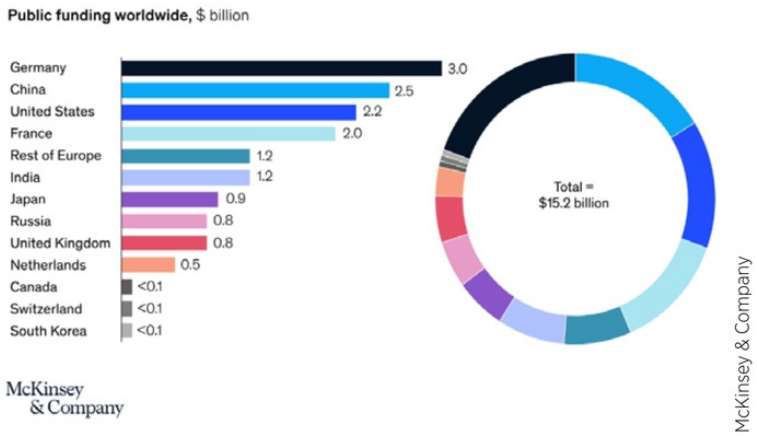
- Difficult combinatorics problems
- Supply chain logistics
- Finance markets
- Drag development
- Data analysis of large datasets
- Weather prediction

How can quantum computing help with these and other similar problems? The advantages are the result of the basic nature of information storage. The bit in classical computing has only two states: 0 or 1. For the quantum bit, or qubit as it is known, things are more complicated. The qubit is of physical size where the laws of quantum physics dominate and as a result it deals with the following phenomena:

- Superposition
- Qubit is in a state between 0 and 1 with certain probability
- Its value is established during the measurement step
- Entanglement
- The probability state of the qubit is affected by the states of other qubits

As a result of these phenomena, the size of information that can be stored in the qubit scales exponentially with the number of qubits N,

Qubits and quantum computing: "more than science fiction"

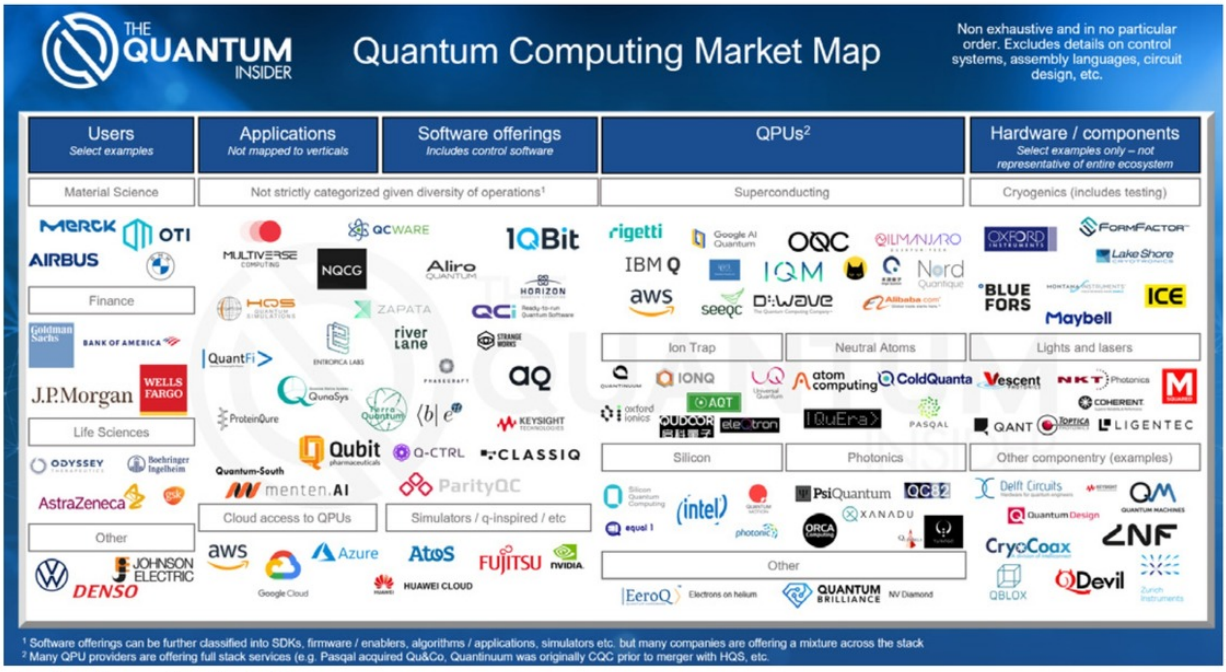


Public funding in Quantum Computing since 2010

making it very suitable for the problems listed above.

One of the questions that often arise is how the implementation of quantum computing in practice will be. There are many options for the design of qubits. One can expect specific problem-tailored computers. However, they will probably not operate independently, since they are not that good for classic control operations. Nor will they replace existing computers. One can expect that they will be connected to the classic computer, which will manage the operation of the quantum computer. This will be very similar to how GPUs work with CPUs today.

The most interesting are the potential applications. Volkswagen is exploring the possibility of using quantum computers in the optimization of road traffic. They are investigating the perspectives for single driver or urban traffic planning. Ford is working on a similar problem, exploring optimization of the diesel delivery truck routes to reduce pollutants while also optimizing vehicle range. Toyota is trying to make progress on the design of solid-state batteries, the Holy Grail of battery design. This problem is very well suited for quantum computing since the phenomenon of consideration

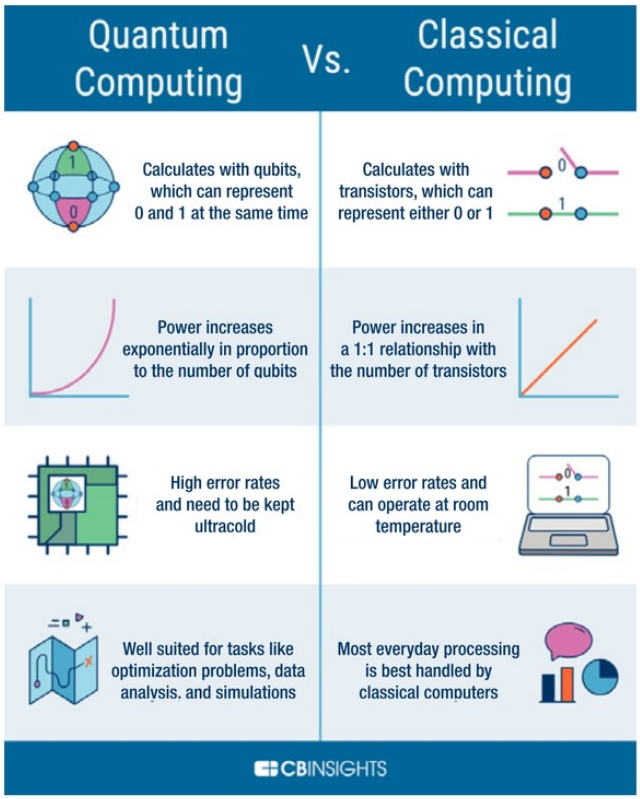


The Quantum Insider

Quantum Computing Market Cap

is governed by quantum mechanics. BMW is testing the use of quantum computing for metal-forming processes. As can be seen, there are many interesting and meaningful projects that have started already in the automotive industry. There are similar activities in other industries, led by companies such as Boeing and Airbus.

Quantum computing has come a long way since the initial ideas more than 50 years ago. Entire ecosystems of companies exist today, working on hardware and software solutions. In addition, the industry is already exploring the possibilities for first engineering applications. It is time to place quantum computing in our strategic plans. ■



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