Connectivity

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Introduction

In today's rapidly evolving digital world, connectivity serves as the essential foundation for innovation, productivity, and societal progress. As the demand for real-time data, low-latency services, and always-on access continues to rise, the networks that underpin our digital lives are undergoing a profound transformation. Connectivity is no longer just about being online – it is about the quality, intelligence, and sovereignty of the connections that digitally pervade our homes, businesses, cities, and governments.

The current transformation in connectivity has three key dimensions: access to networks, intelligent networks, and the growing significance of digital autonomy in a geopolitically fragmented world.

Accessing the networks forms the critical 'last mile' between users and the broader internet. Wireless technologies such as Wi-Fi, Bluetooth and cellular networks (4G, 5G, and in the future 6G) are key enablers of modern digital environments. From smart campuses and smart homes to industrial IoT (internet of things) deployments. When combined with global networks, wireless technologies facilitate seamless end-to-end data traffic that underpins scalable digital ecosystems. Harmonising the specifications and deployment of the cellular networks on a worldwide scale not only boosts efficiency and interoperability but also unlocks new opportunities for innovation and (data) inclusivity across regions.

Beyond network access, connectivity management is being revolutionised by AI and simultaneously challenging the availability of sufficient network operation specialists and their knowledge to keep networks running, for example on campuses (see SURF Tech Trends Report 2023). The shift from manual processes to software-driven orchestration enables intelligent networks with higher responsiveness to the dynamic needs of data users.

Finally, the strategic importance of connectivity is increasing in the realm of digital autonomy. As global tensions reshape alliances and supply chains, nations are rushing to secure control over their digital infrastructures. Investments in fibre-optical networks, satellite communication systems, and alternative data cable routes reflect a broader desire for continuity and resilience. At the same time, big tech's dominance in global data flows and services raises questions around digital sovereignty and cybersecurity. The future of our digital connectivity landscape will be shaped by the dynamic interplay of ubiquitous network access, intelligent network operations and management, and strengthened geopolitical resilience.

TREND #1

Expansion of the use of 5G fixed wireless access

Public Values

Autonomy	Freedom of choice | Independence | Privacy
Justice	Equity | Inclusion| Integrity | Sustainability
Humanity	Well-being

