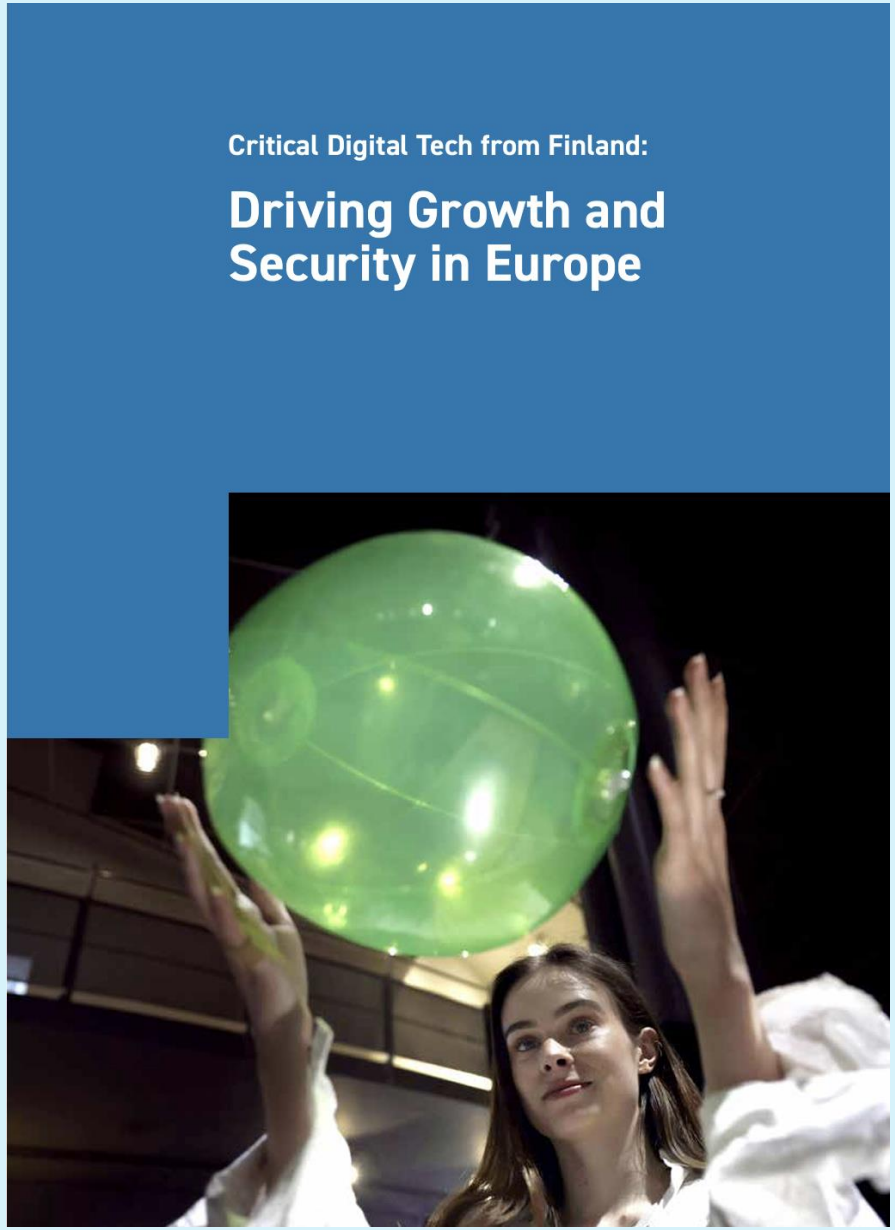

Driving Growth and Security in Europe – Critical Digital Tech from Finland

Overview of the Policy Brief

20 May 2025

SITRA Technology Industries of Finland VTT

Introduction – Critical Digital Tech from Finland: Driving Growth and Security in Europe

Amid accelerating technological breakthroughs and shifting global dynamics, Europe's ability to remain competitive, secure, and sovereign depends on its strength in critical digital technologies.

These slides provide an overview of the *Critical Digital Tech From Finland: Driving Growth And Security In Europe (2025)* policy brief. The aim of this work is to spark debate on how to best enhance Europe's technology resilience and global standing in the field of critical technologies.

Through case examples from the Finnish technology industry and collaborative initiatives within the EU, the slides provide a look into scalable best practices and EU level policy recommendations. With collaborative efforts, Europe can accelerate innovation, build resilient value chains, and ensure leadership in the technologies that define tomorrow.

We warmly thank all experts, organisations, and partners who contributed to the development of these materials.

In Helsinki, 20 May 2025

The Finnish Innovation Fund Sitra
Technology Industries of Finland
VTT Technical Research Centre of Finland

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Why are some technologies critical?

The speed of new technological innovations, escalating geopolitical rivalries and trade wars are contributing to certain technologies emerging as indispensable pillars of economic prosperity and resilience, national security, and societal well-being.

As geopolitical tensions tighten, the need for digital resilience and strategic autonomy within the European Union increases.

Defining critical digital technologies

The European Commission has identified ten critical technology areas as essential for economic security and is conducting further risk assessments on them. These areas are enabling and transformative, with potential for civil–military fusion.

