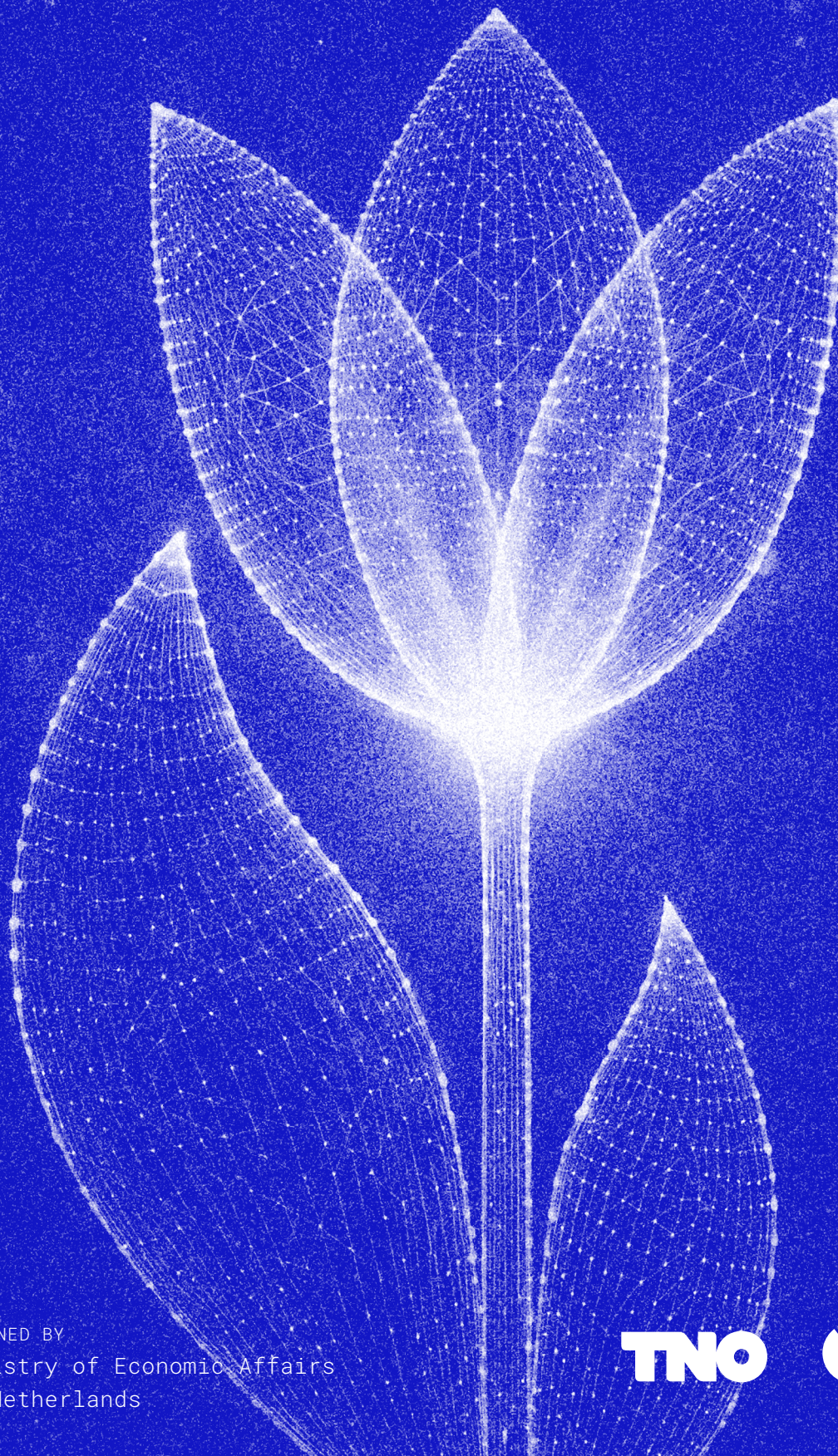


A QUANTUM NETWORK VISION FOR THE NETHERLANDS



COMMISSIONED BY
The Ministry of Economic Affairs
of the Netherlands

TNO

 **QDNL**

Executive Summary

Quantum networking is a sovereign capability: it will amplify the power of future quantum computers and it may provide additional protection against quantum enabled cyber attacks. By mastering this technology, and creating control points^a, companies and countries can protect their strategic autonomy, reduce dependence on foreign solutions, and reinforce their global influence.

