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Turning Finland into the world leader in communications networks

- Digital Infrastructure Strategy 2025

LIIKENNE- JA VIESTINTÄMINISTERIÖ

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- Digital Infrastructure Strategy 2025

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Abstract

The digital infrastructure strategy specifies Finland's technology-neutral broadband objectives for 2025 and the means by which they will be achieved. The needs of both business and consumers have been taken into consideration in the strategy.

The strategy contains measures for promoting the implementation of 5G and supporting optical fibre construction. The strategy also identifies key challenges facing the digitalisation of services and existing infrastructure as well as data needs, which are crucial to, for example, automated transportation. The strategy is in line with global development trends, such as augmented reality, the Internet of Things, automation, artificial intelligence and M2M communication. High-quality and reliable communications networks pave the way for these services and new innovations.

The measures proposed in the strategy involve, among other things, the construction of 5G networks and frequency policy, streamlining network permit and construction procedures, promoting market functionality, and supporting research and innovation.

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Tiivistelmä

Digitaalisen infrastruktuurin strategiassa määritellään Suomelle teknologianeutraalit laajakaistatavoitteet vuodeksi 2025 sekä keinot näiden saavuttamiseksi. Strategiassa on huomioitu niin elinkeinoelämän kuin kuluttajienkin tarpeet.

Strategia sisältää toimenpiteitä sekä 5G:n käyttöönoton edistämiseksi että valokuiturakentamisen tukemiseksi. Lisäksi strategiassa on tunnistettu keskeisiä palveluiden ja olemassa olevan infrastruktuurin digitalisointiin liittyviä haasteita ja tietotarpeita, jotka ovat merkityksellisiä esimerkiksi automatisoituvan liikenteen kannalta. Strategia vastaa globaaleihin kehityssuuntiin, kuten lisättyyn todellisuuteen, esineiden internetiin, automaatioon, tekoälyyn ja koneiden väliseen viestintään. Laadukkaat ja toimintavarmat laajakaistaverkot muodostavat alustan näille palveluille sekä uusille innovaatioille.

Strategiassa esitetyt toimenpiteet liittyvät muun muassa 5G-verkkojen rakentumiseen ja taajuuspolitiikkaan, verkkojen lupa- ja rakentamismenettelyjen sujuvoittamiseen, markkinoiden toimivuuden edistämiseen ja tutkimuksen ja innovaation tukemiseen.

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I strategin för digital infrastruktur fastställs teknikneutrala mål för Finlands bredbandsförbindelser år 2025 samt metoder för att uppnå målen. Både näringslivets och konsumenternas behov beaktas i strategin.

Strategin innefattar åtgärder för att främja införandet av 5G-nät och byggandet av fiberoptiska nät. Dessutom identifieras i strategin sådana viktiga utmaningar och informationsbehov vid digitaliseringen av tjänsterna och den befintliga infrastrukturen som är betydelsefulla till exempel med tanke på utvecklingen av automatiserade transporter. Strategin är ett svar på globala trender som till exempel förstärkt verklighet, sakernas internet, automatisering, artificiell intelligens och kommunikation mellan maskiner. Högklassiga och funktionssäkra bredbandsnät skapar en plattform för dessa tjänster och nya innovationer.

I strategin presenteras åtgärder för bland annat utbyggnaden av 5G-nät, frekvenspolitik i samband med 5G-nät, smidigare tillstånds- och byggförfarande, främjande av marknadernas funktion och stöd av forskning och innovation.

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1 Introduction

High-quality and reliable communications networks, and the digital information they convey, pave the way for new services and innovations. The purpose of the digital infrastructure strategy is to ensure that the digital infrastructure facilitates living, working and business activity everywhere in Finland. The strategy is in line with global development trends, such as the growing role of artificial intelligence, the data economy, automation and robotisation, the Internet of Things (IoT) and virtual reality in the applications and services of the future. In the preparation of the strategy, an assessment has been made of the facilitating official measures required to develop the demand and supply of networks serving future development and to promote innovation.

The needs of both business and consumers have been taken into consideration in the objectives and measures of the strategy. The strategy contains measures for promoting the implementation of 5G and supporting optical fibre construction. The strategy also identifies key challenges facing the digitalisation of services and existing infrastructure as well as the data needs that are vital for, among other things, automated transportation.

Digitalisation is a cross-cutting theme of the strategic programme of Prime Minister Juha Sipilä's Government. Constructing a growth environment for digital business has been set as a key project of the programme, which is aimed at creating a regulatory environment and other conditions supporting innovation and service creation. One of the main measures for the latter part of the parliamentary term set out in the Government’s updated action plan is to continue the improvement of broadband connections and effective services.

1.1 Current situation

1.1.1 Wireless broadband

To remain at the forefront of technological and digital service development, Finland needs an active and progressive spectrum policy. Finland's goal is to be a world leader in the development and use of next-generation mobile networks.

Spectrum is a valuable and a limited resource with great social significance. In Finland, the goal of communications policy has been to allocate as much spectrum as possible for mobile connections. Relative to population, more spectrum, totalling 1170

MHz, has been allocated to licensed mobile networks and wireless broadband than elsewhere in Europe.

Finland has also taken new spectrum into use for wireless broadband more quickly than other EU member states. This has made it possible for operators to build their networks relatively more cheaply. A higher amount of spectrum facilitates radio network planning, reduces congestion and enables subscribers to obtain more capacity with the same number of base stations. In Finland, the frequency bands 450 MHz, 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2 GHz and 2.6 GHz are currently in use for mobile communications and wireless broadband.

Finns use the most mobile data in the world. This is due, among other things, to the fact that in Finland subscriptions are widely offered without data usage restrictions, user prices are relatively inexpensive and the networks are highly developed and comprehensive. In Finland, the present wireless broadband networks (3G and 4G) cover over 99% of the Finnish population. Of mobile communications subscriptions, 1.6 million have a theoretical speed of 100 Mbit/s or faster. Actual data transfer rates usually fall short of the promised maximum speed, however, because in a mobile network the data transfer rate fluctuates greatly according to the time, place and the number of users on the network. For example, a 4G rate implemented on a ‘100 Mbit/s’ subscription is, practice, 5–100 Mbit/s.

The capacity needs of wireless broadband networks will continue to grow in the coming years. The trend towards digitalisation has led to an exponential increase in the amount of data. The amount of data is expected to double in two-year cycles. The number of sensors constantly monitoring the environment is increasing, and all information that can be digitised is collected in machine-readable form.

In the data economy, data accessibility and portability play a key role in value creation. The European Commission estimates that in 2020 the value of the EU data economy will increase to EUR 739 billion – i.e. a doubling in five years – if pro-growth measures are actively undertaken. The number of data companies would increase by one hundred thousand to over 350,000 and the number of data workers would increase from six million to ten million[1]. The total value of the European cloud services market, on the other hand, would be just under EUR 45 billion[2].

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[1] https://ec.europa.eu/digital-single-market/en/news/final-results-european-data-market-study-measuring-size-and-trends-eu-data-economy

[2] Deloitte (for the European Commission) 2017: Measuring the economic impact of cloud computing in Europe.

Information-sharing solutions require constantly available broadband connections. The development of mobile networks has also facilitated the development of the industrial internet and has enabled not only mobile phones but also everyday home appliances, cars and machinery to be connected in real time. At the same time, communication between machines (M2M) has been made possible. Different kinds of production plants are also largely networked and automated. With IoT, new types of digital data infrastructures, for example for transport, healthcare and environmental data monitoring, will be created. The development of artificial intelligence and autonomous transport as well as the evolution of other technologies of the future, such as virtual and augmented reality, will further increase the need for high-speed, almost latency-free and secure wireless networks.