Maturity WATCH PLAN **ACT**

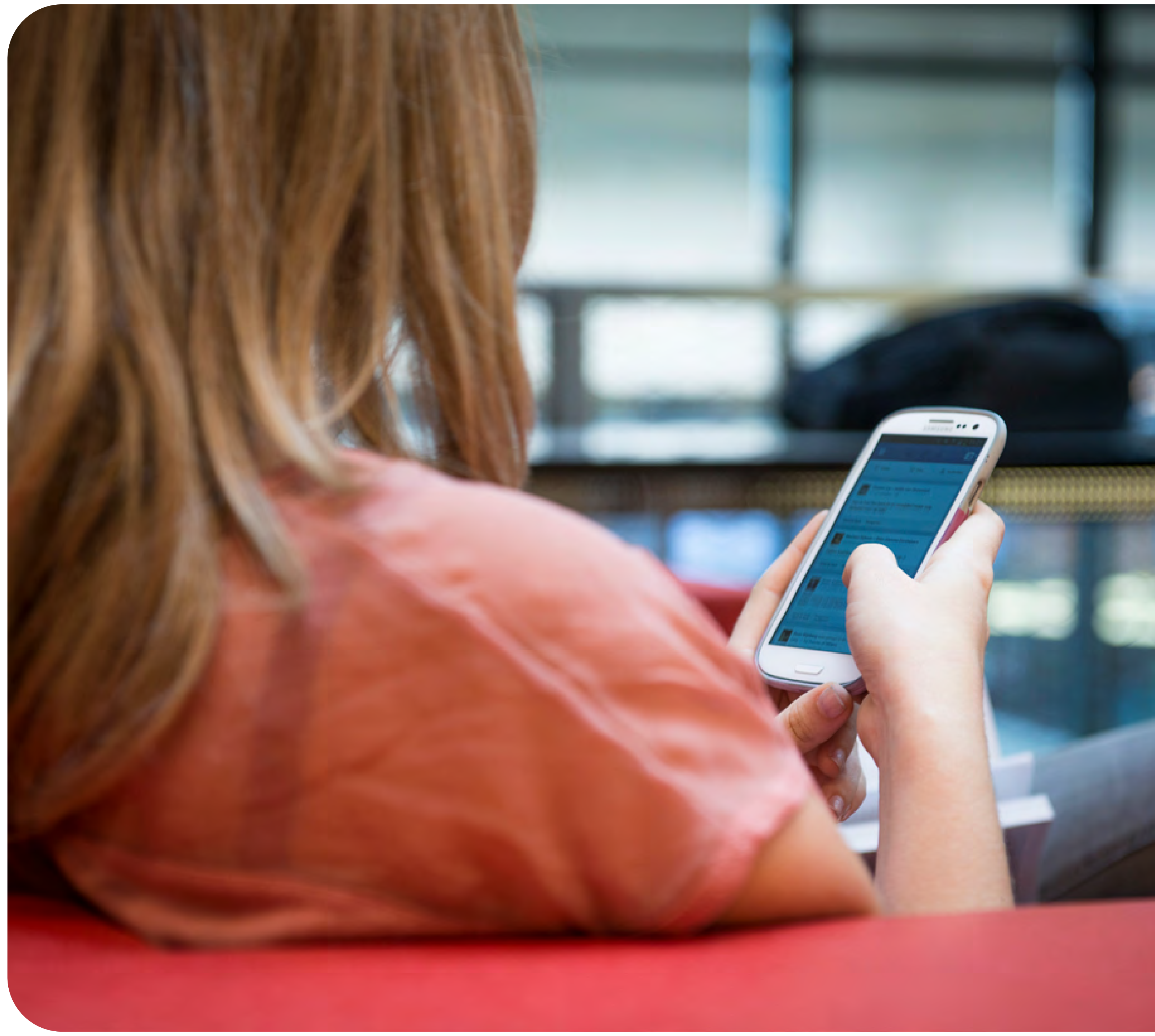
Drivers

Globalisation; Connectivity & interaction; Concentration of wealth & economic inequality

Fixed Wireless Access (FWA) is an alternative to wired broadband connectivity, particularly in areas where fixed networks are too expensive to build and deploy. FWA provides broadband using radio waves – predominantly 5G, and various operators offer subscription and bundled plans for FWA connections to the wired infrastructure, making it a viable option for cost-effective, high-speed internet access.

In recent years, 5G FWA has become widely available in the US and Europe. Other regions like Middle East, Africa, and Asia-Pacific are swiftly following suit by also offering 5G-based FWA services. It is expected that global FWA connections will grow from 160 million (2024) to 350 million in 2030. Half of these global connections will be based in the Asia-Pacific region by 2030.

Another alternative for internet access is via satellite constellations. Recent 5G standards developments will enable non-terrestrial networks to integrate with 5G networks. This will be supported by chipsets and mobile handsets. This could motivate improvements in connectivity qualities.



SIGNALS

Ericsson mobility: Ecosystem collaboration drives innovation (ericsson.com)

5G FWA and its impact on fixed broadband: the trends and strategies driving momentum (gsmaintelligence.com)

Connect Europe (2025), State of Digital Communications 2025 (connecteurope.org)

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Education

FWA strengthens remote learning possibilities by providing access to online digital education platforms to students in underserved or rural areas, reducing the digital divide and providing equitable access to digital learning materials and collaboration tools and virtual classrooms.

Research

- Supports real-time collaboration and teamwork among geographically dispersed research teams.
- Access to cloud-based research tools, data repositories, and virtual labs further enhances faster access to data storage and analysis possibilities.
- Enables the deployment of IoT sensors in remote areas for collecting critical research data.

Operations

- Extends the potential of the future campus; satellite, temporary or new state-of-the-art smart campus locations without the need for laying physical infrastructure.
- Resilience in case of disruption to the physical cable network.

TREND #2

The growing need to harmonise 6 GHz for wireless data traffic

Public Values

Autonomy	Freedom of choice | Independence
Justice	Equity | Inclusion | Sustainability
Humanity	Well-being

Maturity WATCH **PLAN** ACT

Drivers

Connectivity & interaction; Compliancy & regulation; Digital transformation; Globalisation

The radio spectrum is a limited natural resource, and efforts to harmonise the use of radio frequencies across the globe are underway. This leverages global economies of scale for radio-based connectivity of digital devices.