Quantum communication is also an economic opportunity. The Wennink report¹ identified it as a key investment area to secure the country's future earning capacity. The Netherlands holds a strong starting position: it is one of the few countries combining world-leading (applied) research, early quantum network deployments, and a dynamic startup ecosystem.

Yet the market is still emerging: user needs remain unclear and demand is uncertain. Meanwhile, the race is already on: major powers are investing at scale. We have a narrow window of opportunity to convert scientific excellence into commercial leadership. Our startups must be able to compete

with American digital giants and China's state-driven ambition. To succeed, we must overcome the Netherlands' structural difficulty in converting academic advances into sustainable commercial success.

This paper, developed by QDNL and TNO in consultation with experts and the broader ecosystem, proposes a path forward aiming to establish the Netherlands as Europe's centre of gravity for quantum networking and to cement its strategic influence. It lays out a vision, defines a strategy, and identifies the actions the government can take to support this ambition. The approach puts the user at the centre. It seeks to initiate a viable commercial cycle by investing today in technology and infrastructure while proactively generating demand. Ultimately, it shows how quantum networks can strengthen the Netherlands' economy, sovereignty, and geopolitical leverage over the next decade.

^a Resources that provide a competitive advantage and are of economic importance to a specific company/country/party.

STRATEGIC VISION

In 10 years, the Netherlands has user-centric quantum networks:

Leading in the
deployment,
exploration and
adoption of
use cases

Propelling
an industrial
ecosystem that sets
global benchmarks in
targeted quantum
internet domains

Providing Europe
with a durable source
of geopolitical
leverage

From cryptography to new computational frontiers

Quantum communication enables the transfer and exchange of quantum information, unlocking capabilities beyond conventional digital systems. Its applications span secure key distribution for encryption^b, precise and rapid coordination across networks^c, location authentication^d, secure remote quantum computation^e, and connecting quantum computers for enhanced computational power^f. Together, these form the foundation of the quantum internet, extending from cryptography to future paradigms that will transform sensing, timing, and computational infrastructure. Yet the field remains before its “World Wide Web moment”: quantum key

distribution is deployable today but not certified yet for operational cybersecurity, and entanglement-based applications are still transitioning from research demonstrations to practical utility. The use cases, market demand, and commercial viability for many quantum internet services are now ready to be explored.

^b quantum key distribution

^c quantum-enhanced time synchronisation

^d quantum position verification

^e blind quantum computing

^f distributed quantum computing

We stand at a critical turning point

Quantum technologies are at a pivotal moment. The Netherlands has become a global leader in quantum research and has built the foundations of a competitive industry. But the international race is accelerating. National investments are intensifying. Major countries are developing their own quantum network technology and supply chains and tightening the links between research and industry. To stay competitive, the Netherlands must act with speed and focus, leveraging Europe’s ambition to become the quantum continent.

EUROPE LEADS ACADEMICALLY AND NOW NEEDS TO BUILD ITS INDUSTRY

The European landscape is evolving rapidly, driven by strong research and a clear ambition

to accelerate industrialisation. On the policy side, the Quantum Europe Strategy, released in July 2025, reaffirms Europe’s commitment to a leading position in quantum technologies². It addresses key structural weaknesses, including fragmentation, limited scale-ups, and insufficient access to private capital. The forthcoming Quantum Act will translate this strategy into a concrete legal and financial framework.

Meanwhile, tangible progress is taking shape.

EuroQCI is being deployed across Member States to secure sensitive data through quantum communication infrastructures³ with active involvement from major European telecom operators: Deutsche Telekom, Orange, Telefonica, Hispasat, and SES. Efforts are now extending to cross-border links and

space-based quantum key distribution, notably through the Eagle-1 and the SAGA missions⁴, and a few country-specific initiatives to address security certification⁵, a key barrier to the adoption of quantum key distribution.

Looking ahead, beyond EuroQCI and its cybersecurity applications, Europe is preparing the next generation of quantum networks: a general-purpose quantum internet, that distributes entanglement to connect quantum devices and provides networking capabilities such as ultrafast coordination. This ambition is led by the Quantum Internet Alliance (QIA)⁶, with TU Delft at the helm, and further supported by the Quantum Internet Initiative (QI²), which aims to turn this scientific leadership into industrial capability through Pilot and Open Access Facilities.

