Quantum Technologies in the Mountain West

Why It Matters for the NSF ASCEND Engine and Regional Competitiveness

Research brief

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Innosphere
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Contents

Acknowledgements

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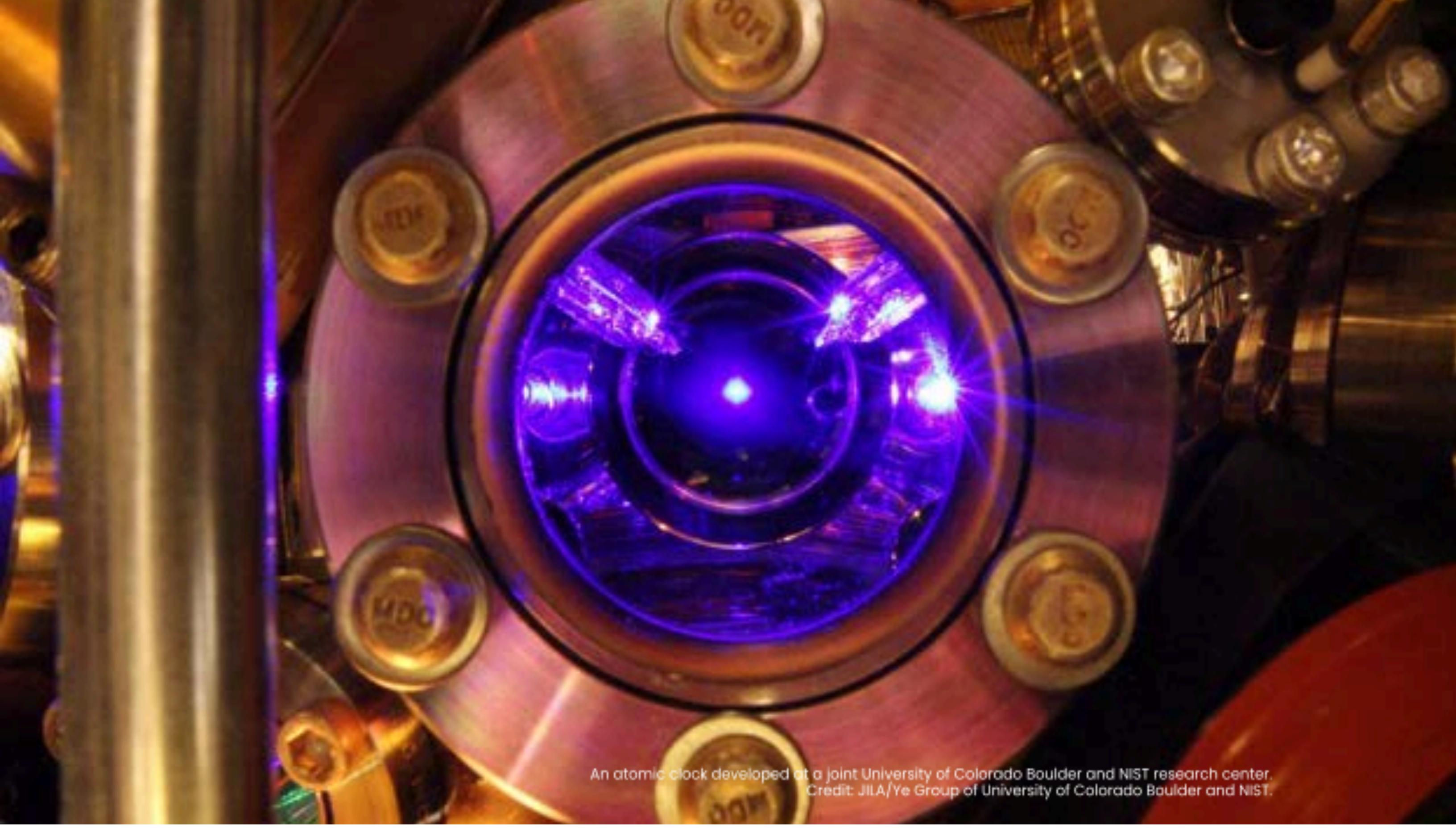
Preface

This brief distills a broader body of research and data analysis to clarify how quantum sensing is evolving, where it intersects meaningfully with ASCEND, and where the Mountain West appears to hold credible advantages. Readers seeking fuller technical detail, methodological explanation, and a more comprehensive treatment of the wider quantum landscape should consult the companion report on which this brief is based.



An atomic clock developed at a joint University of Colorado Boulder and NIST research center.
Credit: JILA/Ye Group of University of Colorado Boulder and NIST.

Introduction

Quantum sensing is moving from frontier research into application. Once treated mainly as a frontier science, it is increasingly being pursued for what it may enable in practice: more precise timing, navigation, detection, and measurement in settings where accuracy, resilience, and trust matter. That shift has raised the strategic stakes of the technology's progress. Quantum sensing now sits at the intersection of scientific competition, industrial opportunity, and mission-driven demand, with implications that reach from national security and critical infrastructure to aerospace, energy, and advanced manufacturing.

For advanced sensing and computing for environmental decision-making ("ASCEND") technologies, the significance of quantum sensing lies in what it could add to the broader frontier of environmental sensing, monitoring, and modeling. Quantum technology is still in its early stages, and many ASCEND-related applications remain emerging rather than market-ready. Even so, the underlying capabilities—especially in measurement, instrumentation, optics, and photonics—are increasingly relevant to a wider set of challenges involving environmental intelligence, infrastructure monitoring, navigation, and geospatial awareness.

Introduction

That relevance is important for a second reason as well: it brings the question of deployment to the foreground. Once quantum sensing is considered in terms of real applications, progress can no longer be judged by scientific advance alone. It depends on validation, ruggedization, integration, and institutional adoption.

These deployment demands extend beyond ASCEND technologies. Quantum technologies do not advance as isolated product categories. They advance through interconnected systems, shared platforms, and enabling stacks: end-use systems such as clocks, inertial sensors, or computing devices; shared platforms such as photonics, precision optics, control systems, and detectors; and the calibration, software, validation, manufacturing, and workflow integration needed for deployment. Sensing sits unusually close to those shared layers. Because it forces quantum performance to hold up under real conditions, it often reveals whether the broader quantum stack is becoming reliable enough to support the field's next stage. In that sense, quantum sensing is not only an application domain. It is also one of the places where the wider quantum field becomes more usable, more interoperable, and more commercially credible.

The Mountain West, defined here as Colorado, New Mexico, and Wyoming, has reason to be taken seriously on that basis. The region holds significant assets in quantum sensing and several enabling technologies that determine whether sensing systems—and, in some cases, the broader quantum stack—can move beyond the laboratory. Those strengths are not evenly distributed across the region, and they do not yet amount to a fully mature commercialization ecosystem. They do, however, create a plausible foundation for a larger regional role in the development, validation, and commercialization of quantum sensing and related enabling technologies. This brief examines why quantum sensing matters now, how the field is evolving globally, where the Mountain West's strongest advantages appear to lie, and what those patterns mean for a region seeking to strengthen its position in ASCEND-relevant sensing technologies and the wider quantum landscape.

