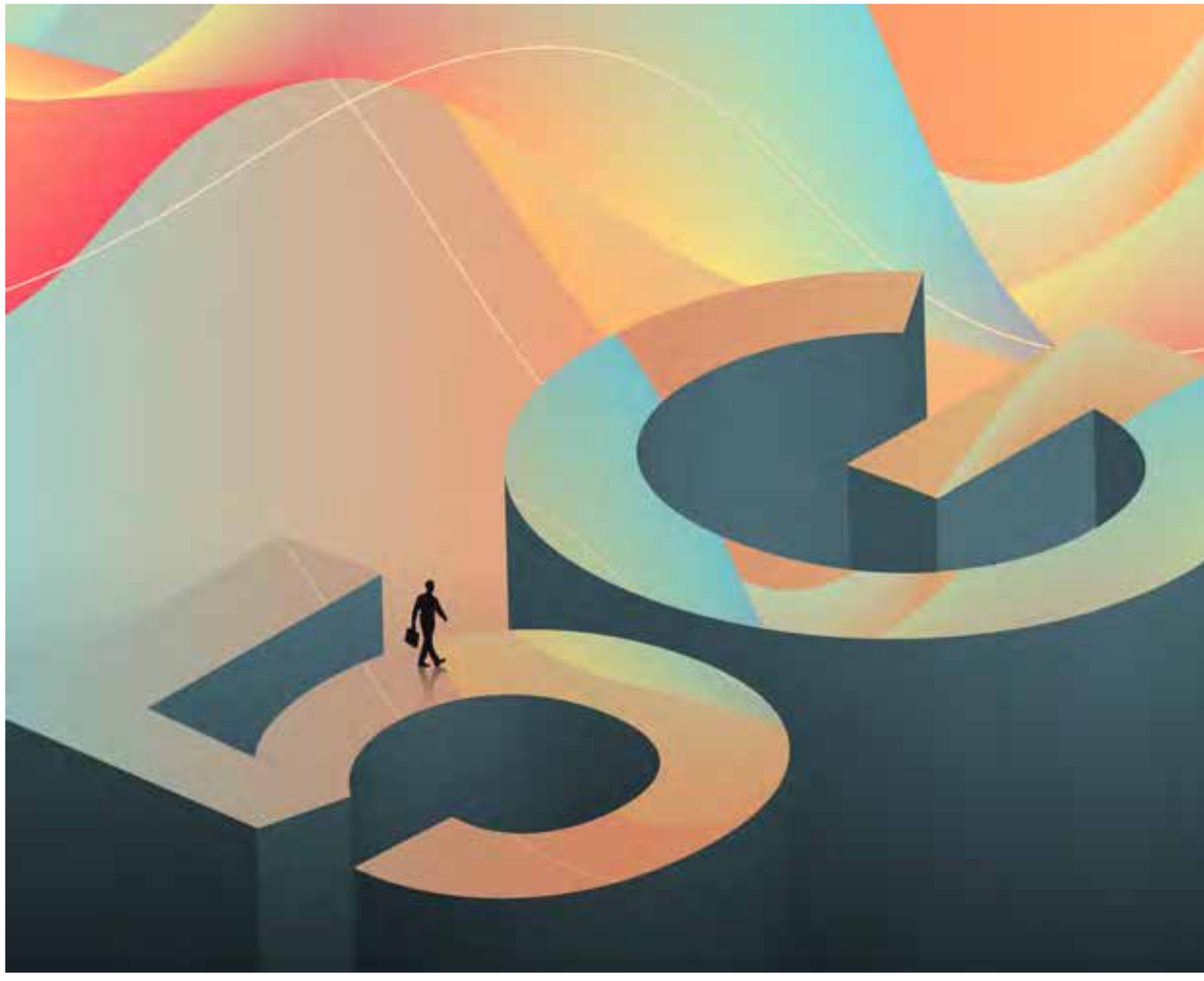


Global Trends, Potential 5G Development and Use Scenarios across Sectors

2020

Global Trends, Potential 5G Development and Use Scenarios across Sectors

2020

Statement from President of PJSC Rostelecom

Technology is rapidly changing the world. Everyone feels the impact of digital technology on their lives, and even more seriously it affects industries and complex manufacturing processes. The pace of change is so high that a transition to a new digital way of life has become crucial to maintaining the competitiveness of enterprises and the entire Russian economy.

One of the most significant technological challenges in Russia in the 2020s is the transformation of the national economy with the implementation of a new generation of digital technologies, which is commonly referred to as the transition to Industry 4.0.

Taking a holistic approach is important at the beginning of this journey. As far back as 20 years ago, Internet visionaries and practitioners predicted that the success of business or any industry from healthcare to the steel industry will be determined in the short term not so much by the optimization of its structures and processes as by scientific and technological breakthroughs, primarily in digital technology. The basis for new production forms will be the capacity, flexibility and availability of modern digital networks – the new economy should implement and develop them first.

The solution to a huge range of technological problems of the digital economy will be enabled by wireless networks of the fifth generation – 5G. They are able to provide opportunities for the implementation of modern technologies, followed by large-scale digitalization, robotization, and automation of many industrial processes.

Being at the forefront of the Russian digital transformation, Rostelecom is fully aware of the need for accelerated network redesign and creation of new digital business models in all industries. For us, it is obvious that today 5G networks are the basic and most effective tool to achieve this in the manufacturing industry and in any other industry. Their technological paradigm has gone far beyond the traditional wireless network, 5G is becoming a universal platform, a technological basis for changing the life and work of people, social and economic activities of society around the world. “Rostelecom makes every effort to develop and implement new digital services and services that are sought by most companies, enterprises, departments, and government agencies in Russia in the new decade. But the solution to global challenges related to the digital transformation of the economy is only possible in close cooperation with industry leaders. Only partnership and experience pooling will allow creating and implementing 5G-based applied services across a wide range of industries. To launch and promote such cooperation, Rostelecom prepared an overview of global trends, the most promising and productive scenarios for the development and use of 5G technologies in a number of key industries.

This white paper is an important step for Russia – an actionable call for leading industries to join their efforts in order to create new 5G-based business models, which can accelerate economic growth and ensure its sustainability in a rapidly changing world. We encourage companies of all industries, departments, federal and regional governments to embark on and complete the digital transformation journey together, moving confidently towards Industry 4.0.

Mikhail Oseevsky,
President of PJSC Rostelecom

Contents

[1.]

Introduction

Cellular networks have been evolving for more than thirty years, unlocking new business opportunities. Initially, the development of cellular networks changed the telecommunications industry itself; then, with the expansion of data transmission capabilities and the massive spread of mobile data, new production and consumption patterns penetrated other industries, forming a new economy.

1G and 2G networks gradually squeezed out wired telephony; 3G and 4G, making Internet access mobile, have had a drastic impact on industries that are entirely internet-based. 5G drastically expands the range of industrial opportunities, digitalizing all industries and enterprises without exception. This is primarily because it enables simultaneous fast and flexible connectivity across multiple digital devices, with high-speed transfer of huge amounts of data from sensors to powerful servers and real-time use of production data.

With the advent of 5G, mobile communications are no longer a technological advantage, but a basic need, a key resource for most industries. With the widespread digitalization and the implementation of ICT in major business systems, the latest generation of mobile networks starts affecting all production processes, industries, the economy on the whole, changing them quickly and dramatically. 5G technologies and services become the basis for digital transformation, the infrastructural and technological foundation for new business models and sectoral development scenarios.

To achieve rapid and comprehensive digitalization of the economy, it is necessary to develop the 5G infrastructure, learn how to use it in creating services and applications for a wide range of organizations, individual sectors and their segments.

In this overview, we have structured the diverse services and solutions from basic 5G capabilities to platform services and then to end-use scenarios, services and applications for specific industries and enterprises.

By the time 5G began to spread widely around the world, various wired and wireless production optimization and automation solutions had already been tested. We demonstrate specific cases to show how 5G enables rethinking and taking industry-specific technologies to the next level, providing greater flexibility, cost effectiveness, and time-to-market for new services and business models in conventional industries.

Fig. 1.1 From basic 5G network capabilities and platform services to new sectoral scenarios and applications

[2.]

Basic capabilities of 5G services

5G technologies were standardised based on the expectations and requirements of sectoral consumers – not telecom operators or equipment manufacturers, but corporate end users of services. Therefore, 5G is initially and above all a platform for developing and implementing industrial digital services.

In terms of their main purpose and basic capabilities, 5G services are divided into three large areas:

- **Enhanced Mobile Broadband (eMBB)** with high data transfer speeds (0.5 Gbps – 100 times higher than in 4G networks), focused on services for private users: access to multimedia, interactive services, and large amounts of data.
- **Ultra-Reliable Low Latency Communication (URLLC)**, which has high and strict requirements for speed, signal latency, bandwidth and service availability time (less than 5 msec – 8 times lower than in 4G networks) and is focused on corporate and public sectors, such as wireless process control, automatic load balancing in smart grids, and integrated transport security systems.
- **Massive Machine-Type Communications (mMTC)** to connect a large number of devices (300,000 units per base station – 100 times more than in 4G networks), usually transmitting a relatively small amount of data and not too sensitive to latencies. Network availability, low cost of terminal devices (most often sensors or detectors), and long battery life without recharging are important for such systems.

Despite their original specialization and focus of application, all three basic 5G services, even those focused primarily on services for private eMBB subscribers, are used in various combinations to organize systems and applications in various industry verticals and segments with specific conditions, tasks, and requirements.

This is another advantage of 5G: it is a flexible programmable service platform. The powerful cloud computing core of the fifth generation cellular network, deployed for a corporate user, exactly as requested by a particular customer enables matching its technological requirements with the necessary basic 5G capabilities in terms of coverage, latency, bandwidth (subscriber capacity and data rate), synchronization, reliability, and security.

The high level of information security is embedded in 5G at the level of standards and architecture, both through the application of special protocols and solutions at the level of the network core, all its nodes, and the cloud infrastructure.

The basic functionality of 5G forms the network foundation of platform services. Some of them can be implemented outside 5G, for example, sensor readings – based on LPWAN, Wi-Fi, or other wireless technologies.

Most promising industrial services require 5G capabilities, as only they enable large-scale and rapid connection of digital devices, providing their flexible configuration and synchronous operation with minimal latencies.

5G is the first and so far the only technology that enables flexible combination of platform services through a single technological platform, relieving corporate consumers from the need to build their own network infrastructure.

These properties make 5G the basis for scalable services, which significantly reduces the time of their development and implementation across a variety of industries.

Experts are convinced that over the next decade, a combination of many popular technological advantages will help 5G replace or complement most wired and wireless networking technologies in any industry automation process.

[3.]

Platform services

The task of digitally transforming economic sectors involves the implementation of innovations that increase the efficiency of a particular industrial or business process. The use of platform services enables developers and integrators to concentrate on solving unique customer tasks without involving special technical competencies in industry implementations.

In essence, platform services are solutions that automate the creation and operation of digital end services. Platforms offer a range of tools and features that greatly simplify the work of product development and integration. With digital platforms, products can be created and managed without the need for additional resources such as time, money, or expertise, and deployment processes can be significantly accelerated while ensuring that end products are of high quality.

Platform services enable developers of industry-specific solutions to quickly create and deploy valuable applications for a wide variety of customers, solving typical, but basic technical challenges arising during any industry digitalization, such as data collection and storage, and device, software module, library and interface management.

5G was designed specifically to work with platform and industry-specific digital services: their architecture and design were focused on enabling flexible management of network resources and smooth integration with other network technologies (Wi-Fi, LPWAN, etc.), creating solutions with edge (peripheral) computing and delivering better quality digital services in general. With a combination of platform services and 5G in each individual industry or across its various segments, it is much easier to implement applied digital development scenarios.

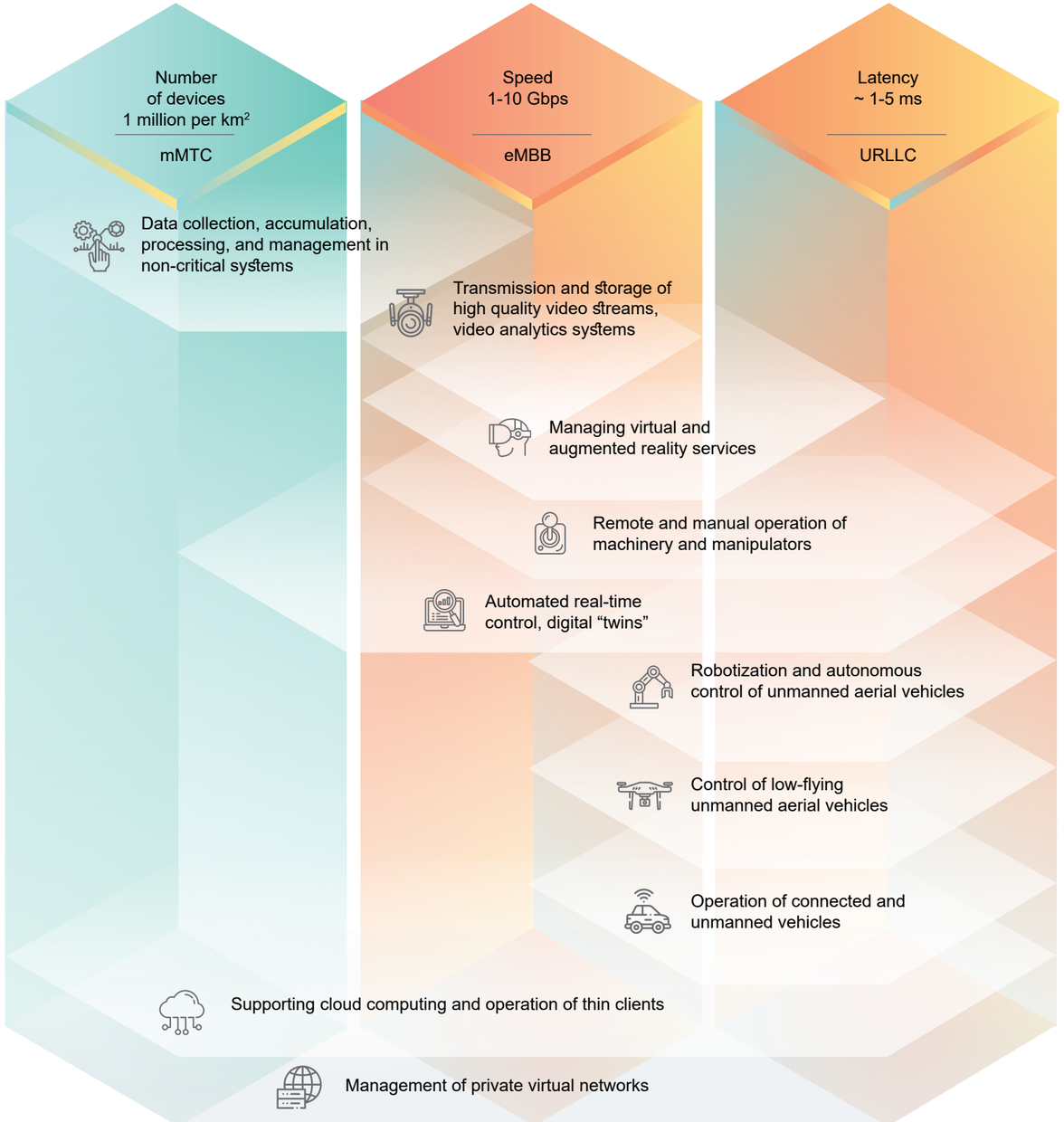


Fig. 3.1 Interconnection between platform services and basic 5G capabilities

The use of this or that platform service depends on the type of the task at hand and the technologies used. Therefore, focusing on a systemic approach, we consider platform services in this review as independent services/products.