THE US CAPITALIZES ON ITS DIGITAL GIANTS AND ITS FEDERAL, SCIENCE-FIRST STRATEGY

With the National Quantum Initiative Act (2018), the United States established a federally coordinated framework to accelerate quantum R&D across agencies such as NIST, NSF, DOE and NASA⁷. Federal guidance reflects a long-term capability-building strategy, emphasizing sustained foundational investment, interagency coordination, testbeds and public-private partnerships^{8,9,10}. In networking specifically, the DOE “Blueprint for the Quantum Internet” sets out a roadmap for scalable entanglement-based networks¹¹, while NIST develops key enabling technologies, including single-photon sources, detectors, and quantum repeaters¹². These efforts build on earlier demonstrations such as the DARPA Quantum Network and are complemented by ongoing research in terrestrial and space-based quantum communication^{13,14}.

Industrial momentum is also growing. North America is expected to hold the largest market share by 2035¹⁵. Major firms such as IBM and Cisco are collaborating on networked, fault-tolerant quantum computing¹⁶ skipping quantum key distribution deployment, in contrast to Europe. Through

recent acquisitions of five quantum networking companies, including one active in space, IonQ has also declared a strategic shift from quantum computing to interconnected quantum infrastructure (evidenced by its acquisition of Lightsynq and ID Quantique^{17,18}).

Together, these initiatives reflect a comprehensive U.S. model that integrates federal strategy, national laboratory testbeds, space-enabled quantum communication capabilities, and commercial scaling.

CHINA PURSUES ITS OWN PATH WITH DETERMINATION

China has made quantum communications a national strategic priority, embedding it in its 14th Five-Year Plan and long-term objectives for 2035¹⁹. Quantum technologies are identified as core areas for sustained R&D investment²⁰, supported by strong government coordination and large-scale financing mechanisms, including the National Venture Guidance Fund²¹.

Academically, China has demonstrated global leadership, notably with the Micius satellite which showcased, as early as 2017, space-to-ground quantum key distribution in two different forms, prepare & measure and entanglement.

Implementation has been equally ambitious, focusing for now on the security use case. Under the leadership of the Ministry of Science and Technology, China has built the world’s largest quantum communication infrastructure. The initial 2,000km Beijing–Shanghai backbone, deployed in 2017²², has expanded into a nationwide infrastructure integrating metropolitan and intercity networks through terrestrial fibre backbones and satellite links²³. Independent analyses confirm quantum key distribution networks over distances exceeding 12,000km, supported by a policy framework that enables both research and large-scale deployment²⁴. On the space side, China currently operates the pioneering Micius and the newer Jinan-1 (2022), whose smaller size and improved performance

signal a shift toward scalable, low-cost, constellation-ready satellites. On the industrial side, companies such as QuantumCTek²⁵ and China Telecom Quantum Group²⁶ have translated this momentum into (quantum key distribution) commercial services, reaching millions of users - underscoring a level of commercialisation and user deployment uncommon outside China²⁷.

The key findings from the global benchmark across the US, Europe, and China are summarised in the table below, setting the context for the Netherlands' positioning.

	EUROPE	UNITED STATES OF AMERICA	CHINA
STRATEGIC MODEL	Public-private, coordination-heavy	Federally coordinated, R&D-led with strong industrial lobby	State-driven, top-down deployment
INDUSTRY	Numerous, specialized, quantum native start-ups + few classical leaders moving to quantum (telecom operators, space primes)	(classical) Digital champions entering the market + quantum native startups	State-backed champions with constrained international penetration
INFRASTRUCTURE	Being deployed (quantum key distribution), with challenges induced by interoperability and transnationality	Experimental testbeds for quantum internet (national labs, metro networks)	Large scale deployed networks (quantum key distribution, fiber + space)
MAIN TARGET SEGMENT	Under exploration, with a current common denominator around sovereignty	Open in federal R&D, focused on the industrial side on networked quantum computing	Security
ROAD TO MOONSHOT	Scale quantum key distribution, evolving toward the quantum internet	Quantum internet only, no quantum key distribution	Scale quantum key distribution, evolving toward the quantum internet

THE NETHERLANDS: A LEADING CASE OF EUROPE'S SCALE-UP CHALLENGE

In this arena, the Netherlands stands at the forefront of Europe's quantum communication transition. It has built a dynamic quantum startup ecosystem²⁸, anchored by leading institutes such as QuTech, QuSoft, TU/e, and the universities of Twente and Leiden, and strengthened by TNO's classical and quantum engineering capabilities. This is supported by a strong photonics ecosystem²⁹, a key enabler for quantum network technology. Yet global competition is intense. The startups must convert scientific excellence into scaleups capable of challenging American digital giants, which benefit from established customer bases, global distribution power, and sustained federal support.