1. Why Quantum Sensing Matters Now

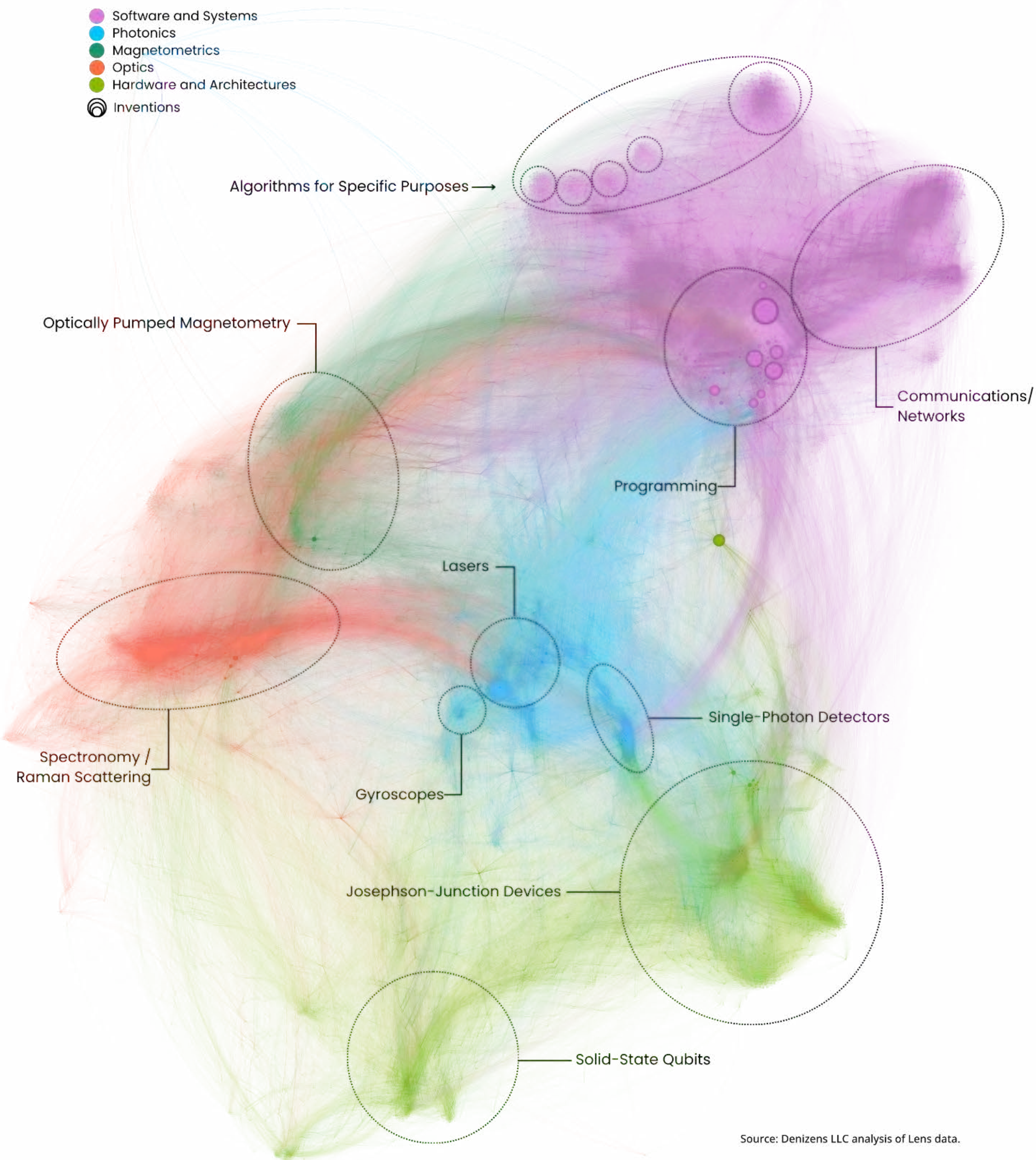
Quantum sensing matters because it promises sharper ways to measure time, motion, gravity, magnetic fields, and other physical signals that conventional systems often capture with lower precision or robustness. That makes it relevant to a wide range of applications where performance depends on trusted measurement: navigation when GPS is degraded, timing and synchronization for critical systems, geophysical and subsurface detection, industrial measurement, infrastructure monitoring, and a variety of aerospace and security uses. The category is broader than any single device. It includes atomic clocks, inertial sensors, gravimeters, magnetometers, and photonic systems that use quantum effects to improve sensitivity, stability, or resilience. In economic and strategic terms, its importance lies in the measurement layer it strengthens. Better measurement changes what larger systems can do.

It also stands out as one of the more actionable parts of the broader quantum landscape. Quantum computing continues to command the most public attention, but many of its most ambitious applications still depend on longer time horizons and unresolved engineering challenges. Quantum sensing reaches operational questions sooner. Sensors have to function outside the laboratory, under noise, vibration, drift, size, and power constraints, as well as the scrutiny of real users. That makes the field unusually revealing. Progress is tested not only by technical novelty but also by whether systems can be stabilized, calibrated, validated, manufactured, and integrated into existing workflows.

It is revealing in a second sense as well: sensing sits close to the shared platforms and enabling layers on which much of quantum depends. Advances in photonics, optics, detectors, timing, control, and measurement do not benefit sensing alone. They can strengthen the technical foundations on which broader quantum capabilities are built. Some of the most plausible near- to mid-term pathways, therefore, cluster around resilient positioning, navigation, and timing; infrastructure-adjacent measurement; subsurface and geophysical sensing; and other environments where even incremental gains in precision or reliability can produce outsized operational value.