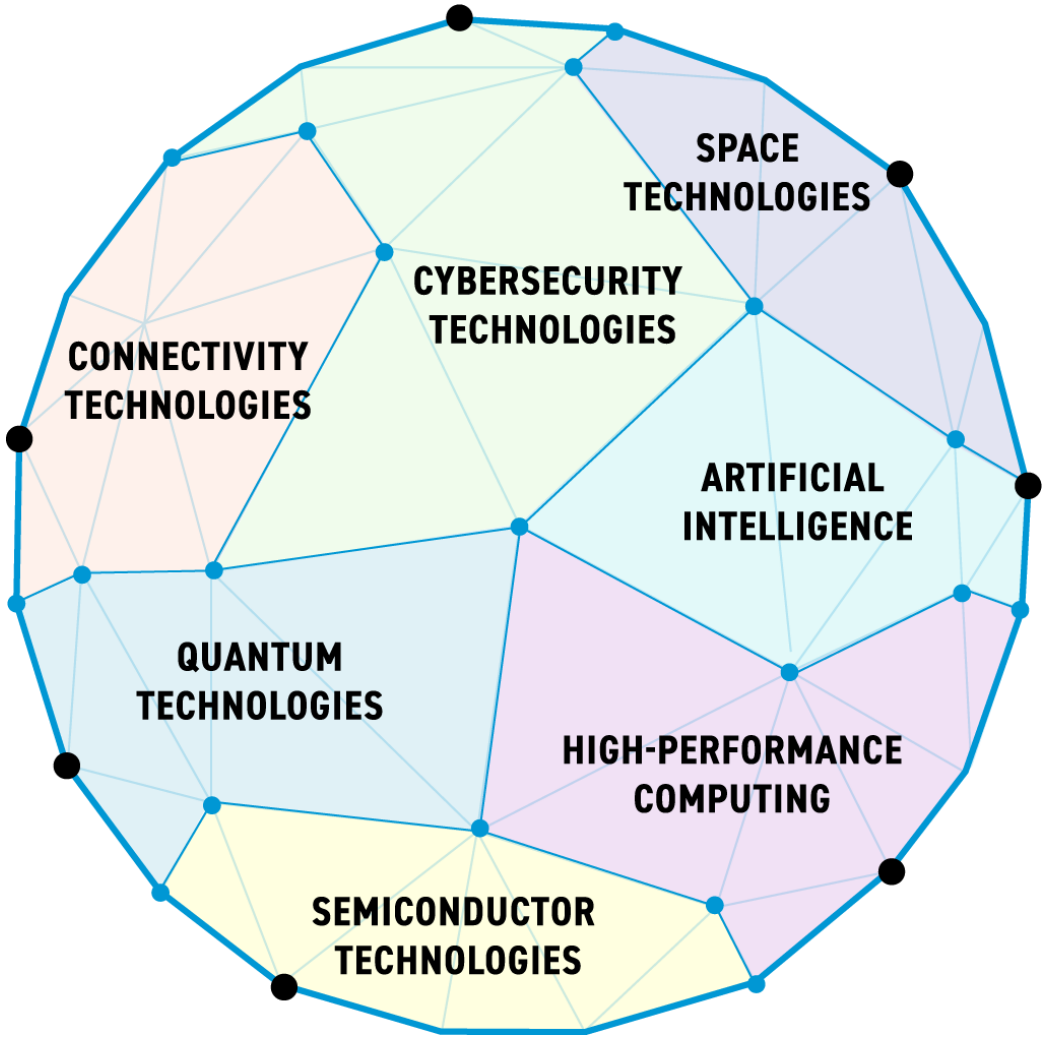
This policy brief focuses on the highlighted digital technologies, defined in this publication as the Critical Core.

1. Advanced semiconductors: Microelectronics, photonics, high-frequency chips, and semiconductor manufacturing equipment.
2. Artificial intelligence: HPC, cloud/edge computing, data analytics, computer vision, and language processing.
3. Quantum technologies: Quantum computing, cryptography, communications, and sensing.
4. Biotechnologies: Genetic modification, new genomic techniques, gene drive, and synthetic biology.
5. Advanced connectivity & digital technologies: 6G, cybersecurity, IoT, virtual reality, digital identity, and navigation.
6. Advanced sensing: Electro-optical, radar, chemical, biological, and underwater sensing.
7. Space & propulsion: Space surveillance, PNT, secure communications, and hypersonics.
8. Energy technologies: Nuclear fusion, hydrogen, net-zero tech, smart grids, and energy storage.
9. Robotics & autonomous systems: AI-driven drones, exoskeletons, and robot-controlled precision systems.
10. Advanced materials & manufacturing: Nanomaterials, additive manufacturing, and recycling of critical raw materials.

The Critical Core

The Critical Core refers to strategic digital building blocks essential for Europe's competitiveness, economic resilience, and security.

By boosting and aligning these domains, Europe can reduce dependencies and strengthen its position in global markets.



European critical digital technology landscape

Critical digital technologies can provide strength and stability to societies, but they also reveal weak spots — vulnerabilities exposed to economic pressures, trade dependencies, and security risks.

This section provides an outlook into the key drivers and trends behind Europe's critical digital technology policy, as well as the current European and Finnish policy initiatives.

What is driving change?

Push of the present

Geopolitical fragmentation leads to the re-evaluation of international partnerships

Demands for competitiveness and resilience spark interest in industrial policy and defence-related R&D

Sustainability is displaced by short-term security threats

Pull of the future

Europe's seeks to increase strategic autonomy through digital infrastructure resilience and end-to-end supply chains

The convergence of critical digital technologies creates opportunities for innovation

Acceleration of global technology rivalries deepens

The futures triangle, Inayatullah 2008.