The US, Canada, Brazil, and South Korea have allocated this upper band for indoor Wi-Fi use, while also exploring its potential for outdoor wireless networks. Other countries – including China – have allocated the upper and even the complete band to 5G/6G services.

In 2021, the European Commission (EC) assigned the lower part of the 6 GHz band to Wi-Fi, enabling Wi-Fi 6e and Wi-Fi 7 in the Netherlands. The current debate is now on how to use the upper part and the debate is focusing on policy recommendations for best future implementations.

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European Commission - Radio Spectrum Policy Group. Public Consultation on the Draft RSPG Report on 6G Strategic vision (radio-spectrum-policy-group.ec.europa.eu)

6G at risk without upper 6 GHz band, Europe's telcos warn regulators (capacitymedia.com)

TNO - Upper 6 GHz band - Overview of current and potential future use in The Netherlands (repository.tno.nl)

UK Consultation: Expanding access to the 6 GHz band for commercial mobile and Wi-Fi services (ofcom.org.uk)

Wi-Fi industry asks EU to reserve upper 6 GHz for unlicensed use (telecoms.com)

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Education

Potential benefits of 6G include the enabling of faster, lower latency, and more reliable connections used for digital classrooms, video conferencing and online learning.

Research

'High-throughput' wireless connectivity will significantly enhance research environments - managing large datasets and data transfer, advanced application possibilities with IoT devices, real-time collaboration, remote access to labs via AR/VR and wireless robotics (telepresence), and edge-AI enablement.

Operations

Monitoring the upper 6 GHz band debates and policy strategies is crucial. If institutions become dependent on mobile operators, costs may rise, and bandwidth restrictions could hinder competitiveness with global peers by limiting experimentation with new applications.

TREND #3

Emergence of AI-enhanced tools in network management

Public Values

Autonomy	Privacy | Freedom of choice | Independence
Justice	Accountability | Inclusion | Equity | Transparency | Integrity
Humanity	Safety

Maturity WATCH **PLAN** ACT

Drivers
Automation & AI; Connectivity & interaction;

Increasingly, vendors are integrating large language models (LLMs) into Network Management Systems (NMS), enabling natural language interactions with the network infrastructure.

This change creates business opportunities as many B2B and B2C customers previously turned to open-source network management tools to avoid vendor lock-in, particularly in wide area networks (WANs) managed by internet service providers (ISPs). As part of network management, AIOps and digital twin technologies are being explored to simulate network changes before deployment.

Contrary to the integrations by major vendors, the open-source alternatives are also advancing with initiatives from the Network Automation Forum and National Research and Education Networks (NRENs).

In addition, AI tools will play a key role in network management for 7G connectivity, which is currently under development and predicted to go live sometime in the next decade.

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Market development of various AI-assisted network management systems

Event-driven automation: Reliable, simple, adaptable data center network automation (nokia.com)

HPE acquires Juniper: Leading the convergence of AI and networking (mist.com)

Top 10 AI-powered tools every network engineer should know (blog.octanetworks.com)

Digital twins and AI in networking operations

Intelligently orchestrating programmable 6G networks of the Dutch National Growth Fund initiative 6G Future Network Services (futurenetworkservices.nl)

What AI means for networking infrastructure in 2024 (forbes.com)

Toward building a digital twin for network operations and management (ieeexplore.ieee.org)

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Education & Research

Higher quality and uninterrupted network services are crucial for various types of research and education activities that rely on data access and data exchange. For example, this would be critical for online student lessons or high-throughput data exchange to execute scientific experiments or perform scientific analysis.

Operations

- AI-driven tools can improve operational efficiency, but institutions must balance the risks of vendor lock-in with investments in open-source skills and flexible architectures for long-term sustainability.
- High-quality network services require a professional incident management approach to effectively reduce the Mean Time to Acknowledge (MTTA) and the Mean Time to Repair (MTTR) following an incident. Leveraging AI in Network Management Systems (NMS), can significantly reduce MTTA and MTTR.

TREND #4

Optimising energy efficiency in network infrastructures

Public Values

Autonomy	Independence	
Justice	Sustainability | Accountability | Transparency | Equity	
Humanity	Well-being	

Maturity WATCH **PLAN** ACT

Drivers

Energy supply & demand; Connectivity & interaction; clean water demand; Biodiversity

The energy transition has increased scrutiny on the energy efficiency of digital infrastructures. Rising energy costs and limited grid capacity, alongside growing data bandwidth, pressurise data centres and networks to reduce power and cooling demands. Consequently, organisations are paying more attention to their hardware investment strategies to align performance needs, total cost of ownership, and sustainability goals.