Analysis of quantum tech. inventions reveals a system of connected platforms

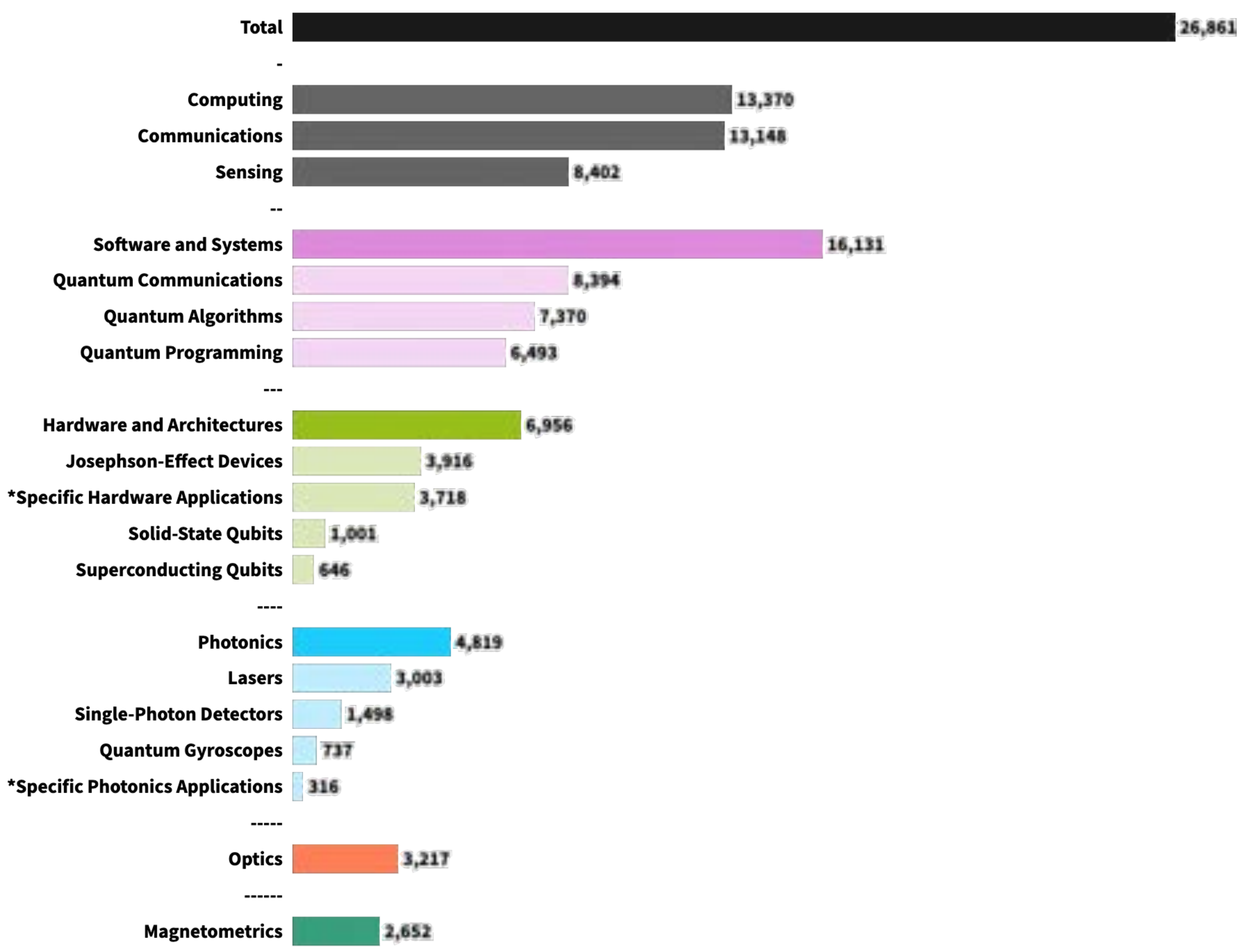
Clustered co-occurrence connections between CPC codes on quantum tech inventions filed since 2010



Source: Denizens LLC analysis of Lens data.

Quantum sensing platforms play a small but highly integral role in the quantum tech. stack

Number of global quantum tech. inventions filed by application, platform, and subplatform since 2010

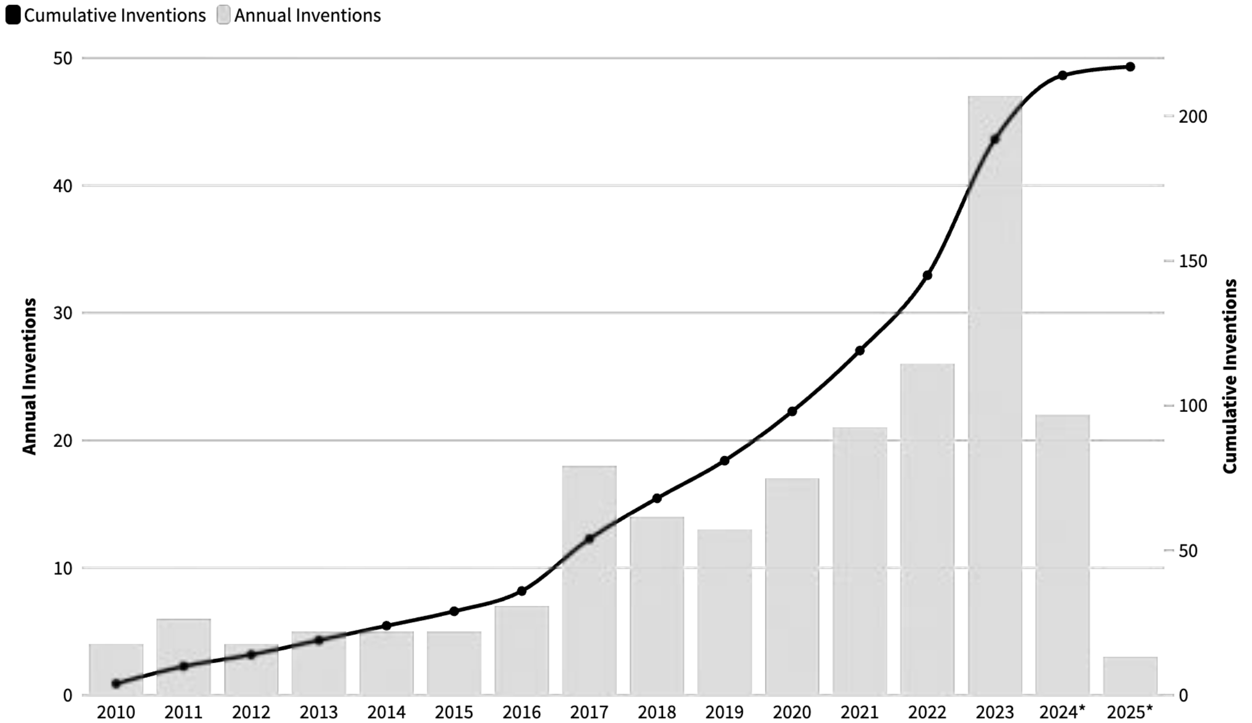


* These categories capture sets of specific applications for the technologies in this platform. • Source: Denizens LLC analysis of Lens data.

For ASCEND technologies, the significance of quantum sensing lies in its potential to expand the frontiers of environmental sensing, monitoring, and modeling to inform important decisions whose outcomes affect lives and property. The field of quantum technology does not yet have a large, mature environmental market, and it would be premature to describe it as such. Even so, the underlying capabilities are increasingly relevant to environmental intelligence, infrastructure monitoring, geospatial measurement, and other domains that depend on more capable sensing and more trustworthy data. That is especially true where better timing, positioning, or subsurface measurement can improve how physical systems are observed and interpreted.