Changes in consumer usage patterns and various utility and entertainment applications will require wireless networks to deliver increasingly higher data transfer capacity, and the amount of data transferred in networks will further increase. Already now, Finnish networks transfer the most mobile data in the world per customer. In 2030, the amount of data transferred is projected to be around 150 times its current level. This need must be met by continuing to allocate sufficient spectrum for the use of wireless broadband networks.

The universal service obligation ensures that everyone has access to an effective internet connection. At present, the minimum speed of an universal-service internet connection is 2 Mbit/s and it must be available to all households and business locations. The connection may be implemented both by landline and wirelessly. In 2017, the Ministry of Transport and Communications conducted a mid-term assessment of the minimum speed, on the basis of which the present 2 Mbit/s minimum speed was still considered to be appropriate. When determining the appropriate minimum speed, the connection speed used by the majority of subscribers, nation-wide technical feasibility and implementation costs are taken into consideration. The Ministry of Transport and Communications is monitoring these changes and will re-assess the appropriate minimum as necessary.

1.1.2 Fixed broadband

Currently, the most reliable and fastest fixed connections are implemented with optical fibre. Fixed connections are needed in particular for services that require a high and predictable connection speed, and optical fibre connections also serve as the basis for high-speed wireless connections. Due to their different characteristics, fixed and wireless connections are not replacements for each other; both are needed. To increase the number of reliable and high-speed connections, it is important that the construction of new optical fibre connections continues and that old copper connections are replaced by optical fibre.

The construction of optical fibre connections has progressed quite slowly in Finland. Currently, a fast 100 Mbit/s fixed connection is only available to just over half of households. A connection fully implemented with optical fibre, i.e. enabling a speed of over 1 Gbit/s, is available to only 17% of households.

Availability does not, however, mean that such a connection is necessarily in use. Setting up a subscription requires investment from the end user, which may be up to thousands of euros. For example, 100 Mbit/s-speed connections are only in use in just under one fifth of households.

In June 2017, there were 1,707,000 fixed broadband subscriptions. The total number of fixed-network broadband subscriptions has remained at the same level throughout the 2010s. The steady shift to faster subscriptions will continue, however, as the number of subscriptions entirely and partly based on optical fibre increases.

In Finland, the number of subscriptions based entirely or mainly on optical fibre is rather low, but they have also increased in number in recent years. In June 2017, the number of subscriptions based entirely on optical fibre and built into the home and was around 100,000, compared with 62,000 in 2014. In addition, the number of subscriptions built into properties, where optical fibre extends at least as far as the property distribution box, stood at around 641,000 in June 2017.

1.2 Future needs

1.2.1 Service and technology development

Effective communications networks form the foundation of modern society and are a prerequisite for digitalisation. Phenomena such as artificial intelligence, the data economy, the Internet of Things (IoT), machine-to-machine (M2M) communication, automation and robotics development, and virtual reality require high-speed, almost latency-free and secure networks.

Electronic commerce, the growing number of electronic services, and consumers’ shift to mobile and online services will increase further the need for capacity in both wireless and fixed broadband networks in the coming years. More and more services will be accessed with devices that use wireless networks. Users will seek access to mobile services 24/7 on all devices and in every location. Network functionality, accessibility and coverage will be all the more important.

Broadband network capacity needs will also be increased by the change under way in TV viewing, where people are shifting gradually from real-time viewing towards online services viewable at any time and place. Online media services (such as MTV Viewer, Ruutu, Yle Areena) and online video services (such as Netflix, HBO, Viaplay, Amazon, YouTube) are taking over the video viewing market. For example, according to a study by Finnpanel Oy, just over third of households are watching TV on a tablet and/or smartphone, and almost one in ten households report that they watch TV mainly with a computer, tablet or smartphone. This change has taken place over a few years, and the use of network-connected smartTVs continues to grow. In addition to television, radio services are also increasingly offered over the internet.

Constantly evolving virtual and augmented reality also require a lot of network capacity. Recording events and producing content with so-called 360 techniques increase the number of bits in video images and the transfer rate required to transmit it. In addition to creating entertainment services, augmented reality applications in particular can also be used to meet the needs of industry and other occupational use. Augmented reality applications, for example, can provide real-time visual instructions to installers and service technicians, or can display detailed designs or structures of various machines, devices or buildings without them having to be dismantled. Augmented reality solutions are also one form of teleoperation in education and health services.

Vehicles are expected to become terminals connected to a wireless network. Autonomous transport will impose great demands on the development of artificial intelligence, real-time information and wireless networking. Development will require high-quality information about a vehicle’s operating environment, other road users, infrastructure, and conditions such as the weather. The vehicle will collect and analyse a vast amount of information, which will be communicated to central servers supporting the control and mobility of the vehicle as well as to traffic control, other vehicles, and infrastructure devices such as traffic lights. In an emergency, information on braking must be transferred to other vehicles in milliseconds to avoid accidents. Information collected by the vehicle’s measurement and imaging devices will be transferred in real time to update the map data required by the automated vehicle, but also generally for real-time control of road maintenance and the needs of winter maintenance, in particular.

Traffic solutions will require mobile networks that are comprehensive and fast in every respect. In 2025, it is expected that every new car will be connected to a network. Estimates of the amount of data to be transferred vary, but the amount of data transferred by one vehicle will in any case be thousands of gigabytes per day, with one vehicle being equivalent to the daily usage of thousands of smartphones. This also sets requirements for server capacity and for the wireless network’s fixed support connections in road traffic.

Similarly, the development of autonomous maritime transport will place great demands on digital information and communications links. With regard to maritime transport, an implementation project for autonomous maritime transport has been launched in Finland with the aim of creating the world’s first unmanned shipping products and services as well as a functioning ecosystem by 2025. In the Finnish maritime area, increasing automation of ships and marine operations will require the transfer of large amounts of data as well as reliable and efficient digital data transmission links between ships and shore. The development of port automation will also be affected.

The stunning increase in the amounts of mobile data transferred can be seen as signalling the growth in the capacity needs of both wireless and fixed broadband networks. In 2016, 16 gigabytes of mobile data per person per month was already being transferred in Finland, which is an exceptionally large amount compared with the rest of the world. According to calculations based on current use, however, use is expected to grow to more than 1,500 gigabytes per person by 2030, i.e. around one hundred times higher. Forecasts have been made of even higher utilisation rates than this, and one estimate suggests that the usage rate would increase to over 2,000 gigabytes per person per month. In addition to mobile devices, other terminals, sensors and detectors used for wireless communications will also become more widely used. It is therefore important that Finland has comprehensive and high-speed fixed and mobile broadband networks that can handle the increasing data transmission volumes.

In the future, an increasing number of different players and network technologies will be seen in the communications market. For example, in addition to mobile network operators that use 2G, 3G and 4G technologies, new companies providing wireless network communication services using new types of network technology (such as LoRa and Sigfox) suitable for IoT have already entered the communications market. In the future, an increasing number of so-called vertical players, who can also build and maintain networks according to their own needs, will probably also be evident. The technologies used will also be updated and new technologies created alongside them. Global growth and development expectations are also being directed at NewSpace activities. Small satellites of different kinds can also serve the needs of data transmission in the future. In addition, high elliptical orbit (HEO) satellites can best serve northern and Arctic regions.