Weight of history

Risk-aversion has led to insufficient national and EU-level commitment to clear technology choices

Fragmentation of EU funding and markets create difficulties in scaling innovations

Outsourcing of technologies and digital infrastructures has built strategic dependencies

Bottlenecks in skills and talent and lack of cross-sectoral collaboration hinders innovation

EU’s agenda: Secure and reliable technologies

Currently, the European Union relies heavily on imported digital infrastructure and technologies. The EU is sharpening its focus on building resilience and autonomy, especially in critical technologies.

This approach is shaped by several key policy concepts:

- **Technological sovereignty**: Ensuring Europe retains the ability to develop and control critical technologies without undue reliance on external actors
- **Open strategic autonomy**: Striking a balance between technological self-sufficiency and global collaboration
- **Economic security**: Safeguarding the EU’s industrial base, mitigating external dependencies, and preventing the weaponisation of economic linkages
- **Security and defence**: Recognising the dual-use nature of many critical technologies, with growing investment in capabilities that enhance both economic and military resilience

Finland's strengths reinforce the EU

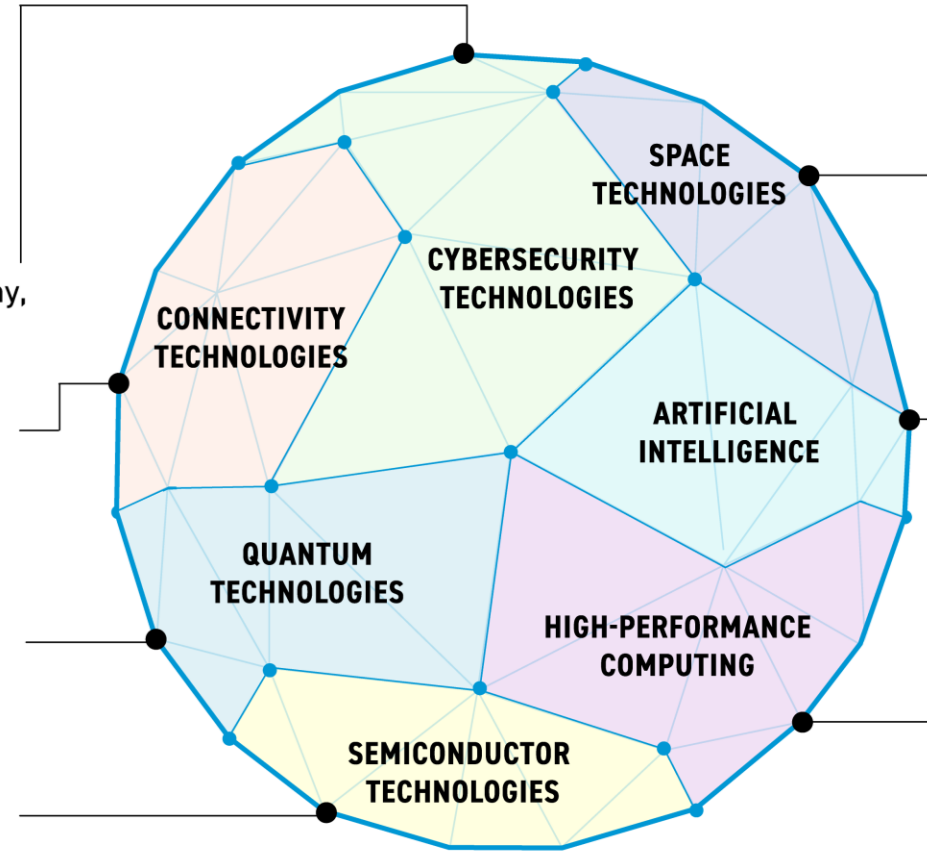
With deep expertise in several key technology areas which underpin digital societies, Finland plays a vital role in strengthening European resilience and competitiveness. Finland’s strong emphasis on technological trustworthiness and sustainability enhances Europe’s ability to develop reliable and competitive digital solutions.

Unique capabilities in quantum-safe cryptography, secure comms, and AI-driven threat detection.

Leader in 6G development, with strong wireless research, edge cloud expertise, and Nokia driving global telecom innovation.

Leading end-to-end quantum computing hub with industrial pilot line, quantum-classical integration, and superconducting chip R&D.

Global niche leader in advanced materials, process technologies, MEMS, design, and photonics with 5 EU pilot lines hosted.

