IQBN

Official statement on

Germany’s Action Plan on Quantum Technologies

Executive Summary

Quantum technologies, including quantum computing and simulation, quantum communication, and quantum sensing, imaging and metrology have a huge innovation potential and will enable us to tackle the most pressing global and societal challenges. Impacting almost all industries from healthcare over finance to space, quantum technologies will provide prosperity, security, and sovereignty. Coordinated efforts are imperative to prevent Europe and Germany from falling behind global competitors including China and the USA, preserving its competitive edge in quantum technologies.

In April 2023, the German government unveiled the "Handlungskonzept Quantentechnologien" (eng. action plan quantum technologies) as a strategic framework for the next 4 years to 2026 with a total budget of € 2.8 bn aiming to establish Germany as a world leader in quantum technologies. As a response, QBN, the world's leading business network for quantum technologies, and its 80 members have compiled a set of key recommendations in terms of quantum technologies, as well as organizational, structural, and general issues that need to be addressed in order to make quantum technologies an industrial and political success story for Germany and Europe.

QBN's 11 KEY RECOMMENDATIONS

1. Strengthen the ecosystem through close collaboration efforts across Europe's existing national quantum programs and the promotion of Public-Private Partnerships.
2. Promote and incentivize innovation, collaboration, and competition by providing favourable conditions for entrepreneurs and technology transfer.
3. Enable commercialization by eliminating bureaucratic barriers that hinder funding for industrialization, creating incentives for product development and sales and procuring devices and software from startups and SMEs.
4. Link quantum technologies hardware development to the Chips Act and make the production of quantum chips a priority and German and European UPS.
5. Align the national quantum strategy with Germany's and the EU's green and digital transformation strategy.
6. Provide fast and uncomplicated grant awarding schemes to support young companies and SMEs and prioritize them for significant projects.
7. Eliminate the lack of private investments as a barrier for technology transfer and commercialization.
8. Foster the development of talent in quantum technologies with a priority on education and training and improved tax and visa regulations.
9. Align QC hardware, software, and real-world application development in a realistic and ambitious manner and develop a long-term disruptive vision for large-scale quantum systems (~1 million qubits).
10. Make fiber-based QKD a cornerstone of the quantum communication strategy.
11. Define clear goals and KPIs for quantum sensing, imaging, and metrology technologies and promote tailored application-oriented development.

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Introduction

Quantum Technologies

Quantum technologies (QT) leverage the principles of quantum mechanics to revolutionize numerous aspects of technology, science, and industries. They harness the unique properties of quantum systems, such as superposition and entanglement, to enable advanced computation, communication and encryption, and sensing and imaging capabilities.

Some of the key value propositions of quantum technologies include:

- Exponential speedup: Quantum computers can solve certain computational problems exponentially faster than classical computers. This makes quantum computing valuable for applications such as optimization, machine learning, and cryptography.
- Secure communication: Quantum cryptography provides secure communication channels that are immune to eavesdropping, which is important for protecting sensitive information and infrastructures in industries such as finance, defence, and healthcare.
- Improved precision and sensitivity: Quantum sensors and imaging devices can measure extremely small changes in physical properties such as magnetic fields, allowing for higher precision and sensitivity in various fields including medical imaging, environmental monitoring, and mineral exploration.
- Novel materials and devices: Quantum materials and devices have unique electronic and optical properties that could enable new applications in electronics, energy, and materials science.

These technologies hold immense potential for transforming industries, addressing computational challenges, and unlocking new possibilities in research and innovation.

Quantum Technologies Public Funding Programs in Germany and Europe

The European Union (EU) launched the Flagship Initiative on Quantum Technologies (Quantum Flagship) in 2018. Building on Europe's excellence in quantum research the € 1 bn research and innovation initiative aims to consolidate and expand scientific leadership and excellence to kickstart a competitive and strong quantum industry.

The German government allocated a significant sum of € 2 bn in 2020 to bolster quantum technologies, building upon the existing € 650 million framework program. The goal behind this substantial investment was to enhance the technological sovereignty of Germany and Europe in a cutting-edge key technology.

On April 26, 2023, the German government unveiled the "Handlungskonzept Quantentechnologien" (eng. action plan quantum technologies), with the aim to establish Germany as a world leader in quantum technologies and secure sovereign access to this important future technology. The action plan developed under the leadership of the BMBF with contributions from BMWK, BMF, BMI, BMVg, BMG, and BMDV and with a total budget of € 2.8 bn, including € 850 million from the science organizations co-financed by the federal government will serve as a strategic framework for the next 4 years to 2026.