Packaging of services, where connection to the public internet is only part of the service package, will also probably increase. Car manufacturers, for example, have already launched combined services, which enable vehicles to be connected to the public internet and the vehicle manufacturer’s own services, and for which the car owner only pays a usage fee to the vehicle manufacturer. The vehicle manufacturer also often ensures that the services are accessible abroad at the same package price.

In other words, the vehicle manufacturer or its subcontractor has negotiated with the network operators of different countries on the use of roaming services.

1.2.2 Future needs in different sectors

Digitalisation will have a significant impact on all administrative branches. For example, the Government has pending the following projects, the implementation of whose goals requires high-quality communications networks.

The administrative branch of the Ministry of Transport and Communications will promote the development of robotics and the digitalisation of logistics as well as the automation and servitisation of transport. With the development of autonomous transport, the aim is to improve transport safety, increase the cost-effectiveness of transport, and reduce emissions. Digital infrastructure will create the foundation for autonomous transport, new transport services and digitalisation of logistics. These will require reliable, high-quality networks with sufficient data transfer capacity.

The Ministry of Transport and Communications will create conditions for the world's most reliable corporate digital systems, for example with the National Information Security Strategy. Maintaining protection of privacy is also a prerequisite for reliable communications. The Ministry will also contribute to promoting the digitalisation of rural areas. Digitalisation can play a major role in Finnish rural areas, where private and public services are rapidly changing and distances to physical service points are increasing. Digitalisation can bring services closer, reduce costs and streamline processes.

The Ministry of Employment and the Economy has under way an Artificial Intelligence Programme, aimed at ensuring that Finland is a frontrunner in the utilisation of artificial intelligence. To maintain Finland’s competitiveness, it is necessary to ensure that shortcomings in the quality and coverage of communications networks do not become an obstacle to the utilisation of artificial intelligence. In industry, for example, automation can improve operational efficiency and occupational safety.

Through devices and infrastructure connected to the Smart Cities network, the goal is to improve security and efficiency and to reduce emissions. With regard to energy management, the focus is on developing energy networks towards decentralised energy production and storage as well as on the optimal management and protection of energy networks, and facilitating smart monitoring.

In the administrative branch of the Ministry of Social Affairs and Health, the coverage and reliability of communications will be increasingly emphasised in the future. Healthcare has already been extensively digitalised, and telemedicine and robotics are widely used, even today. Also in social services, the utilisation and development of digitalisation requires adequate connection speeds.

The objectives sought by digital healthcare include cost savings and universal accessibility to care services. These objectives can be achieved, for example, with the aid of healthcare virtualisation as well as telecare, which makes extensive use of telecommunication links. Health promotion and prevention of illness through health monitoring also constitute a key area whose large-scale application requires effective broadband connections.

Digitalisation is also emphasised in the basic education and vocational education reform projects under way in the administrative branch of the Ministry of Education and Culture as well as in the reform of upper secondary education, which is just beginning. The connection speed requirements of educational institutions will grow in the future as teaching shifts to utilising more and more digital services and materials. The quality and coverage of telecommunication networks is also central with respect to opportunities to utilise the digitalisation of cultural services such as libraries.

The administrative branch of the Ministry of Agriculture and Forestry has a number of digitalisation projects under way that require reliable and comprehensive telecommunications links nationwide. As services are digitalised, it is important that every citizen has access to a high-speed broadband connection, including in rural areas. In sparsely populated rural areas, future developments, such as e-services, teleworking, telemeetings and the digitalisation of services, will be based on high-speed telecommunications links.

Robotic barns and remote-controlled agricultural machinery and equipment are already to a large extent part of farms’ everyday life, and they require high-speed broadband connections in order to work. In addition, wireless networks are utilised in, for example, hunting and commercial fishing, and IoT services are increasingly being used in forest machines and in agricultural monitoring.

The aim of the Government’s key project on improving accessibility to the Ministry of Agriculture and Forestry’s forest data is to ensure that forest resource data is more accurate and supports electronic timber trading by 2020. To achieve this goal, it is important to promote data mobility and develop electronic services. Effective telecommunications links are needed throughout the country, to ensure that forest owners also have the opportunity to handle matters electronically.

Sparsely populated rural areas cover 68% of Finland’s area and account for 5.3% of the Finnish population, which means 293,442 people (2015). Of those living in sparsely populated rural areas, under 18-year-olds account for 17.2% (whole country

20.7%) of the population and over 65-year-olds for 30% of the population (whole country 20.5%).

Of Finnish businesses, 98% are small and medium-sized enterprises. Micro-enterprises, i.e. companies with less than 10 employees, account for more than 93% of businesses. 80% of industrial companies are located outside the Helsinki Metropolitan Area. This is due, among other things, to the location of raw material resources as well as to logistical reasons impacting cost efficiency. Business is promoted by a safe and stable operating environment, efficient travel connections and support services. Effective, fast and reliable telecommunications as well as roads are of great importance in terms of attracting businesses.

Tourism is growing in rural areas, and expansion of tourism is taking place within the framework of rural development. There is also a growing need for high-speed connections in the tourism sector, because additional digital services are constantly being developed in tourism. Nature tourism is also on the rise. Nature tourists need hiking support services and map services, so it is essential that telecommunications links also work in the forest.

In the administrative branch of the Ministry of the Interior, the extension of broadband connections to sparsely populated areas and nature is also a safety issue, as contacting the rescue authorities is critical in an emergency. The coverage and quality of networks are also essential matters for the Emergency Response Centre Administration, which belongs within the administrative branch of the Ministry of the Interior. In addition, the administrative branch of the Ministry of the Interior has numerous new digitalisation projects that require now and in the future high-speed broadband connections. Moreover, the reform of the emergency response centre system, the public authorities’ pan-European mission-critical service and national work on wireless broadband, Police mobile strategies, Border Guard drone projects and numerous citizen e-services, such as permit services, require high-quality telecommunications links.

The administrative branch of the Ministry of Finance has under way a number of significant projects that require effective telecommunications links for all citizens. The government programme’s key project on the digitalisation of public services, for example, will require for its implementation effective connections throughout the country. The objectives of the project include, among other things, that in ten years’ time Finland has taken a productivity leap in public services. The transition to e-commerce and digital citizenship requires connections accessible to all citizens.

2 Vision and objectives of the strategy

2.1 Turning Finland into the world leader in communications networks

The digital infrastructure promotes competitiveness and wellbeing by supporting living, working and entrepreneurship throughout Finland. Networks enable new digital services and business models. They facilitate the full utilisation of the technologies and phenomena of the future, such as the data economy, artificial intelligence and IoT as well as automation and robotisation for the consumer's benefit in both private and public services. Finland is a hub for the movement of data, people and goods.

2.2 Objectives

The goal of the strategy is that the fixed and wireless broadband networks offered in Finland are adequate in terms of speed, quality and latency to provide the services and innovations of the future. The strategy is aimed at achieving a situation in which digital infrastructure better supports the utilisation of automation, robotisation and the real-time data economy, thereby promoting the development of, among other things, the next stages of healthcare, media, education and transport. Adequate digital infrastructure contributes to enabling accessibility to public services that are increasingly in digital form. The introduction of new services and technologies, such as remote electronic services and operations, should not be hindered by legislation that could contribute to undermining investment in digital infrastructure. A further goal of the strategy is that Finland can by a frontrunner globally in, for example, the testing, development and introduction of 5G networks.