At the same time, platform services can be either completely independent, for example, cloud solutions and thin clients, or embedded in special industry solutions, often combined between themselves. For example, augmented/virtual reality (AR/VR) services are used for video streaming and video analytics. However, universal AR/VR devices, functions and software in various industry applications allow us to categorize them as a separate platform service.

The capabilities of each platform service in combination with 5G in individual industry-specific use cases are presented in the corresponding sections of this review.

The methodology for selecting promising scenarios for industry-specific use of 5G and industry-specific services based on this network platform can be found in Section 4.

3.1. Data collection, accumulation, processing, and management in non-critical systems

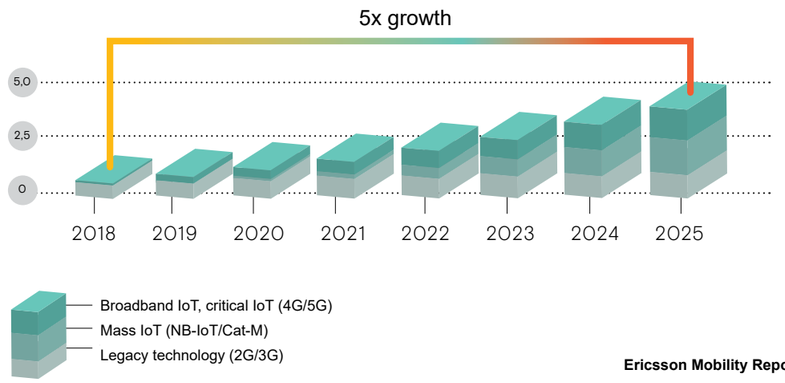
Thanks to the basic capability of 5G to connect a large number of digital devices, such networks enable implementing a wide range of services known as the Internet of Things (IoT), which has finally opened the door to a world where the gastronomic preferences of a person will be understandable to household devices, enabling the automation of the ordering, delivery and payment processes. Similar 5G based systems unlock unbelievable opportunities for any sector or industry, from the automated control of humidity and watering of fields (non-critical systems) to automated design and release of new products through unmanned processes (critical systems).

The 5G-based radio interfaces for NB-IoT and LTE-eMTC low-speed applications coming from 4G enable the transmission of telemetry or sending commands to sensors and actuators in a wide variety of automated monitoring, analysis, and control systems. Numerous new 5G interfaces enable connecting both low-power devices, for which the only criterion is battery life, and powerful devices, with high requirements for data rates and latency, within a single network. Data centers integrated into a 5G core create a cohesive cloud infrastructure that identifies and manages all connected devices, providing a high level of security.

The 5G cloud infrastructure combined with an open interface enables developers to build applications and specialized platforms for any industry using powerful ICT resources and information collected online. For simple systems, such as meter data collection, they can be developed by the operator using a standard architecture, without knowing or analysing industry-specific details. In complex processes and highly productive innovative business models, industry expertise and partnerships with industry players are critical.

Projections and estimates

Number of IoT connections in different segments, billion

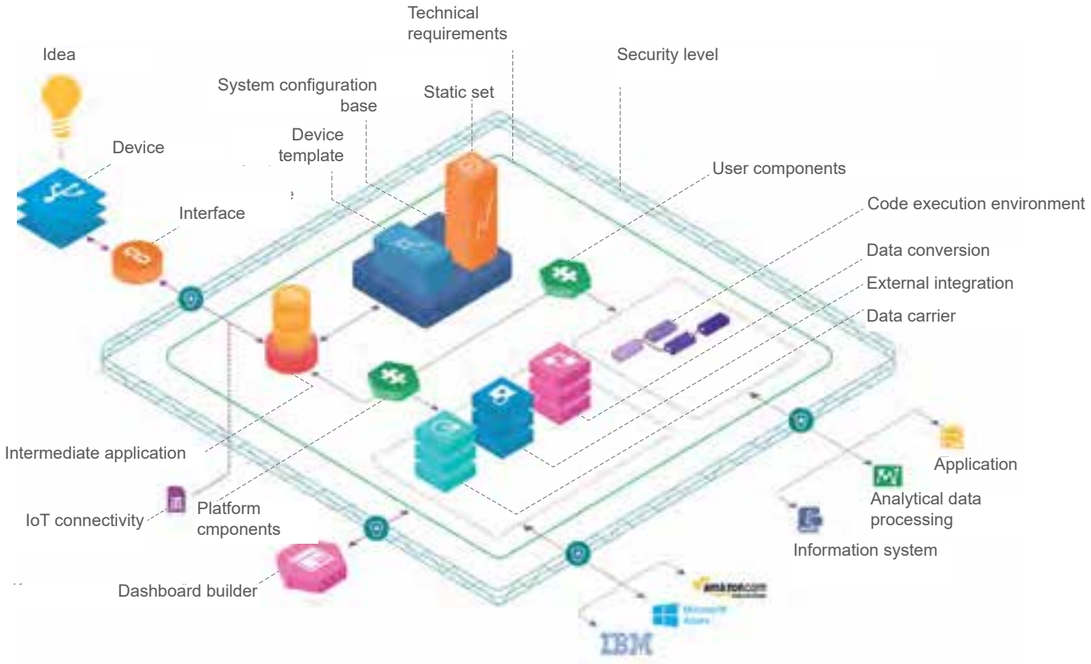


Ericsson Mobility Report, June 2019

Sample cases

Cloud-based IoT platforms such as Azure by Microsoft, Watson IoT by IBM, and AT&T's IoT platform (all from the US) are positioned as a basis for various industrial solutions. They all support device connection to networks of many operators based on different technologies. The combination of high performance, reliability, information security, sets of ICT services and processing algorithms, as well as data visualization, has already attracted many customers, including those in the industrial and energy sectors.

Rostelecom acts as an engineering center for digital support of the product life cycle, developing a platform for the industrial internet based on the IIC (Inter-Integrated Circuit) methodology, taking into account best practices and the specifics of the Russian market. Rostelecom's industrial internet platform is a multi-component system providing a full data processing cycle for various connected devices. Its purpose is to provide a technical basis for creating full cycle solutions for industrial production, from collection and



Operation of AT&T's IoT platform

processing of primary data (from meters, detectors or sensors) to the provision of visualization and analytical tools. The IIoT platform already facilitates the implementation of management systems in the energy, municipal and utility segments. Successful projects include the system of automated street lighting in Balakovo, Saratov Region; monitoring of boiler houses and engineering facilities in the Moscow Region; online monitoring of a residential building in Perm, and other projects.

3.2. Transmission of high quality video streams, video analytics

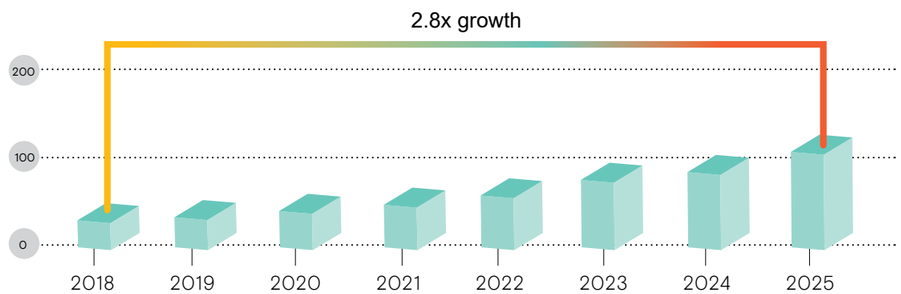
Demand for video data services is growing, including within regional and municipal programs such as Safe City and Smart City, which require video monitoring to address a number of economic and security issues.

As the cost of video technology and storage services provided by data centers decreases, providing a video streaming channel has become the main challenge for large-scale implementation. 5G with an additional radio frequency capacity helps drastically increase the capacity to meet any video transmission needs.

At the same time, the 5G network core ensure the reception, accumulation and processing of video streams with low latency and load on the backbone channels. 5G data centers offer sufficient computing capacities to recognize, for example, license plate numbers and even ripening crops. The 5G core works in synch with Mobile Edge Computing, a facility for storing and analyzing video streams in or near a base station. Video streaming services – basic services for 5G – can be easily complemented with standard analytical services, such as face recognition. As a rule, industry-specific services that use specific video analytics algorithms require the efforts of specialized developers, relevant terms of references and program interfaces.

Projections and estimates

Estimated capacity of the global market for Video Surveillance as Service, USD billion



Adroit Market Reseatch, 2019

Sample cases

Amazon Cloud Cam (USA), a cloud-based intelligent video surveillance platform for private users using Amazon’s proprietary cameras with an intelligent assistant, Alexa. Amazon Cloud Cam supporting smartphone integration offers an expandable activity and sound recognition library: movements outside the window, broken glass, dog barking, baby crying, etc.

OWAL (USA), created by former Google’s video project manager, offers companies and individuals a cloud-based intelligent video surveillance, monitoring and security service with cameras of any model: real-time activity detection in video images enabled by machine learning. The company also develops video processing algorithms for the healthcare, logistics and construction sectors.

Shutterstock/Fotodom

Visualization of an attendance counting algorithm

Rostelecom's cloud-based intelligent video surveillance offers video analytics functionality, which recognizes, among other things, the sex and age of shoppers, determines the length of the queue and the highest footfall spots in the selling areas, recognizes car license plates, as well as monitors the presence of employees at the workplace. The need for video data collection, storage, processing,and analysis will increase as more and more video cameras are installed and connected to 5G.

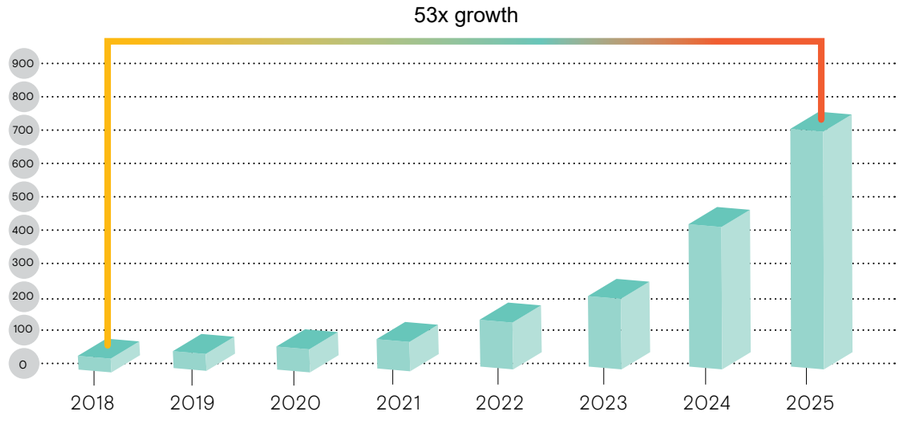
3.3. Augmented and virtual reality (AR/VR)

Augmented and Virtual Reality (AR/VR) services have been developing for several years, but have not yet become widespread. Their expansion is constrained by the lack of a platform for collaboration in an AR/VR environment. The expansion of 5G will make AR/VR widespread, enabling the delivery of large datasets and 3D video at high speeds with low latencies and high interactivity.

5G will be a key platform for AR/VR based service development. The high bandwidth of 5G channels and cloud computing capacities will drive the development of miniature AR/VR portable devices, eliminating the need for local video processing. Due to high data speeds and synchronization, 5G will drive east joint AR/VR immersion for several remote users. External developers of data heavy AR/VR content will have access to all technical capabilities and services available with 5G.

Projections and estimates

Estimated global spending on AR/VR solutions, billion USD



BI Intelligence, 2017

Demonstration of additional reality technology by Rostelecom

Sample cases

With the release of the second generation of its AR headset, Microsoft (USA) has launched a platform for industry-specific AR/VR applications, HoloLens, based its Azure cloud infrastructure. Today, it is one of the most popular platforms among various industries around the world. The HoloLens ecosystem integrates and distributes third-party partner applications for various sectoral applications.

The EON reality AR/VR platform (USA) offers a development environment to increase productivity and provide training and career development opportunities in the energy, aircraft and machine building, transportation and healthcare industries.

The AR/VR content platform of LG U+ 5G operator (South Korea) offers five applications for viewing sports and music events, and playing interactive games. They alone generate about 20% of LG U+’s 5G traffic and support accelerating growth of its subscriber base.

3.4. Manual remote control

Production processes are optimized in a number of industries using remote control equipment and robotic manipulators. Remote operation optimizes the use of machinery and qualified personnel. Latency in remote manipulation depends on the speed of human reaction and the additional delay in the transmission of video and commands from the operator. The predictable inertia of manipulations enables implementing remote control of equipment, such as surgical operations with latencies of 10 ms to 100 ms.

5G will be a universal platform for remote control of equipment in remote and inaccessible areas, and for transfer of information about processes to other production units, partners and controlling bodies.

Remote control uses video streaming and AR/VR platform services, but0 requires cooperation with manufacturers of machinery and equipment and development of special applications. Therefore, it is logical to categorize remote manipulations as a separate platform service to be scaled up and rolled out across various sectors covering multiple types of operated machinery.

Sample cases

Construction equipment manufacturer Doosan Infracore and operator LG U+ (South Korea) are creating a joint platform for equipment control and construction automation. While staying in an exhibition stand in Munich and using a 5G-enabled 3D machine guidance console from a distance of 8,500 km, theiroperator was able to control a 40-ton Doosan DX380LC-5 crawler excavator in Incheon, Korea.

An association composed of Obayashi (a construction corporation), NEC (a vendor) and KDDI (an operator) (Japan) has developed a 5G-enabled computer system for remote control of construction

Remote control of an excavator via Doosan Infracore’s 5G networks

equipment. The system ensures smooth operation of several construction equipment units within a shared remote control environment.

The mining automation platform of Boliden, ABB, SICS Swedish ICT, Volvo Construction Equipment, and Ericsson (Sweden) involves remote control of all equipment. The use of remote control based on an underground 5G network enables fully abandoning complex, expensive, and energy-intensive ventilation systems in mines with the transition to fully unmanned mining using remotely operated equipment.

[3.5.] Automated real-time control, digital “twins”

Modern industrial processes involve synchronous operation of multiple systems. Despite the high level of automation based on existing technologies, any smooth and efficient work still requires human control and intervention, and any redesign of processes needs careful manual setup of equipment.

5G becomes a technology platform to bring automation to the next level, providing fast reconfiguration and customization of production to meet the changing needs of industries and markets.