The Netherlands also benefits from strong expertise in laser satellite communications and industrial production capabilities, particularly in optical inter-satellite links and user terminals. Yet, translating this know-how into competitive quantum products remains a key challenge. In parallel, Europe's experimental space-based quantum communication programmes are primarily implemented through ESA, where the Netherlands' limited financial contribution restricts early industrial positioning.

Still, national documents, including the Wennink Report³⁰ and the National Technology Strategy³¹, highlight quantum as a critical technology where the Netherlands can develop high-tech niches and capture economic value through strategic investments. Concrete progress is visible: metropolitan quantum networks in Utrecht, The Hague–Amsterdam and Eindhoven act as living labs and form part of EuroQCI³². Projects such as BENELUX-QCI and SEEWQCI extend this infrastructure across borders and into space³³. The Netherlands is also at the forefront of next-generation quantum entanglement technology: QuTech progresses rapidly and achieves critical milestones ahead of global competition,

such as the first 'on-demand' entanglement link³⁴, a rudimentary quantum entanglement link between Dutch cities³⁵, and the first quantum network operating system³⁶.

Domestic demand is also beginning to emerge. The Ministry of Foreign Affairs and the Port of Rotterdam have started to explore the capabilities of the technology in their own contexts. Quantum networks are identified as a priority area in the Dutch defence strategy for industry and innovation³⁷. Concerns over the quantum computing threat to the protection of sensitive data are also increasing policy attention³⁸.

Momentum is accelerating. TU Delft has secured a leading strategic role for the Netherlands within the EU by leading QIA³⁹ and QI² establishing its influence in shaping the EU's quantum communication strategy. In parallel, TNO advances the Dutch laser satellite communications sector toward industrial scale and international competitiveness. QDNL's Growth Fund Phase 3 (2026–2028) supports next-generation hardware, system integration, and establishes a national quantum network operator⁴⁰. Investors interest is growing, companies such as Q*Bird and QPhoX have raised venture capital. Yet, structural risks remain. Growth Fund financing ends in 2028 with no confirmed successor. Scaling is constrained by the lack of standards and certification, immature hardware, limited early revenues, scarce venture capital, and regulatory complexity. Limited resources for proofs of concept and network access further slow next-generation development. Without a credible long-term strategy and funding trajectory, the ecosystem risks losing momentum as the technology nears commercial readiness.

Summarizing the above leads to the following SWOT-matrix, presented on the following page.

SWOT-MATRIX

OPPORTUNITIES

- Europe is strongly engaged in quantum networking and shaping the legal framework around it.
- Quantum technology market predictions present significant opportunities for value capture.
- As the value chain is still not clearly established, it leaves room for positioning Dutch control points.

THREATS

- End user needs are still unclear, convincing use cases for quantum internet now need to be proven.
- Market adoption for quantum key distribution is low, translating into a very small, often subsidised user base.
- Fierce competition is shaping at full speed.
 - Mass adoption and R&D in China which has a clear advantage in space networks.
 - American commercial giants taking positions with established global operations.
 - Several other candidate leaders in Europe.

STRENGTHS

- The Netherlands has global R&D leadership in quantum communication:
 - Strong academic foundation.
 - World-class ecosystem of quantum startups: Q*Bird, Delft Networks, CUbiQ, QphoX, Qblox, QSA, QuDef, SingleQuantum, Delft Circuits, etc.
 - Supported by a leading photonics ecosystem.
 - EuroQCI deployment experience.
- The Netherlands has strategic influence in Europe via its leadership in QIA and QI², initiatives strongly supported at the EU level.
- The domestic space ecosystem has edge technical expertise (optical comms), and strong industrial / mass production knowledge.

WEAKNESSES

- Dutch quantum and space companies have not yet built a sustainable competitive advantage in quantum communication.
- No systematic capability for quantum network use case development (no open access facilities) nor to deliver quantum-enhanced services to users (no operator).
- The Dutch National Security Agency, together with a few other European NSAs, considers quantum key distribution currently immature and insufficient as a standalone quantum-secure solution.
- Other markets (e.g., Germany) actively resolve non-technical barriers (trust, certification, standardisation), domestic inaction risks driving startups to more attractive jurisdictions.

