Digital Gipfel

5G Usage Scenarios for Industrial Communication

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A report by the 5G Focus Group

Digital Networks and Mobility Platform

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01
Introduction and rationale

Digital transformation is driving ever-more dynamic data capture and processing across almost all sectors of the economy. Increasing numbers of devices, things and sensors are being digitized and connected, and not just in the consumer space. As we enter the era of Industry 4.0, processes and products across the entire value chain stand to benefit. This extends well beyond manufacturing, and impacts the entire economy – including agriculture, the energy sector, healthcare and the media, with its production, event and conference technologies.

Potential 5G applications

Real-time, mobile processing of large volumes of data is enabling entirely new services and business models. Over the next few years, rapid hardware and software innovation, in conjunction with new network architectures (such as edge cloud computing and network slicing) will allow ever more usage scenarios – many of them beyond our imagination today. The backbone of digitization will be high-performance 5G telecommunication networks with guaranteed quality of service. The aim of current international standardization efforts is to make the first version of 5G available from about 2019/2020. Subsequent releases will see further development of 5G, in particular to address emerging needs. Implementation of the corresponding networks will require a legal and regulatory framework

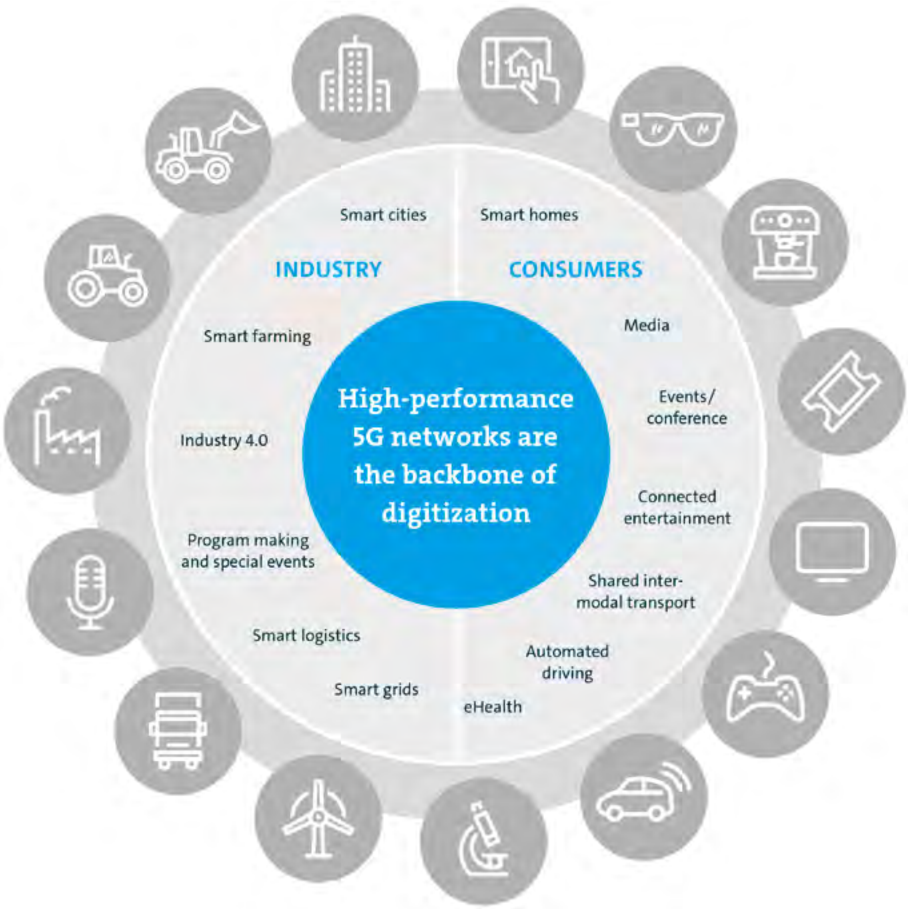

Figure 1: High-performance 5G networks are the backbone of digitization for industry and consumers

conducive to capital expenditure on the corresponding infrastructure, and on the development of new services and business models based on guaranteed quality of service for the various usage scenarios.

At the IT Summit 2016 and Digital Summit 2017, the 5G Focus Group identified future usage scenarios as an important topic for further discussion. In this context, the declared aim of the 5G Focus Group is to encourage all future users to cooperate closely to shape 5G functionality in line with the 5G vision. This paper describes the current state of this discussion and formulates recommendations for political decision makers.