The Action Plan for Quantum Technologies Does Not Meet the Challenges.

QBN welcomes the action plan and the coordination between the German ministers. The government's investment in quantum technologies is commendable and both Germany's and Europe's young quantum economy is generally in good shape. But since it's still at risk falling behind international competitors there are certain areas that need development and others that require reconsideration.

Given the huge innovation potential of quantum technologies, their deep economic & societal impact as well as their indispensability for national and European sovereignty and security; considering the current leadership of China and USA in all critical technologies including advanced manufacturing, artificial intelligence, computing and communications, energy and environment, quantum technologies, biotechnology, gene technology and vaccines, as well as sensing, timing and navigation and defence, space, robotics and transportation (source: Australian Strategic Policy Institute, Critical Technology Tracker, Report No 69/2023); and taking into account the tax money Germany & the European Union spend in deeptech underlying education of their own and foreign citizens (EU vs USA: deeptech graduates +14%, Spinoffs -30%, Deeptech Unicorns -75%), in funding research and development in science and industry with great research results and in financing the foundation and initial steps of startups; if we look at this realistically and really want to achieve our goals, then we need to do better to ensure successful, fast and sustainable technology transfer including the commercialization, the exploitation the commercial results and the guarantee that knowledge and businesses will stay in Germany and the European Union.

Key players in the field can play a crucial role by advocating strategic alliances and collaborations among national governments and the European Union. The EU Strategic Foresight initiative of 2022, particularly the integration of the green and digital transitions in the evolving geopolitical landscape, offers a forward-looking and comprehensive perspective on the interplay between these twin transitions leading up to 2050. The radically transformed European security and political landscape necessitates a careful examination of how quantum technologies can address present and future challenges. Accordingly, Germany and the EU must reassess its global role to safeguard its prosperity and security effectively. Focused research efforts in these areas are crucial. This entails enhancing science diplomacy, strengthening security capabilities, and developing instruments to tackle security issues collectively across the union. Thus, a

concrete roadmap in the quantum sector for implementation of projects with specific milestones, budget planning and functions must be drawn up.

Therefore, QBN calls for better defined goals and indicators as well as more concrete measures in the strategy, that goals are very general and vague in some areas. It is not very advisable to first concretize such an important strategy in its individual measures, as this inevitably means that these are not perfectly coordinated, and all pursue a vague goal. In addition, applications of quantum technologies need to play a major role through a parallel approach to technology development but aligned with hardware and software development. That includes the development of competences on the end-user's side. Also, the integration of quantum technologies in existing (IT) infrastructure is left unclear in the span, to only name a few.

For such an important topic a closer and permanent coordination of the strategy in terms of goals, measures, and timeline between the German ministries, avoiding private interests as in the past but working together as close as possible, and with EU strategy as well as with the EU member state initiatives is absolutely necessary and essential. We can only achieve our goals together.

QBN’s Recommendations

QBN calls on the federal government to launch and implement a bold and ambitious strategy that meets global challenges in the main priorities for the coming years. In the following, the most important points in the areas of quantum technologies and applications as well as organizational, structural and general barriers and opportunities are presented, which are missing in the strategy or should be adjusted. It is recognized that some of the recommendations go beyond the competencies and powers of individual ministries and require extra efforts and close cooperation and should be complemented with more diverse experts. These overarching and not just technological measures are seen as indispensable for the successful development of a strong quantum industry. In this way they will simultaneously promote deep tech and high tech as a whole and thus represent an important pillar of Germany's future location.

Quantum Technologies & Applications

Quantum Computing

Hardware and software development should be chronologically aligned in a realistic and ambitious way. It is important to develop applications and real-world use cases because of multiple reasons, not at least the acceptance in industry and politics, and finally most commercial gain once developed will be in software, but the strategic resource is in the quantum hardware (see impact of Google AI or IBM Quantum in recent years).