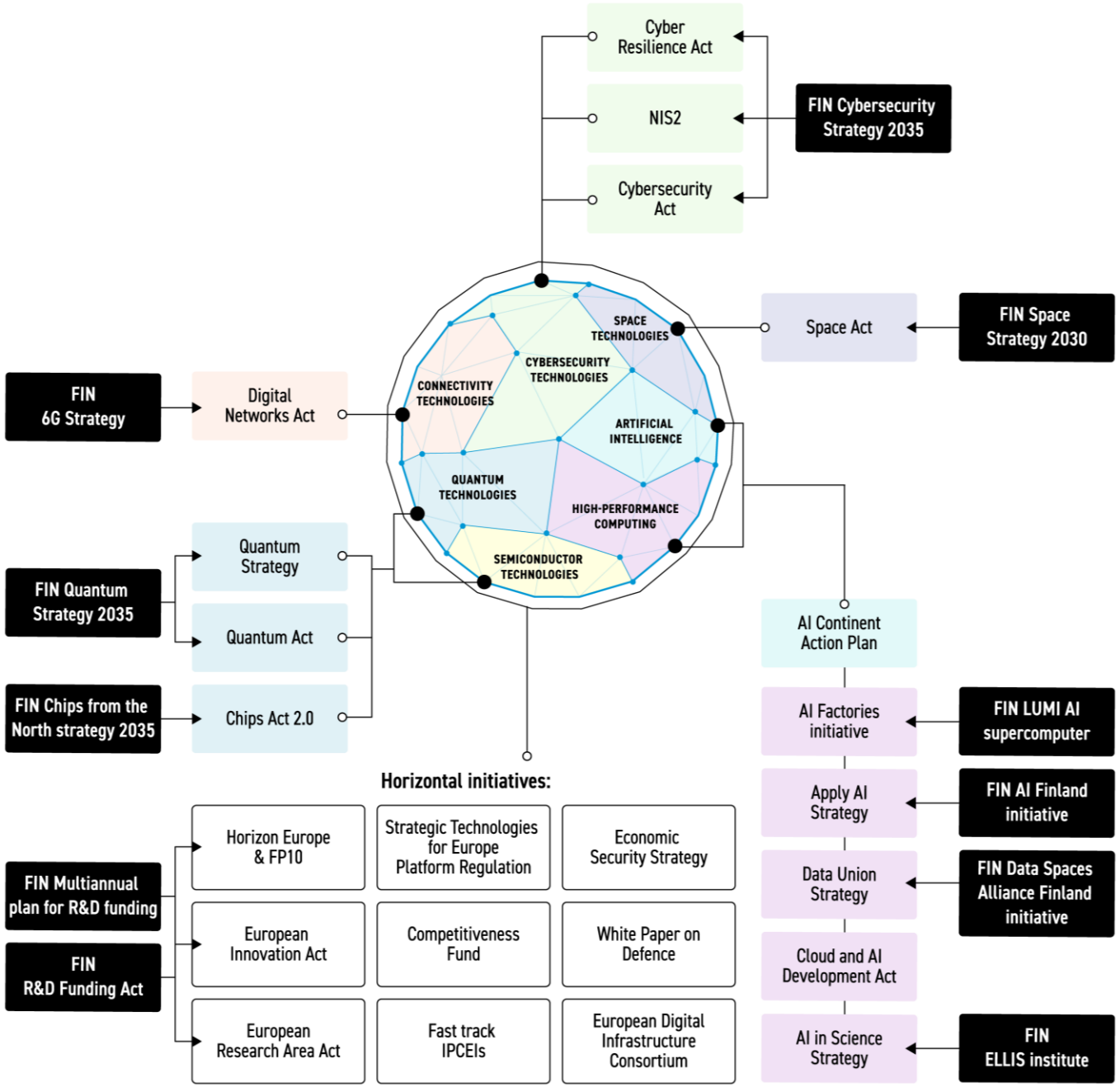


Rapidly growing space sector with strong satellite expertise, innovative startups, and key role in EU space programs.

Top tier research, dense startup ecosystem, and leadership in applied AI and ethical frameworks.

Home to LUMI supercomputer and AI Factory with strong integration of data, computing, and quantum systems.

Initiatives from the EU and Finland



The European Union is advancing a plethora of policies that balance openness and security, aiming to reduce strategic dependencies while maintaining its role as a global economic power.

Subsequently, Finland has developed its strategic initiatives to complement and enhance EU policies, ensuring a comprehensive approach to advancing critical technologies.

The illustrative map provides an outlook of EU initiatives and Finland's undertakings and national strategies across the Critical Core, outlining initiatives tied to critical technology domains while highlighting horizontal policies supporting multiple sectors.

Europe's must-win battle:

Technological convergence

Europe’s future competitiveness hinges on the successful integration, development, and commercialisation of critical digital technologies.

Ideally, these critical digital technologies form a mutually reinforcing ecosystem, where convergence—the deep integration and interdependence of different technological domains—amplifies capabilities and accelerates innovation.

Technological convergence

Technological convergence appears once previously isolated technologies become interlinked and functional together, developing into new applications.

Emerging hybrid fields, such as quantum-AI, illustrate this transformation. Advanced AI models of the future will not only be enhanced by quantum computing but will also require it to unlock unprecedented capabilities. Similarly, the development of 6G networks will benefit a seamless fusion of quantum and AI technologies.