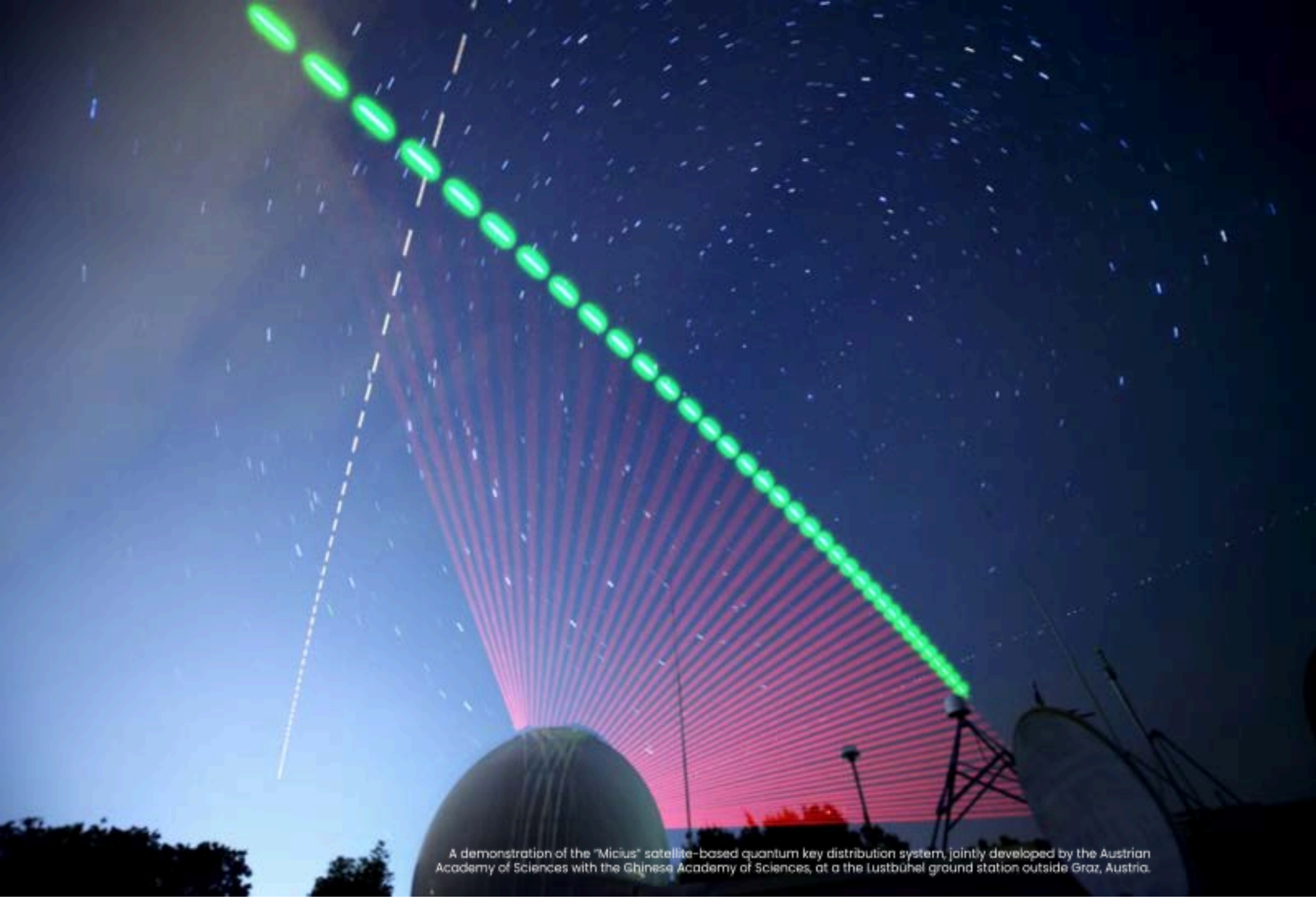
The nexus of ASCEND and quantum tech. has grown rapidly as science meets application

Number of new quantum inventions filed by year of first filing that contain ASCEND-related technology codes



* Partial year data. • Source: Denizens LLC analysis of Lens data.

The strategic value, then, is not simply that quantum sensing exists. It is that it could expand what advanced sensing systems can detect, model, and support over time—provided those capabilities can move through the harder work of validation, standards, integration, and operational adoption. Quantum sensing, therefore, belongs in conversations about the development of ASCEND technologies: not as a finished market category, but as an emerging layer of advanced sensing capability with credible long-run relevance to environmental and infrastructure decision systems.



A demonstration of the "Micius" satellite-based quantum key distribution system, jointly developed by the Austrian Academy of Sciences with the Chinese Academy of Sciences, at a the Lustbühel ground station outside Graz, Austria.

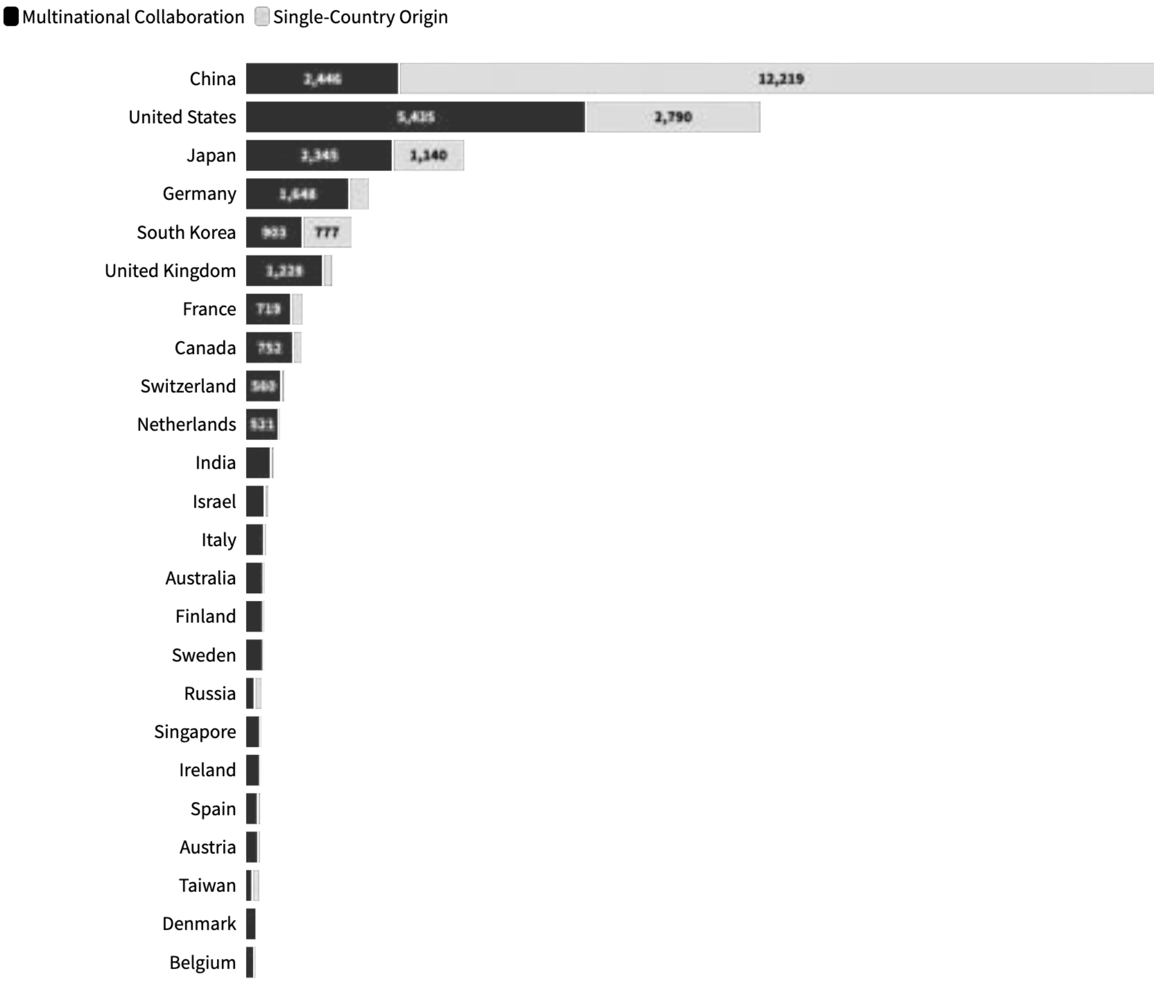
2. Competition Is Intensifying

Quantum sensing is advancing amid intensifying strategic competition. China has become the largest source of aggregate quantum-invention activity, with a particular emphasis on communications and other deployment-adjacent pathways. The United States, meanwhile, remains broadly positioned across the quantum landscape and retains especially strong standing in quantum sensing. Allied economies contribute important upstream capabilities in areas such as photonics, metrology, and other enabling platforms. The result is a field shaped not only by scientific advance, but by industrial policy, security priorities, and the effort to secure positions in technologies that affect resilient navigation, secure communications, and high-precision measurement.