A 100 qubit-based quantum computing stack in 2-3 years is still not more than a demonstrator and will not really strengthen the German approach. IBM for example is already putting out a 433 Qubit system now, Google is showing first steps in direction of a few logical qubits (surface code) and topological protection (braiding of non-abelian anyons). Therefore, we recommend to not just trail behind the other strong quantum computing regions and already existing quantum computing systems, and Germany and the European Union should not only focus on short to mid-term ~1000 qubit systems, but have a long-term pathfinding, disruptive vision on really large scaled systems ~1 million qubits.

In addition, quantum computing hardware development needs to be closely linked to the Chips Act including a strategy for pilot lines, since among others silicon spin qubits, superconducting transmon qubits and linear optical quantum processors can be manufactured by Complementary Metal-Oxide-Semiconductor (CMOS) compatible means. Right now, almost no traditional semiconductor industry has really quantum computing chip manufacturing on the official roadmap, and it makes economically no sense to produce computer chips in Germany for laptops that are made in Asia. QBN sees a great opportunity for Germany by clearly defining the strategic purpose of the national semiconductor industry and the type of chips we want to produce. The alignment of this definition with the economic and technological goals of Germany and the European Union leads directly to the high priority of quantum computing chips and such for our local machine builders, car manufacturers and providers of crucial telecommunication technologies.

In terms of software and application development, QBN sees a main priority in coordination with the hardware development roadmap considering independencies to attract industry. The ministries aim for a largely from public funding independent within the next 3-5 years. Therefore, the goal of having 60 end-users is not enough since we are close or already over this indicator, depending on the definition. But nevertheless, it is especially nearly not enough to have a market for quantum companies.

Quantum Communication

Fiber-based quantum key distribution (QKD) will provide the highest secure key rates and availability for securing internet data transmission also taking the existing infrastructure into account. We want to state that at first sight in the document provided, fiber-based QKD implementations are invisible. It is in the interest of QBN and QKD manufacturers like KEEQuant and especially of the German government to establish a much better visibility. Whereas satellite-based QKD will provide long-distance links with limitations in performance and availability, fiber-based QKD will provide the bulk of future key material and services. Fiber-based QKD must become one of the cornerstones of the quantum communication strategy.

Furthermore, in the same part of the document we observe a large abundance (4/9 points) of post-quantum cryptography (PQC) implementations. PQC protects, to the best of our knowledge, against well-known attacks performed by quantum computers on deployed cryptography, however it does not provide provable security or long-term security of key exchange (see QBN whitepaper[1]). It is therefore of utter necessity to deploy PQC as soon as possible. However, from the quantum technologies and QBN's point of view, PQC is not a quantum technology but rather a set of classical algorithms running on classical computer hardware. PQC is currently being implemented by providers of classical security products, and first PQC products are already available. We would therefore argue that PQC should not be part of the quantum technologies action plan. PQC should rather be part of a more general security strategy that is already established by security key players like the BSI. Of course, this more general security strategy should link to the quantum action plan to ensure the smooth integration and collaboration of PQC with QKD devices for hybrid use cases, which is the most realistic implementation for future high security data networks.

QKD key management and network integration are a cornerstone of any future application of quantum cryptography. Good progress is being made in public-funded national and EU research projects. However, sustained support will be necessary to allow widespread adoption of this security relevant quantum technology.

As a native cybersecurity technology, QKD requires a broad ecosystem of organizations encompassing the fields of security certification and government approval. This encompasses the NCSAs like BSI who set the requirements, along with the organizations performing the actual certification work, all the way to the public or private purchasing departments for cybersecurity products. Their respective employees need a certain

[1] QBN Whitepaper on Quantum Cybersecurity and Secure Communications, https://qbn.world/qbn-whitepaper-on-quantum-cybersecurity-and-secure-communications

amount of quantum cryptography training in order to take the right decisions, and as such a dedicated workforce is paramount. Only under these conditions, Germany and the EU will remain sovereign and prosperous in the quantum future.

Quantum Sensing

Quantum sensors as well as quantum imaging and metrology technologies are underestimated and underrepresented in the action plan. The global annual revenue of quantum sensors for magnetic fields alone is projected to rise to over $1 bn by 2029 with more than half of that market in the health care sector according to a market study by Inside Quantum Technology. Appropriate research and development can guarantee Germany a significant share of this emerging global market. Sensors are always the hidden champions connecting the digital with the real world and they are crucial for national security. Quantum sensor technology has far-reaching prospects for industry, research, medical technology, etc. Hence, the exploration of the possibilities in a wide variety of applications, including completely new ones, should be promoted. Especially because of the huge technological potential but the almost unknown potential applications in industry it is advisable to define clear goals and KPIs for quantum sensing, imaging and metrology technologies and to develop them with tailored application-oriented measures and in close collaboration with industry end users.