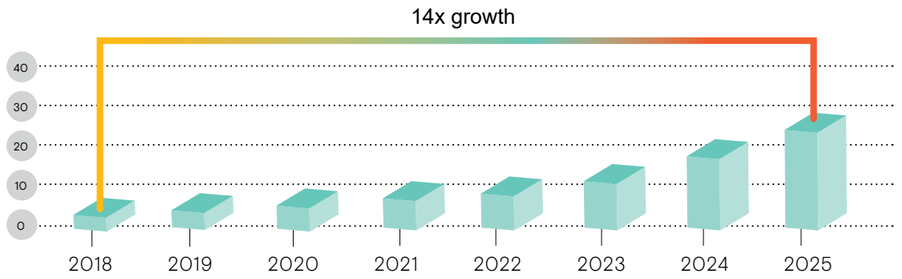
New automation will be based on much larger numbers of 5G-enabled detectors and sensors embedded in the production equipment. The integration will provide real-time data on the production process. Fast processing of various data enables the creation of electronic models of units throughout the value chain. A digital model of a process based on information from multiple sensors is an integral part of building a “digital twin”.

The next step in its development is the use of digital twins to optimize production processes. Digital twins and mathematical models are already used for predictive analytics to schedule and determine the parameters of preventive repairs or model and improve processes without stopping production. Digital twins are used to build AR/VR models of units and processes. Data processing algorithms use data from multiple different sensors for automated real-time control, reconfiguration and setup. Automated control increases the robotization of industry, which must also be considered as a separate platform service.

Such transformation is possible only in close cooperation between 5G, ICT infrastructure and industry experts, who create digital twins and automated development algorithms for specific sectors.

Projections and estimates

Estimated capacity of the global market for digital twins, USD billion.



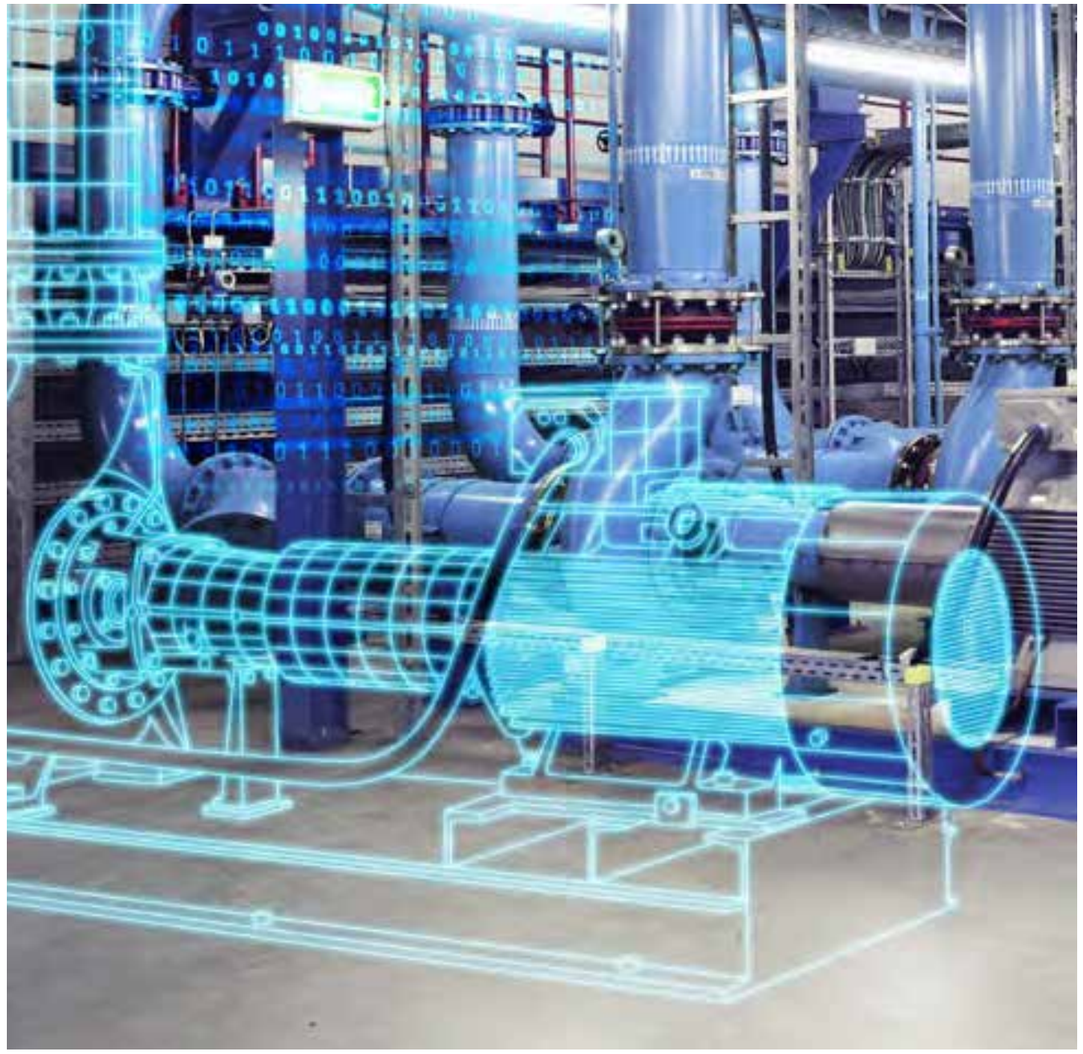
Marketsandmarkets, 2019

Sample cases

Comau (Italy) has joined forces with Ericsson, a Swedish vendor, to build next generation platform systems for plant automation using digital twins, predictive analytics, and 5G-enabled robots.

General Electric (USA), the leader in platform automation solutions for industrial enterprises, develops and promotes its own platform, Predix. It features a modular architecture with close integration of equipment management, enterprise management, data collection, creation of digital twins, and machine learning modules. The platform operates from cloud-based infrastructure, but can also offer all functionality from the enterprise's edge data centers.

The cloud platform of Plex Manufacturing (USA) is compatible with any brand of production equipment and any set of functions. It enables automating any production process that covers heterogeneous systems and combining different sensor networks and independently created digital twins to comprehensive predictive analytics for the enterprise.



The use of digital "twins" in General Electric's Predix platform

[3.6.] Robots and unmanned vehicles

In our review, robotization is viewed in a relatively narrow sense as the creation of networks and control systems for robots and robot groups at industrial facilities, as well as control systems for specialized autonomous unmanned vehicles employed in the mining, construction, agricultural, and other industries and operating in vast, hazardous or inaccessible areas.

In discrete industries, the use of robots is widespread, but robotic control is mainly based on wired communications.

This increases the cost and complexity of robotization, leads to frequent breakdowns with wear and tear and damage to wires in moving parts of mechanisms, and also makes it difficult to reconfigure sites. 5G offers a much more convenient, flexible, and cheaper way to use wireless connections equal in speed and reliability. In doing so, 5G provides connectivity and synchronization, as well as supports the use of cloud infrastructure and rapid software updates to improve production processes and unlock new opportunities.

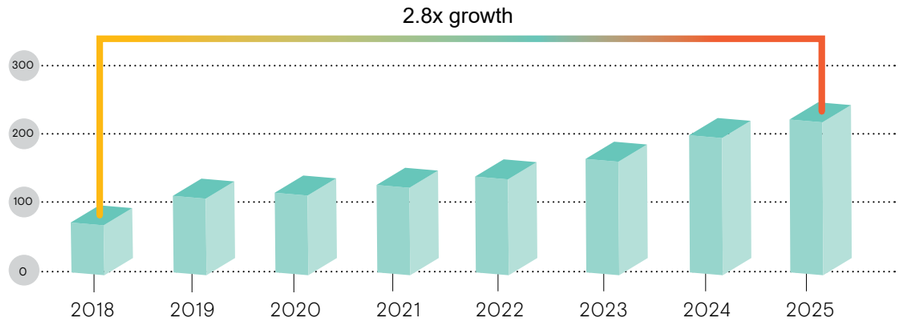
5G enables implementing automatic loaders and carriers in any area, automating the control of and interaction between various special equipment units on construction sites, agricultural land, open pits and mines. Processing data onboard moving vehicles is difficult and expensive. With a fast and reliable 5G network, all information and control logic can be migrated to cloud infrastructure.

But ICT companies operating in 5G cannot do without cooperating with technology experts in robotics and control systems.

A family of cooperative robots and examples of replaceable manipulators from Universal Robots

Projections and estimates

Estimated capacity of the global industrial robotics market, USD billion



Marketsandmarkets, 2019

Sample cases

In addition to common plant automation processes, the joint solutions of Comau and Ericsson (Italy–Sweden) include 5G-enabled robot control systems. The remote control platform for construction equipment of LG U+ and Doosan Infracore (South Korea) also provides for the creation and development of solutions for autonomous equipment and monitoring of construction.

Universal Robots (Denmark) has brought forward a new approach to automation involving the use of several robots that perform operations together, known as Cobots (Collaborative Robots). Collaboration on the whole has turned out to be cheaper than complex specialized robots. Universal Robots creates versatile robotic manipulators with open interfaces that can be combined to perform a variety of complex tasks. In addition to its proprietary products, the open platform uses products from many companies and startups to provide ready-made robotic solutions for various industries and processes (Ready Robotics, Fetch Robotics, and Voodoo Manufacturing). The success of Cobots is largely driven by their well-coordinated synchronous operation with a shared network, with the widespread 5G multiplying the effect of using the Universal Robots.

3.7. Unmanned Aerial Vehicles (UAVs)

Applications of low-flying unmanned aerial vehicles (UAVs), and drones in particular, are very different from the use of unmanned aerial vehicles in controlled areas. UAVs often interact with objects and people outside their operating areas. Separate platform services are required for their use.

The key obstacle to the widespread use of UAVs is the complex regulation of civil and other aircraft, and the high risk of a surge in aerial accidents in the event of their large-scale use. The solution lies in creating a dedicated air traffic control system for low-flying UAVs with reliable location tracking and unambiguous in-flight identification of the UAV. The control system must be supported by a reliable wireless connection to control and receive information from the UAV.

Already at the stage of standardization, 3GPP (3rd Generation Partnership Project), an international consortium developing specifications for next-generation mobile communications, has provided for a special type of subscription-based terminals (aerial UE) with special profile SIM cards for low-flying UAVs. There are special mechanisms for identification, radio channel allocation management and status tracking. The mobile-based functionality for creating and operating a traffic control system for low-flying UAVs is planned to be fully standardized in 2021.

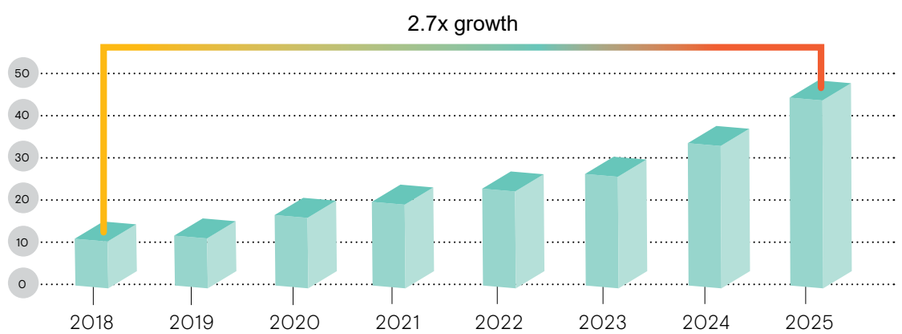
However, the ecosystem of services for low-flying UAVs is much wider than organizing connection and building an air traffic control system.

5G provides a reliable system for identifying the owners and operators of UAVs, a control system, and a system for delivering useful information from UAVs. Effective UAV operation also requires a platform for data collection, accumulation, analysis, and processing. All this is easier to implement via a 5G core data center. It is important to integrate the UAV platform service with special services supporting flight planning and selection of UAV operators.

Tests for drone control via the 5G networks of Telia, Sweden

Projections and estimates

Evaluation of the global UAV market, USD billion.



Marketsandmarkets, 2019

Sample cases

UAV flight management in China is based on a non-standardized (proprietary) solution of the Civil Aviation Administration of China. The latter is working together with China Mobile and Huawei to develop a 5G-enable UAV control system.

As part of the European Union’s Horizon 2020 innovation program, a project is underway to investigate the use of 5G networks for low-flying UAVs. It includes a number of companies: European Aeronautic Defence and Space Company (EADS), including Airbus, Thales (manufacturer of avionics and onboard radars), Nokia (mobile vendor), and Orange (mobile operator). The project aims to design a 5G-enabled UAV flight control system, while also looking into the opportunities for applying UAVs across other industries.

[3.8.] Connected and unmanned motor vehicles

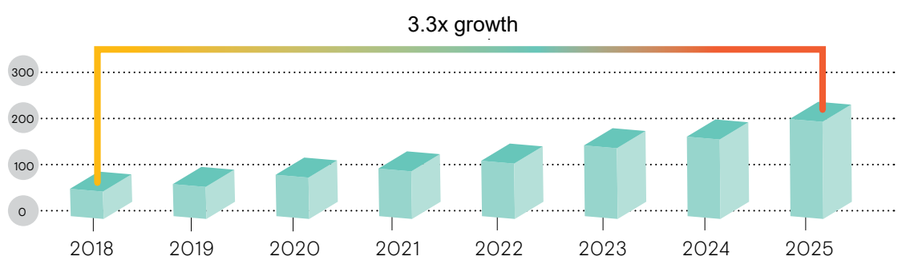
Connected and unmanned vehicles on public roads is a separate issue of standardization. The specifics of unmanned vehicles consist in decentralization and interaction between the vehicles outside the networks. This is due to the need for minimal latencies, uninterrupted coverage of roads with mobile networks, and the lack of sufficient data centers on long highways. Therefore, an unmanned vehicle needs a powerful on-board computer, which can do without connecting to a shared network. In any case, an unmanned vehicle uses radio communication to receive and transmit information using video cameras, radars, and active optical distance meters (lidars). Unmanned vehicles should be able to “communicate with each other” via a direct radio interface. Initially, developers planned to use IEEE standards, but more and more car manufacturers now consider a special 5G radio interface, C-V2X.

However, not all unmanned traffic control tasks can be best solved only by using direct communication between vehicles. C-V2X assumes communication with road infrastructure and the use of traffic information from mobile networks. The interaction between unmanned vehicles and road infrastructure is necessary both in large cities and on freeways. Smart intersections inform the on-board computer in advance that traffic lights are about to switch or other vehicles are approaching. Notification about accidents ahead will be delivered via a base station much more effectively than from vehicle to vehicle.

Connecting unmanned vehicles to a network increases safety, provides information about the road situation, the optimal route, and weather conditions, and enables additional technical condition monitoring and smart insurance. The potential future transition from connected vehicles to fully unmanned vehicles encourages car manufacturers, regulators, and 5G operators to cooperate more closely.

Projections and estimates

Estimated capacity of the connected/unmanned motor vehicle market, billion USD



AdroitMarket Research, 2019

Sample cases

The Chinese Ministry of Industry and Information Technology has adopted the C-V2X standard and allocated the 5,905 MHz–5,925 MHz radio frequency band with an option for nationwide expansion. China is in the process of certifying C-V2X devices and deploying intelligent road infrastructure.