2. Competition Is Intensifying

China's autonomy makes it a leader in quantum invention counts at the cost of capability

Quantum technology inventions filed by country since 2010 by location of sponsors or inventors

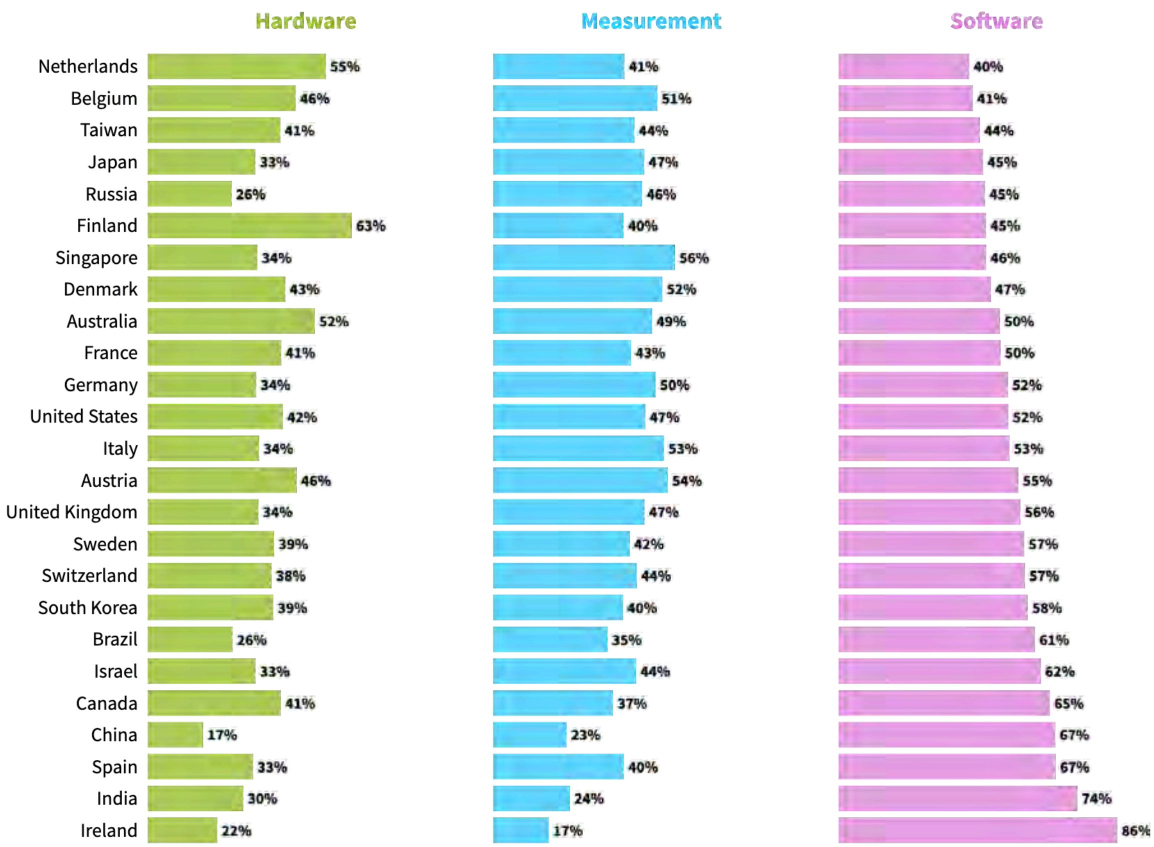


Source: Denizens LLC analysis of Lens, USPTO, and OECD data.

Raw invention volume, however, is an incomplete guide to long-run influence. Lasting advantage depends on who controls the physical platforms and interfaces that other actors must use: photonics, control systems, calibration regimes, validation pathways, and the collaborative networks through which standards and practices spread. That is where the United States and its allies retain an important position. The U.S. sits at the center of the global quantum collaboration network, acting less as a single-track producer than as a system integrator that connects disparate technical efforts and helps shape the terms of interoperability. In quantum, influence does not flow only from scale. It also flows from the ability to coordinate across institutions, absorb knowledge from multiple sources, and turn distributed experimentation into usable systems.

U.S. and allied countries focus on physical quantum capability creates strategic advantage

Share of country's quantum inventions since 2010 by stack position (can sum to greater than 100%)



Source: Denizens LLC analysis of Lens, USPTO, and OECD data.

Commercialization, in that context, is harder than the public conversation often suggests. Quantum technologies do not move into the market as single finished products. They emerge through layered stacks of components, platforms, and workflows: devices paired with optics, control electronics, software, calibration routines, validation infrastructure, and end-use operating environments until performance becomes repeatable and trusted. Quantum sensing is especially important in that process because it forces those layers to prove themselves early on. Conventional markers of market readiness can therefore mislead. Venture investment is meaningful, but it is only a partial signal. It captures where translation is becoming plausible for a subset of firms, not where the wider system has matured. The harder bottlenecks remain familiar: ruggedization, manufacturability, testing, supply chains, standards, and the types of buyers willing to absorb long qualification cycles.