Finland aims to develop digital infrastructure at least in line with the European Union's broadband targets. According to the targets set by the European Commission for 2025, European households, in both cities and rural areas, should have the opportunity to access connections with a transfer rate of at least 100 Mbit/s and which can be increased to one gigabit per second. All of the main socio-economic actors, such as schools, universities, research centres and transport centres, as well as all public service providers, such as hospitals and agencies, should have the opportunity to access very high capacity connections that allow users to transfer data at a rate of 1 gigabits per second. In addition, by the end of 2018, every EU member state should have 5G pilot networks. By the end of 2020, every member state should have at least one large city in which the introduction of 5G is possible. The largest cities and their main transport routes should be covered by 5G networks by the end of 2025.

The measures outlined in the strategy will make infrastructure construction more cost-effective and licence procedures more streamlined that at present. Service competition will be promoted through network openness. In Finland, the optimal utilisation of next-generation mobile technology has been made possible by allocating appropriate spectrum for wireless broadband use.

To assess the achievement of the strategy's objectives, the accessibility of households and businesses to telecommunications links, as well as the availability and use of services, should be monitored, particularly in the fields of healthcare, industry, media, education and transport.

3 Strategy measures

3.1 Spectrum policy measures to promote 5G network construction

The next generation of mobile technology, 5G, will fundamentally change the role of wireless technologies in society. It will enable faster wireless connectivity, reduce data transfer latency, improve security and energy efficiency, and increase new services and business opportunities in different sectors. The key sectors that will utilise 5G technology include intelligent transport, intelligent industry and healthcare, smart cities, and the media and entertainment Industry.

5G technology is currently being intensively developed, and various test and preliminary versions will be gradually introduced. The high frequencies to be allocated to 5G, such as the 26 GHz band, will be decided internationally in 2019 at the World Radiocommunication Conference (WRC-19). A technical specification containing the key features of 5G will be completed in 2020. 5G networks will be deployed more widely for commercial use from the beginning of the 2020s.

Lower frequency bands, such as 3400–3800 MHz, which have been identified as ‘pioneer spectrum’ in Europe, will not be decided on at WRC-19. The first 5G services will be offered and the first 5G networks built using this spectrum. At the lower frequency bands, geographically comprehensive networks can be built more cost-effectively. In the future, 5G technology will use both low and very high frequencies, which differ in their usability, for example, in coverage and capacity.

Alongside the development of 5G, the development of current 4G technology will also continue. Functionalities enabling 5G services, such as lower latency and support for larger numbers of devices, will be incorporated gradually into 4G networks. The spectrum of the present broadband networks can therefore be used for services that use a narrower frequency band, such as the IoT and M2M. A comprehensive 99% population coverage has already been implemented at 4G frequencies in Finland.

At the beginning of 2017, Finland became the first EU country to assign the 700 MHz frequency band for nationwide mobile communications use. The spectrum has been used for 4G network construction. The low frequency band enables the construction of wide coverage cost-efficiently as well as better indoor coverage than higher frequencies. The 700 MHz frequency band is not a proper 5G band, but it is internationally recognised as a band that can provide 5G services that need wide coverage. Nationwide coverage can be built with the 700 MHz band, but the narrowness of the band means that it cannot implement high-speed 5G data transfer connections.

High-speed data connections can only be implemented with proper high-frequency 5G bands, which are significantly wider than the current frequency bands. Internationally and at the EU level, Finland is actively advocating that adequate and appropriate spectrum is allocated to next-generation mobile technology. Adequate availability of lower frequencies must also be secured. For example, Finland has sought to promote the allocation of the terrestrial TV lower UHF band (470–694 MHz) for mobile communications use in Europe. In Finland, it may be appropriate to assess the possibility of the national allocation of spectrum in this band for mobile use even before international decisions are made.

In addition, Finland supports and promotes 5G testing, research and product development. The Finnish test environment serves as an innovation platform that companies can use when trialling new products and business models. A Government Decree has permitted the allocation of spectrum for the research and product development of different technologies, and the Finnish Communications Regulatory Authority (FICORA) facilitates various trials and tests by granting radio licences flexibly for 5G development. To date, around 30 licences have been granted for 5G testing.

The high data transfer rates enabled by 5G networks will require transfer links of optical fibre standard to connect base station transmitters to the core network. The cost-effective construction and rapid spread of 5G networks would be facilitated by dense and comprehensive availability of optical fibre links for base station use.

In addition to mobile networks, satellite systems can also be utilised as part of the future wireless communications infrastructure. Commercial constellations of low-orbit telecommunication satellites offer new opportunities for the provision of high-speed wireless links, particularly for difficult to reach areas such as maritime and coastal areas as well as sparsely populated areas of mainland Finland. In addition, high elliptical orbit (HEO) satellites can best serve northern and Arctic regions.

As wireless technology evolves and its use becomes more widespread, questions have also been raised about the potential health effects of radiofrequency radiation on the population. In Finland, the Radiation and Nuclear Safety Authority considers that 5G mobile technology does not differ significantly in terms of radiation safety from the technologies currently in use. The radiation safety of 5G mobile networks can be ensured by means of radiation legislation. In Finland, the exposure of the population to radio frequency radiation is limited by the maximum exposure values stated in the Ministry of Social Affairs and Health Decree 294/2002. The maximum values are in line with the Council of the European Union Recommendation 1999/519/EC. The mobile networks and communication devices used in Finland must not, taking into account conditions of use, result in exposure to the population exceeding the maximum values. Radiation legislation is currently being reformed in a project led by the Ministry of Social Affairs and Health. In connection with this, the regulation of radio frequency radiation will also be reformed.

In the assessment of the Radiation and Nuclear Safety Authority, the base stations of the 3.5 GHz frequency band, for example, will not differ significantly from the base stations of existing mobile technologies (2G, 3G, 4G) in terms of exposure to radio frequency radiation. At the higher 5G frequencies, in addition to the outdoor base stations and antennas, a large number of indoor base stations will be required to ensure a network's indoor coverage. The small-cell base stations use low transmission power, in which case exposure to radio frequency radiation will be low. A dense base station network also enables 5G terminals to operate at low transmission power.

In a 5G environment, the positioning of base stations and antennas must also take into account the applicable regulations and guidelines on radiation protection. Mobile device manufacturers and mobile operators have a duty to ensure that devices do not cause exposure to radio frequency radiation above the maximum values. The Radiation and Nuclear Safety Authority supervises operators and actively monitors the development of international research data related to the health effects of mobile network radiation, and participates in the industry's safety standardisation.

The health effects of radio frequency radiation have been investigated in thousands of studies. International expert organisations, such as the World Health Organisation (WHO), the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and the International Commission on Non-Ionising Radiation Protection (ICNIRP), have examined health impacts through extensive literature reviews. According to the expert organisations, the current maximum values of radio frequency radiation protect against any documented adverse effects in both short- and long-term exposure.

3.1.1 3.5 GHz spectrum to be deployed for wireless broadband use from beginning of 2019

In 2018, taking into account protection bands[3], the entire 3.5 GHz spectrum was auctioned for the construction of nationwide networks. The licence conditions allow tailored network solutions in, for example, hospitals, factories, ports and limited sections of the transport network.