The C-V2X standard has become official for direct communication between vehicles in Europe since mid-2019. Major car manufacturers such as Audi, BMW, Daimler, and operators such as Deutsche Telekom and Vodafone have announced the launch of technology development projects for cars and smart road infrastructure.

In Russia, the Autonet National Technology Initiative is planning to create pilot road infrastructure zones with C-V2X-based solutions in six regions with a potentially further rollout across the country. Autonet experts highlight that a large-scale implementation of C-V2X services will require expanding 4G and 5G coverage on highways.

[3.9.] Cloud computing and “thin clients”

The basic idea of cloud solutions is to migrate data collection, storage, and processing from terminal devices to data centers. Access to this information and related services is organized through simple applications or a browser. Applications that transfer information processing tasks to a remote server – “thin clients” – are widely used in organizations that have powerful in-house computing resources, where fixed communications cover all ICT needs of business processes. Cloud solutions and “thin clients” considerably reduce the cost of operating and administrating virtually any information system. With the implementation of 5G comparable in speed to wired connection, and data centers integrated into their core, clouds and thin clients will be involved in all industry processes.

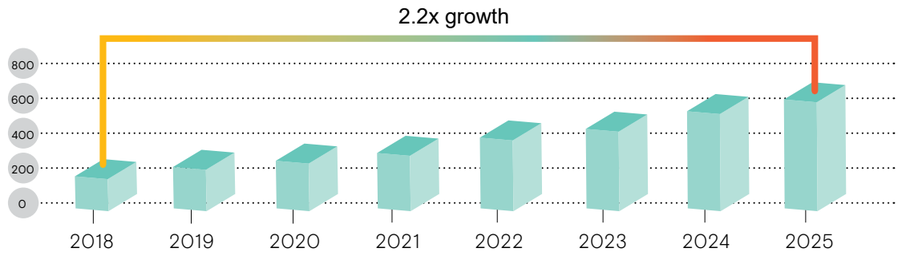
The move away from local systems towards a centralized cloud infrastructure ensures the unity and controllability of ICT services on the server cloud, their availability to a large number of users, security of data and applications, independence from local computer systems, and smooth migration of data and services to other data centers.

In addition, peripheral computing (Mobile Edge Computing, MEC) becomes possible in local data centers near the base station to offload user traffic of from transit communication lines and the network core. This provides maximum speed and reliability to the data center, which is critical for a number of industry applications requiring low latency and/or large data volumes.

By migrating to the cloud infrastructure, 5G operators can easily and quickly deploy links and infrastructure for external applications as well as multiple services for a wide range of applications.

Projections and estimates

Forecast revenue in the public cloud services market, USD billion



Source: Gartner, 2019

Sample cases

Amazon Web Services (AWS), the global cloud leader, has created a MEC-based cloud infrastructure in local 5G data centers of Verizon (USA). As a result, the partners were able to access the powerful cloud of AWS with very low latency, opening it up to many critical industry applications. This was not possible with traditional data centers used by AWS to build its cloud infrastructure. A hybrid 5G-enabled cloud infrastructure distributes the load independently between traditional data centers and MEC.

Absolutely the same was done by a partnership between Microsoft and AT&T: Azure’s integration with the operator’s edge data centers provided the fastest possible access to shared resources over 5G links, unlocking a host of opportunities for developing new applications for Azure platforms and accelerating AT&T’s network monetization.

Rostelecom’s data center for cloud infrastructure

A suite of Rostelecom’s integrated ICT systems based on its own data centers provides cloud services to government, businesses, and households. The company offers applied services to the healthcare, education, security, utility, property, and land management sectors. SMEs are offered office work, customer relations, and business accounting services. With the spread of 5G, access to computing infrastructure will become even easier and faster, which will dramatically boost the demand for cloud services in Russia.

3.10. Private virtual networks (VPN)

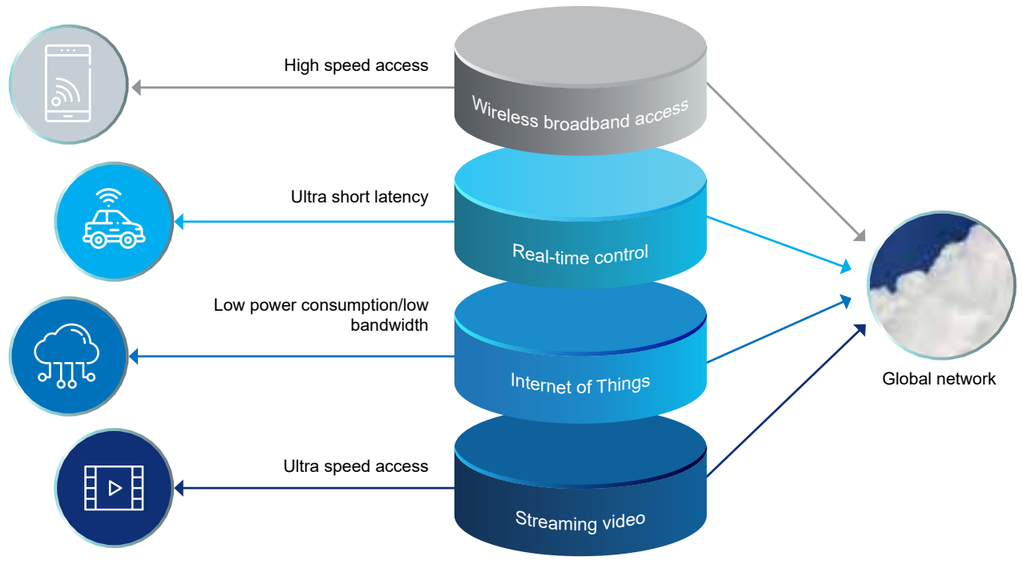
Most platform and industry services require high data rates, connection reliability, and minimal signal latency. To meet the stringent requirements for speed, reliability, availability, and quality of service, dedicated 5G-enabled segments – Virtual Private Networks (VPNs) – are organized in critical industry processes. The 5G virtual core enables creating virtually independent network segments with dedicated resources. These segments are called layers, which are organized into a multi-tier architecture (Network Slicing). Isolation of individual private virtual networks with dedicated computing resources guarantee a preset service level. Network Slicing, combined with the necessary mobile network coverage, guarantees virtually any set of network quality parameters for critical services in a particular location.

To ensure information security and specific industry requirements, dedicated 5G segments can be strictly separated from public networks. Dedicated networks can be deployed for individual organizations exclusively to support their production processes.

Sample cases

Deutsche Telekom and Nokia tested Network Slicing functionality for automation of logistics processes in the Port of Hamburg (Germany). The partners tested the ability to track the position and condition of ships using data from ship sensors, manage port traffic lights, and transmit images to AR glasses to search for freight items. A guaranteed level of service was achieved everywhere within the Port's special segment of the 5G public network

China Telecom, State Grid, and Huawei (an ICT vendor) tested 5G Network Slicing for China's Smart Grid system. The tests fully confirmed that the power utility's requirements for the quality of mobile service over the virtual 5G layer were met. In parallel, China Telecom, together with Zhejiang Bluetron (a chemical company), and ZTE (a vendor), conducted Network Slicing tests for a plant automation scenario. The tests also showed that all critical requirements for the 5G service level were met.



The Network Slicing concept at Intel

[4.]

Approach to selecting promising sectoral use scenarios

In this review, high-potential 5G use scenarios and corresponding industry services were selected in several stages. At the first stage, we explored over 120 global digital transformation cases across various industries based on modern ICT and wireless communication technology. Then, we analyzed information about new 5G products and startups that have received initial investment or financial support worldwide. We also analysed investment funds created to support the development of 5G services and their focus areas. The study and overall analysis demonstrated that, despite the diversity of services and their specific applications across industries, platform services form the basis for all, even unique industry solutions, developments, and services. De facto, they are an intermediate link between basic 5G capabilities and industry-specific services. At the same time, the 5G-enabled combination of platform services and industry-specific solutions generates synergies translating into improved efficiency and reduced costs.

After classifying platform services as a separate category, we broke then down into ten types. They are described in detail in Section 3.

We had to break down a significant number of use scenarios and specific services by industry. To assess the impact of the implementation of new sectorial digital services on national macroeconomic performance, we adopted the All-Russian Classifier of Economic Activities (OKVED 2) as the basis for sectoral classification. The analysis of incumbent and startup projects was used to identify sectors for which digital transformation of production processes is particularly relevant. They attract the attention of investors, ICT companies, and 5G operators in the first place.

We grouped a number of industries due to the similarity of their tasks; specifically, water supply and electric utilities were grouped into one subdivision. At the same time, due to significant differences in the implementation of applications, public administration and public safety were broken down into urban economy and public safety subsectors.

As a result, we drafted a list of sectors with the highest potential for efficient 5G implementation:

- Agriculture
- Industry
- Healthcare
- Mineral extraction
- Water supply and electricity
- Construction
- Trade
- Transportation and storage
- Public security
- Culture and leisure
- Municipal services

Thus, we highlighted promising platform solutions and clearly systematized industry-specific innovative services.

At the second stage of the review preparation, we shortlisted the companies and startups that use platform services and are already 5G-enabled or plan to use 5G for development. We used these short-listed companies to assess the potential and relevance of platform services with regard to the business objectives of each individual industry. The result was a matrix of demand for platform solutions in various industries as shown in Figure 4.1.

A deeper understanding of the effects of platform services and their combinations on each industry requires an in-depth analysis of specific use scenarios. In order to select the most promising services, we built the relevant criteria and assessed the services against them.

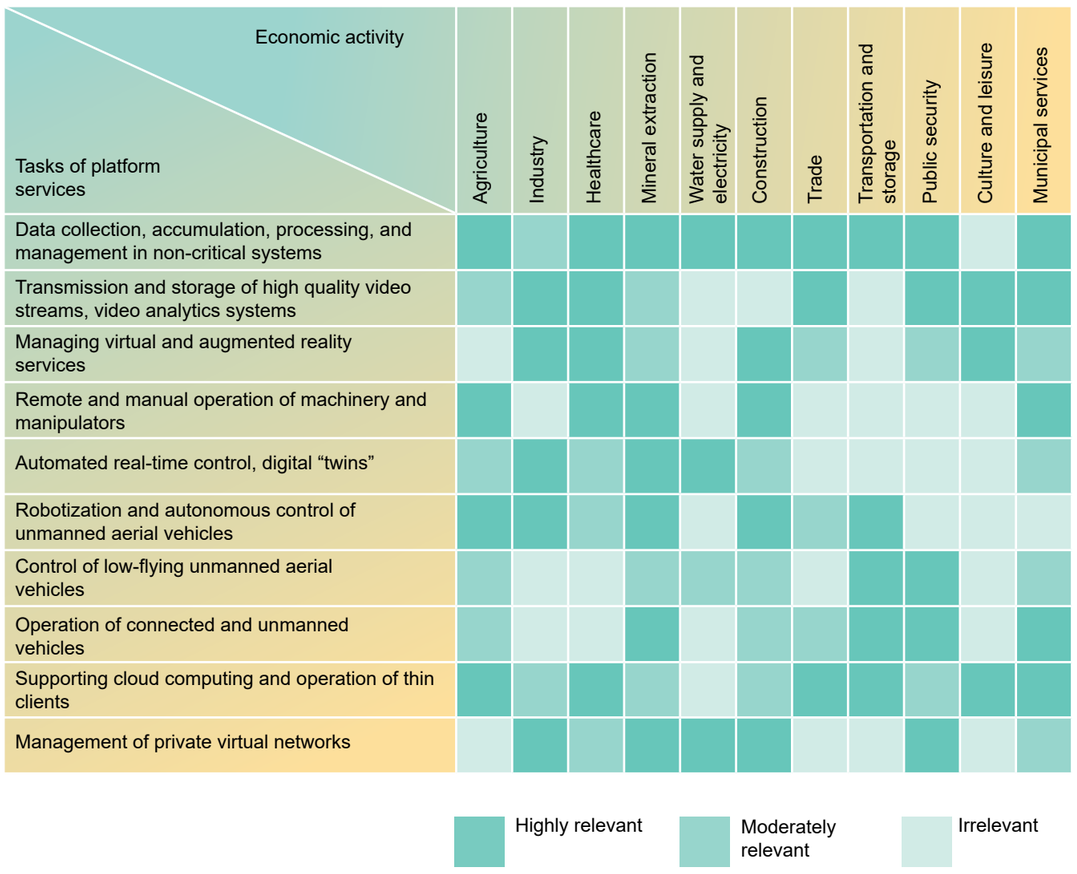


Fig. 4.1 Matrix of demand for platform services covering various industries (based on expert assessments)

Six criteria were assessed to select the most promising services.

- Demand: the importance of the service’s objective;
- The service’s relevance for implementation in 5G;
- Potential capacity of the Russian and world service markets;
- Project capabilities and payback period based on the effect achieved;
- Related technology readiness for the service’s development and implementation;
- Complexity and rate of the service’s development and rollout.

The methodology for selecting promising scenarios was also based on the analysis of 5G requirements in particular industries. They include the peak data transmission speed, signal latency, mobility, user density, energy efficiency, and network throughput capacity.

Based on the developed criteria, a list of 33 industry-specific transformation scenarios was compiled based on expert assessments with a description of the benefits gained/expected from efficiency improvements and cost reductions.

These scenarios are supported by case studies of incumbents and startups operating across various industries in Russia and worldwide, primarily those already using or planning to use 5G. Figure 4.2 shows the potential use scenarios. Their detailed descriptions across various industries are provided in the respective sections below.

Section 5 provides a more general description of the main applications of 5G and the tasks to be solved with its help. The following information is provided: a description of the use scenario; expected benefits and effects; the most popular platform services; an expert assessment of the scenario against a number of criteria.

Fig. 4.2 Promising use scenarios for various industries

The use scenarios, as well as platform services, are supported by sample case studies of incumbents and startups. These examples are diverse, but all of them demonstrate the immense capabilities of 5G. A number of projects by industry leaders have already attracted the attention of large ICT companies and venture funds, with their investments also discussed in the review.

The challenges that have led to the emergence of the selected scenarios arise in many industries. The review provides an opportunity for all interested managers to review each of the presented scenarios and find similar tasks in their domains that can be solved faster using 5G.

[5.]

Promising sectoral use scenarios

5.1.

Agriculture

Agriculture is an industry with a relatively long production cycle, exposed to numerous environmental risks, with large losses during the growing, harvesting and storage of crops, with many non-automated biological processes; an industry that is perceived by many to be historically a low productivity economic sector lacking any innovation or progress.

For a long time Russian agriculture was a business unattractive for investors. The use of ICT technologies in agricultural enterprises was limited to the use of computers and software for financial management and transaction support. Without radical technological innovations, the average annual productivity gains of most Russian agricultural enterprises were decreasing.

Not long ago, large farms began to use ICTs to monitor crop and livestock growth, as well as irrigation, field treatment, and product storage processes.

