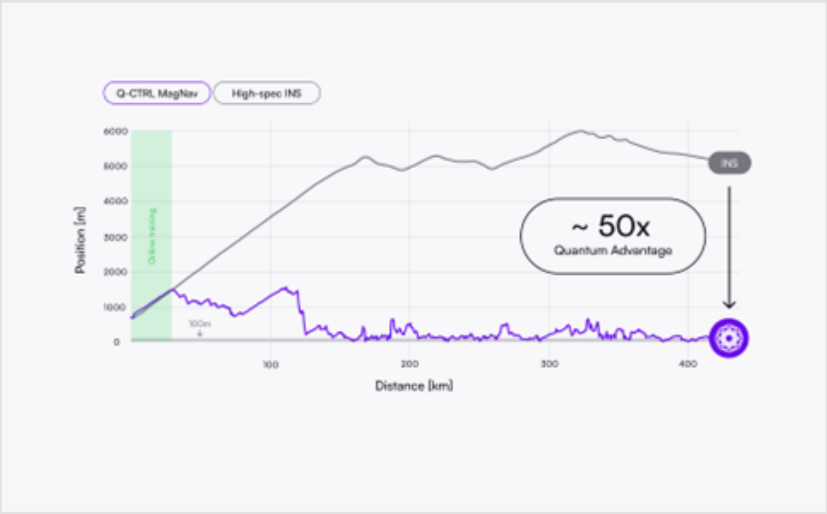
Q-CTRL overcomes GPS-denial with quantum sensing, achieves quantum advantage

World-first demonstrations validate the company's quantum navigation technologies work in real-world environments and outperform GPS backups by up to 50x



SYDNEY, AUSTRALIA, April 14, 2025 /EINPresswire.com/ -- Q-CTRL, the global leader in quantum infrastructure software, announced successful field trials of a new generation of quantum-assured navigation solutions validated to outperform comparable conventional alternatives in challenging real-world settings. This marks the first achievement of commercial quantum advantage for any of the recently posed applications of quantum technology, cementing Q-CTRL's role as the dominant leader in the quantum sector.

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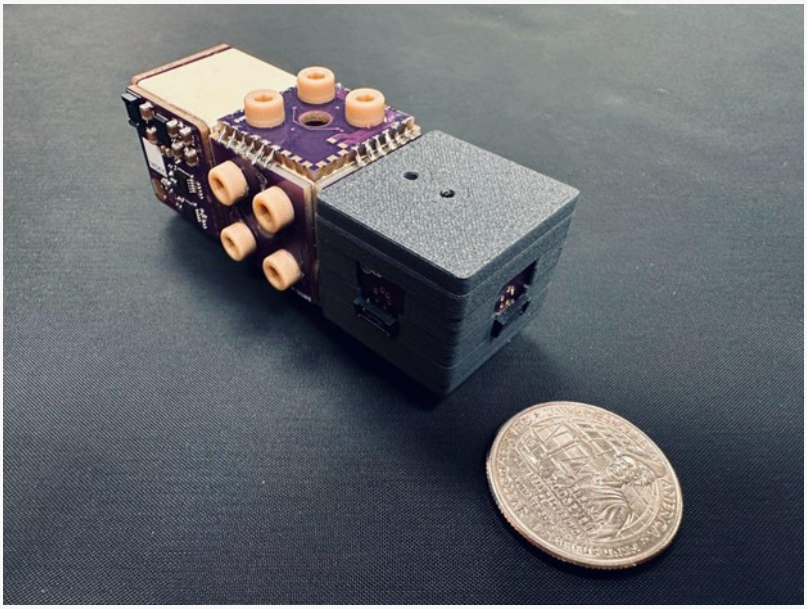
>
> *Michael J. Biercuk, CEO and Founder of Q-CTRL*

Today, almost all navigation in vehicles, from airliners to passenger cars, relies on the Global Positioning System (GPS). But amidst growing international conflict, GPS denial is becoming a weapon of both traditional warfare and nontraditional economic sabotage; an outage is estimated to cost $1 billion per day, over 1,000 flights per day are now disrupted by GPS jamming incidents, and the adoption of autonomous systems is becoming challenged by the unreliability of GPS.

Meanwhile, existing GPS backups face major shortcomings that have made new solutions for GPS-free navigation a strategic technology of the highest importance.

Q-CTRL has produced a new generation of quantum-assured navigation systems, Ironstone Opal, that delivers GPS-like positioning, is completely passive and undetectable, and cannot be jammed or spoofed. It solves the most pressing navigation challenges in the defense and civilian

domains, enabling new missions, streamlining transport operations, and powering autonomous systems.



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In a world-first, Q-CTRL conducted real-world ground and airborne trials showing its quantum-assured navigation solution enabled successful GPS-free navigation, outperforming a high-end conventional GPS alternative by up to 50x. These tests deliver true commercial and strategic quantum advantage in navigation, an elusive goal across the entire quantum industry.

The Q-CTRL quantum-assured navigation system uses quantum sensors to detect tiny, otherwise imperceptible signals arising from Earth's structure that serve as magnetic "landmarks" for navigation -- only quantum sensors provide the sensitivity and stability needed to continuously "see" these landmarks from a moving vehicle.

"We achieved an accuracy in some trials comparable to a sharpshooter hitting a bullseye from 1,000 yards away," said Q-CTRL CEO and Founder Michael J. Biercuk. "But because our quantum-assured navigation system allows a vehicle to position itself accurately irrespective of how far it's travelled, by analogy that sharpshooter can hit the same bullseye no matter how far away they move from the target."