02
Future communication requirements for industrial applications

To date, the need for wireless communication in industrial applications has been met by local solutions (Wi-Fi, industrial Wi-Fi, BluetoothTM , etc.), primarily in license-exempt bands, and/or via cellular networks (e.g. TETRA, 2G/3G/4G) in licensed bands. Due to divergent needs in terms of user device, spectrum, network infrastructure and network operation, these solutions had to be physically segregated. This can be expensive, and can be an obstacle to achieving economies of scale. Going forward, 5G networks will be designed to support the various requirements of multiple industries. 5G will enable a "network of networks" that will, with the help of LTE, create immediate nationwide coverage, and allow economies of scale on the device side, through usage of the same spectrum, and in terms of network infrastructure and operation.

Many future applications will need far better data transmission rates, latency and reliability, necessitating tailored user networks, based on powerful 5G networks, in particular with robust, assured quality of service.

Economically, it makes sense to use international ecosystems. This is the only way to create low-cost solutions for chipsets, devices and infrastructure. Against this background, the conditions for domain-specific 5G deployment are being widely discussed both nationally and internationally in standardization, research and regulatory bodies – with the aim of enabling new usage scenarios above and beyond existing solutions, i.e. public and local networks. Applying the possibilities of 5G to business models and translating it into value added for society as a whole will depend greatly on an environment conducive to corresponding investment, i.e. encouraging and enabling commercial relationships

Examples of specific requirements of selected applications are described below.

Industry 4.0
In the smart factories of tomorrow, static and sequential manufacturing processes will be replaced by modular production systems that are flexible in terms of time and location. This will include mobile, versatile production plants that require high-performance, efficient wireless communications and localization services. Cyber-physical production systems of this kind will need a dependable, powerful digital infrastructure that delivers high-quality communications for flexible, secure and reliable collaboration between people, machines, products and all types of devices. Today's industrial communications infrastructure is already complex in nature, and requires flexible ways of integrating diverse technologies to ensure stable production processes. To achieve the corresponding degree of reliability will call for industrial production process expertise – and for flexible operation models for integration of diverse wireless technologies within the network infrastructure.

In the future, therefore, additional options for network operation will be needed. These extend from resource-efficient shared use of public networks to stand-alone private networks, e.g. required on account of liability issues. Moreover, highly dynamic manufacturing requires real-time mechanisms that are only possible with local network resources, potentially with a dedicated local spectrum. Protecting confidential business information and combatting cyber attacks can make it necessary to outtask operation, maintenance and monitoring of the wireless network for a production facility to a local service provider.

Automated driving

Road vehicles already leverage diverse wireless solutions for a wide range of tasks (e.g. telematics, route planning, Internet connectivity, anti-theft systems, etc.). In addition, from April 2018, eCall, the automatic emergency call system, has been mandatory for new vehicles registered in the EU. Technologies for direct vehicle-to-vehicle communications in the intelligent transport system (ITS) frequency band are now ready for market rollout. Personal transportation is hugely important to our society, but is about to undergo a fundamental transformation. Automated, connected and self-driving vehicles will change our lifestyles, and will impact many aspects of manufacturing and the service industry, such as logistics and insurance. In addition to greater personal convenience, a key objective is to improve road traffic safety and efficiency. A central element of vehicle automation is cooperation. This is achieved by connecting vehicles with each other, and with roadside infrastructure. Sufficient, high-availability resources of a defined, predictable minimum quality of service are essential for vehicle-to-vehicle communication, and communication between vehicles and backend systems or the cloud. In this context, universally accessible solutions are needed that support vehicle-to-x communications at all times, regardless of the vehicle make or model.

Power supply / smart grids

The electricity grid comprises a huge number of distributed systems, but must nevertheless be operated safely and reliably. The defining characteristic of smart grids is that they digitally connect and integrate many individual local components. Monitoring of power consumption and of electricity feed-in, in combination with communications between various market players, is driving markedly rising volumes of data.
5G communication technology offers ways of resolving the grid operation challenges associated with the increasing use of often intermittent renewables – for example by allowing tailor-made ICT resources aligned with regional energy grid infrastructures.