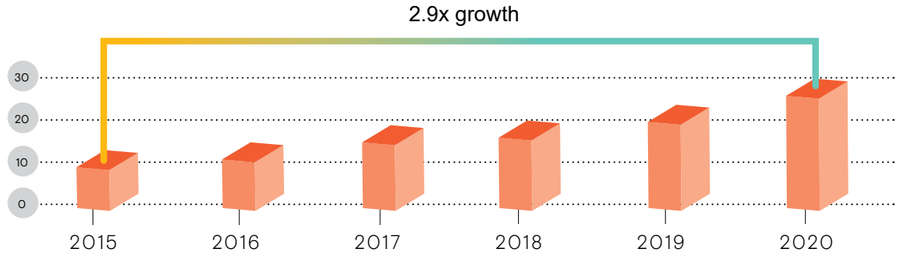
A dramatic change in investor attitude towards the agricultural segment occurred when technological and ICT companies paid attention to it. Together with new investors and partners, they have learned how to control the entire crop and livestock farming cycle via devices that measure the ongoing parameters of objects and the environment such as agricultural equipment, soil, animals, and plants, and transmit data through specially deployed communication channels for processing and informed decision making. The exchange and management of data, the growth of computer power, the development of software and cloud platforms has led to the automation of many agricultural processes, including the creation of a digital model of the agricultural production cycle. Many links in the value chain have been optimized in this way. The technologies allowed planning the work schedule with high precision, taking timely measures to prevent losses, calculating yield, cost, and profit.

Digital agriculture has become a reality: the farming of live products via autonomous self-adjustable production and business processes using mathematical models that describe interrelationships between metrics of these processes with primary data received directly “from the stall” or “from the seedbed” from IoT devices and sensors IoT. It is based on mathematical models of end-to-end processes of agricultural production and marketing based on actual, relevant, accurate, and complete data about all processes.

It is the availability of data that enables almost automatic optimization of agricultural production and marketing in terms of economic performance, sustainability, and minimization of negative impact on nature.

Projections and estimates

Capacity of the smart agriculture market, USD billion



The Connected Farm — A Smart Agriculture Market Assessment, Huawei, 2017

Key tasks to be addressed:

- Enhancing the industry’s performance
- Optimizing the processing and storage of agricultural products
- Ensuring national food security

5.1.1. Smart field

Smart fields are based on what is known as precision farming approach – the use of systems to control and monitor soil, crops, and the environment, providing stable agricultural yield with preset parameters.

The scenario of industry development and digital transformation includes:

- monitoring movements and modes of operation of machinery, route optimization
- autopiloting equipment
- failure prediction for field equipment and processing equipment
- dynamic adaptation of machinery parameters during sowing and fertilization depending on vegetation phases, weather conditions, and soil types
- remote sensing of harvested crop quality
- monitoring storage conditions, identifying processes leading to spoilage
- controlling the movement of products during the harvesting, storage, and processing stages
- monitoring staff workload
- monitoring the availability of resources at facilities: water, lighting, heat, and fertilizers
- forecasting demand for raw materials: fertilizers, seeds
- monitoring soil conditions (humidity, temperature) and weather conditions
- forecasting plant diseases;
- monitoring to prevent theft during harvesting, transportation, or storage.

Target indicators and metrics

- Area covered by digital data collection tools
- Effectiveness of data-enabled management decisions
- Area and number of farms that have mastered precision farming technology

Shutterstock/Fotodom

Precision farming

Most popular platform services

Collection of data on the operation of machinery and soil conditions, optimization of processes, control of harvesting, resulting in savings on machinery resources with the use of cloud services

Remote control of agricultural machinery using unmanned aerial vehicles for sowing, cultivating, and harvesting

Video surveillance, field condition analysis, high-precision fertilization and application of pesticides from drones

Existing and expected benefits:*

- Profitability growth by up to 20%
- Productivity increase by up to 100%
- Savings of up to 50% on fuel, seeds, and fertilizers
- Yield growth by up to 15%
- Product losses reduced by up to 15%
- Intelligent productivity management
- Minimization of management risks
- Reduced shortage of qualified personnel.

Sample cases

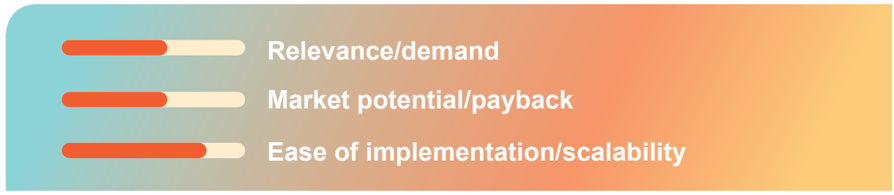
XAG Co Ltd in partnership with ICT vendor Huawei (China) is developing unmanned aerial vehicles, platforms, and IoT devices based on HiSilicon chips for smart agriculture. XAG's UAV replaces the man in the sowing and field cultivating processes; XAG's sensors supply meteorological data and soil characteristics, while portable cameras provide HD images from the fields.

The RuralFirst Consortium of 30 organizations supported by the UK government is led by Cisco Communications (USA) and Strathclyde University in Glasgow. The purpose of the consortium is to test 5G applications in the 700 MHz, 3.5 GHz and 26 GHz bands in rural areas, including for improving yields, efficiency and profitability across the agricultural industry. In Shropshire County, RuralFirst has deployed 5G to monitor, transmit and analyze soil and crop condition data with UAVs and operate standalone tractors for automated fertilizer application.

The Agrosignal Trade (Russia) cloud-based agricultural production control and metering system contains an interactive field map and records the history of field operations. With its help, agrotechnicians form technological maps, calculate the output, control the movement of finished products throughout the agricultural value chain, and conduct online monitoring of transport. For a number of agro-industrial companies, Agrosignal Trade installs satellite tracking sensors on the equipment, displaying its real routes on the tablets of supervisors.

* Quantitative estimates based on data from Agrosignal, Ltd.

Agrosignal Trade's projects have already covered more than 200 farms and more than 5 million hectares of land. According to IIDF, investments in the project amounted to about RUB 100 million. 5G supported by LTE-M and NB-IoT radio interfaces will significantly expand the coverage of rural areas, respectively enhancing the possibilities for digital transformation.



5.1.2. Smart farm

Livestock breeding is another major segment of the agricultural industry, in many ways similar, but still different from crop production in terms of a number of physical and biological, and hence technological and organizational, business processes. A smart farm is also based on a control and monitoring system using digital sensors and detectors, with their data processed via machine analytics to monitor and predict the condition of animals online. ICT based on network platforms can also significantly improve production efficiency and the quality of products such as meat, milk, and wool.

The industry development scenario includes parallel processes:

- Monitoring the feeding, milking, and grazing;
- Identification of livestock coordinates, alerts about animals leaving the permitted area;
- Monitoring the animals, incident alarms (slaughter, theft);
- Monitoring animal health, calling a veterinarian for inspection or vaccination;
- Forecasting fodder requirements;
- Monitoring the movement of animal products;

- Monitoring the safety of finished products during production and transportation;
- Monitoring and control of on-site water, electricity, and heat consumption;
- Monitoring storage conditions, identifying processes leading to spoilage.

Existing and expected benefits:*

- Animal mastitis morbidity reduced by up to 70%
- Product profitability increased by up to 40%
- Quality of dairy products improved by up to 40%
- Increase in animal productivity
- Minimization of management risks
- Reduced shortage of qualified personnel.

Most popular platform services

Collection and processing of data about livestock condition via cloud services for farms

Animal monitoring and care based on machine recognition video

Sample cases

The Intelligent Dairy Farmer's Assistant (IDA) is a network system by Connecterra (Netherlands) that transmits data from sensors on animals to an artificial intelligence (AI) system, building a behavior model for each animal by precisely identifying how and at what time a healthy animal eats, drinks, defecates, walks / lies, and sleeps.

* Quantitative estimates based on a Smart Farm research by the Analytical Centre of the Ministry of Agriculture of the Russian Federation.

The system also recognizes the first signs of a disease in the animal, and automatically makes predictions of periods of decline in productivity, or readiness for reproduction. The total investment in IDA development were EUR 5.9 million. Connecterra provides services to livestock farms in Belgium, Great Britain, Germany, Spain, USA, Canada, Kenya, Mexico, and the Netherlands.

SCR Dairy (Israel) offers a cloud platform with a range of services for tracking animal health and improving farm performance. The platform collects and processes animal sensor data online, analyzes the data, and provides recommendations and operational guidance on maintenance based on specific algorithms for the production of milk and beef, as well as sheep and goat products.

An example of how Connecterra sensors are placed on cows

Relevance/demand

Market potential/payback

Ease of implementation/scalability

5.2.

Industry

First of all, let us consider scenarios of automation and optimization of production processes using 5G for discrete industries where assembly, testing, and packaging is carried out in several phases.

Modern industrial production is largely automated; Supervisory Control and Data Acquisition (SCADA) systems are used everywhere to optimize production. SCADA are software solutions for developing or supporting operations in real time, including the collection, processing, and display of information about the monitoring or control target. The transition to 5G-enabled wireless technology and cloud solutions will considerably0 deepen and expand the automation of processes, bringing them to a new technology level.

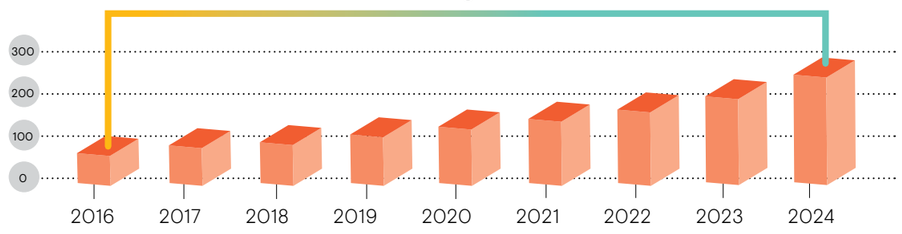
While providing a level of service comparable to that of wired connections, 5G enables a dramatic increase in the number of sensors and actuators that can be used, simplifies the installation of sensors on mobile units used in a production process, and significantly reduces the cost of automation scale-up. 5G unlocks new possibilities for creating digital twins – cyber-physical systems providing a virtual rendering of real-life production capacities and processes. Digital twins enhance optimized automation and robotics by connecting powerful computing resources to manage real production data in real time. Connecting a variety of sensors over powerful 5G channels and cloud computing platforms has brought about, among other things, the previously unattainable flexibility to reconfigure production lines for new product types, reducing the time and financial cost of any changes to production processes.

Process digitization includes automated mechanisms for searching and selecting input materials, conveyor automation and robotization, testing, packaging, and warehouse management. All processes are monitored and visualized in real time, enabling predictive fault analysis and accurate reporting of product availability to suppliers, contractors, partners, and consumers at all stages.

Chemical production processes are fundamentally different from, say, mechanical engineering in most key processes. Professionals say that all plants in the world are different from each other, even they manufacture the same products. Therefore, a qualitative leap in process automation systems generally requires close cooperation between industry experts, 5G operators, ICT equipment manufacturers, all developers, and technology companies.

Projections and estimates

Estimated capacity of the global market for smart factories, USD billion



Marketsandmarkets, 2019

Key tasks to be addressed:

- Increasing labor productivity
- Reducing energy and material consumption
- Reducing reject rate and increasing the output of useful products
- Reducing downtime, and enhancing predictive equipment repair
- Increasing flexibility of and speeding up capacity reconfiguration
- Ensuring transparency and control over all production and sales processes - Improving occupational safety

5.2.1. AR/VR for production and repair work

Full automation of modern production processes is complicated and costly, requiring the engagement of highly qualified specialists to develop, assemble, adjust, and test an automation solution. In projects of high complexity, even the most experienced employees commit errors that require additional labor costs and expertise.

One of the ways to increase productivity when performing complex, critical operations is to use virtual and augmented reality (VR/AR) technology. A considerable amount of time spent for assembling complex equipment or mechanisms includes verification, including visual comparison with design documentation. Complexity and multi-tasking combined make specialists less focused. Fortunately, many AR applications have already been developed to help such operations. They can be fully and flexibly implemented only via 5G.

For instance, cameras placed on AR glasses transmit the image to the cloud service, which recognizes the equipment and uses the same headset to superimpose the necessary image over a physical object, with all drawings, instructions, and references where necessary. This technology enables the specialists to immediately make the next step of the assembly process and estimate whether the operation has been carried out correctly, without distracting their attention by performing a manual search and comparison of images in the technical documentation. The AR image can be animated, showing the correct assembly method and the future operation of the unit in motion. Together with embedded sensors, which are also 5G-enabled, the specialist gets an understanding of the equipment performance in real time with a full-scale visualisation. AR/VR technologies are also used to train personnel to work with new production processes. They eliminate the need for physical testing benches and diversion of production resources, further reducing costs, eliminating a number of operations, and resource wastage and rejects when launching a new production process.

Existing and expected benefits:*

- Time for assembly operations reduced by 15%-30%
- Time for training and retraining of personnel reduced by 30%-75%
- Repair costs and equipment downtime reduced by 40%-75%
- Cost of personnel training reduced by 25%-50%
- Elimination of assembly errors and correction costs
- Decrease in work-related injuries

Most popular platform services

Visualization of production processes and analytics, optimization of the work of personnel involved in assembly and complex production processes

Reliable and continuous operation of AR/VR services with minimal latencies using dedicated computing resources and a special in-plant radio access network.

Ericsson (Sweden) uses industrial AR/VR solutions at its own factories, in particular for the assembly of discrete elements, which has not yet been robotised, and for final assembly checks. The use of special transparent tablets between the board and the employee enables the visualization of the correct layout without AR glasses.

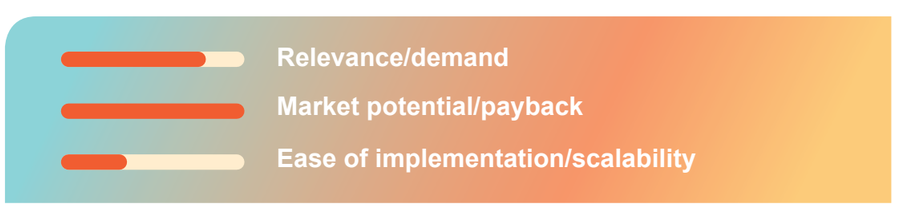
To accelerate faultless assembly, Boeing (USA) uses AR/VR to help technicians install wiring in the aircraft fuselages during aircraft construction. Techicians can see 3D renderings of all structural elements and devices within the wiring area, which speeds up installation and eliminates errors.

* Quantitative estimates based on data from Boeing, Lockheed Martin, Ericsson, and Atheer Inc.

Ericsson using augmented reality to test microchips

Atheer (USA) has developed an AR platform to assist in the assembly and repair of complex machines and mechanisms. The solution visualizes assembly instructions and manuals, and provides remote expert advice and tips during the work. The process image is transmitted from the assembler's wearable camera to remote supervisors, who send tips and infographics to the assembler's AR headset.

The RemoteVU platform of GetVu (USA) is designed in a similar way to remotely advise field technicians during complex repair and assembly operations.