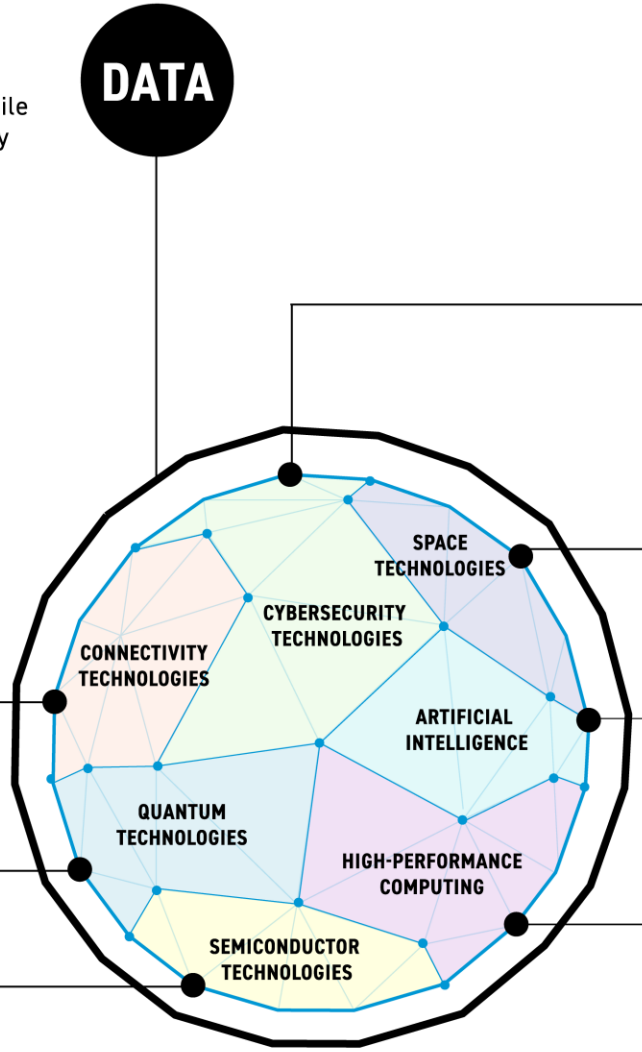
The governance of technological convergence emphasises complementarity and interdependence of technological fields, including data, talent and techniques. The aim of the approach is to create hybrid solutions that can be effectively implemented and scaled.

For nations seeking to maintain an edge in global markets, technological convergence is no longer an abstract concept—it is a defining force that will shape the next era of innovation.

Forward-thinking governance frameworks must adapt to this reality, fostering collaboration across disciplines while anticipating new risks.

Convergence in the Critical Core

At the core of these technological advancements lies **data**—its availability, quality, and security directly impact the effectiveness of AI models, the performance of HPC systems, and the reliability of quantum and secure communications. Europes ability to process and utilise massive datasets while ensuring data sovereignty will be instrumental in allowing industries to fully harness the potential of interconnected digital technologies.



Cybersecurity serves as a cross cutting enabler, safeguarding all layers of this interconnected ecosystem. AI-driven threat detection, quantum-resistant encryption, and secure-by-design semiconductor architectures will be crucial to ensuring Europe's digital resilience in an era of increasing cyber risks and geopolitical uncertainty.

Space technologies provide a critical infrastructure for global connectivity, earth observation, and AI-driven analytics. The fusion of AI with satellite imagery enhances climate monitoring, disaster response, and autonomous navigation, while space-based quantum encryption will play a key role in securing global communications.

Artificial intelligence (AI) relies on high-performance computing (HPC) and advanced semiconductors to process vast datasets, simulate complex models, and develop next-generation AI systems. Breakthroughs in AI architectures, such as neuromorphic computing, further drive the demand for specialised semiconductors and scalable computing power.

High-performance computing (HPC) fuels AI model training, quantum simulations, and secure communications, requiring cutting-edge semiconductor architectures optimised for massive computational workloads. As HPC infrastructure evolves, it enables faster AI-driven scientific discovery, financial modeling, and climate simulations, reinforcing Europe's technological edge.

Connectivity, including 5G and future 6G networks, acts as a backbone for real time AI applications, industrial automation, and secure digital infrastructure. Ultra reliable, low latency communications will accelerate edge AI, smart manufacturing, and autonomous systems, with direct implications for cybersecurity, quantum communications, and next generation computing.

Quantum computing and communications hold the potential to revolutionise problem solving, encryption, and secure networks, benefiting from HPC, AI, and next generation connectivity. Quantum computers, in synergy with AI, will address optimisation challenges in logistics, materials science, and drug discovery, while quantum-secured networks will redefine the security architecture of Europe's digital backbone.

Semiconductors are the foundation of all digital technologies, with their fabrication and supply chain playing a decisive role in ensuring technological sovereignty. Advances in semiconductor manufacturing will enhance AI efficiency, quantum-processing capabilities, and ultra-secure communication networks.

Examples of synergies between critical digital technologies and Finland's strengths

↘ Enables / Depends on	AI	HPC	Semiconductors	Quantum	Space	Connectivity	Cybersecurity	Data
AI	—	Needs large-scale training on supercomputers	Drives demand for specialised chips	Supplies error-mitigation and optimisation algorithms for quantum devices	Provides on-board analytics and autonomy for satellites	Generates traffic for 'edge AI' in 5G/6G cells	Powers adaptive threat-detection and response tools	Requires plentiful, high-quality datasets
HPC	Accelerates AI model training and inference	—	Depends on cutting-edge semiconductor nodes	Performs quantum-system simulation and error-correction workloads	Crunches vast Earth-observation datasets from space missions	Feeds ultra-fast 'edge' computation close to 5G/6G base-stations	Must be shielded against intrusions and data leaks	Processes petabyte-scale inputs
Semiconductors	Supplies AI-specific chip designs	Provides high-bandwidth memory for supercomputers	—	Enables control electronics that operate at cryogenic temperatures for quantum chips	Delivers radiation-hardened components for spacecraft	Manufactures radio-frequency front-ends for 5G/6G	Integrates secure-by-design hardware 'roots of trust'	Embeds on-chip data-protection features
Quantum	Works with AI to solve complex optimisation tasks	Uses HPC clusters for quantum-circuit simulation	Relies on ultra-pure semiconductor fabrication lines	—	Hosts space-based quantum-key-distribution links	Needs synchronised, low-latency 5G/6G channels for control	Provides quantum-safe encryption	Requires high-integrity, verified datasets
Space	AI interprets high-resolution satellite imagery	HPC fuses data from many on-orbit sensors	Uses advanced semiconductors for imaging sensors and payloads	Will carry quantum repeaters and atomic clocks	—	Offers satellite backhaul for 5G/6G in remote areas	Demands secure 'telemetry, tracking & command' links	Generates geospatial big-data streams
Connectivity	Brings real-time data to AI at the network edge	Interconnects geographically distributed HPC centres	Requires dense-input/output and phased-array radio chips	Can transport quantum keys over optical fibre or free-space links	Provides up- and down-links for mega-constellations of satellites	—	Needs end-to-end secure 'network-slicing' and 'multi-access edge computing'	Streams massive, distributed datasets
Cybersecurity	Protects the AI supply chain and trained models	Secures supercomputers, job schedulers and data	Ensures trusted semiconductor intellectual property	Develops encryption resistant to quantum attacks	Shields navigation and satellite-payload links	Hardens network slices, base-stations and edge nodes	—	Maintains data integrity, authenticity and privacy
Data	Determines AI accuracy, fairness and bias	Influences reliability of scientific simulations	Guides semiconductor process control and yield improvement	Trains hybrid quantum-classical systems	Underpins Earth-observation climate insights	Optimises traffic flow in 5G/6G cores	Needs confidentiality, provenance and verifiable lineage	—