Some areas of application for quantum sensors were even not mentioned in the action plan. For example, quantum sensors can make major contributions to materials science and improvement, especially through imaging magnetic field measurements on small scales, and provide a better understanding of material fatigue processes. Quantum magnetometry can make major contributions in the transition to electromobility (electric motors, monitoring, etc.) and in battery research and improvement.

Nitrogen vacancy (NV) centers or color centers in particular in diamond, as a technology that has been extensively researched in Germany, should also be promoted in the transition to new developments and applications in order to use Germany's technological advantage.

Organizational Aspects

Startup & SME Support

Startups and SMEs play a crucial role in the commercialization of quantum technologies in Europe and in Germany. First startups can create technology and supply chains that simply do not exist, and which are in other countries like the USA completely covered by large IT companies. Second, their agility, innovative mindset, and ability to quickly adapt and bring novel applications to market constitute the fastest vehicles of comprehensive technology transfer. SMEs are a driver of innovation and represent a strong economic basis in Germany in both development and industrial application of quantum technologies; but due to chronic lack of resources and surrounded by a low-risk-mindset, their dear potential is difficult to unlock.

On a positive note, there is a focus on supporting German startups in the action plan that hopefully can also leverage synergies with the German Startup Strategy that was adopted in 2020 by the cabinet. In addition to these efforts, we recommend a fast and uncomplicated grant awarding scheme for young companies in order to ensure that they can focus on technology and product development. Furthermore, it is imperative to prioritize and support German startups and SMEs by allocating significantly sized projects to them. By providing substantial opportunities, including projects with profit margins, the government can play a pivotal role in establishing a startup culture even within large companies. Addressing this issue is crucial as it is seen as a major competitive disadvantage for Germany compared to the United States. While this transition may require some time for preparation, it is a path worth considering fostering innovation and entrepreneurial growth in the country.

Commercialization

As outlined above, the commercialization of our brilliant research results is key to achieve the goals set by the German government. We have open questions regarding the very general and academic approach to this incentive. Instead, we push towards an approach of clear signals, decisions, and concrete measures from the ministries in charge. Commitment to commercialization means eliminating bureaucratic barriers that only allow funding for precompetitive research and buying intellectual property from young companies. These barriers force startups & SME to leave their track of developing prototypes and securing their IP. Rather, they are incentivized to produce research results instead of sales for the company. They also keep potential entrepreneurs at universities and RTOs due to the great research opportunities and missing incentives to think about commercialization.

Talents & Workforce

To foster the growth and successful implementation of quantum technologies, it is crucial to prioritize the development of necessary talent and keep them in the country. We observed some progress in closing the talent gap, but it's still challenging for the emerging quantum industry to find talents and they also expect some shortage in the long term. This includes addressing the workforce requirements including those for security certification in quantum communication. From NCSAs like BSI to network operators, there is a strong need for people who understand aspects of QKD in order to implement the technology widely.

Due to the complex and non-intuitive nature of quantum physics, incorporating quantum technology education and training elements into various disciplines and industries are recommended to ensure early a deep understanding of at least the application potential of quantum technologies across future potential users and key enabling technology developers.

In order to attract talent, to compete with large US companies or attractive industries including consulting and finance, and to be able to keep building talents and startups, the access to employee participation and early-stage venture support should be facilitated through improved tax regulations and enhanced visa regulations.

The German innovation potential in quantum technologies in particular and deeptech in general would highly benefit from showing STEM students, especially physicists, an alternative career path to academia, like an industry or entrepreneurial career. The establishment of stronger connections between academia and industry would not only provide STEM graduates with business and industry experiences and thus grow the future quantum technology innovators, but it will also drive the technology transfer and collaboration impact from in short to long-term.

Funding

Public Funding

Public funding is crucial to enable new research results in quantum science and technology and to stimulate technology transfer in deeptech including quantum which is why we welcome the action plan with a budget of € 2.8 bn up to 2026. However, the budget is not on top of the previous initiatives but already-allocated money which makes the process less transparent and it's not clear what previous goals were abandoned and replaced with the new strategy. Furthermore, the action plan still uses the same funding instruments.