5.2.2. Production sensors and predictive repair

Industrial equipment, especially used in mass production, contains a large number of elements, including moving loaded units, wears out quite quickly, and frequently breaks down. However, not all production operations can be automated and often require manual control. The risks of equipment setup errors and breakdowns are often very high. However, an emergency shutdown of a single unit or machine sometimes completely disrupts the production process of the entire plant, resulting in huge losses. For this reason, enterprises are increasingly using detectors and sensors to monitor the condition of the equipment to schedule the most relevant preventive inspection and maintenance.

Wired data networks have many limitations in terms of sensor placement and maintainability. These include complex and diverse spatial arrangement of sensors, significant deployment and reconfiguration time, lower achievable sensor density, and wear and tear of wires on moving structural elements.

A powerful wireless network in this regard will help enterprises survive. Wide implementation of 5G will significantly simplify and improve data collection from running equipment. With 5G, achieving target levels of connection reliability will be much easier, given the high density of sensors, low latency, and high transmission speed.

A large volume of accurate data received in real time enables creating digital twins and building predictive algorithms to monitor equipment condition, schedule predictive repairs, and develop effective flexible maintenance programs. According to various estimates, predictive repairs increase enterprise productivity 5%–20%. 5G will make it possible to implement them at many enterprises.

Existing and expected benefits:*

- Productivity increased by 5%–10%
- Unscheduled equipment downtime and repair time decreased by 20%–50%
- Maintenance and service costs reduced by 5%–10%
- Increase in maintenance efficiency
- Prevented equipment breakdowns and industrial accidents
- Increased speed of emergency response to breakdowns

Most popular platform services

Data collection and processing in non-critical systems and latency insensitive tasks for building digital models of processes

High reliability real-time data collection and processing, digital production modeling, simulation-based management

Visualization of production processes and analytics, optimization of the work of personnel involved in assembly operations and complex production processes

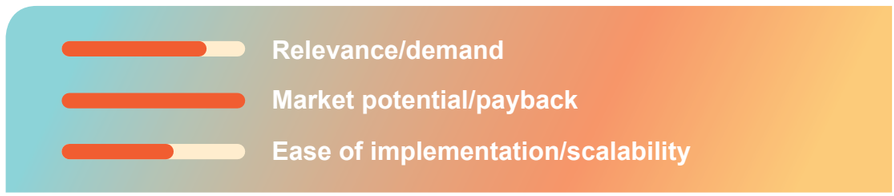
Reliable and continuous operation of platform services using dedicated computing resources via a special in-plant radio access network

Sample cases

Bosch’s heating systems plant in Worcester, UK, has become a pilot site to test industrial 5G applications. The plant uses predictive repair models generated in real time from a huge number of sensors installed in the production equipment. Downtime has been

Use of digital controls at a Bosch plant in Worcester

significantly reduced already in the initial testing phase. Bosch plans to extend this experience to its other facilities in the UK and in other countries. The production automation cloud platform from Seebo (USA) focuses on creating digital process twins based on analytics and data processed by machine learning algorithms The goal is to develop models and flexible schedules for predictive repair and product quality prediction. A unique feature of the platform includes a rich algorithm toolkit that does not require any special code for modelling. Azure Microsoft has been chosen as the cloud base of the Seebo project. Ansys (USA) has presented a new application for building digital twins, Ansys Twin Builder. Using ready blocks of algorithms from a wide library of models, Twin Builder creates digital twins for various pieces of equipment. Their main application is predictive repair. Ansys’s digital twins are integrated with various IIoT platforms, providing them with real-time sensor readings, visualizing processes, and providing recommendations on repair schediles and nature.



* Quantitative estimates based on Deloitte, Gartner and Seebo research.

5.2.3. Smart factory

Digital automation and robotization throughout the value chain lead to building plants with minimum human involvement. Building smart factories or transforming the old ones based on new ICTs is a separate service from the platform solutions category. Key elements to achieve the highest level of automation include the use of robots and analytics based on digital twins. Depending on the type of production, the transformation journey will vary, but generally includes:

- deployment of a network of detectors and sensors, video monitoring and analytics systems at production lines and in warehouses to track equipment, materials, and finished products
- creation of digital models and algorithms to model the operation of the entire value chain, visualization of models and algorithms, including using AR/VR
- creation of algorithms for automatic control of processes and equipment setup to improve productivity, efficiency, and failure prevention
- creating a system of automated trolleys, loaders, and manipulators to move materials and finished products
- application of industrial robots at conveyors
- use of automatic algorithms to collect information from sensors, evaluation of the quality of products using video analytics.

The remaining manual work is complemented by AR/VR services. The overall connectivity and synchronization of all systems up to milliseconds is critical for uninterrupted smooth operation of production facilities. 5G combines heterogeneous services using universal broadband radio channels, a shared cloud infrastructure and synchronization environment, and will therefore will gradually replace low-speed and proprietary solutions.

Existing and expected benefits:*

- Downtime and repair time for critical components reduced by 20%
- Power consumption reduced by 3.5%
- Personnel expenses reduced by 18%–33%
- Productivity increased by 20%–33%
- Rejects reduced by 88%–100%
- More flexible product range and production processes

Most popular platform services

- Data collection and processing in non-critical systems and latency insensitive tasks for building digital models of processes
- High reliability real-time data collection and processing, digital production modelling, simulation-based management
- Visual recognition of actions and situations during manual operations
- Visualization of production processes and analytics, optimization of personnel work, primarily in assembly operations
- Use of automatic loaders, robotization of conveyors and other production processes
- Cloud platforms for data collection, digital twins, process simulation, robotic control
- Reliable and continuous operation of platform services using dedicated computing resources via a special radio access network

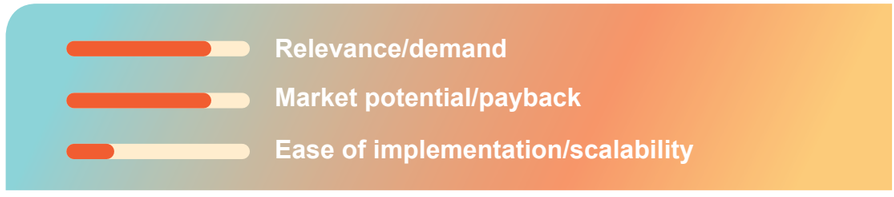
* Quantitative estimates based on the Bank of America research and data from Schneider Electric, Bright Machines, and DataProphet.

Tracking employee activities at Omron factory using 5G networks

Sample cases

5G NTT DoCoMo (Japanese operator) and Nokia (Finnish vendor) are working on a smart factory for Omron medical equipment. All equipment and premises of the factory are fitted with sensors connected and controlled via 5G. Complete automation of the key production processes and a shared 5G-enabled environment allow for quick reconfiguration of all production sites for new types of operations. Omron materials and finished products are moved on trolleys, also controlled via 5G radio. Most manufacturing operations are performed by robotic equipment controlled from the 5G cloud infrastructure The correctness and quality of all operations is controlled by a 5G-enabled intelligent video surveillance system. Schneider Electric (France) has launched its first smart factory in Lexington (USA) after a deep upgrade of its production of electrical load control devices. SE has created its own automation platform, EcoStruxure, which includes modules for AR-enabled assistance to repair technicians, smart resource and electricity metering, and fully electronic document management. EcoStruxure centrally collects sensor readings from various processes across the factory, transmitting data to the control and visualization system to track the operation of the enterprise via its digital model.

Smart Factory Integrator Fideltronik (Poland) offers a technological platform to build smart manufacturing. The platform includes robots controlled by artificial intelligence based on bulk data collection and analysis, and a product quality control system, also with AI-elements. Fideltronik integrates and adapts its system to a specific production process, ensuring a smooth transition to intelligent production. The cloud automation service of Bright Machines (USA) implements the idea of a fully reconfigurable factory or conveyor using a digital production cycle model, robotic manipulators, and unmanned machines. Bright Machines' solution offers fast readjustment, setup, and self-diagnostics of equipment depending on the production objective and monitoring of the equipment operability and product quality.



5.3.

Healthcare

Better quality of the healthcare system on the whole can be achieved through implementing digital technologies across all healthcare processes. Digitalisation of healthcare is based on medical information systems (MIS) that offer quick and easy access to all medical data about the patient, and all related medical information and equipment to diagnose, consult, and treat the patient remotely. Such systems help perform a significant part of clinical work remotely, process online diagnostics data, perform electronic medical monitoring of the patient's condition, use aggregated data to prevent diseases, and respond quickly and effectively in emergency situations.

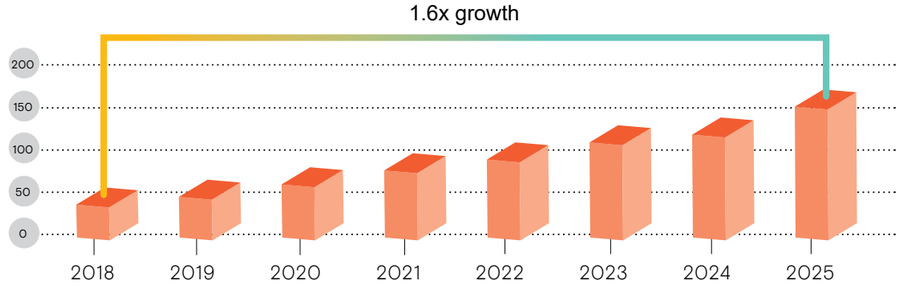
The use of modern means of communication for remote delivery of any healthcare services is known as "telemedicine". Today, it is one of the fastest growing healthcare segments worldwide, with an annual growth rate of about 20%. The development in this segment over the last five years has been catalysed by the widespread use of fourth-generation mobile networks.

5G provides even more opportunities for healthcare: the wide spread of wearable medical devices, online diagnostics, multiple remote procedures and manipulations, and even remote surgery. The implementation of 5G reduces the use of medical and medical resources, while improving the availability and quality of in-patient and out-patient care.

Apart from conventional telemedicine services, 5G provides a cloud infrastructure for developing a wide range of cutting-edge and pioneering medical applications, such as the use of machine learning to diagnose all diseases and AR/VR for complex surgery operations.

Projections and estimates

Estimated size of the global eHealth market, USD billion



Global eHealthMarket, Express Release, 2019

Key tasks to be addressed:

- Improving performance of healthcare professionals and medical institutions
- Improving diagnostic accuracy
- Optimizing the medical staff workload
- Reducing the time spent by the patient in hospital
- Managing new health control and disease prevention services
- Reducing the overall healthcare-related costs

5.3.1. Remote monitoring and diagnostics

Clinical and out-patient care is becoming drastically more accessible and efficient through the use of special, including wearable, devices to collect and transmit biological and medical readings from sensors on patients, as well as through intelligent machine analysis of such data in diagnostics and treatment assessment.

Key tasks to be addressed:

- Monitoring body temperature, pulse, blood pressure, brain activity, analysing video information from patients
- Wireless transmission of received data to data centers for collection and storage
- Biometric data analysis
- Predicting dangerous conditions
- Emergency alerts (panic buttons, fall sensors)
- Medication reminders
- Monitoring the stock of necessary medications

5G radio interfaces such as LTE-M and NB-IoT have enabled the wide use of portable autonomous diagnostic devices in the hospital and at home 24 hours a day without movement restrictions. Patient data is processed within the cloud infrastructure of 5G networks not only for diagnostics and treatment purposes, but also for their overall health improvement. In particular, new medical information systems are widely used for health monitoring and emergency care for elder patients.

The use of 5G in medicine implies close cooperation between network operators and medical experts, medical facility management, and medical technology vendors.

Existing and expected benefits:*

- Reducing treatment costs by 25%–30%
- Reducing hospitalizations by 20%–60%
- Reducing the need to see a doctor by 20%
- Reducing the cost of medical personnel visiting the patient
- Increasing the level of medical care in remote areas and in poorly equipped medical institutions with staff shortages
- Improving diagnostic accuracy and treatment quality

* Quantitative estimates based on Business Insider Intelligence research and data from Care Innovation Corporation, AdsuM+, Breathcount, and iHealth Labs Europe.

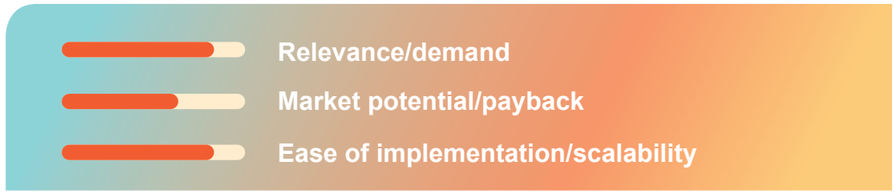
Most popular platform services

Data collection and processing in non-critical systems and latency insensitive tasks for building digital models of processes

Sample cases

Cloud platform by OneCare Inc. (USA) collects and stores health data from any remotely-connected device for healthcare professionals to run remote diagnostics and health monitoring and provide emergency medical assistance.

In 2019, the company began offering monitoring services using a special sensor-enabled watch continuously connected to a cloud via NB-IoT and LTE-M interfaces. The device has considerably simplified monitoring, expanding the data collection scope and providing exceptional patient experience. By early 2024, OneCare plans to reach up to 5 million people with cloud monitoring. Similarly, the cloud platform of Mediguard (Poland) includes a service for medical facilities and a mobile application for patients with a large set of medical devices and body sensors from different suppliers connected via Bluetooth for 24-hour remote monitoring of their cardiovascular systems, lungs, blood sugar, temperature, and pressure.



5.3.2. AR/VR for diagnostics and surgical operations

The human body is a unique sociobiological system. Even for a specially trained, talented, and experienced doctor, complex diagnostics, treatment, and surgery are always a non-trivial task. Augmented reality systems now provide significant assistance in their work.

Real-time machine analysis of data and UHD images from a remote patient builds a model used by the doctor online through a connected AR/VR headset. Comparison of the digital model of a specific patient with numerous digitized images and information from a powerful cloud-based MIS simplifies diagnostics, with the doctor able to identify potential health problems, analyse their causes, suggest prevention and treatment measures and implement them remotely. The use of AR tools in surgical operations is even more valuable. The intervention often needs to be completed as soon as possible; manipulations are complicated by the difficulty of distinguishing between tissues and organs. Augmented reality images visually highlight affected tissues, while online recommendations and evaluation of actions taken significantly reduce the risk of medical errors and speed up the work of the surgeon. Real and VR images and 3D models are transmitted to other doctors for consultation.

Standardised and flexible solutions for AR/VR-enabled surgical operations with low signal latencies and massive UHD video streams can only be made possible today via 5G. Moreover, 5G ensures strict synchronisation of data displayed in AR/VR headsets of surgeons operating remotely. A shared 5G cloud infrastructure is essential for quickly creating and replicating digital models based on patient data.

Existing and expected benefits:

- Surgery time and risk of infection reduced
- Risk of medical error minimized
- Decrease in postoperative mortality and complications
- Reduced costs of medical equipment due to the use of the cloud.