Policy recommendations

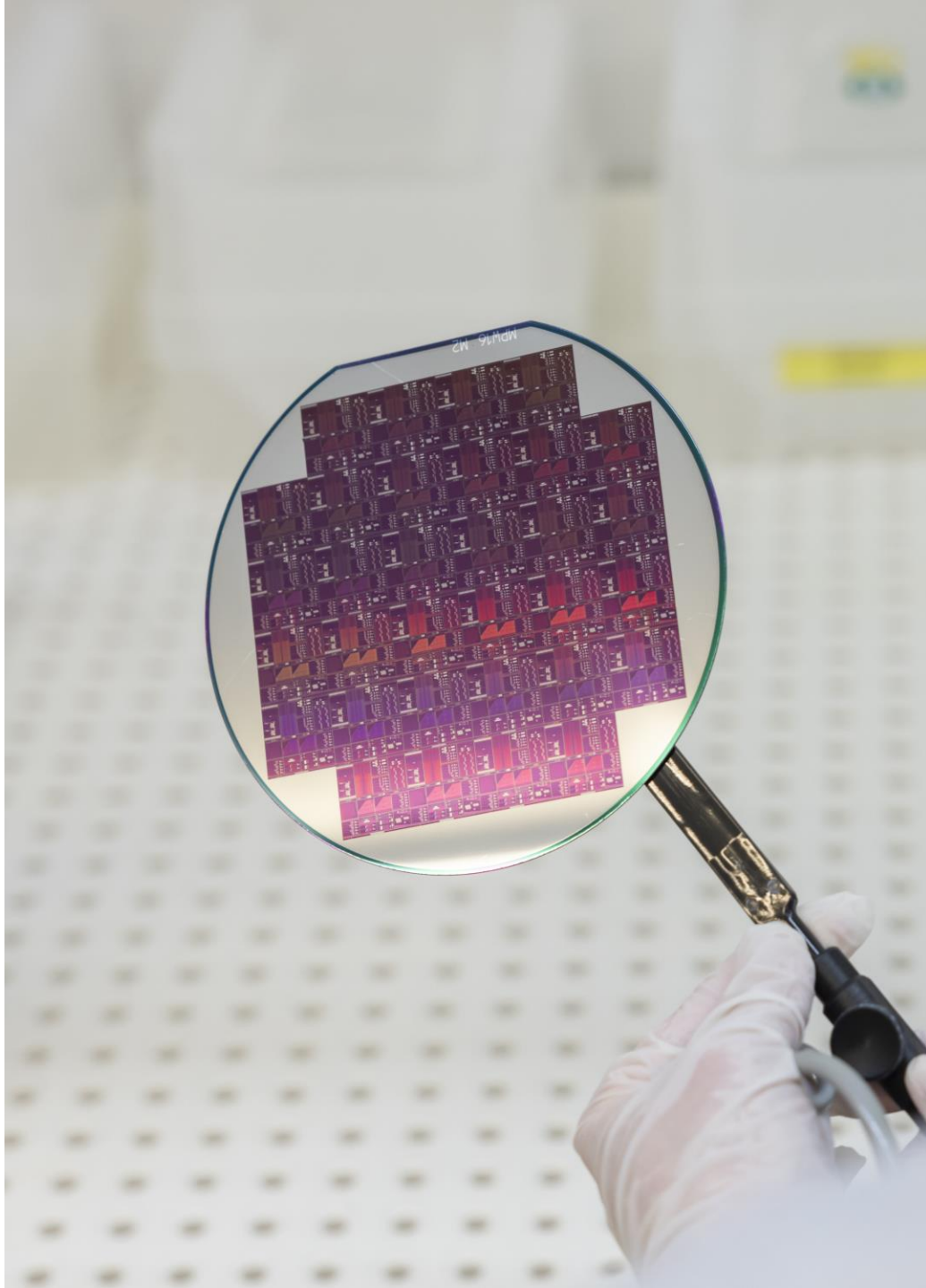
To strengthen Europe's strategic autonomy and global competitiveness, targeted policy actions are needed to accelerate the development and deployment of critical digital technologies.