Program making and special events

The term PMSE (program making and special events) encompasses all applications in production, event and conferencing technology. PMSE refers in particular to audio (e.g. microphones and public address systems), video (e.g. cameras, spotlights and special effects), and other aspects of stage technology. PMSE systems are therefore primarily found in the arts and the creative industries. PMSE systems can be mobile (e.g. for TV teams), nomadic (news conferences, music concerts, road shows) or permanent, fixed-location (i.e. in theaters, conference centers, stadiums). In all cases, they require low latency and reliable transmission. Major events, in particular, cause high, local demand for the radio spectrum and infrastructure – generated by audio and video production, and the activities of security services, media representatives, event organizers, traders and of the attendees themselves. It takes a combination of solutions, effectively blending public networks and private infrastructure, to support all these user groups. In the future, the 5G network architecture will enable the seamless integration of these various communication channels.

03
Similarities and differences between various fields of application

As was the case with earlier cellular network generations, the transition to 5G is evolutionary in terms of the technology deployed. It is a network of networks with attributes inherent and exclusive to the new 5G standard, but it also characterized by the coexistence, integration and further development of 4G/LTE and other network technologies. There are use cases that can be implemented by means of 4G/LTE both today and in the future, and that can be evolved further, in line with real-world requirements. These include, for instance, agricultural applications that call for extensive geographical coverage and remote electricity meter readings.

The development and application-specific availability of 5G will be shaped by further standardization. 5G-ready base stations are already being rolled out, and as 5G user devices become available, these stations will merely require a software update to enable 5G usage.

5G will also take into account the diverse imperatives of specific use cases, e.g. in terms of latency, reliability, throughput and energy efficiency. With regard to Industry 4.0, for instance, there will be a need for a latency of < 1 ms, whereas < =10 ms will be sufficient for automated driving.

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Network architectures tailored to industrial networks

5G technology boasts multiple capabilities for industrial communications. Corresponding network architectures must address two issues: firstly, device-centric networks with a large number and many types of connected terminals that must be served by a local 5G network; and secondly, cooperation with public networks, for example to enable the efficient use of resources and also for connections from and to the outside world.

The choice of network architecture(s) depends upon the specific use case. Four types of 5G networks are described below:

Local 5G networks combining multiple technologies
A local 5G infrastructure can combine a large number of sensors, devices, machines, robots, actuators and terminals with industrial network functions in order to capture, coordinate and share data. Some of these devices can be directly connected to a stand-alone 5G network or connected to the 5G network via gateways.

This cooperative network infrastructure allows industrial users to phase-in 5G for ongoing operations. In addition, new applications with high quality requirements can be executed in a licensed 5G quality spectrum via a stand-alone 5G network.

