# Quantum Artificial Intelligence Tackles the Impossible

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NASA's quantum computing project is an experiment to assess the potential of quantum computers to perform calculations that are difficult or impossible using conventional supercomputers in a realistic timeframe. The project is a collaboration among teams at NASA, Google and the Universities Space Research Association.

The NASA team aims to demonstrate that quantum computing and quantum algorithms may someday dramatically improve the agency's ability to solve difficult optimization problems for aeronautics, Earth and space sciences, and space exploration missions.

Quantum computing is based on quantum bits, or qubits. Unlike traditional computers, in which bits must have a value of either zero or one, a qubit can represent a zero, a one, or both values simultaneously. Representing information in qubits allows the information to be processed in ways that have no equivalent in classical computing, taking advantage of phenomena such as quantum tunneling and quantum entanglement. As such, quantum computers may theoretically be able to solve certain problems in a few days that would take millions of years on a classical computer.

In summer 2013, engineers installed a D-Wave Two quantum computer in the new Quantum Artificial Intelligence Laboratory located in the NASA Advanced Supercomputing facility at Ames Research Center in Moffett Field, CA. The Vesuvius processor is housed inside a cryogenics system within a 10-square-meter box that blocks out natural magnetic radiation. Currently, it is the most powerful system of its kind in the world, with 512 superconducting flux qubits.

The D-Wave Two system began operating in September, and researchers at NASA Ames and other NASA centers have begun initial studies on quantum approaches to optimization problems in areas such as air traffic control, machine autonomy, verification and validation, and mission planning and scheduling. Through testing of problems in these disciplines, NASA's quantum computing team hopes to demonstrate that large-scale quantum computers will be able to solve certain problems much faster than any classical computer using the best currently known optimization algorithms.

One initial application is in the area of planning and scheduling. Automated planners developed at NASA Ames have been used extensively for missions, such as the Mars Science Laboratory's Curiosity Rover and for software that helps optimize operations of the International Space Station's solar arrays. So far, researchers have developed benchmark sets of hard optimization problems that allow them to compare the effects of different quantum annealing approaches and existing state-of-the-art classical planners. They have also developed four representations of these planning problems, in a form suitable to be run on the quantum hardware

Another early application is related to the NASA Kepler mission's search for habitable, Earth-sized planets.

For more information about NASA's quantum computing project**,** visit www.nas.nasa.gov/quantum [1]

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