QBN strongly recommends an extensive mixture of quantum/deeptech-tailored political funding instruments with transparent budgets, processes and goals. That includes a purchasing strategy for "early products" which startups are capable of providing, in contrast to "established products" which they cannot provide (yet). This can be partially compensated by public money invested directly into procurement of devices and software from the startups. This "100% financing" strategy will provide a more reliable early market, and therefore a basis for further growth and existence of the companies. It will prove sales and traction, which in turn lowers risk and therefore eases VC investment decisions. This includes low-TRL devices and software which may lack highest performance, long-term reliability, full functionality, and which may require extensive support by the startup and/or the operator/customer, or even be in a prototyping stage. For many companies and the whole quantum industry, this will bridge the gap over the valley of death of startup financing and the commercialization in general.

Furthermore, the recent BMBF funding in tools and infrastructure with the QNC-initiative would need a parallel project funding program to utilize those investments (pilot lines).

Another assumption is that universities and RTOs including Fraunhofer and Max Planck are expected to have all necessary technology expertise for commercializing a quantum technology. This is true for a fraction of expertise needed e.g., in experimental physics. In the area of theory, algorithm design and software development startups note the inverse situation of companies training the institutions.

In addition, as a consequence of Fraunhofer's inability to leverage their MP3 research results, some organizations hold on to their knowledge and intellectual property in a way that significantly slows or completely hinders technology transfer. A better framework including incentives for science organizations is needed, as well as increased fundamental research funding for start-ups and SMEs. This should take into account the risk of

fundamental research because transfer is not exclusively from universities and RTOs to companies. Simultaneously the long-term transition from building the talent base in academia to a value-creative basis of future talents and workforce in industry would be stimulated.

Private Funding

The obvious lack of VC funding in Germany and Europe is one of the main barriers in technology transfer and commercialization of quantum technologies and slows down the transition of a quantum science community to a quantum industry. Early markets with proven sales and traction for startups, e.g., through more direct procurement, are prerequisite to attract and stimulate private investors. In addition, we strongly recommend educating potential private investors by increasing the knowledge about deeptech and in particular quantum technologies and creating better incentives for long term return of investments (ROIs).

QBN strongly recommends addressing the following issue: The High-tech Gründerfonds (HTGF) is focussing on high tech startups including those developing quantum enabling technologies and quantum technology suppliers like cryogenic system technology or single photon emitter technology with probabilistic revenue stream from academia customers. But quantum technologies including quantum computing, quantum sensing and quantum communication startups that address non-niche markets with substantial size will probably have no or less revenue in the next 2-3 years are out of scope. On the other hand, the deep tech and climate fund invests in companies that already have a customer base, which is an important "gap" but affects the "older" and "established" startups. So, the gap for quantum computing, communication and sensing startups remains the same in Germany. To solve this crucial issue, a fund of funds specialized in quantum and deep tech with significant government backing is needed. We demand the German government to set up the legal framework for pension funds to invest in startups, in a way that the entire society will take part in the decisions and the profits.

Structural Aspects

Ecosystem, Supply Chain and Infrastructure

QBN welcomes the third pillar addressing the creation of suitable conditions for a strong quantum ecosystem, because a strong ecosystem, fruitful collaborations and sustainable and holistic infrastructures are key to reach the goal of technology sovereignty and a strong industry. Germany would benefit from an even stronger focus on proactively shaping the European ecosystem and speeding up collaboration efforts across Europe's existing national quantum programmes. In order to compete with China and the USA, we need sustainable and complete supply chains that can only be fully achieved within the EU, not within member states. To achieve this, funding of joint research of industry and academia, research orders by DLR and focused networking events are nothing new; of course, it's the fundamental basis, but not enough.

It is essential to promote more Public-Private Partnerships in the quantum sector. Quantum computing companies are at the forefront of technological advancements and

thus capable of facilitating the transfer of technology and innovative solutions to address societal challenges. This exchange of knowledge and resources can drive the development of new technologies, products, and services that have a positive impact on society. This exchange of knowledge and resources accelerates the development of new technologies, products, and services that positively impact society. Moreover, collaborations enable rapid scaling and implementation of solutions on a large scale, leveraging government infrastructure, regulatory support, and reach. Such partnerships also stimulate economic growth, create job opportunities, and attract investments to foster entrepreneurship and sustainable development. By working together, businesses and government ensure that the emerging field of quantum technology is established on a foundation of fairness and ethical practices. Governments play a crucial role in setting regulatory frameworks, standards, and incentives to promote wider corporate social responsibility and ethical standards in these fields. Thus, it would be necessary to establish a unified ways of working on quantum technology at the EU level.