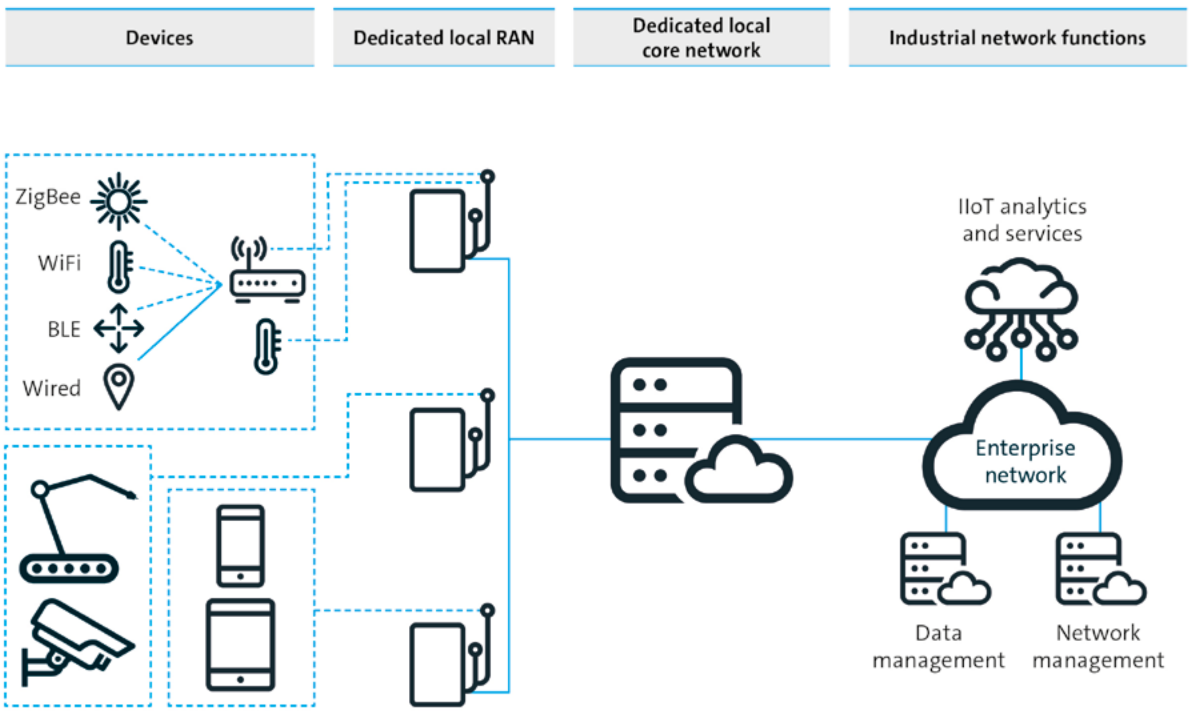

Figure 2: Factory of the future using a non-public network for industrial automation[2]

2 Source: 3GPP TR 22.804

Edge cloud / multi-access edge computing (MEC)
To achieve faster response times, distributed network architectures are being developed that allow data to be processed close to its source. With conventional architectures, the time required for transmission over the network can sometimes exceed the time needed to process and then transmit the data wirelessly. Shortening transmission paths and eliminating the number of network components along those paths delivers faster overall response times.

The European Telecommunications Standards Institute (ETSI) is looking into this technique, which it terms multi-access computing (it is also commonly known as mobile edge computing, edge cloud or cloudlets).[3] The underlying principle is that data processing is performed on standard IT equipment but brought closer to the user, e.g. by providing compute resources directly at the radio access point or at the initial point of aggregation. This minimizes the resources required for data transmission and makes it possible to achieve the latency foreseen for 5G, i.e. just a matter of milliseconds. At the same time, local data processing means confidential data can be kept on-premises, e.g. within a factory.