This section outlines concrete recommendations for the EU to foster innovation, attract investments, and ensure long-term resilience across key technology domains. The proposals are intentionally horizontal in nature, aiming to support multiple critical technology areas highlighted in this policy brief, rather than focusing on any single domain.

Crucially, policies must also create predictability and trust in rules and norms, as these are foundational to a stable innovation environment and effective public-private collaboration.

Policy recommendations for the European Union

1. Company-led approach to EU RDI funding
2. Excellence-driven EU budget for critical digital technologies
3. European Critical Tech Fund
4. Europe as the primary destination for global tech talent
5. Future-fit EU tech regulation
6. Innovative procurement of critical digital technologies
7. EU leadership in standardisation for critical digital technologies
8. Europe’s global influence through secure digital infrastructure



Policy recommendations

1 Company-led approach to EU RDI funding

Boosting Europe's digital competitiveness requires rapid breakthroughs in critical technologies and a faster transition from lab to market. The Lead Company model operated by Business Finland, an innovation funding agency, has demonstrated how empowering companies to steer the RDI agenda leads to stronger ecosystems, higher private investment, and faster growth. Now is the time to scale this approach to the European level.

The model is fully compatible with existing EU instruments like Horizon Europe and the European Innovation Council—and ready for immediate deployment. By aligning EU RDI funding with a company-led model, Europe can pool its top talent, channel funding into mission-driven projects, and foster globally competitive, resilient ecosystems.

Key elements

Empower leading companies to drive strategic RDI
Let Europe's technology frontrunners define high-impact RDI missions in areas of strategic importance. These companies lead the project design and select the most capable partners — startups, SMEs, and research organisations — forming dynamic, goal-oriented ecosystems.

Mobilise EU funding through agile co-investment
Use existing EU RDI instruments to co-fund large-scale lead company projectas (e.g., €20 million for lead companies, €50 million for ecosystems) alongside strong private investment. Prioritise speed and simplicity in proposal, evaluation, and negotiation processes.

Build flexible, open ecosystems across Europe
Ensure project structures are adaptable over time and open to new partners. Protect IPR fairly while encouraging knowledge exchange, and link project goals directly to Europe's digital sovereignty and competitiveness objectives.

2 Excellence-driven EU budget for critical digital technologies

The European Union should shift its funding strategy under the Multiannual Financial Framework (MFF) to place a stronger emphasis on supporting critical technologies, with clear differentiation between excellence-based and cohesion-based funding mechanisms, each governed by separate rules.

In particular, funding for research and innovation in critical technologies should prioritise excellence, as cohesion-based allocations are not suited for driving breakthroughs in highly competitive and fast-moving technological domains.

Key elements

Prioritise excellence-based programs
Funding for critical digital technologies should be channeled predominantly through instruments based on excellence, not cohesion. This alignment boosts efficiency and directs resources toward initiatives with the strongest innovation potential and long-term impact.

Encourage cross-border collaboration
Cross-border collaboration among leading research institutions, industry, and universities boosts knowledge sharing, strengthens Europe’s research base, and speeds up tech commercialisation. Partnerships should be driven by excellence and complementary expertise.

Implement evaluation and agile reallocation
Ongoing performance monitoring, paired with flexible funding mechanisms, ensures that support is responsive to results and adapts swiftly to emerging technological developments.

Policy recommendations

3 European Critical Tech Fund

Europe must close its critical tech investment gap to remain globally competitive. Efforts like VentureEU and InvestEU are helpful but fragmented.

A new European Critical Tech Fund would unify these initiatives, pool public and private capital, and focus on the most promising companies developing technologies vital for the EU's prosperity and security.

By establishing this fund—and completing the European Savings and Investments Union—Europe would streamline investments, foster industrial champions, and lead the development of critical technologies for the digital age.

Key elements

Accelerate innovation immediately
Provide patient capital to promising EU-based startups and scaleups, ensuring they can rapidly innovate and reach global markets while staying headquartered in Europe.

Invest strategically in deep tech
Invest in transformative technologies like quantum computing and next-generation AI to secure Europe’s leadership and technological sovereignty.

Scale up funding ambitiously
Launch with €10 billion, scale to €150 billion in five years, and ultimately aim for €300 billion by 2035—financed by EU member states, institutional investors like pension funds, private capital, and the European Investment Bank.

Policy recommendations

4 Europe as the primary destination for global tech talent

As Europe's demand for highly skilled professionals in critical digital technology sectors grows rapidly, the EU has a unique opportunity to position itself as a global magnet for talent.

Traditionally, the United States has been the primary destination for international tech experts and scientists. However, recent shifts — such as tightening immigration policies and declining attractiveness due to political and social uncertainty — have made the US a less certain choice for global talent.

By responding with agile, forward-looking policies and robust, well-funded support structures, the EU can not only fill this gap but firmly position itself as the world's premier destination for digital talent.

Key elements

Create tailored EU-wide tech visa pathways
Simplify and harmonise work visa processes across Member States. Introduce a dedicated "EU Tech Talent Visa" to streamline and speed up entry for experts and scientists in key fields like AI, cybersecurity, and semiconductors.

Strengthen public-private collaboration on talent development
Foster partnerships among governments, universities, and tech companies to co-fund specialised attraction, training, and education programs.

Prioritise support for tech talent abandoning or avoiding the US
Actively target skilled tech professionals who may be leaving or opting against the US due to immigration hurdles and the shifting political or social climate with specialised incentives to attract high-value experts to the EU.