However, networking events focusing on specific topics, providing the environment for knowledge and technology transfer and the initiation of collaboration as well as addressing current and future trends in R&D and business are already organized by QBN on a regular and professional basis. We believe, combining forces and building on existing networks and initiatives like QBN and SQuaD, instead of even more and doubled activities, pave the way to success. One can say that competition creates better actions, but the opposite is the case since ecosystem stakeholders, in particular SMEs and potential end-users cannot distinguish between the flood of events and activities and a higher quantity usually comes with less quality, to the chagrin of everyone and ultimately the actual goals.

The same can be observed with the regional quantum hubs and valleys that are of big advantage for regional stakeholders, which need closeness to physical labs, equipment and infrastructure. On the regional scale funding easier access for startups and academia to large infrastructure, similar to the FMD/QNC-initiative but more focused on promising QC-concepts, would be beneficial. Considering the big picture of Germany’s strategy and the experience from other key enabling technologies like photonics, location promotion, missing coordination and collaboration between the hubs and valleys creates “small kingdoms'' which is highly counter-productive for technology development and collaboration, increases the costs for the federal government and makes it partly harder for potential end-users to approach quantum technologies.

Since the transfer from a public funded community to a sustainable and self-supporting industry with strong companies is crucial and of high priority for the German government, we need to stimulate the creation of markets and therefore much more quantum companies to collaborate with each other (companies & universities) for application development. A realistic view on the collaboration activities of successful quantum companies reveals knowledge and technology transfer as well as collaboration happening on a global scale. Hence, the benefit of regional clusters became limited over the past decades due to an even more globalized and digital world and global clusters gain importance, so for quantum technologies.

In addition, if technology transfer, innovation support and commercialization is of high priority, it is advisable to involve more industry experience not only in the technology development process, but also in the development of ecosystems, innovation hubs and transfer agencies instead of commissioning universities or research institutions and in general scientific staff with such crucial tasks. In order to foster ecosystem building, technology outreach, and knowledge and tech transfer, it is essential to involve organizations beyond universities. Often, universities lack the necessary resources, expertise, and mission to fulfil these roles. By enabling organizations that are not universities but have valuable expertise in innovation support and ecosystem building to apply for substantial funding and involve them in the entire process, we can leverage their expertise and resources to drive ecosystem development and facilitate knowledge and technology transfer.

As pointed out in the technology section, it is also important to give a focus on the actual (chip) manufacturing of scaled concepts, so that the process is ready for industry and easy transferable. Therefore, Germany can use the existing and growing microelectronics and semiconductor ecosystem, e.g., in Saxony and Bavaria and directly involve German and European foundries and integrated device manufacturers. This is not only a big chance from an industrialization perspective but for Germany in particular to become the manufacturer and global supplier of future chips.

Governance

Fostering an entrepreneurial state pushes the boundaries of innovation and addresses the reluctance of universities towards embracing it. To foster an environment conducive to innovation, it is crucial to implement policies that promote competition and provide favourable working conditions for entrepreneurs. This includes ensuring an innovation-friendly competition policy that encourages healthy competition among businesses.

In addition, there is a need to optimize patent law specifically for universities, we can incentivize innovation and collaboration between academia and industry and thus stimulate technology transfer and the commercialization in particular of quantum technologies and deeptech in general. Moreover, offering tax reductions for profits generated from patents would further encourage industry to invest in research and development and thus accelerate the transfer and increase the innovation potential of Germany.

To support deeptech and thus quantum startups and industrial research and development (R&D), it is essential to provide interest-free or reduced-rate loans. Accessible and affordable financing options would enable these startups to focus on technological advancements and drive innovation in the field of quantum technologies. Incentives such as tax benefits for direct financing of R&D projects at Research and Technology Organizations (RTOs) and startups through industry partnerships would create a mutually beneficial collaboration. By involving big companies in R&D endeavours, knowledge sharing, and resource pooling, we can accelerate the pace of innovation and bridge the gap between academia and industry.