The 3.5 GHz spectrum (3400–3800 MHz) has been identified in Europe as a key frequency band for the construction of 5G networks. At least in the early stages, the spectrum will be primarily used to provide faster broadband. The first commercial devices supporting the frequency band are expected to enter the market during 2019. Until the end of 2018, the frequency band was used in Finland for fixed wireless access networks, radio amateurs and radio links. The entire 3.5 GHz band was auctioned in 2018 for the construction of nationwide wireless broadband. Networks can be built from 1 January 2019. The licence conditions for the auctioned frequencies ensured that the frequency band would be used by three telecom operators. This is to ensure that the industry remains competitive.

For different uses, networks may be required to have different characteristics so that they can be utilised in the most appropriate way. The characteristics required of networks may differ significantly from each other in different uses, which may require individually realised local solutions. Tailored and individual networks using 5G technology, as well as the applications used through them, may be in demand in industrial plants, ports, hospitals and shopping centres, for example, to utilise automation and robotisation. Taking the needs of different users into account will facilitate the development and offering of new services and innovations. Licence conditions allow tailored network solutions. The 3.5 GHz network licences require the licensee to lease on reasonable and non-discriminatory terms the right to use the frequency to another operator to provide a network service in a geographical area for which the licensee does not offer a tailored network service despite a request to do so. This will allow sufficient spectrum availability for the construction of national commercial networks, but at the same time promote the implementation of tailored and local solutions.

The usability of the 3.5 GHz frequency band in Finland will be significantly restricted by Russia's frequency usage. If better terms than now for using the upper part (3600-3800 MHz) of the frequency band are not agreed, restrictions on the use of wireless broadband in Finland will be considerable, at worst a few several hundred kilometres from the border. In the lower part (3400-3600 MHz) of the frequency band, the use of

[3] A 10 MHz protection band is required to protect use under 3400 MHz.

frequencies in Finland may be restricted around 100 kilometres from the border. The distance will also depend, however, on the technical solutions used and the effects of the terrain, which should be taken into account when building the networks.

The goal is that the wireless networks will achieve at least the EU targets. According to the targets set by the European Commission, by the end of 2020 every member state should have at least one large city where 5G deployment is possible, and the largest cities and their main transport routes should be covered by 5G networks by the end of 2025.

5G will be intrinsically associated with automated transport and other socially important activities. Intelligent transport and transport automation will utilise many different communication technologies. Much of the current capacity needs of evolving intelligent transport can be met with the existing 4G networks, but later there will also be a need for the lower latency, higher reliability and high capacity of 5G. It is evident, for example, that the 3.5 GHz and 26 GHz frequency bands will be used, at least in the first phase, in urban areas, in other population centres and at transport hubs. Covering the entire road network and all transport routes with these frequencies will require considerable investment, but lower frequency bands can be used more cost-effectively to achieve wider coverage. It should also be noted that communications associated with the critical functions of intelligent transport cannot be based on a connection to the mobile network being available in every place and at all times.

3.1.2 Part of 26 GHz spectrum to be deployed during 2018 and whole spectrum in 2020

User rights will be issued for the 26 GHz spectrum in spring 2020. FICORA Communications Regulatory Authority radio licences have been issued for the uppermost gigahertz (26.5–27.5 GHz) of the spectrum for a fixed term and for limited, shared use from the beginning of 2018. Current testing activity with this spectrum will also continue.

The 26 GHz spectrum (24.25–27.5 GHz) has been identified in Europe as a key frequency band for the construction of 5G networks. The spectrum will be probably be used primarily to provide faster broadband. The introduction of the spectrum would increase data transfer capacity and rates, and reduce latency. The first terminals covering the entire 26 GHz spectrum may not come on to the market until 2020, but will appear earlier for the 26.5 to 27.5 GHz part of the spectrum. Wide frequency bands enable large data transfer capacity, but their high frequency means that the coverage areas realised with them are small. A high frequency band is well suited to providing very high connection speeds, for example in cities and at traffic hubs and public events.

In Finland, the 26 GHz spectrum currently has low radio connection and vehicle radar usage, which are shifting to other frequencies. The harmonisation of the spectrum for 5G technology use will be decided at the International Telecommunication Union (ITU) World Radiocommunication Conference (WRC-19) to be held in late 2019. If the whole spectrum were to be taken into use before the WRC-19's decisions, it is possible that technical terms of use would have to be added afterwards. Therefore, it would not be appropriate to grant longer user rights to the spectrum before the WRC19's decisions.

5G devices will likely become available first for the uppermost part of the spectrum (26.5 to 27.5 GHz). It would therefore be appropriate to issue this top gigahertz of the spectrum on a shared basis to operators interested in 5G piloting for a longer fixed period than normal for testing activity before the WRC19's decisions, taking into account possible use restrictions in border areas. Commercial 5G use of a pilot type for a fixed period using the top gigahertz of the spectrum would be implemented with radio licences issued by FICORA from 2018, provided that the user group is sufficiently limited and public telecommunications activity is not involved. After a fixed-term pilot stage, user rights could be issued for the whole 26 GHz spectrum at the beginning of 2020.

3.2 Promote cost-effective and fast construction of networks

Special permission is needed for the placement of telecommunications cables on an area owned by another party. Permission is always sought from the party on whose land the cable is to be placed. In the case of private landowners, an agreement is made between the parties on the placement of the cable in the area. Placement of a cable on the land of a municipality or on a road area, on the other hand, requires a location permit, which is issued based on a location plan prepared by the applicant. The location plan is often required to be supported by various official statements whose purpose is to ensure that environmental requirements are taken into account in the project. Location permit applications relating to road areas are handled centrally in the Pirkanmaa Centre for Economic Development, Transport and the Environment.

Depending on their planned location, other permits, such as a water permit, may be also required to place telecommunications cables on an area owned by another party. However, the permit procedure under the Water Act has been eased significantly for telecommunications cables through an amendment that entered into effect at the beginning of 2018. Moreover, for road areas, there is no longer a need in all cases to apply for an location permit; sometimes the notification procedure introduced in 2016 may be used. Although permit procedures have been eased in recent years, for example by the above-mentioned legislative changes, further development of permit procedures could promote further the efficient and rapid construction of high-speed connections.

In addition, it is believed that a reduction in construction costs will promote construction of digital infrastructure. Only a small part of the cost of optical fibre construction is due to the cost of the optical fibre cable. On the other hand, 60–80% of the costs of constructing a fibre link consists of excavation costs. Broadband construction in conjunction with other projects, such as electricity network construction, reduces construction costs for all of parties involved. Joint use and construction of infrastructure has been promoted with new legislation since 2016. Joint construction is promoted by FICORA's online information point, where planned network projects are announced.

A significant part of the construction and permit procedures falls within the competence of the municipalities, as they are responsible for the construction permit procedures in their areas. Practices and requirements vary from one municipality to another, which adversely affects permit applications and utilisation of various construction methods.

3.2.1 Develop permit procedures according to the one-stop-shop principle

Location permit procedures will be eased in connection with the drafting of the Highways Act. Permit procedures will be developed with the aid an electronic services system.

In developing permit procedures for the placement of telecommunications cables, the aim is an operating model according to the one-stop-shop principle, where customers access services with the authorities through a single interface. This means that the authorities' procedures must be combined and coordinated as widely as possible, and that flow of information between the various actors is ensured.