To address the need for energy-efficient operations, adaptive energy-saving strategies are being explored. Such strategies include approaches such as router tuning and powering down unused systems supported by standards like Energy-Efficient Ethernet and green computing practices. In support of this, predictable data traffic patterns enable the possibility of automating energy optimisation, potentially leading to significant energy efficiency.

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Power saving in hardware

Saving energy on Juniper's PTX routers with PFE (packet forwarding engine) power off (community.juniper.net)

Nokia and Orange announce extreme deep-sleep energy-power-saving mode at Mobile World Congress 2024 (telecomtv.com)

Standards & green computing

What is energy efficient internet? (fs.com)

From awareness to action: Evaluating green computing engagement among IT professionals for effective policy design (journalwjarr.com)

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Education

- Prepare students for careers in green tech, smart cities and general awareness of good sustainable computing practices.
- Integrate energy efficiency topics into network engineering, IT management, and sustainability courses.
- Education programmes should be aware of the sustainability implications of data centres and large-scale data network services regarding power consumption and cooling demands.

Research

- Sustainability-oriented innovation will drive further research in low-power hardware, software-defined networking (SDN), and AI for energy optimisation.
- Look out for funding opportunities with grants that are aligned with climate action and sustainable development goals.
- Research groups should be aware of the sustainability implications of data centres and large-scale data network services regarding power consumption and cooling demands.

Operations

- Institutions should include sustainability parameters, like power consumption and cooling requirements, in their procurement and operations policies, alongside hardware performance needs and total cost of ownership.
- Consider the significant bandwidth growth that is expected over the next decade when making network design choices regarding service and hardware requirements.

TREND #5

More attention to subsea data cables to secure network access

Public Values

Autonomy	Privacy | Independence
Justice	Integrity | Transparency | Accountability | Sustainability
Humanity	Safety | Well-being