To create a ground from which the European quantum sector can flourish, we need measuring standards for further cooperation within the industry. Co-operation between different European suppliers could create positive outcomes on a wider level, but this necessitates united standards of working and measuring the success of the work. This is not only critical given the global competitive landscape but also for ensuring shared data security, robust supply chains, and adherence to common values and trust within the union. Such alliances also promote equal opportunities within the EU, aligning with broader European values of equality. To gain a genuine competitive advantage, it is vital to foster shared knowledge and expertise within research and development (R&D), academia, and business agendas. Other critical area is standardization of governance. It important to recognize the value of startups in emerging and critical fields and take concrete actions at the national and European levels. One approach is implementing tax optimization measures, such as providing tax-free status for startups during their initial 2-5 years, as these stages are often the most critical for their development. Laws should be enacted collectively to foster an ecosystem that goes beyond isolated hubs.

To ensure fair competition and harmonized framework conditions, it is vital to safeguard a level playing field across the EU27 states. This includes establishing transparent investment screening and export control mechanisms to avoid any unfair advantage or security risks. Improving the regulatory framework would provide clarity and stimulate better collaboration, trade, and export opportunities with countries like the UK, Switzerland, and others. Such a workable mechanism to engage with European quantum players in the UK and Switzerland would create a 'geographic' European market of meaningful size.

Standardization

Despite the numerous ongoing standardization efforts in various sectors, small startups often face a significant challenge: a lack of manpower to make meaningful contributions. These startups are the main drivers of the commercialization of quantum technologies in Germany and Europe, brimming with innovative ideas and potential, require specialized funding to overcome this hurdle. By providing targeted financial support, specifically tailored to the needs of small startups, we can empower them to expand their workforce and execute their ideas more effectively. This, in turn, would enable startups to drive innovation and make significant contributions to their industries.

General Aspects

QBN would welcome more transparency, providing information on budget allocation and expenditure until 2026. This includes understanding which organizations are responsible for specific technologies, such as whether the German Aerospace Center (DLR) focuses solely on quantum computing or also funds projects related to quantum communication and quantum sensors. Clear visibility into these details helps in understanding resource distribution and within the quantum sector.

To set realistic expectations in industry and the broader public about the technology and development timelines and thus support the commercialization process, outreach

activities should be conducted to engage the broader public and potential end-users. These activities aim to educate and inform about the potential benefits and limitations of quantum technologies, aligning expectations with the current and planned state of the field.

In general, accelerating these programs and the awarding process is highly recommended. Money would have to be awarded quickly now that a 3-years project could start at the beginning of 2024, considering hiring, material orders etc., especially to have products on the market (point 5 quantum sensing) these projects should actually already be running.

Since the mid-term goal is an independent and sustainable quantum industry that no longer needs extensive public funding, the question, how can we achieve a suitable market after these three to four years with this action plan, remains open and should be the leading thought for the development and implementation of further measures.

Conclusion

In general, QBN welcomes the strategy for the next few years and the long-term vision until 2036. The action plan includes beneficial and necessary measures. However, there are concerns about falling behind international competitors and the need for development and reconsideration in certain areas. To unfold Germany's innovation potential and create significant economic impact, and sovereignty, we emphasize the importance of a bold and ambitious strategy to address global challenges and overcome barriers for the successful development of a strong quantum industry. QBN seriously believes that more is needed to manage the transition from a public funded community to an established quantum industry and markets.

QBN has a proven track record in ecosystem building and innovation support as well as the structures. Together with currently 80 members, QBN represents an extensive network and resources, and thus is happy to support the coordination and implementation with a proactive approach for all fields of quantum technologies. We will keep working with conviction and passion to build a strong quantum industry in Germany and Europe.

About QBN

QBN is the world's leading business network with around 80 members that promotes networking, business creation and the development of organizations working in the field of quantum technologies and its value chains. We provide our members with growth acceleration and technological advancements through industry collaborations, deep market insights, increased visibility and supportive structures, business development, technology transfer and innovation support as well as entrepreneurial mentoring and fast access to private and public funding.

In our working groups on quantum computing and applications, quantum communications, quantum sensors and diamond quantum technologies as well as with our standardization and unique networking activities, we bring together people from industry, science and politics, connect them with the entire value chain and provide them a supportive platform to build a strong Quantum Industry together.

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