"Unlike quantum supremacy [in quantum computing], the technology is truly innovative and meets a growing market need in aerospace, defense, and autonomous cars," said Jean-Francois Bobier, Partner & Vice President, Deep Tech, at the Boston Consulting Group. Bobier noted the BCG estimate of quantum sensing becoming a $3bn industry by 2030 and added, "Q-CTRL is paving the way to unlocking this potential with a proven quantum advantage."

Q-CTRL provides a new solution from top to bottom, built around the concept of "software ruggedized hardware." This validated concept uses proprietary AI-powered quantum control software to shield the delicate quantum sensors against interference encountered in the real world and allows the systems to be miniaturized by trading hardware for software to enable deployment on nearly any vehicle.

"At Q-CTRL, we're thrilled to be the global pioneer in taking quantum sensing from research to

the field, being the first to enable real capabilities that have previously been little more than a dream," said Biercuk from Q-CTRL. "This is our first major system release and we're excited that there is much more to come as we introduce new quantum-assured navigation technologies tailored to other commercial and defense platforms."

Q-CTRL's quantum magnetic navigation system is small enough to fit on small fixed-wing drones or autonomous cars, and powerful enough to enable navigation in passenger airliners. Nothing in the industry approaches the combination of performance, stealth, and SWaP (size, weight, and power), making this a truly unique technology. The company is working with government agencies, including the Australian Department of Defence, the UK Royal Navy, and the US Department of Defense, to deliver new quantum-sensing technologies for defense platforms. In addition, Q-CTRL is working with Airbus on quantum navigation solutions for commercial aviation.

Editor's note:
"Quantum advantage" indicates when a quantum solution outperforms its competitive classical counterparts under realistic conditions in a commercially relevant task. It has been an elusive milestone across a range of candidate applications of quantum technology; the first quantum advantage dates back to the realization of the atomic clock in 1955 but few other clear demonstrations exist. Quantum advantage has recently been the subject of intense speculation and competition among tech companies vying to claim the upper hand in the application of quantum computing. The lack of verifiable quantum advantage in the most prominent contemporary areas of exploration - quantum computing, quantum sensing, and quantum communications - has been used as a criticism of the sector's true commercial relevance.

The Q-CTRL demonstration showcases that quantum navigation has delivered a near term application achieving true commercial advantage, and rewrites the narrative on when current developments in quantum technology might provide relevant and useful solutions.

The Q-CTRL quantum-assured navigation solution was based on magnetic navigation. It leveraged in-house, high-stability magnetometers in a unique architecture combined with proprietary software ruggedization to detect the Earth's magnetic fingerprint - small variations in the Earth's magnetic field due to changing composition. The measured information about the local magnetic field in the moving vehicle could be compared against a known map drawn from a public domain or commercial database to estimate the vehicle's position relative to the map.

Software ruggedization
Achieving these results required a concerted effort to ensure quantum technology solutions worked in real operating environments. Heavy vibrations and electromagnetic interference have blocked the transition of most experimental quantum navigation solutions from the lab to the real world, but are counteracted by unique Q-CTRL technology.

Core to the Q-CTRL achievement was the development and integration of the world's best (publicly known) "magnetic denoising" software. The Q-CTRL team combined advanced machine learning techniques with physics expertise to produce an algorithm for interference rejection that was both highly effective and efficient. In a head-to-head comparison against a competitor's algorithm using open-source magnetic flight data, the Q-CTRL software achieved 3x better positioning with 15x faster learning on the same data.

More importantly, the Q-CTRL denoising software was able to learn all relevant information about the interference experienced "on the fly", meaning it did not require any pretraining, calibration, or special vehicle maneuvers as commonly required in competitive approaches. This is a major operational advantage for end users who are not obligated to perform hours of special training tests before use.

Field-trial details
The Q-CTRL team performed tests in both ground vehicles and in flight. It achieved quantum advantage in both, delivering superior performance to a strategic-grade GPS alternative strategic-grade known as an inertial navigation system (INS), a gold-standard GPS backup system that operates by measuring vehicle motion. In these trials magnetic map information was taken from publicly available databases, requiring no special surveys in advance of the trials.

During flight tests, the Q-CTRL system achieved 99.97% uptime and operated successfully under a wide range of operating conditions, temperatures, altitudes, and maneuvers. The team achieved a maximum of 50x lower positioning uncertainty over a ~500km flight vs an INS, with positioning uncertainty just ~0.03% of the total distance traveled via externally mounted quantum sensors. The best trials achieved ~0.01% final positioning uncertainty; this places the new MagNav solution's performance as outcompeting public-domain figures for a range of other GPS backups, including Doppler radar, Doppler velocity lidar, and visual odometry, without the need to emit external signals that give away your position to an adversary (as in radar) or subject to weather conditions in flight.

Magnetic navigation in flight was successful with multiple sensor configurations, and outperformed the INS by at least 11x with the entire full-stack system located inside the aircraft, where magnetic interference from avionics and other equipment is over ten times larger than typical external sensor mounting points. This is a testament to the efficacy of Q-CTRL's software-ruggedization technology.

Q-CTRL's quantum-assured magnetic navigation system also successfully enabled navigation in a ground-based vehicle with the system strapped into the cargo bay of a van. As in flight tests, position was inferred relative to a magnetic map provided from public-domain databases. In these trials the Q-CTRL technology outperformed the INS by over 6x, and represents the first ever successful demonstration of magnetic navigation in any ground vehicle.

DoD Engagement:

Q-CTRL announced in 2023 a partnership with the Australian Department of Defence to deliver quantum-assured navigation for defence platforms. In addition, it has been contracted by the UK's DASA accelerator, and supported by the UK Royal Navy via the Disruptive Capabilities and Technologies Office, to field trial mobile quantum-assured gravimetry for maritime operations

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