2. Competition Is Intensifying

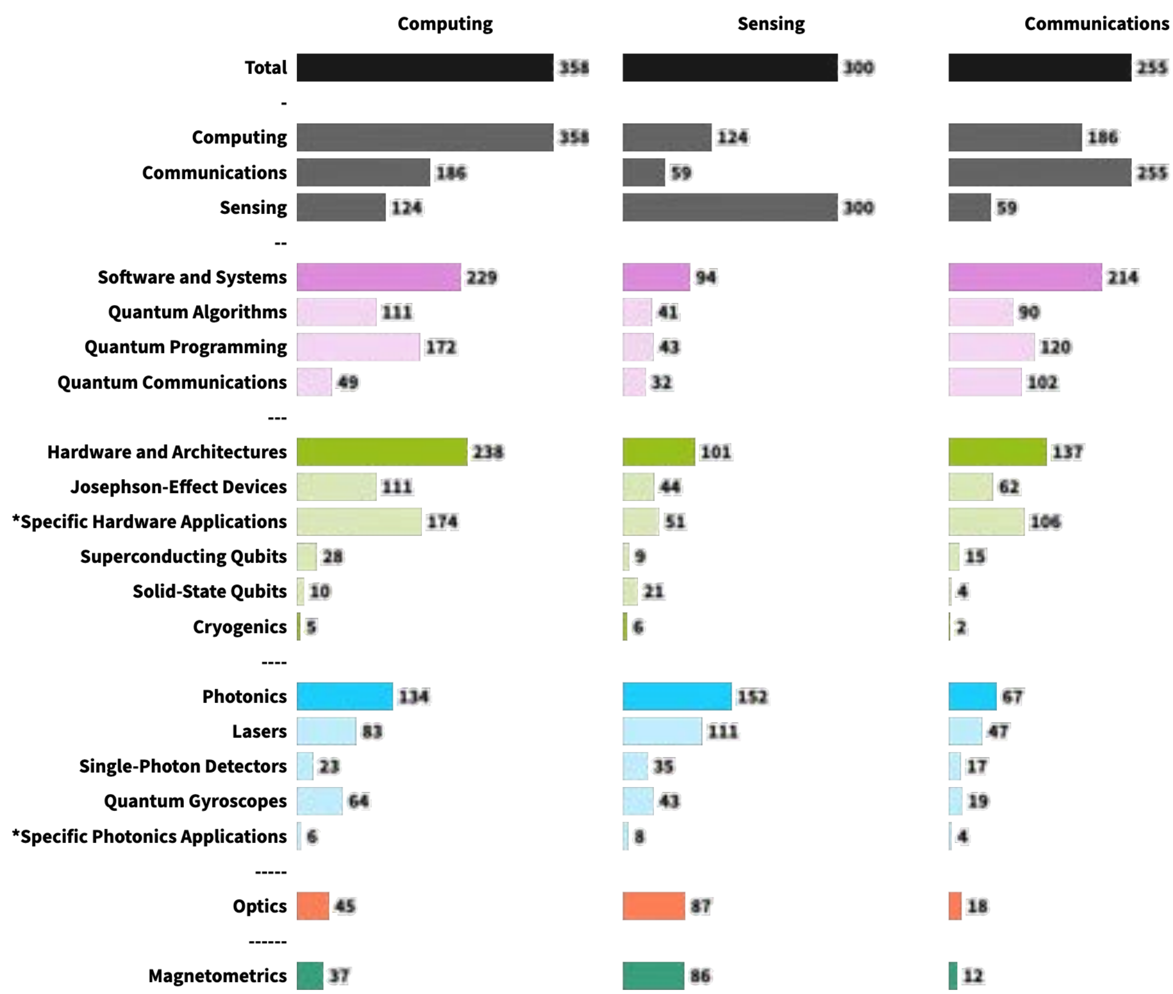
For regions seeking a larger role, that raises the bar considerably. Strong science and a promising startup base are not enough on their own. Regions matter when they can connect local technical strengths to federal missions, industrial partners, validation environments, standards-setting processes, and external markets. Quantum sensing belongs in conversations about the development of ASCEND technologies for the same reason. Advanced sensing technologies increasingly sit at the intersection of environmental intelligence, infrastructure resilience, and dual-use demand, and their economic value depends on the same connective tissue that the earlier work by Innosphere and the U.S. NSF ASCEND Engine identified: technology transfer, partnerships with large institutional players, and test environments that help promising systems move toward deployment. In the Mountain West, the opportunity is therefore inseparable from outward connectivity. A region that links its discoveries to broader networks of commercialization and use is far more likely to shape where the field goes next.

3. The Mountain West Has a Credible Opening

The Mountain West is not a speculative entrant in quantum sensing. It already has a meaningful base of quantum activity, with roughly 600 inventions since 2010, the overwhelming majority of which are tied to Colorado and New Mexico. Just as important, that activity is not confined to a single narrow lane. The region shows substantial invention across computing, sensing, and communications, with notable overlap among them rather than clean separation into silos. For external stakeholders, that matters because it suggests a regional system with real technical depth rather than a thin collection of disconnected efforts. The broader Mountain West is therefore best understood as a region with a genuine foothold in quantum technology, particularly sensing.

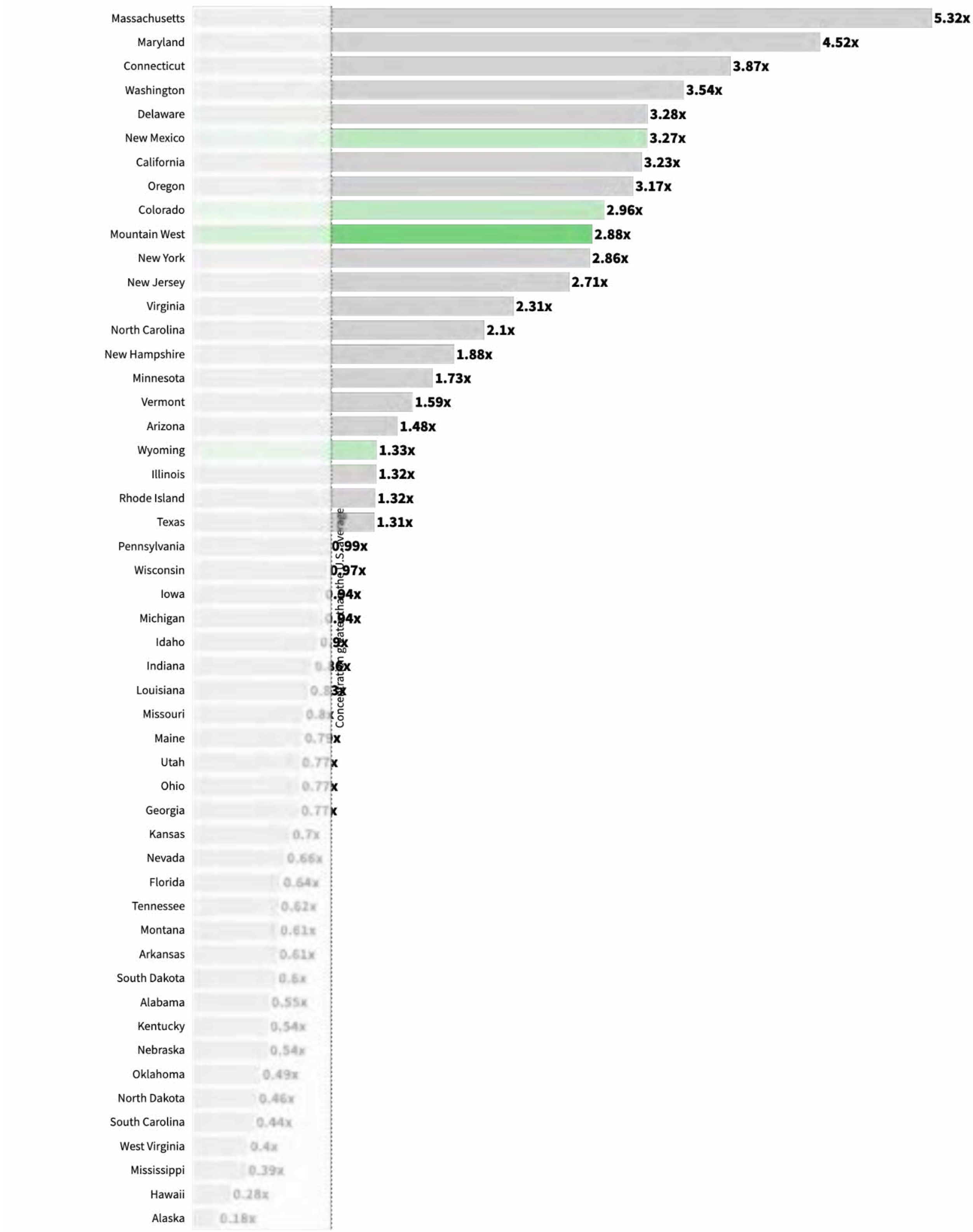
The Mountain West is a major player in global quantum tech. innovation

Number of quantum technology inventions tied to inventors or sponsors in Colorado, New Mexico, and Wyoming by application



* These categories capture sets of specific applications for the technologies in this platform. • Source: Denizens LLC analysis of Lens data.