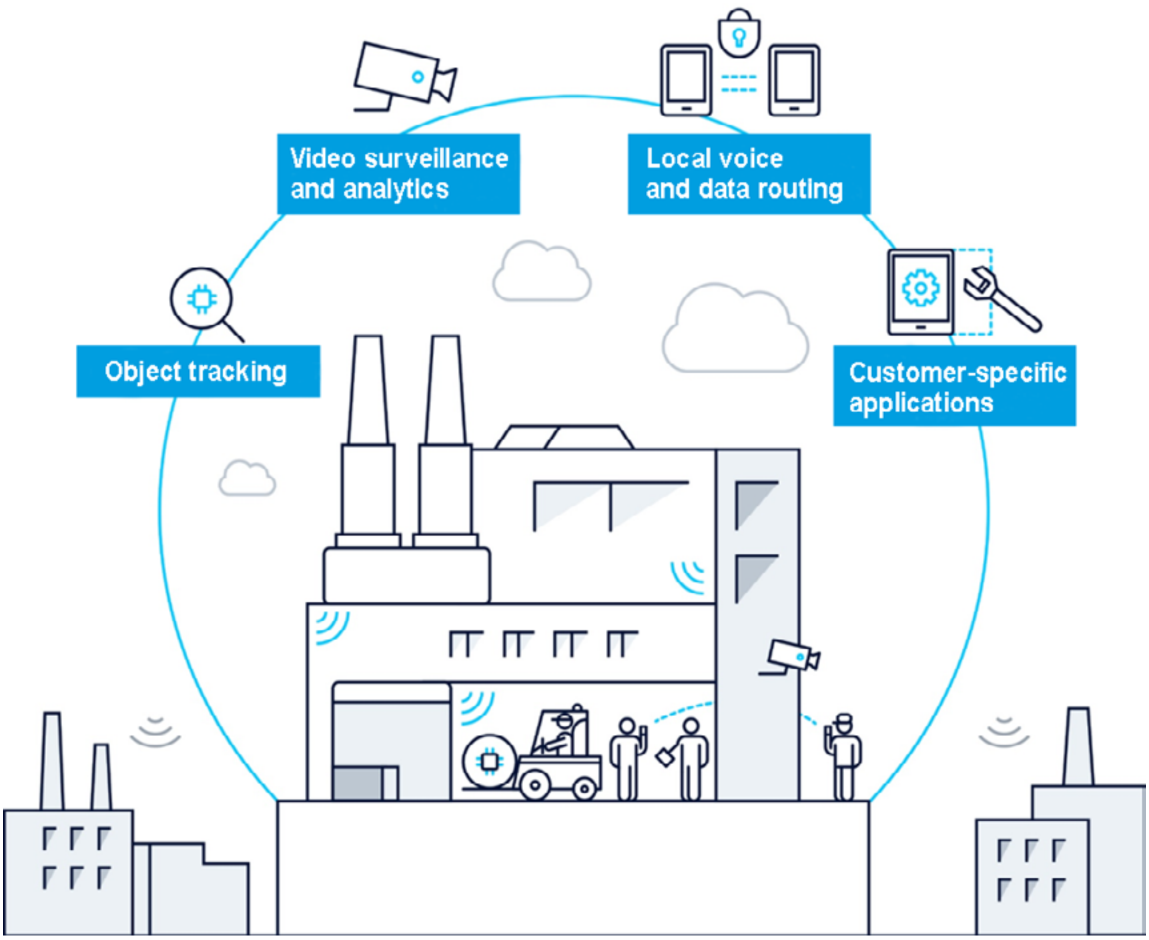

Figure 3: Edge cloud network architecture

3 See also http://www.etsi.org/technologies-clusters/technologies/multi-access-edge-computing

Network slicing (tailored network resources)
Network slicing is a key 5G concept. In essence, it entails the establishment of independent sub-networks for specific services and users on the basis of a physical 5G network infrastructure. The sub-network consists of base stations, transmission functions and core network functions. The underlying technological principles are to be found in software-defined networking (SDN) and multi-tier cloud architectures for all network functions.

Each individual sub-network can have its own specific characteristics with regard to 5G network parameters such as maximum throughput, end-to-end latency and data traffic density. Industrial users are currently discussing, in particular, special networks for ultra-reliable low-latency communications (URLLC) to be deployed simultaneously on the same network infrastructure as e.g. video-heavy mobile broadband services as well as slices for Internet of Things scenarios, with extremely high device density. A further benefit of slicing is flexible resource allocation, i.e. network resources can be allowed to "breathe", in order to balance out peaks and troughs in load, for example. This is the major advantage of the new concept. The ability to establish and share cloud architectures on commercially available components is not only cost-effective, it also has the greatest potential in terms of meeting diverse user needs. This will necessitate investment in the network infrastructure and resources that can then be flexibly provisioned to the corresponding applications by means of slicing.

Multi-access edge computing and network slicing
The combination of multi-access edge computing and network slicing makes a wide range of use cases possible. Latency-sensitive applications can be supported entirely locally, while other ICT applications can run on central processing nodes. Central and local services can share the licensed and/or license-exempt spectrum and radio access points. Frequency usage rights, investment in and operation of wireless networks and local processing nodes can be in the hands of a public network operator, a private network operator, or both.

