USAF Scientific Advisory Board Study
Utility of Quantum Systems for the Air Force

Study Abstract

There has been explosive worldwide growth in research and development in quantum science and technology. As a result of this research, quantum theory suggests that there may be entirely new ways of performing important Air Force tasks such as sensing, communications, and computing. In principle, quantum-based systems could provide technology-driven opportunities to enable new U.S. military capabilities. Similarly, a surprise in a quantum-based system created by an adversary could threaten key U.S. capabilities.

The Scientific Advisory Board (SAB) gathered data from across the Air Force, academia, and industry to clarify the current status, realistic performance potential, and possible Air Force utility of various types of quantum systems. This included identifying and assessing the US technical maturity for these emerging technologies and comparing their performance with more classical approaches.

The SAB concluded that three categories of quantum systems are sufficiently advanced to merit attention by the Air Force: quantum sensing, quantum communications, and quantum computing. Other quantum technologies, such as quantum imaging and quantum networks, were found to be too immature to merit substantial AF attention. However, the Board noted that across all areas of quantum technology, the current intense level of worldwide research activity implies that fundamental breakthroughs with potentially large implications are possible but unpredictable.

Based on the present state of quantum technology readiness, the SAB found that (1) current technology maturity and potential Air Force utility varies widely across quantum systems, (2) the path from theory to practical systems is formidable, and (3) there is large variability and uncertainty in timelines for maturing such systems. Specifically:

1. Quantum navigation sensors can be an important part of achieving GPS-denied advantage. Quantum inertial sensing (e.g., cold atom IMUs) can provide extremely low drift rates and is not susceptible to jamming. It is feasible to achieve TRL 6 for such systems within 5-10 years.

2. Better timing precision would enhance Air Force missions/capabilities such as signals intelligence (SIGINT), counter-DRFM (digital radio frequency memory), electronic warfare (EW), and more robust communications. Exploiting quantum effects can improve clock precision by several orders of magnitude, with an advance to TRL 6 feasible within 10 years. However, utilizing these better clocks will require major reductions in system size, weight, and power.

3. The more complex quantum approaches for improving the performance of laser communications will yield limited benefit to the Air Force while adding significant complexity.

4. Quantum key distribution significantly increases system complexity but is unlikely to provide an overall improvement in communication security as it provides little advantage over the best classical alternatives.

5. Computational solutions to Air Force problems in many areas (e.g., aircraft radar cross section computation; computational aerodynamics; software verification and validation) are constrained by the speed and memory capabilities of classical computers. However, despite claims heralding imminent breakthroughs, as of now no compelling evidence exists that quantum computers can be usefully applied to computing problems of interest to the Air Force.

Based on these findings, the SAB recommends that the Air Force should:

1. Lead development of quantum navigation sensors (including fusion with other sensor suites) and include a TRL 6 demonstration within 5-10 years. Also, component technologies should be developed to reduce cost and size in order to extend these to smaller aircraft and weapon platforms.

2. Lead development of quantum clocks to enhance Air Force missions and capabilities. These include miniaturization of current laboratory quantum clocks for use in Air Force missions such as SIGINT, counter-DRFM, and EW. The volume of these clocks should be reduced, and the reduced sized clocks should achieve a TRL of 6. Also, to enable robust communications, the timing accuracy of such small quantum clocks should be improved to be at TRL 3-4.

3. Continue a modest research effort in quantum computing focused on algorithms targeted to solve Air Force computational problems. This should be accomplished by leveraging the existing community (academia, FFRDCs, Government) to work on problems with the highest potential for payoff, connecting Air Force application experts with quantum-algorithm developers. In addition, the USAF should actively watch new hardware architecture developments to be ready to take advantage of advances as they become available.