In connection with the drafting of an act on transport and roads (Highways Act), the Ministry of Transport and Communications has commissioned a report aimed at evaluating procedures for controlling the placement of cables and other structures in road and railway areas and in the vicinity of them. The report evaluates, among other things, opportunities for developing legislation, taking into account different parties' interests, such as transport safety, road maintenance difficulties, service efficiency and the customer's right to due process, the consistency of legislation, and ongoing administrative reform projects. Key changes proposed in the report include the harmonisation of cable and advertisement announcement procedures and the introduction of an administrative fine in certain types of case, such as cable placement in violation of permit regulations.

Effective implementation of the one-stop-shop principle in permit procedures requires that services in different authorities are realised electronically. The permit procedures of different authorities can then be standardised so that the procedures and the authorities responsible for them are not linked. Led by the Ministry of Economic Affairs and Employment, a one-stop-shop electronic services system will be prepared within the framework of the licensing and supervision key project of Prime Minister Sipilä's Government Programme. The key project is part of a project package for the digitalisation of public sector services, aimed at making public services more user-oriented and, in principle, digital by reforming operating practices. According to the Government Programme, internal administrative processes will be digitalised and public administration will undertake to ask people and businesses for the same information only once.

3.2.2 Promote construction of passive infrastructure in connection with underground electricity cabling

Means will be explored to facilitate electricity companies' investment in optical fibre.

According to the Electricity Market Act, electricity companies have to make significant investments in improving reliability of supply by the end of 2028. It is considered that a significant number of electricity companies will improve the performance of their networks with underground cabling.

Particularly in population centres, in the coming years there will be significant potential for constructing telecommunications networks in conjunction with underground cabling. In addition to joint construction, the electricity companies could build a passive telecommunications networks themselves. If electricity companies leased access to these networks on an open and non-discriminatory basis, this would promote the creation of service competition.

Currently, the Electricity Market Act requires that optical fibre network construction be separate from the electricity grid business, and optical fibre network construction cannot be part of regulated business. It would be appropriate to examine whether electricity companies' optical fibre investments would support the achievement of the strategy's objectives and whether this could be facilitated by legislative changes.

3.2.3 Promote the placement of base stations on state-owned land

Light poles will be used in the placement of mobile network base stations.

In the future, the construction of 5G networks will require a denser base station network also in road areas. According to the Finnish Transport Infrastructure Agency's preliminary estimates, the placement of a mobile network base station on a light pole requires, at least, that the electricity is connected to the luminaire 24 hours a day. This, in turn, means that in road lighting there must be luminaire-specific control instead of the centralised control currently in use. In 2018, the Finnish Transport Infrastructure Agency studied in pilot projects the cost and other effects of switching from centralised control to luminaire-specific control of road lighting.

3.2.4 Promote joint construction and use of networks as well as security of cable information

The Verkkotietopiste.fi (network information point) service will be enhanced to support joint construction and use, and to improve service accessibility. The security of cable information associated with critical communication infrastructure will be improved.

The objective of the Verkkotietopiste.fi service is to increase the joint construction and use of networks. The service will be developed to better support the search for possible joint construction projects as well as agreement on joint construction. In addition, the provision of information will be facilitated by providing new ways of doing so. At the same time, service accessibility and performance will be improved.

The information content of the network information point service will be standardised by preparing a conceptual model for the information management of cable infrastructure. This will enable the transfer of network and construction project data between different systems and services and will reduce costs resulting from data reconciliation.

In addition, the security of critical infrastructure information will be improved in the disclosure, storage and processing of telecommunication cable location information, for example. Critical infrastructure includes physical infrastructure whose endangerment might give rise to significant public risk or a deterioration of national security.

3.2.5 Support streamlining of municipal licensing procedures and encourage municipalities to introduce new construction techniques

Municipalities will be supported in the construction of high-speed connections by sharing best practices.

A significant proportion of broadband construction takes place in population centres and the areas of municipalities, so municipal procedures have a significant impact on the smooth running of construction projects. Municipalities will be actively encouraged to develop their own procedures to facilitate the efficient implementation of broadband construction. The importance of good telecommunications links for the vitality of municipalities will increase significantly in the future. Through flexible procedures and innovative solutions, municipalities can evolve into attractive construction sites for high-speed infrastructure.

Municipalities could, for example, allow more microtrenching, increase the use of notification procedures, utilise existing infrastructure by permitting its use for broadband needs, instal optical fibre in public buildings, build passive infrastructure in connection with roadworks, and facilitate the placement of base stations. Municipalities can be supported by, for example, sharing good practices identified from both the state and other municipalities, and by raising awareness of various innovative construction methods. To achieve the objectives of the strategy for municipalities and cities, it is essential to integrate the development of broadband connections required by automated transport with the streamlining of licensing procedures for transport and, in particular, for land use.

3.3 Ensure adequate investment and financing

Optical fibre construction in Finland has mainly taken place on market terms. An exception to this is the Fast Broadband support programme (formerly known as Broadband for All), launched in 2010. Within the scope of this programme, networks have been built in areas where connections are not built on market terms. In addition, optical fibre construction has been supported under the Rural Development Programme for Mainland Finland.

Around EUR 135 million, of which EUR 69.5 million comes from the state, has been allocated to support for the Fast Broadband support programme. By the end of

January 2018, a total of EUR 50.5 million of state aid had been granted to broadband projects, of which EUR 34.8 million had been paid. Around EUR 24 million had not yet be granted. In these projects, optical fibre accessibility has been built for over 82,000 users. This corresponds to around one quarter of Finland's Fibre to the Home (FTTH) accessibility. To date, 63 broadband investments, to which a total of EUR 22 million has been committed, have been financed under the Rural Development Programme for Mainland Finland 2014–2020. The Rural Development Programme's broadband projects are funded in areas where connections are not built on market terms.

Finland invests significantly less than the other Nordic countries in telecommunications networks. In 2016, EUR 242 million was invested in fixed network operations and EUR 591 million in telecommunications activity.

The opportunities of the upcoming EU programme period starting in 2021 to support broadband investments should be taken into account, particularly in improving the connections of sparsely populated rural areas.

3.3.1 Promote use of WiFi4EU funding in municipalities

Municipalities will be encouraged to be active in applying for WiFi4EU funding.

The EU provides public support for building municipal Wi-Fi connections. This funding can be used to build connections in public spaces such as schools, libraries and hospitals. The state does not participate in the granting or payment of the funding.

The first WiFi4EU funding call was held in 2018. Municipalities will be encouraged to be active in applying for funding. In addition, awareness of funding will be increased and best practices for building publicly supported Wi-Fi networks will be shared.

3.4 Promote market functionality

Effective competition is a key factor in developing markets and creating investment. In Finland's mobile market, effective competition has led to the rapid construction of networks and both affordable and high-quality services. No corresponding competition has emerged in the optical fibre market. The largest fixed network operators are also mobile operators and can be considered to have focused in their operations on competing in the mobile market in particular. In addition, the regional markets for fixed broadband services have traditionally been concentrated, often only on one operator. In some areas, there is currently no optical fibre provision at all. There are such areas in both cities and sparsely populated areas. Due to market concentration, telecom operators have not been subject to much pressure to develop their fixed networks; they have been able to collect revenue from their ageing copper infrastructure.

There can be both network and service competition in the optical fibre market. Network competition means that there are overlapping competing networks in a particular area. Due to the long distances and low subscriber numbers in Finland's sparsely populated areas, however, it is not profitable on market terms to invest in multiple networks. Such areas could benefit from service competition, where several service providers operate on one network. The emergence of service competition is currently hampered by the fact that most of the broadband operators provide retail services themselves on their own networks, which means that there is little incentive to allow competing operators to provide services on their network.