Most popular platform services

AR/VR visualization of complex and remote operations in medical training

Remote control by a robo-surgeon

Sample cases

Medivis (USA), established by surgeons, radiologists and engineers, is developing an AR platform for preparing and performing surgical procedures based on traditional diagnostic systems and artificial intelligence. To receive the service over 5G, Verizon migrates the platform into its cloud infrastructure. Based on the same principles, SentiAR (USA) is building a platform to project high-quality 3D images of internal organs to AR glasses during a surgical procedure: the images are projected to monitors installed above the operating table in real time, providing detailed visualization during surgery. The project is being developed jointly with Microsoft. The software AR solution of the medical company Proprio (USA) also improves the preparation of surgical operations: its AR renderings are displayed to several qualified doctors at a time for online consultations during the operation.

5.4.

Mineral extraction

The extractive industry plays a big role in any country's economy and is associated with huge labor and energy costs everywhere. Often, the location of deposits away from infrastructure is exacerbated by difficult climatic and geographical conditions. ICT is transforming mining and geological exploration. An increasing number of companies developing fields and deposits are implementing automated management systems: they process and analyze information in real time, provide quick access to all available information, allowing for emergency decision-making and improving field development efficiency.

The implementation of remote equipment control and autopilot systems supported through a network of sensors, detectors, and controllers enables development to be carried out without virtually any on-site personnel.

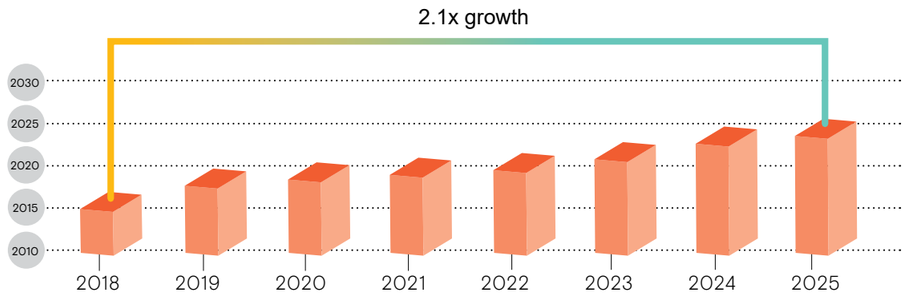
Geological exploration currently uses automated data collection solutions as well as remotely piloted aerial sensing systems and highly accurate and detailed landscape digitization. Together, this makes it possible to form a unified information base of fields, create their digital twins, and use bulk data during the construction and operation of mining infrastructure.

The digitization of the extractive industry implies the creation of shared ICT infrastructure combining automated mining, a remote control and monitoring system for vehicles and special equipment, a autopilot system, analytical systems to optimize cargo flows, mining meters, equipment and work metering systems, as well as security and occupational health systems.

5G has opened up new opportunities to combine technological systems into a single ICT environment, allowing the use of controls with high data speeds and low latencies and stepping up the number of detectors and sensors in the upstream sector. The huge amount of data coming from different monitoring, control, and management systems into a single information environment made it possible to build intelligent predictive models of facilities and predict threats, estimate resource consumption, and forecast the output. Digital models of deposits enable optimization with a guaranteed increase in productivity and safety.

Projections and estimates

Estimated capacity of the smart extractive industry market, USD billion



Statista, 2018

Key tasks to be addressed:

- Increasing labour productivity
- Reducing fuel and energy consumption
- Increasing control of position, workload, and operation of equipment, vehicles and personnel
- Reducing maintenance costs for large equipment
- Overall optimization of business processes
- Improving safety of property
- Improving control over the extraction of particularly expensive natural resources
- Reducing accidents, improving occupational safety

5.4.1. Automation and optimization of open pit mining

The use of ICT in open pit mines has made it possible to automate and optimize many processes, for example, in extraction of non-metallic minerals (sand, clay, limestone), crushed stone, and concrete production. The installation of detectors and sensors at mining sites, in transport, at storage facilities, and the collection and analysis of information in a single system enabled its accurate automated recording and access rights management. This is particularly important in the mining of noble metals and gemstones. Rigorous international and Russian reporting rules require careful measurement and documentation, transportation and storage control, and the use of special quality control equipment.

Scenarios for digital transformation of the mining industry involve the integration of heterogeneous systems into a single information space. In general, transformation involves:

- organization of security and safety systems with intelligent video surveillance and specialized sensors, access control systems, document management, anti-theft, etc.
- monitoring of the condition of heavy mining equipment and trucks: their position, km traveled, fuel level, tire pressure, load, operating hours, data from on-board systems
- monitoring of employee location, their health condition via detectors and sensors installed in the equipment
- remote control of mining equipment and trucks via a wireless video streaming channel
- autopiloted trucks or carriages integrated into a single intelligent system with vehicle load monitoring
- control of access by personnel to work sites (e.g. blasting sites) with video cameras and recognition, alarm, and emergency shutdown systems.

Existing and expected benefits:*

- Productivity increase by 10%–40%
- Power consumption reduced by up to 10%
- Reagent savings of up to 10%
- Production losses reduced by up to 25%
- Capacity utilization increased by up to 3%
- Operating expenses reduced by 10%–25%
- Forecasting and preventing accidents and equipment failures
- Increased efficiency of equipment fleet use
- Improved personnel safety at facilities

Sample cases

Baogang Group (mining), China Mobile (operator), and Tage Idriver (startup) have deployed 5G at the Bayan-Obo mine in China to demonstrate the unmanned operation of dump trucks based on a combination of lidars, radars, C-V2X radio interfaces, and cloud-based control data processing. On-site ICT systems control movement, accurate parking, and obstacle avoidance in two modes of movement: remotely manned and fully unmanned. The transformation has increased work speed and performance and reduced fuel and payroll costs.

Boliden (a mining group) in partnership with Ericsson (vendor) tested 4G and 5G in a project to automate the largest open-pit copper mine in Europe, Aitik (Sweden). The key innovation was the automation and remote control of special equipment and trucks. A number of drilling operations were also automated, and a smart mine monitoring system created, reducing the need for personnel.

* Quantitative estimates based on General Electric and Ericsson studies.

Most popular platform services

Collection, processing, and analysis of data from sensors installed on technical equipment, personnel equipment, fire safety systems, air, water, ground, and hazardous emission control systems

Remotely controlled equipment: heavy specialized equipment, heavy vehicles, including vehicles operating in conditions that threaten human lives and health

Industrial autopiloted heavy machinery, including railway trains with automatic loading, unloading, and transportation of resources

Data-driven digital twins of the enterprise and production processes Automated management of processes and interaction between corporate units Predictive equipment repair and maintenance models

Organization of movement of unmanned aerial vehicles within the territory

Close-loop information system of the mining facility Minimization of latencies in remote control and robot operation

Autonomous 5G-enabled dump truck operating at the Bayan-Obo mine, China

Relevance/demand

Market potential/payback

Ease of implementation/scalability

5.4.2. Mine automation, robotization, and safety

The coal industry is actively introducing automated control and management systems: conveyor lines; chair lifts; mine shaft alarm systems; water drainage systems; monitoring, warning, and personnel search facilities; main ventilation fans; air and gas control; and mine power supply control.

The implementation of 5G has allowed combining and scaling up heterogeneous automatic systems into a single information environment with significant capabilities for rapid response, configuration, analysis, and development of process models for predictive analytics. Digital transformation of mines includes the implementation of:

- safety systems with installation of detectors and sensors (humidity, gas concentration, dust deposits, power supply, temperature, geophysical and seismic data – with data processed via a single center remotely controlling ventilation, gas extraction, and degassing plants
- video surveillance systems – stationary, including infrared and thermal imaging – at drifting faces, in the mine workings with belt conveyors, and mobile – on cars, crates, and electric locomotives
- remote control and automated unmanned operation of mine equipment systems with installation of various sensors, passive safety systems and video cameras on rolling stock with integration into a single intelligent mine transport control system
- sensor systems on coal miners supplying data on the current size and strength of the coal bed, presence of solid inclusions, and other parameters for the automated adjustment of the miner's operating modes (cutter angle, face movement vector) in real time
- systems to control and position machinery and miners, monitor dangerous areas, and track people present in such areas
- weight control systems on loaders, belt conveyors, railways, and elevators to meet equipment load requirements and measure performance
- systems to collect data on coal beds, current geological and geotechnical processes for 3D modelling and mine development design.

Existing and expected benefits:*

- Productivity increase by up to 10%
- Power consumption reduced by up to 10%
- Reagent savings of up to 10%
- Production losses reduced by up to 25%
- Capacity utilization increased by up to 3%
- Operating expenses reduced by up to 25%
- Forecasting and preventing equipment failures
- Improved quality control over extracted minerals
- Improved safety of mine operations

Volvo CE 5G-enabled unmanned excavator operating in a mine

* Quantitative estimates based on General Electric studies.

Most popular platform services

Collection, processing and analysis of data from sensors installed in vehicles, including data on their location, technical condition, volume and consumption of fuels and lubricants, amount of work done, operating hours, and mileage. Helmet-mounted sensors to track the location and condition of personnel. Sensors for fire safety, and air, water, ground and emissions monitoring systems

Remotely controlled equipment for operating in hazardous or unhealthy conditions, resource and personnel transportation

Digital twins of extractive enterprises and processes based on sensor data. Automated management of processes and interaction between business units. Predictive models for repair and maintenance of machinery

Close-loop information system for mining enterprises. Latency minimization for remote control and robotization

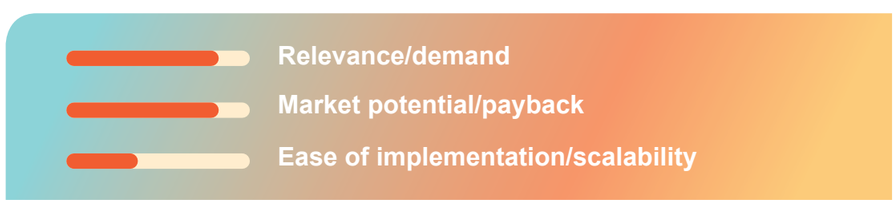
Autopiloted equipment, automated interaction between technological equipment units of different types

Unmanned machine movement in mines

Boliden (mining company), Telia (mobile operator), and Ericsson (vendor) deployed a 5G underground network at the Kankberg mine in Sweden to pilot a fully automated mining operation. The goal was to switch remote control and then to fully unmanned operation, while maintaining full control over all processes without any personnel at the mine. Control from the surface will eliminate downtime during shift change and ensure full safety of people. The automatic mode will only enable ventilation and lighting systems to be switched on locally to save on energy costs.

Yangquan Coal Industry Group, together with Huawei and China Mobile, has deployed a test 5G project in one of the coal mines in Shanxi (China). The partners are also practising mining automation, safety and monitoring scenarios, and are exploring the possibility of full mine autonomy to eliminate the need for downsizing and abandon expensive ventilation systems.

Rio Tinto has maximised the automation of its Pilbara iron ore mines in Australia based on existing technology by introducing unmanned trucks, drilling rigs, loaders, and an unmanned railway to transport ore. Rio Tinto has already designed a plan to develop, simplify, and roll out the system with a transition to 5G.



5.5.

Water and energy supply

Automated water metering systems in the central water supply system help save time and money of end users, and promptly detect and eliminate leaks in water pipes. Smart meters automatically transmit readings to information systems for calculation, making the process of charging utility bills transparent and minimizing losses. Automatic collection and processing of readings eliminates errors or deliberate distortion of data about resources consumed, providing significant benefits for the supplier.

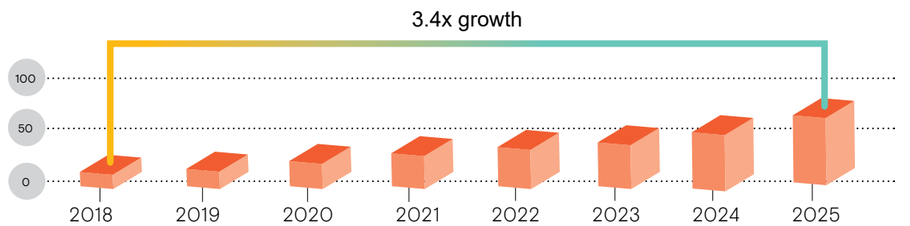
One of the key challenges of global energy systems consists in developing new, digital approaches to modernization and innovative development to improve the reliability and quality of electricity supply. Approaches based on automatic data collection and processing have opened up the possibility of active interaction between generators and energy consumers, intelligent consumption management and large-scale implementation of environmentally friendly energy technologies. They are generally referred to as Smart Grid.

Unification of data transfer interfaces from meters to concentrators and from concentrators to the data processing system plays a key role in this movement towards a new smart metering market. In addition to challenges related to accurate consumption metering and unauthorized connections that need to be address in the water supply sector, the implementation of Smart Grid will also address the problem of automated optimization of the entire energy industry.

The main reason for the emergence of a full-fledged network digitalization model in the power industry, which seems a remote possibility for most industries, is that an economic effect far exceeding the cost of implementation can only be achieved in the power industry through end-to-end optimization, covering at a time generation, distribution, marketing, and consumption by end users. The main difference between the Smart Grid and the traditional hierarchical power supply networks with manual control consists in automatically executed optimization algorithms for hierarchical and distributed heterogeneous systems. Cross-cutting optimization has been made possible by the accelerated development of IIoT platforms that integrate digital models of power systems and consumer behavior.

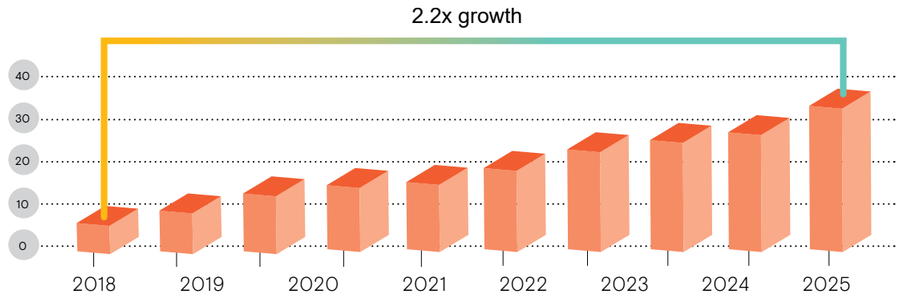
Projections and estimates

Estimated capacity of the smart grid market, USD billion



Marketsandmarkets, 2019

Size of the market for smart water supply systems, USD billion



Maximize MarketResearch, 2019

Key tasks to be addressed:

- Optimizing water and electricity consumption by end users through automated meter reading transmission systems
- Minimizing damage from leaks in water supply systems and unauthorized connections to the electricity grid
- Self-monitoring and reporting on any user of the power grid; ensuring availability of complete information on the electricity generated and transmitted, with estimates of efficiency, losses, and economic benefits

- Increasing the network reliability ensuring smooth transition between sources in case of a source failure, unnoticeable for users
- Increasing the overall network productivity through reducing transmission losses, ensuring optimal load distribution, and identifying the most efficient connection routes for large consumers
- Increasing energy efficiency of the country's economy on the whole.

5.5.1. Energy and water consumption data collection and metering

The highest-potential industry scenario implies a widespread and systematic implementation of smart meters - meters with data transmission over networks for monitoring and payment for public utilities. The main effect is achieved not by installing meters per se, but by collecting and processing data in cloud platforms. Their intelligent algorithms perform settlements with consumers, detect unauthorized connections to electricity grids, promptly detect water leaks, and automatically organize processes for system-wide network optimization.