The Mountain West is highly specialized in quantum tech.
Number of quantum technology inventions per job compared to the U.S. average



* Inventions can originate from more than one state. • This is a comparison of two ratios, similar to a location quotient (LQ) or "revealed comparative advantage" (RCA).
Source: Denizens LLC analysis of Lens, USPTO, and OECD data.

3. The Mountain West Has a Credible Opening

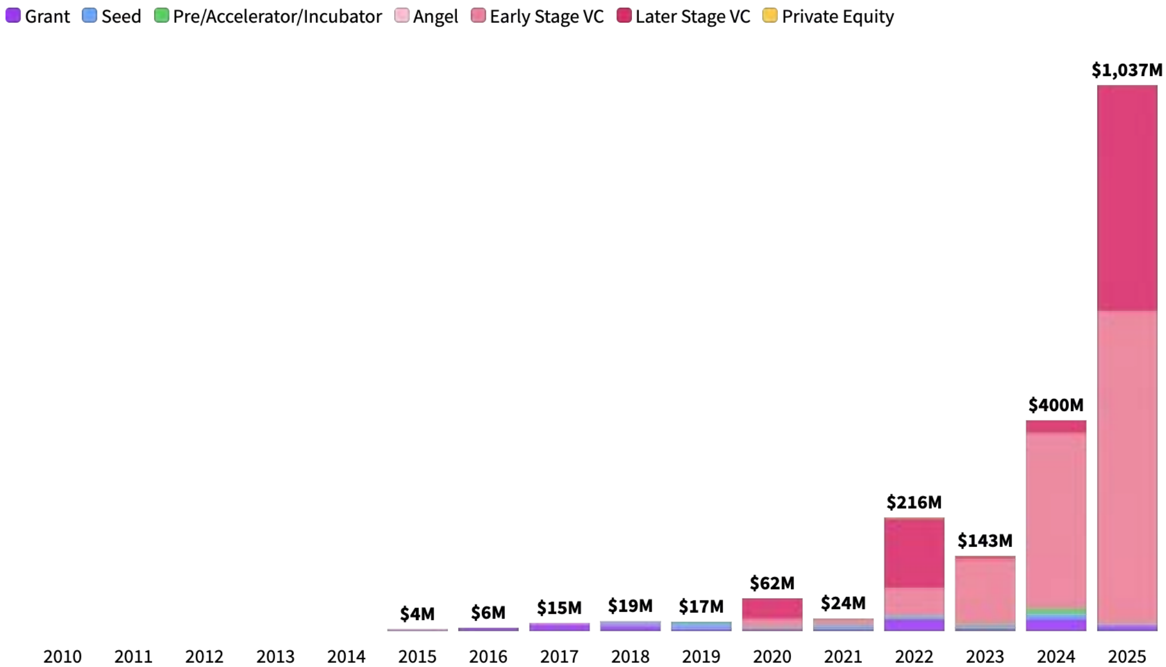
What makes the regional case stronger is not simple activity volume but the quantum field in which the region appears to specialize. On an employment-normalized basis, the Mountain West's overall quantum concentration is nearly three times the national average, with New Mexico at 3.27 times and Colorado at 2.96 times. Within that profile, sensing is the strongest domain signal, ahead of computing and communications. The platform evidence is sharper still. The region is especially concentrated in photonics, lasers, quantum gyroscopes, magnetometry, optics, and single-photon detectors. Those are not marginal categories. They sit close to the measurement, readout, stability, and control layers that often determine whether quantum systems remain impressive only in controlled settings or become credible in real ones. These strengths matter beyond sensing end markets because they are among the enabling platforms that make the broader quantum field more usable, interoperable, and commercially viable. The Mountain West's strongest signals, therefore, align with a strategically important part of the broader quantum economy: the layers where performance must become dependable, not just novel.

The region's strengths are unevenly distributed, and that unevenness matters. Colorado carries most of the region's visible scale and much of its private-sector breadth. New Mexico contributes a different but equally important form of capacity: mission-oriented engineering depth, federal laboratory infrastructure, and environments more closely associated with validation, hardening, and qualification. Wyoming belongs in the regional frame, but it does not yet function as a comparable anchor. That asymmetry is not something to smooth over. It is central to the strategic logic of the Mountain West. The region's opening lies less in uniform strength across states than in complementary roles across a two-anchor system. Colorado is better positioned as a locus of research, entrepreneurship, and platform development. New Mexico is better positioned as a locus of mission relevance, systems testing, and real-world qualification. In a field where commercialization depends on closing the gap between prototype and deployment, that division of labor could prove more important than simple symmetry ever would.

3. The Mountain West Has a Credible Opening

Startups based in the Mountain West have raised over $1.9 billion in growth capital

Capital raised by startup companies to finance growth, in current U.S. dollars



* Partial year data. • Note: Deals missing a value were assigned an investment value of $1 Million. • Source: Denizens LLC analysis of Lens and PitchBook Data Inc. data

Commercialization signals reinforce the opportunity, but they do not justify overstatement. The region's quantum invention activity has grown rapidly, at roughly 31 percent annually from 2010 to 2023, with especially fast growth in photonics and quantum programming. Its sponsor structure also points to a distinctive mix: a much larger government role than the national average, alongside an above-average presence of growth-capital-backed invention sponsors. Growth capital flowing to regional quantum startups reached $1.9 billion between 2010 and 2025, and three-quarters of that total arrived in 2024 and 2025. These are significant signals. They indicate that some pathways are becoming legible to investors and that the region is attracting meaningful attention. But they do not describe a broad, mature commercialization engine. They describe a field that is gaining momentum through a limited number of firms and pathways, under conditions where integration, qualification, and repeatable deployment remain the real tests of durability.

3. The Mountain West Has a Credible Opening

This is also where the relevance to ASCEND technologies becomes apparent. The Mountain West's quantum opportunity does not hinge on the claim that environmental applications are already a large, mature market. Instead, the Mountain West claims strengths in several of the sensing, photonics, instrumentation, and measurement layers that could extend the next frontier of advanced sensing and computation over time. In that respect, the opportunity is promising but still early. The climate and environmental potential of quantum sensing should be judged less by whether a device can, in principle, measure something than by whether the surrounding systems are being assembled: calibration regimes, field trials, qualification pathways, integration into models and decision workflows, and the institutional conditions that make better measurement trusted and usable. Its long-run position will therefore depend as much on connectivity as on technical depth. Its most plausible role is not as a self-contained cluster, but as an outward-facing node that links Colorado's measurement and entrepreneurial strengths with New Mexico's validation environments and with the national missions, industrial partners, and external networks through which advanced sensing systems become deployable in practice.