The development of the communications market towards the needs of the digital society requires a competitive market. Without effective competition, telecom operators have little incentive to renew and invest in new, faster infrastructure. Effective and fair competition benefits consumers and other end-users, such as businesses, by encouraging telecom operators to lower prices and diversify the services they offer.

In exceptional cases, market functionality may require regulatory measures by the state, for example in relation to significant market power (so-called SMP regulation). Furthermore, other measures, such as disseminating information on best practices, can also contribute to the better functioning of the market.

In addition to competition, market functionality is also affected by demand for connections. So far, demand for optical fibre connections has not been sufficient. The use of the most popular digital services is currently also possible without a high-speed broadband connection, so consumers have not felt the need for an expensive optical fibre connection. In the near future, the need for high-speed connections is expected to grow significantly as new services and applications emerge.

3.4.1 Promote open networks and create regional competition

Construction of open optical fibre networks will be promoted by sharing best practices and encouraging new operating models.

Currently, provision of fixed broadband in Finland is often regionally concentrated on just one operator. Increasing competition at the regional level would promote the availability of optical fibre connections. Particularly due to the long distances and low subscriber numbers in Finland's sparsely populated areas, however, it is not profitable on market terms to invest in multiple, overlapping networks. In such areas, networks should, in principle, be implemented on the open network principle. In open optical fibre networks, the network builder and owner do not operate in the retail market themselves; they offer access to their network to willing service companies, enabling the creation of service competition. To date, open networks in Finland have been created mainly in the sphere of regional network companies that have received public support.

3.4.2 Promote leasing of passive infrastructure

Means to promote leasing of existing infrastructure will be assessed.

More efficient use of passive infrastructure, such as cableways and pipelines, would promote the emergence of network competition in the broadband market. By leasing existing infrastructure, telecom operators would be able to advance their own optical fibre connections without expensive and slow excavation and permit processes. In principle, network operators are obliged under the Joint Construction Act to provide access to such infrastructure on fair and reasonable terms. The act allows a leasing request to be refused on a number of different grounds, however, and as yet there is simply no experience of its application.

It would therefore be appropriate to commission an extensive study of the leasing of passive infrastructure. The study would assess the regulatory or other means available to utilise the existing infrastructure, and therefore how best to promote the construction of cost-effective optical fibre networks in Finnish market conditions.

3.4.3 Stimulate demand for high speed connections

Counties' and municipalities' awareness of the benefits of high-speed connections will be increased. Broadband constructors' awareness of the building and opportunities for financing optical fibre networks will also be increased.

The state can stimulate demand for high-speed connections by digitalising public services more widely than is currently the case. Public and other services that require high-speed connectivity cannot, however, be widely launched or introduced without a comprehensive and functional network infrastructure. High-speed connections should be built to meet current and future needs. All of the strategy's measures are therefore aimed at increasing demand.

Demand for high-speed broadband connections can also be stimulated by ensuring that the introduction of new technologies that utilise such connections is possible. Remote electronic services and operations, especially in healthcare, as well as automation, particularly in transport, will facilitate broad societal benefits, but at the same time there are many legislative and data-access issues associated with them that need to be resolved. The European Commission estimates that the European market for connected and automated vehicles will grow by nearly EUR 300 billion. By removing barriers to the development of this market, and by promoting in particular the availability, sharability and interoperability of critical digital data, demand for high-speed connections can be significantly increased and companies encouraged to invest in digital infrastructure.

Digitalisation has enormous potential for development of the counties. Its full exploitation requires an effective communication network, however. The counties could be supported in their development by sharing information about the benefits of communication networks and the available funding, for example.

The Laajakaistainfo.fi website disseminates information on broadband funding opportunities as well as practical tips for builders and municipalities. The website is operated by the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, FICORA and the Agency for Rural Affairs. Laajakaistainfo.fi is part of the European Broadband Competence Office (BCO) network, which, among other things, shares information and best practices on broadband between EU countries.

3.5 Supporting research and innovation

High-speed, flawlessly functioning communication networks will continue to be a prerequisite for the development of an innovation environment in Finland. In Finland, there are a number of public sector-coordinated or publicly funded research and development projects under way related to digital infrastructure and digital services. Moreover, there are several projects pending related, in particular, to 5G technology and to intelligent transport and transport automation.

The development of services and innovations related to digital infrastructure can also be influenced by public procurement. In Finland, public sector procurement totals around EUR 35 billion per year. The Government’s goal is to direct 5% of public procurement to innovative procurement.

3.5.1 Continue supporting and enabling testing and innovation projects

Publicly or partly publicly funded research and development on wireless 5G networks and services will be continued. Efforts will also be made to promote research and development on the financing, construction, business models, ecosystems and social impacts of optical fibre networks and other communication technologies.

The joint 5G testing ecosystem project of certain Ministry of Transport and Communications administrative branch agencies (FICORA, Finnish Transport Infrastructure Agency, Trafi, Finnish Meteorological Institute), coordinated by FICORA, will facilitate test and trial platforms based on 5G technology and will promote the emergence of innovative services developed through them. The goal is to utilise 5G technology to develop the operations and services of businesses and the authorities. The project may also assist in evaluating legislative effects as well as possible development needs to promote the flexible and efficient deployment of 5G technology. It will also be possible to generate new business activity and business models through the knowledge and experience gained from the project. The trials conducted in the project will increase citizens' and businesses' awareness of and trust in new digital services and 5G technologies. Citizens, society and businesses will benefit from the rapid deployment of 5G technology as well as from well-functioning and secure digital services.

Tekes' 5thGEAR programme, which provides innovation funding, has created an ecosystem for the testing of services and networks. It consists of partly interconnected research projects, located in Oulu, Turku, Ylivieska and Espoo. The scope of the current five-year programme is approximately EUR 100 million, of which Tekes (The Finnish Funding Agency for Technology and Innovation) accounts for approximately half. The operator 5GTNF (5G Test Network Finland) has been established in Finland for the 5thGEAR programme's test network projects. 5GTNF coordinates collaboration between test environments and the construction of a common test network for the study of 5G technologies, applications and concepts. The actors involved are multinational companies, research institutes and organisations. In addition, the Challenge Finland project, in which VTT Technical Research Centre of Finland and the Finnish Meteorological Institute, together with a business consortium, are developing new intelligent transport and road weather services for the 5G network, has been established under the auspices of Tekes. At the beginning of 2018, Tekes and Finpro, a provider of internationalisation, investment and tourism promotion services to businesses, merged to form a new entity, Business Finland. Many of Tekes' functions, such as finance and programme services, continue to operate under Business Finland.

In the Aurora project, coordinated by the Finnish Transport Infrastructure Agency, an Arctic intelligent transport testing ecosystem is being developed on Highway 21, offering opportunities for the testing of automated vehicles and intelligent transport solutions in all road and weather conditions. In the project, a section of Highway 21 will be equipped to enable and support trials on intelligent transport and intelligent road asset management. One of four subprojects relates to digital transport infrastructure, and the intention is also to provide a 5G test network for the use of actors conducting trials. A high-speed network will also be tested in the Aurora subproject Arctic Challenge, which will focus in 2017–2019 on intelligent infrastructure and road transport automation in Arctic conditions.