Policy recommendations

5 Future-fit EU tech regulation

To lead in critical digital technologies, Europe must modernise its regulatory approach. Today's framework is fragmented, analog in design, and often burdensome—especially for smaller companies.

A new regulatory model must be simple, digital-first, and built for cross-border innovation. 'Future-fit tech regulation' would deliver this shift by embedding digital logic into EU lawmaking, coordinating enforcement, and enabling compliance through technology. Impact assessments must also be strengthened to more accurately evaluate both the growth potential and possible negative consequences of regulation, ensuring a balanced and evidence-based approach.

By adopting this approach, the EU would turn regulation into a competitive advantage—harmonising the Single Market, supporting innovation, protecting rights, and powering Europe's digital leadership.

Key elements

Use simplification as a strategic tool
Undertake a rolling "digital fitness check" to eliminate outdated, unclear, or overlapping regulations.

Ensure new legislation is 'born digital'
Mandate that all new EU tech legislation be machine-readable, API-ready, and built to enable automation.

Coordinate enforcement across Member States
Establish joint mechanisms for enforcement across Member States, supported by expert bodies like the AI Office and European Data Innovation Board.

Leverage RegTech to enable smarter compliance
Promote regulatory technology (RegTech) tools that simplify compliance—especially for SMEs. While RegTech should not be seen as a substitute for better regulation, it can help alleviate the administrative burden that EU rules often place on businesses.

Policy recommendations

6 Innovative procurement of critical digital technologies

As Europe strives for strategic autonomy, public procurement must become a driver of European innovation in critical technologies.

A shift toward advanced, risk-sharing procurement methods—such as pre-commercial procurement and innovation partnerships—can unlock breakthrough solutions, catalyse private investment, and sustain a globally competitive industrial base.

By lowering the risks for public procurers—for example, through phased funding, co-financing mechanisms, or outcome-based payments—and creating predictable demand, Europe can accelerate the development and uptake of emerging technologies.

Key elements

Leverage procurement to accelerate innovation
Use advanced methods, such as pre-commercial procurement, innovation partnerships, and outcome-based models, to reduce risk and enable public buyers to engage in high-uncertainty projects. Use experimental legislation and regulatory sandboxes to test and scale novel solutions in real-world settings.

Use procurement to fast-track deployment of key technologies
Target procurement efforts toward priority areas such as secure cloud infrastructure, AI systems, and cybersecurity. Design procurement calls that focus on piloting and scaling these technologies in real-world public sector settings.

Develop a common European procurement toolbox:
Establish joint EU procurement instruments and shared frameworks to consolidate demand, enable cross-border pilots, and increase efficiency. Ensure inclusive governance and broad Member State participation to align incentives and deliver mutual benefits.

Policy recommendations

7 EU leadership in standardisation for critical digital technologies

Europe's technological leadership depends on shaping global norms and standards for key emerging technology fields.

By setting guidelines and specifications early on, European businesses gain a clear competitive advantage, paving the way for patents, commercialisation, and solutions rooted in democratic values.

Active engagement within organisations such as the International Telecommunications Union ensures the EU's principles of neutrality, security by design, and sustainability are embedded globally, while also addressing geopolitical tensions around technology development.

Key elements

Prioritise joint positions and strategic guidance
Develop a unified EU stance before international negotiations. Ensure that technical experts and digital policy specialists work in tandem, anticipating geopolitical considerations and aligning responses.

Build coalitions and expand global partnerships
Coordinate with partner countries and regions to amplify Europe's voice in key standardisation forums. Actively seek to harmonise or mutually recognise standards with important third countries. Reinforce democratic and transparent approaches to emerging technologies.

Reinforce the link between research, industry, and policymakers
Strengthen collaboration between European research institutions, the tech sector, and public authorities to anticipate standardisation needs, address technical challenges, and support smaller companies' involvement in shaping EU and global norms.

Policy recommendations

8 Europe’s global influence through secure digital infrastructure

Europe’s single market, with its harmonised regulatory framework and robust financing instruments, can be leveraged more effectively to advance secure connectivity and other information security technologies worldwide.

Strategic partnerships should drive the deployment of trusted 5G networks and other vital technologies in third-country markets. At the same time, greater emphasis on export funding and technical assistance will help European businesses remain competitive while reinforcing global cybersecurity requirements and standards and sustainable digital transformation.

Key elements

Prioritise connectivity and data infrastructure
Focus on Trade and Technology Councils, digital partnerships, and the Global Gateway to align strategic investment with clear deliverables for secure, high-quality networks and services.

Enhance cooperation among financing and export mechanisms
Pool resources from both Member States and EU-level funds to enable trusted European vendors to submit competitive bids in open tenders worldwide.

Strengthen export promotion and market access:
Develop tailored digital economy packages to equip European enterprises with the tools they need to compete globally while advancing European standards of data protection and network security.

Strengthening Trade and Technology Cooperation
Create a forum to enhance cooperation on technology and trade issues with key non-EU countries.

Finland’s commitment to building security and growth in Europe

Together, Europe can convert today’s risks into tomorrow’s opportunities. By aligning national strengths, prioritising strategic technologies, and embracing responsible openness, we will not only preserve our autonomy but also shape global norms for decades to come.

Finland invites partners across Europe and beyond to join us in this endeavour. A secure, innovative, and competitive Europe is the strongest foundation for shared prosperity and wellbeing in an uncertain world.

Read the full Policy Brief:

Critical Digital Tech from Finland: Driving Growth and Security in Europe

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