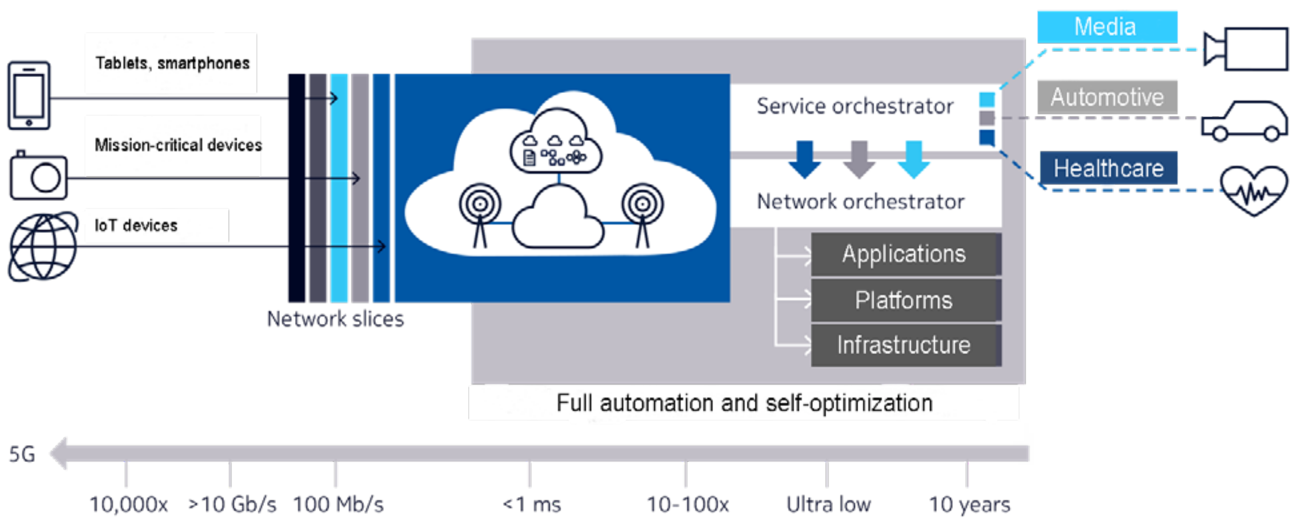

Figure 4: Network slicing architecture

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Network operation models

From the user's point of view, reliable network operation is a combination of the following elements: an available spectrum, a rolled-out radio access network, and a form of network management that corresponds to the specific use case. While today it is still generally possible to distinguish between public and private networks (which are typically stand-alone), in the future it will be possible for multiple models to cooperate and therefore fulfill diverse requirements.

Cooperation between public and private networks allows the efficient allocation of network resources in line with specific needs. Public networks typically support the simultaneous availability of differing frequency resources, to provide e.g. suitable indoor coverage, in conjunction with high data rates and capacity by means of carrier aggregation. Private networks are designed to guarantee the high reliability and security required by, for instance, man/machine collaboration in manufacturing. A private network can be planned, installed and/or operated by the user organization themselves or by an external service provider. The public network operator can also provide such services, and this might be particularly relevant to small and medium-sized enterprises. –To support both scenarios, standardized and flexible technical solutions are needed.

<table>
<tr><th></th><th colspan="3">TODAY</th><th colspan="3">ADDITIONALLY IN THE FUTURE</th></tr>
<tr><th></th><th colspan="2">Public network</th><th>Private network</th><th colspan="3">Cooperative network for industrial applications</th></tr>
<tr><td>Spectrum resources</td><td colspan="2">Harmonized</td><td>Partly harmonized</td><td colspan="3">Harmonized</td></tr>
<tr><td>Spectrum usage rights</td><td colspan="2">Licensed</td><td>Typically license-exempt</td><td colspan="3">Both licensed and license-exempt</td></tr>
<tr><td>Economies of scale</td><td colspan="2">High</td><td>Low</td><td colspan="3">High</td></tr>
<tr><td>Network owner</td><td colspan="2">Network operator</td><td rowspan="2">Industrial user</td><td>Public network operator</td><td>or</td><td>Industrial user</td></tr>
<tr><td>Network operator</td><td colspan="2">Network operator</td><td>Public network operator</td><td>or</td><td>Industrial user</td></tr>
<tr><td>Application management</td><td>Network operator</td><td>Industrial user</td><td>Industrial user</td><td>Public network operator</td><td>or</td><td>Industrial user</td></tr>
<tr><td>Interoperability</td><td colspan="2">With other public networks</td><td>Application-specific</td><td colspan="3">With public and/or other private networks, according to requirements</td></tr>
</table>

Table 1: Usage scenarios for industrial 5G networks[4]

4 Licensed spectrum are spectrum usage rights individually allocated by the regulator.

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Conclusions and recommendations for political decision makers

The 5G Strategy formulated by the German government[5] foresees the country being the lead market for 5G applications. The goal is to establish the preconditions for 5G network roll-out by the end of 2020 at the latest. The federal government is therefore promoting the development of sustainably competitive markets, and plans to promote an innovation-friendly environment that encourages infrastructure investments and a diverse service offering suitable for various use cases.

The aim should therefore be a frequency policy on national and European level that is geared to real-world needs, as the basis for the broad economic development of Germany's strong user industries. The principle of technology- and service-neutrality, as already practiced in Europe, and the establishment of conditions that enable flexible business models, are key to achieving this goal.

5G infrastructure roll-out therefore requires the following:

- An environment conducive to investment and innovation in order to facilitate the introduction of nationwide and local network infrastructures, and the development of new services and business models.
- Both private and public networks need suitable spectrum resources capable of supporting all users, particularly in industry. This necessitates the development of a suitably flexible and transparent conditions.
- Users require certainty with regard to the long-term availability of the spectrum.

Moreover, standardized interfaces are required for monitoring, configuration and seamless interoperability of networks. These must be defined by the appropriate standardization organizations. Agreements on reciprocal use and commercial charging/billing models have to be established to enable integration of private and public networks.

5 See 5G strategy for Germany / An initiative for the development of Germany into the lead market for 5G

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