The SOD5G project, coordinated by the Finnish Meteorological Institute, is building a 5G network test environment for a vehicle winter testing track at Sodankylä Airport. In addition to the 5G network, a C-ITS inter-vehicle communication network is being built in the area. The objective is, among other things, to compare the functionality of these two technical solutions in an intelligent transport environment.

In order to experiment in Finland with new technologies and services based on them, it is appropriate to continue to provide and support high-quality, collaborative research environments and development platforms.

3.5.2 Continue issuing radio licences for product development and testing

Provision will be made to ensure that, in the future, there will also be sufficient spectrum for wireless communications testing and that radio licences will continue to be issued flexibly for the testing of new innovative radio technologies and systems.

FICORA has issued numerous radio licences for use in the research and development of 5G and other technologies to equipment manufacturers, research institutes and research projects operating in Finland. The test licences will enable the creation of a 5G ecosystem so that different core, radio and access network services can be provided for different research projects. The propagation of radio signals in different environments, among other things, has been studied using test licences.

It is important to assess the realisation of testing activity spectrum needs with regard to the supply and testing environment of commercial mobile networks. It would also be appropriate to continue testing in the 3.5 GHz and 26 GHz frequency bands in order to ensure the continuation of equipment manufacturers' and research institutes' testing and product development activities in Finland.

Dedicated frequencies within the licensed frequency bands are currently allocated to product development, testing and educational use. Commercial mobile networks operating in these frequency bands are subject to restrictions set out in a Government Decree for certain geographic areas, to enable equipment manufacturers' and research institutes' testing and product development activities. Such restrictions exist, for example, in Espoo and Oulu. As regards the frequency bands enabling the construction of commercial 5G networks, there is a need to assess the most appropriate way of fulfilling the above-mentioned testing and product development needs. The goal is to reconcile the commercial interests of telecom operators as well as the interests of network and equipment manufacturers and other parties engaged in testing and research.

3.5.3 Promote innovative public procurement

Innovative public procurement will be promoted in all administrative branches in line with a Ministry of Employment and the Economy action programme announced in December 2017.

In many fields, the public sector and its procurement are a significant factor influencing market activity. The public sector can create demand for innovations and thereby inspire businesses to develop new products and services. The Ministry of Employment and the Economy has prepared an innovative procurement action programme, whose measures are intended to encourage a strategic approach to administrative branches' innovative procurement, the management of innovative procurement and the preparation of actual procurement transactions as well as to create a systematic development process for cooperation across governmental sectors and administrative branches. The measures will be put into practice in the second phase of the project, which is currently under way. A networked centre of excellence for sustainable and innovative public procurement has also been established to increase public procurement. The centre was launched in March 2018.

3.6 Support through network policy for the development of intelligent transport and transport automation

Finland's goal is to be at the forefront of intelligent transport development and to ensure the best possible operating environment for autonomous transport. Increasing traffic automation and smart services present significant opportunities to improve the safety, efficiency and fluency of transport and to reduce harmful environmental impacts. The development of autonomous traffic will also enable new mobility services and business models and free up resources for other tasks. Many different types of support and operational functions underlying transport activity can be considerably improved by increasing the automation and interoperability of back-end systems. These include traffic control and information services.

The use of transport automation applications has increased significantly in recent years in all modes of transport. Automation is advancing via local solutions and demand. Topical examples include truck platooning and minibuses that test automated driving. Large-scale deployment will not take place until a later stage. Independent inter-vehicle communication is constantly evolving. Vehicles’ capacity to visualise their surroundings and connect to the network is progressing, driven by the interests of the automotive industry.

The development of a communications network infrastructure is creating a basis for automated transport and intelligent transport services. Automation and intelligent transport applications’ various requirements for communication networks and network technologies may vary depending on their purpose and use. Some of these will require more speed and capacity from the data transmission network, while others will primarily require, for example, reliability and trouble-free operation. The interoperability of the various network technologies is also crucial.

Communication between vehicles and infrastructure can be implemented with frequencies allocated from the 5.9 GHz spectrum for the use of intelligent transport systems (ITS). In road transport, the development of 5G mobile technology and positioning accuracy will also be key. In addition, development requires sufficient availability of road optical fibre links as well as equipping routes and vehicles with various devices and sensors.

In the case of mobile networks, the availability of high-speed connections on key routes has so far been promoted by licence policy, among other things. At present, mobile operators’ 2G and 3G networks cover the mainland Finland road network (highways, main roads, regional roads and connecting roads). Telecom companies’ 4G networks do not yet fully cover the road network in northern and eastern Finland. The licences issued in December 2016 for the 700 MHz frequency band require, however, that the network be constructed to cover all mainland Finland highways, main roads, regional roads and connecting roads as well as the entire Finnish state-owned rail network.

In addition to network infrastructure, the evolution of intelligent traffic will also be strongly guided by the emergence of new transport services, consumers’ trust in automated transport and the creation of new patterns of behaviour.

3.6.1 Evaluate intelligent transport needs for mobile networks when preparing 5G network access rights

The needs of intelligent transport and transport automation will be taken into account when preparing spectrum access rights.

With regard to mobile networks, intelligent transport will use the existing nationwide 4G networks and future 5G networks. Current 4G technology will be developed further and will remain in use alongside 5G technology into the 2030s. The nationwide 4G networks can provide connectivity over geographically extensive areas and they will evolve gradually towards 5G. High-capacity 5G networks, on the other hand, will be built on market terms primarily in cities and at transport hubs and in other areas where there are high numbers of potential users. For the most part, the current capacity needs of emerging intelligent transport can be met with the present 4G/LTE networks, but as new applications appear there will also be a need for the lower latency and high capacity of 5G. Thus, in the first phase, the existing comprehensive 4G networks and ITS links will provide connectivity.

The needs of intelligent transport for mobile networks will be evaluated when preparing 5G spectrum access rights. It evident, for example, that the 3.5 GHz and 26 GHz frequency bands will be mainly used in urban areas, in population centres and at transport hubs. Covering the entire road network and all transport routes with these frequencies will require considerable investment, but lower frequency bands can be used more cost-effectively to achieve wider coverage. It should also be noted that communications associated with the critical functions of intelligent transport cannot be based on a connection to the mobile network being available in every place and at all times.

3.6.2 Promote fixed broadband availability for autonomous transport needs

If necessary, the state will participate in the construction of optical fibre connections at transport hubs and main roads to ensure an infrastructure solution that supports transport automation. In state road areas, cableways and pipelines will be laid in connection with improvement projects.

Transport hubs, such as ports and terminals as well as main roads will be at the forefront of the development of autonomous traffic in the initial stage. It is likely that communications network connections supporting intelligent transport services will be built on market terms for these areas over the longer term, starting with local business needs. The state will actively monitor the construction of such connections. Because these areas are very important for the development of autonomous and intelligent transport, the state will react to the situation, if necessary, should these connections not be built in key road areas on market terms. For the continuity of services, cities will play an important role, particularly in the case of route network nodes, such as transport corridors leading to ports. At the same time, autonomous transport can be expected to increase traffic on the main routes, due to a simpler operating environment than urban areas.

Construction of communications links can also be promoted in connection with road improvement projects. Since cable excavation costs represent a significant proportion of the cost of building a communications network, it is worthwhile in conjunction with road improvement projects, where this is technically and economically sensible, to excavate cableways and pipelines into which an optical fibre cable can be drawn without earth construction work in the future.