Maturity WATCH PLAN **ACT**

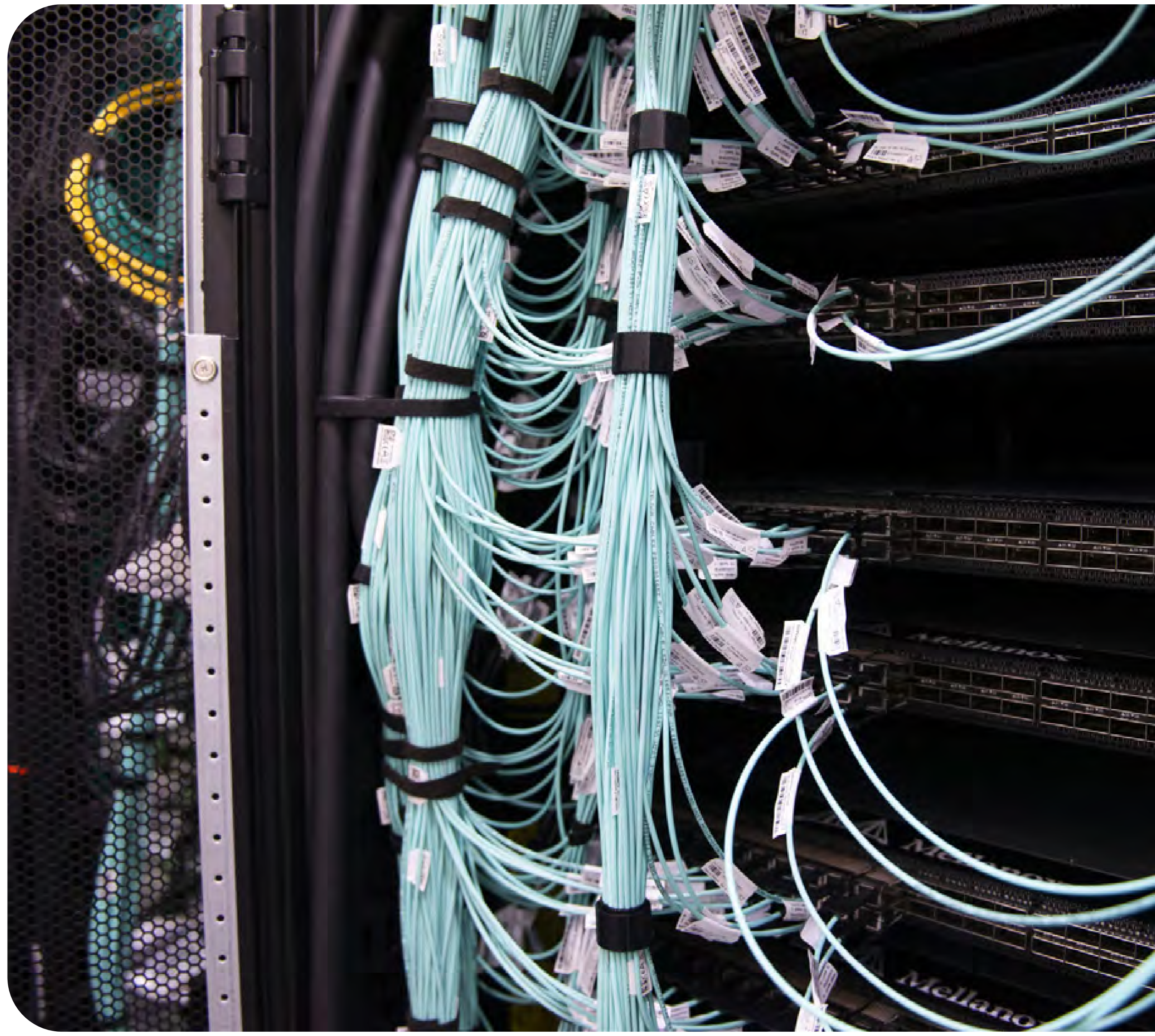
Drivers

Globalisation; Connectivity & interaction; Geopolitics & (digital) sovereignty; Critical infrastructure;

Fibre-optic networks are vital to the global digital infrastructure, and to deliver high-speed, low-latency connectivity that is essential for economic development and national security. Recent advancements allow subsea fibre-optic cables to detect seismic activity, monitor ocean conditions, and identify physical disturbances; thus improving both infrastructure security and environmental monitoring.

Geopolitically, there is a growing urgency to decrease dependence on foreign-controlled network infrastructures and to diversify global cable routes to minimise traffic at vulnerable chokepoints.

In response, alternative subsea routes through the Arctic are being explored. These routes provide enhanced redundancy and lower latency between continents, but they may also heighten geopolitical tensions. As fibre-optic networks evolve into tools of geopolitical leverage, it is crucial to ensure their resilience, sovereignty, and (data) protection.



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Nationalisation of commercial fibre infrastructure

'Strategic' submarine telecom cable manufacturer ASN nationalized by France (lemonde.fr)

Arctic fibre infrastructure

Built-in resilience for Arctic subsea cables (nordu.net)

Arctic Fibre is a three-phase submarine cable project, planned to connect Asia, Canada and Europe through the Arctic Ocean (submarinenetworks.com)

Global interest in undersea cables

The geopolitics of undersea cables: underappreciated and under threat (static1.squarespace.com)

The new geopolitics of undersea cables

- hinrichfoundation.com
- research.hinrichfoundation.com

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Education

- Geopolitical tensions surrounding undersea cables could disrupt digital access services, impacting online learning and cloud-based education tools.
- Regions with weak cable infrastructure or limited alternative routes are most affected, widening the digital divide between well-connected and under-connected institutions and learners.

Research

As data flows through politically sensitive regions, there is a heightened risk of government surveillance and data interception, which can impact how researchers collaborate and share sensitive information internationally.

Operations

- Investment required in redundant connectivity, local cloud services, and stronger cybersecurity to maintain operational continuity amid potential cable disruptions or surveillance risks.
- Transferring sensitive academic and student data through geopolitically sensitive routes raises the need for compliance with data protection laws, increasing legal and technical workloads.
- Current geopolitical dynamics encourage institutions to align with national priorities and enhance digital sovereignty by reducing dependence on foreign infrastructure and supporting local innovation.
- Well-connected institutions provides room for collaboration and access to knowledge, so informed value-based decision-making for investments in critical digital infrastructures remains essential at all levels.

More info about Connectivity? Visit surf.nl

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