The path ahead

As we have seen in the previous section, in quantum communications, the Netherlands combines world-class research, strong technical capabilities, a dynamic ecosystem of quantum startups, and an industrial know-how in space. Now, it faces its next challenge: translating technological leadership into sustainable commercial success, and a source of geopolitical leverage for Europe.

OBJECTIVE: FROM RESEARCH LEADERSHIP TO STRATEGIC CAPABILITY

By 2036, the Netherlands aims to operate user-centric quantum networks delivering tangible operational advantages to Dutch and European users. Built and run by Netherlands-based European champions, these networks will position the Dutch ecosystem as a leader in European quantum networking, with a deliberate focus on selected segments where it can achieve global leadership. This targeted approach will strengthen European technological sovereignty while contributing to the delivery of the pan-European quantum internet.

① Establish the Netherlands as the centre of gravity for quantum networking and cement the country's strategic influence in Europe

The strategic priority is to build European champions in entanglement-based networking, the long-term objective of quantum communications. The Netherlands, already a global leader in this field, is well positioned to play a driving role in Europe, building on its strong position in the EU through initiatives such as QIA and QI².

This ambition builds on the Quantum Europe Strategy and is anchored in the Dutch component of QI² which combines advanced R&D with a strong focus on users and use case developments. As part of this effort, Pilot Facilities and Open Access Facilities will be deployed across Europe, including

A DUAL-TRACK DEVELOPMENT STRATEGY, IN FULL SYNERGY WITH THE EUROPEAN CONTEXT

Quantum communication technologies are evolving along two timelines: a long term one, and a closer one.

- Entanglement-based networking is the strategic destination. It opens the gate to distributed quantum computing, advanced cryptography, and new coordination capabilities, but needs to find its market(s).
- Quantum key distribution is ready for deployment and user test today, and a few other near-term applications are on the horizon: quantum time transfer, quantum position verification.

This duality calls for a dual-track development strategy (1 and 2), united by an access provider, and an Open Access Facility (3).

one of each in the Netherlands. The Pilot Facility will be developed and deployed by SMEs to support the demonstration of commercial use cases with early-adopters in standard telecom environments, while the Open Access Facility will provide shared access to quantum internet technologies, enabling product development, fostering collaboration, supporting standardisation, and developing a skilled workforce.

The objective is to leverage the Dutch front-runner position to establish the Netherlands as a hub for the quantum internet, attracting global companies, developing talent, strengthening the national ecosystem, and shaping Europe's vision and strategy in this domain. This requires patient capital to sustain R&D and overcome key engineering

and manufacturing challenges. It also calls for long-term financing instruments, beyond standard venture capital models, which are often hesitant about long payback horizons. Such mechanisms are essential to maintain Dutch leadership through the transition to maturity and reduce the risk of strategic acquisition by foreign players.

② Foster market uptake for near-term applications: initiate the commercial cycle and incentivise a sovereign supply chain

Patient capital positions the Netherlands as a leader in the quantum internet. However, overcoming a major challenge of the sector, limited and still nascent demand, requires a user-centred strategy to demonstrate the value of quantum communication. By acting as a launching customer and incentivising uptake across the public and private sectors, the government acts upon key barriers such as trust, certification, and standardisation, bridges the pre-revenue gap, and supports the emergence of a sovereign supply chain – particularly critical for applications such as cryptography, where reliance on non-European technologies could limit usability in sensitive or classified contexts.

Stimulating demand across government⁴¹, international organizations⁴², finance⁴³, healthcare⁴⁴, and critical infrastructure⁴⁵, will both build the initial user base and lay the foundations for the future quantum internet. It demonstrates commercial viability, fosters private investment and supports the retention of startups that might otherwise relocate to more supportive countries. In parallel, QI² Pilot Facilities are already advancing, developing, and testing the next-generation use cases through proofs of concept with early adopters.

③ Connect the demand and the supply via accessible networks: an Open Access Facility and an access provider

To unite the long-term R&D trajectory with the immediate commercialisation strategy outlined above, the Netherlands will deploy two

complementary pillars that create a continuous pipeline from vendors to market operation.