4. Implications for Regional Competitiveness

The Mountain West's position in quantum sensing will depend less on how much additional activity it can accumulate than on how effectively it connects and organizes the assets it already has. The field is globally contested, commercialization pathways are networked, and the region's own strengths are distributed across different institutions and places. The region can build a more durable advantage by becoming a well-connected node within a larger national and allied system: one that links local capabilities to federal missions, industrial primes, standards-setting environments, and external markets. Competitiveness will hinge on whether the region becomes easier for outside partners to understand, engage, and partner with.

Quantum sensing becomes economically meaningful only when it can be tested, calibrated, qualified, and integrated into real operating environments. For the Mountain West, that puts a premium on the institutions and shared assets that reduce deployment risk: field-test environments, validation pathways, metrology capacity, technology transfer, and partnerships with the large public and private actors able to absorb long qualification cycles. An innovation ecosystem developer can play a particularly important role here by building connective tissue—helping promising capabilities move from research settings into pilots, demonstrations, procurement channels, and industrial workflows. That is the kind of support that makes a region more credible to investors, primes, and mission-driven customers alike.

Because regional strengths are uneven, strategy should be organized around complementarity rather than symmetry. Colorado's scale, entrepreneurial activity, and photonics- and measurement-oriented base give it one kind of advantage. New Mexico's national-laboratory infrastructure and mission-oriented engineering environments give it another. Wyoming may yet extend regional advantage through niche specializations or testing environments. The strategic task is to make those different capabilities legible, connected, and easier to combine across places and institutions. Regions create more value by reducing the friction of handoffs. In quantum sensing, where commercialization depends on moving from prototype to trusted system, those handoffs are central rather than secondary.

4. Implications for Regional Competitiveness

Quantum sensing is best understood not as a standalone technology bet, but as part of a broader advanced-sensing and systems-integration agenda. Within that agenda, ASCEND technologies matter not because quantum sensing is already a mature environmental market, but because it offers the region a commercialization and partnership frame around advanced sensing and deployment-oriented problem sets. That makes it a plausible on-ramp for moving some quantum sensing pathways from laboratory science toward operational use. The regional opportunity, however, extends beyond ASCEND applications. The Mountain West's strengths in photonics, optics, instrumentation, control, and validation sit in enabling layers that matter not only for future environmental and infrastructure applications, but for the wider quantum field as well. The region's advantage lies in its potential to help close the gap between quantum science and deployable systems: supporting ASCEND-relevant applications as they mature, while also strengthening the platforms and commercialization pathways on which quantum sensing, communications, and computing increasingly depend.

Conclusion

Quantum sensing is becoming more consequential as the field moves closer to real-world use in domains where precision, resilience, and trusted measurement matter. For the Mountain West, the opportunity is not simply to participate in that shift, but to shape it. The region combines meaningful strengths in sensing, photonics, instrumentation, and validation-relevant capabilities—anchored above all in Colorado and New Mexico—that position it to play a larger role in the development of deployable quantum systems. Those strengths matter to the continued regional focus on development of ASCEND applications because they could extend the next generation of such technologies for environmental intelligence, infrastructure monitoring, navigation, and related decision systems. They matter more broadly because progress in sensing strengthens enabling platforms on which the wider quantum field depends. The strategic task is therefore clear: not to treat quantum advantage as a function of scientific activity alone, but to connect the region's assets to the partnerships, validation environments, commercialization pathways, and external networks through which promising technologies become trusted, fieldable, and economically meaningful.

Kendall Mehling and Catie LeDesma with an atom "interferometer" on the University of Colorado Boulder campus. Credit: Glenn Asakawa/University of Colorado Boulder.

Appendix: Methodology and Data Sources

This analysis of quantum sensing and adjacent enabling technologies is based on a structured methodology that integrates global patent data, hybrid corpus construction, geographic benchmarking, and structural network analysis. It builds on the same general methodology used in an earlier analysis of the global ASCEND innovation landscape for Innosphere, while adapting that framework to the more boundary-sensitive landscape of quantum sensing, quantum communications, quantum computing, and the enabling platforms that connect them.

Defining Quantum Technologies: Quantum patent landscapes are unusually sensitive to how the field is defined. Rather than relying on a static keyword search, this study constructed the field through a multi-stage retrieval process. A high-recall candidate universe was assembled using CPC-title screens and full-text seed terms, then refined through taxonomic and semantic anchoring, followed by iterative probabilistic NLP expansion to capture relevant inventions that static CPC or keyword rules might miss. Inventions were then non-exclusively tagged to quantum sensing, quantum communications, and quantum computing using a hybrid rule system that combines CPC-based and text-based signals.

Data Sources: Patent records were retrieved from The Lens via API export in August 2025. The export included patent family identifiers, bibliographic metadata, CPC classifications, and text used for screening and tagging. Patent party names and locations were standardized and cross-validated using USPTO PatentsView and OECD patent resources, with limited ownership-related cross-checking where needed. Data processing and corpus construction were carried out primarily in R, with conservative entity reconciliation performed in OpenRefine.

Unit of Analysis: The base unit of analysis is the invention, operationalized as an INPADOC extended patent family. Patent families were used to reduce duplication across jurisdictions and patent authorities, and inventions were assigned to the year of their earliest priority date. The analysis focuses on inventions filed from 2010 forward. Whole counts were used throughout in order to preserve overlap across domains, technologies, sponsors, and geographies.

Geographic and Sponsor Attribution: To examine global and regional positioning, inventions were linked primarily to inventor locations, with whole-count assignment used to preserve visibility into distributed invention and cross-border participation. Sponsor reporting is tied to the geography of invention rather than sponsor headquarters, so sponsor tables show which organizations appear on inventions created in a given place. The methodology also incorporates an internationalization lens that distinguishes domestically anchored activity from more internationally integrated invention and protection strategies.

Structural Analysis: Where the companion analysis extends beyond counts and shares, it uses network-derived measures to interpret technologies and platforms by role and trajectory within the broader quantum system. In particular, Generativity identifies technologies that behave like enabling platforms, while Emergence identifies technologies that appear nascent but accelerating. These measures help clarify which parts of the quantum system matter most for leverage, integration, and future growth.

Interpretation: Because domain tags, CPC assignments, sponsor participation, and geographic attribution are non-exclusive and whole-counted, disaggregated totals may exceed the number of unique inventions. The findings should therefore be read as comparative, system-level signals about specialization, participation, and position within the broader quantum landscape, rather than as definitive rankings of technical merit or exact field boundaries.

Together, these methods provide an empirical foundation for understanding the structure of the quantum technology landscape, the role of enabling platforms within it, and the Mountain West's position within this emerging domain.

The U.S. NSF ASCEND Engine connects research, capital, and industry to develop and deploy technologies that help communities better anticipate risk, protect lives, and adapt to the growing impacts of natural hazards across the Colorado and Wyoming region.

This report was prepared by Denizens LLC. For more information, please contact info@denizens.com.

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