The QI² Open Access Facility, as part of the larger network of QI² facilities, drives the development of a European ecosystem of developers by serving as an open platform, providing access to entanglement-based networking technologies for researchers, startups, and system integrators. This facility enables experimentation along the full quantum internet value chain, allowing developers to co-create applications with early users as the underlying technology matures.

In parallel, a national network of quantum access providers, a collaboration of established telecom operators, deploys operational services based on mature near-term technologies. These providers focus on developing, delivering, and commercialising complete solutions, such as hybrid PQC+QKD offerings, and connecting to the ever-more connected EuroQCI. This operational layer addresses the adoption barriers that go beyond the technology such as trust, certification, operational support, and connectivity, by delivering complete end-to-end services and a network of connected users rather than raw technology access.

These pillars function as a unified innovation system. The Open Access Facility develops the ecosystem and feeds validated prototypes and technical insights to the access providers, while operational data and real-world user requirements flow back to refine the use case development agenda. Together they shorten the transition from R&D to revenue enabling the shift from subsidies to sustainable operations and ensure that infrastructure investments simultaneously serve current needs and future quantum internet capabilities. By anchoring both pillars domestically, the Netherlands creates the physical convergence point where the two timelines merge into a sovereign, sustainable national capability.

PAVING THE WAY TO A QUANTUM DIGITAL SOCIETY

Over time, this can support a broader industry of quantum-enhanced services. In analogy with the classical internet, the hypothesis is that greatest value lies not in equipment manufacture or network provision, but in turn-key applications that solve end-user problems⁴⁶. By reducing technical barriers for application and network software developers, who can build upon established quantum infrastructure rather than negotiating experimental prototypes, the combination of next-generation QI² facilities in combination with an access provider enables the capture of the full value chain and locks in the direct interface to the end-user.

MEASURING SUCCESS

By 2036,

- The Netherlands has converted research leadership into European champions

headquartered in the Netherlands, leading the development of the European quantum internet.

- The Dutch government uses quantum network technologies to fulfil critical missions, validating the technology's strategic value while ensuring technological sovereignty.
- Quantum communication services are bought and sold on a commercial basis without structural subsidies, with demand driven by clear operational advantages rather than innovation programmes.

This has been achieved not by waiting for markets to mature abroad, but by leading the way and investing in next-generation technology while deliberately engineering the conditions for commercial cycle ignition at home.

Getting started

BUILD THE QUANTUM INTERNET NOW OR BUY IT LATER

The Netherlands faces a structural timing challenge: strategic sovereignty requires investment in technology and infrastructure today, while markets and user demand are still emerging. Waiting for clear demand risks losing the opportunity to shape architectures and standards. On the other hand, investing without users risks building infrastructure without the commercial momentum needed to sustain it. Thus, a sequential approach—first perfecting the technology, then deploying

networks, then attracting users—is also unlikely to succeed.

The key to success lies in **combining immediate technology and infrastructure investments with early demand creation united by a national access provider and pilot facilities**. This approach can anchor expertise locally and ensure the Netherlands contributes as an architect - and a control point - of the future quantum internet, rather than merely a supplier within ecosystems shaped elsewhere.

OUR CALL TO ACTION

To secure a leading and sustainable position in quantum communications, the Netherlands must now move decisively from technological leadership to market creation. With the Quantum Act under development, this is a unique moment to solidify the Netherlands' role at the core of the European Quantum Internet.

We call upon the Dutch government to:

- **Consolidate Dutch leadership by accelerating quantum internet development through the EU quantum strategy (QI²).** Engage patient capital and establish Pilot and Open Access Facilities to mature entanglement technologies, ensuring Dutch leadership survives the maturity gap and graduates from research into a European quantum internet.
- **Empower adoption of near-term applications to bridge the commercial gap.** Act as strategic launch customer for quantum key distribution and adjacent services, incentivising public and

private sectors to create the user base necessary to initiate the market, sustain infrastructure while creating instruments to resolve non-technical barriers (trust, certification, standardisation).

- **Incentivise terrestrial/space telecom collaboration to establish a quantum access provider.**

Establish a national quantum access provider, serving as the Dutch EuroQCI node, with infrastructure architected for immediate quantum key distribution service and seamless upgrade to entanglement networks, bridging R&D and QI² facilities to scalable market offerings.

Taken together, these measures will establish Dutch-based companies as European champions, reduce strategic dependencies, and ensure that by 2036 quantum networks deliver tangible advantages—no longer dependent on permanent state support and with strong leverage across the supply chain.

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