The best way to penetrate the Russian market with modern smart water meters is to introduce multi-level systems for dispatching the readings of home water meters in apartment buildings and at large industrial consumers. Installation of meters at the entrance of each apartment and residential building enables accurate separation between individual and overall consumption of resources. Additional installation of meters in the distribution grid between the sales company and residential buildings has enabled almost real-time detection of water leaks or unauthorized connections to the energy supply networks.

5G, or more precisely LTE (4G) networks evolving into 5G, provide radio interfaces, cloud infrastructure, and applications to build intelligent systems to collect and record energy and water consumption data. Over the next few years, most smart meter connections will be to LTE-M and NB-IoT mobile IoT interfaces. Experts note that LTE-M is likely to become the most used technology for transmitting data on electricity consumption, as it provides readings at intervals of less than 1 second. NB-IoT with lower power consumption but longer latencies will deliver data for intelligent water optimization systems.

Existing and expected benefits:*

- Collection of payments for water consumption increased by 30%
- The difference between the readings of apartment and building meters reduced to 1%–2%
- Power losses reduced to 5%–6%
- Improved collection and analysis of water and electricity consumption data
- Reduced water and electricity consumption

Most popular platform services

Interaction of smart meters and devices with data collection and storage systems; automated billing solutions

* Quantitative estimates based on research by the Financial University under the Government of the Russian Federation" and WAVIoT's data.

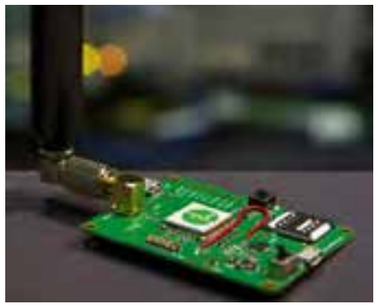
Sample cases

In June 2019, Landis+Gyr (Switzerland), the world's leading provider of integrated power management solutions for the utility sector with a USD 1.8 billion turnover, announced a contract to supply its Gridstream Connect solution to cover a million metering outlets of E.ON in Sweden.

The project uses an NB-IoT/M1 interface, with data collection and processing enabled through the Gridstream Connect platform. This solution will enable E.ON to increase the transparency and control within its distribution grid as well as the quality of customer service by controlling production and consumption in a quasi-real-time mode.

Freestyle Technology, a startup from Australia, has become the market leader in smart water metering in South Korea. Intelligent water meters and leak detection and management platform developed by Freestyle Technology are deployed in 24,000 houses in Gochang under a USD million contract. The project's geography was then expanded to include the cities of Pohang, Gimje, and Bucheon. Freestyle Technology's platform uses the cloud of Korea Telecom, enabling users to see information online on their mobile devices, and the water utility to bill and inform the municipality about any irregularities and incidents related to water supply. For example, if an elderly resident has not used water for several days, the system will sends an alarm notification to the municipality.

MegaFon (Russia) has completed a large-scale implementation of its NB-IoT networks and offered a cloud-based service, Smart Utilities to a wide range of organizations. The integrated solution combines an automated system for collecting and transmitting data from public utility meters, a web application for users, a large library of drivers for various models of digital meters, and extensive opportunities for integration with external systems. Smart Utilities enables metering and monitoring electricity, heat, water, and gas consumption. It is also possible to connect all fire and security sensors, leak detectors, and motion and opening sensors to the system. For certain meter models, the MegaFon solution enables remote programming and control of metering devices. The operator can connect up to 80 thousand IoT devices to one base station of its NB-IoT network.



Example of an NB-IoT module used for connecting MegaFon's meters

Relevance/demand

Market potential/payback

Ease of implementation/scalability

5.5.2. Smart Grid energy distribution

Smart Grid is a concept and technology providing for a fundamental upgrade of power supply networks, automatically increasing the efficiency, reliability, economic benefits, sustainability of production and distribution of electricity through the collection and intelligent processing of data on energy generation and consumption through the latest ICT-based 5G networks.

Smart Grid solutions cover five key areas: meters and devices; advanced control methods; advanced network technologies and components; integrated interfaces and decision support methods, energy demand management technologies, distributed monitoring and control systems, ongoing generation control systems, automated process measurement systems, new planning and design methods for power system development; and integrated communication tools.

The Smart Grid concept significantly improves the efficiency and accuracy of the automated information and measurement system for commercial electricity metering (AIMS CEM). The platform for automation of electricity trading AIMS CEM is a hierarchical system that unites all hardware and software tools for remote collection, storage and processing of data on energy flows within power networks and monitors the operation of electrical equipment. Based on the collected information, the system also generates a number of reports to build consumption forecasts and make cost estimates. The main obstacle for AIMS CEM's evolution towards Smart Grid consists in the complexity and cost of a dedicated ICT infrastructure covering the country's entire distributed power system. Implementation of the Smart Grid concept via 5G will ensure an efficient upgrade of AIMS CEM simply through connecting new generation sources and more accurate and ubiquitous energy consumption meters.

Without significant additional investment in information infrastructure, 5G will reduce latencies and ensure the transfer of all data on generation and distribution of electricity, and time synchronization in the power supply network. Among other things, it will enable the arrival of new power suppliers.

Existing and expected benefits:*

- Energy consumption reduced by 20%–45%
- Accident rate and repair costs reduced by up to 10%
- Losses due to power supply interruptions reduced by up to 15%
- Commercial losses of electricity reduced by 95%
- Potential decrease in the new capacity requirements by 20%
- Improved efficiency of energy utilities' asset management;
- Improved integration of renewable and distributed energy facilities
- Improved power system reliability in emergency situations

Most popular platform services

Collection and processing of data from electric power meters, automated billing systems

Collection of data from meters and distribution stations in real time, informing the decision making related to generation and power supply

Ensuring high reliability and low latency in power system management

Operation of the intelligent power supply management system of Yantarenergo

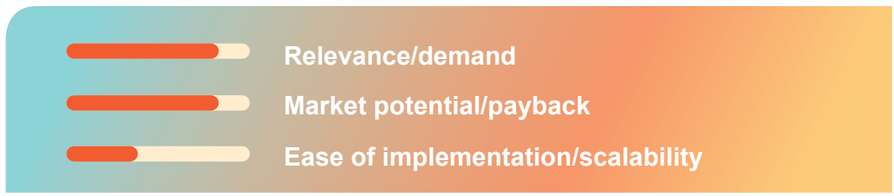
* Quantitative estimates based on research by the Financial University under the Government of the Russian Federation" and MPEI.

Sample cases

ABB, a Swedish manufacturer of equipment and systems for the power industry, and Nokia (a Finnish vendor) conducted tests of 5G, including Network Slicing technology, for intelligent load distribution in the power grid. The partners tested data reception and transmission guarantees with minimum latency for measuring and switching substations for real time energy consumption balancing. The tests proved the 5G reliability and latency required for the Smart Grid.

Peninsula Light Company (USA) selected Verizon to upgrade the Washington State's mobile-based power distribution system, which includes smart meters and a data analytics platform. Verizon will replace analog meters with digital meters connected via NB-IoT in 33 homes and businesses. Verizon's Grid Wide PaaS (platform as a service) solution enabled utilities to remotely set up, monitor, and manage their terminal energy consumption, increase meter accuracy, and manage outages. Verizon plans to implement advanced 5G-based power supply management systems, maximizing load balancing capabilities. Developed under the patronage of the Digital Horizon venture fund (Russia), the Edison power management platform includes smart metering devices that transmit readings to the information and computing system of the service provider and management organization. The data is then forwarded to the Edison platform where it becomes accessible to all systems and services of settlement participants.

Based on this data, an invoice is issued to the customer, which can be paid in their personal account through a mobile application or a web interface. In this case, payments are instantly split according to the terms of smart contracts and then credited to the corresponding accounts of companies participating in the system, with a relevant record simultaneously made in their personal accounts on the platform. When debt is accumulated, Edison's smart contract allows automated disconnection of the customer from the electricity grid or another resource within a few minutes, with the power supply connected as soon as the debt is repaid. In December 2019, the Edison platform was implemented in the network of JSC Yantarenergo, the largest grid company in the Kaliningrad Region.



5.5.3. Drones for transmission line monitoring

The significant expansion of 5G wireless channel capacity enables the creation of UAV-based extra remote continuous monitoring, remote sensing, and real-time video transmission systems.

Air monitoring of power lines from the UAV enables effectively assessing the technical condition of wires and insulators, the impact of natural factors on them, identifying defects and irregularities in wires and insulation, inspecting the adjacent areas, detecting unauthorized activities or vehicles appearing in the security zones. Data from UAV-based HD video cameras and thermal imaging cameras are transmitted online 24/7.

5G minimizes response time and provides real time UAV control with virtually no latencies, while the UAV owner can be hundreds of kilometers away. Using 5G instead of line-of-sight control systems ensures that the UAV is ready to be used without physically deploying a control station in the flight area. This is particularly important for emergency and unauthorized access management in 5G-covered cities. Equipped with 5G modules, drones can be grouped into synchronous networks, significantly improving their reliability and flight safety, as well as simplifying the coordination of flights.

Existing and expected benefits:*

- 6x reduction in the survey cost per km of power transmission lines
- Survey time per thousand km of power transmission lines reduced by 58 days
- Increased speed and accuracy of detecting transmission line defects
- High-altitude operations without deenergization
- Elimination of accident risks

Most popular platform services

Monitoring of power transmission line conditions for prompt detection of accidents and illegal activities

Emergency organization of flights using drones available from different owners to organize of VSaaS services

Sample cases

Tianjin Municipality in Northern China has completed the country's first transmission line inspection using unmanned aerial vehicles and 5G. The inspection involved 5G-enabled UAVs equipped with a high-definition camera. The UAV flew 6 km in the Binhai area and sent online video records of the transmission line to engineers, who found signs of defects. The ultra-low 5G latency ensured high accuracy and safety of the drone flight.

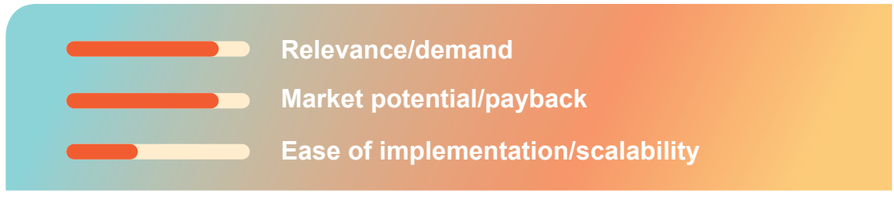
An integrated UAV solution of the Geoscan Group (Russia) offers aerial photography, aeromagnetic survey, including photogrammetric

* Quantitative estimates based on data from the Russian Drone portal

data processing and visualization. The solution provides accurate highly detailed terrain photomaps, elevation models, and 3D models of the surface, supports, and overhead line wires. Geoscan analyzes data using Sputnik LEP Geoinformation System to estimate the length and profiles of spans, distances from wires to hazards, e.g. tree crowns, suspicious objects or activities within protected areas, and so on.

Shutterstock/Fotodom

Recognition and creation of a digital power transmission line model based on the drone photography in Geoscan software



5.6.

Construction

The evolution of bulk data transmission, analytics and processing technologies unlocks an increasing number of opportunities in construction. New automation and optimization solutions are primarily emerging for the actual construction of buildings and structures, but innovations also cover their design, development, and coordination of investment projects, commissioning of life support systems, road building, and low-cost dismantling of dilapidated buildings.

The transition to 5G, cloud solutions, and platforms enables a significant increase in the digitalization of construction processes: given a drastic increase in the number of detectors and sensors, 5G simplifies their installation on the construction site, construction equipment, integrating all controls and monitoring devices into a single system, and unlocking new opportunities for automation, robotization, and optimization of construction processes. 5G provides previously unattainable transparency, control of resources and operations, strict compliance with design documents, and flexibility in changing technologies and designs during construction.

The large-scale digitalization of processes leads to completely unmanned operation of equipment and further to a single ecosystem of an intelligent construction site based on a digital model with coherent and flexible interaction of all stakeholders. Online processing of bulk data will ensure the optimal volume of materials on the site, predictive equipment maintenance schedule, rapid response to failures and emergencies.

Key tasks to be addressed:

- Increasing labor productivity
- Reducing energy and fuel consumption by construction machinery
- Increasing control over the consumption of building materials
- Increasing control over the position, workload, and activity of machinery and personnel
- Increasing control over compliance with design and estimate documentation
- Increasing safety of construction processes

5.6.1. Remote control of construction equipment

Remote control of on-site equipment using portable video cameras, detectors and sensors of the video surveillance system, and 5G-enabled on-site video data transmission includes:

- Organization of a high-speed 5G private virtual network for data transfer between devices, a single physical or virtual control center
- Use of special equipment with built-in video surveillance, active security systems, and detectors and sensors to monitor its status, workload, amount of fuel and lubricants, position at the site, and personnel safety
- Monitoring by an operator over a two-way wireless channel with full information on the target delivered via streaming video from surveillance cameras
- Autonomous operation of the equipment when performing a large amount of similar operations with partial control and switching to remote manual control in emergency situations or in case of complex manipulations
- Autonomous movement of all equipment within the local intelligent transportation system along automatically determined optimal routes

Existing and expected benefits:

- Work without risk of harm to people’s lives or health
- Reduced cost of delivering operators to the site
- Autonomous operation of equipment at sites that hard to access for people
- Hiring qualified operators for high precision work only
- Instrumental control of displaced materials and workings
- Savings on overtime for night and weekend hours

Most popular platform services

Collection, processing and analysis of data from sensors installed in vehicles, including data on their location, technical condition, volume and consumption of fuels and lubricants, amount of work done, operating hours, and mileage.

Management of heavy machinery and construction cranes from the on-site information center, in case of particularly difficult operations – from remote centers by highly qualified personnel

Autopiloted equipment for the delivery of construction materials within the construction site, automated forklift trucks, partial robotization of operations, such as brick laying

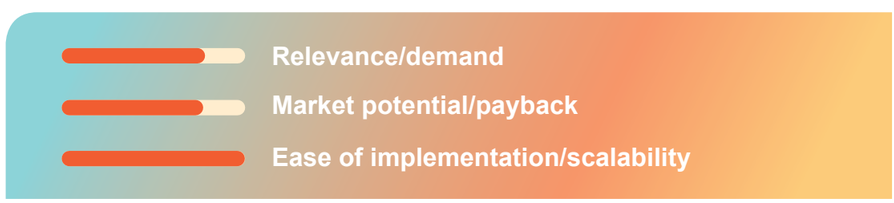
On-site high-speed data transmission networks, rapid provisioning of virtual networks for faster data transmission

Sample cases

Hyundai Engineering & Construction with 5G operator KT (South Korea) use 5G for construction automation. The partners are testing autonomous construction robots on two sites, with 5G applied for control and productivity enhancement.

Cellular operator and technology giant NTT DoCoMo (Japan) has demonstrated its proprietary 5G platform for remote control of construction equipment: four cameras on a remotely operated excavator and a panoramic view camera transmitted video with minimum latency to the operator’s monitor in a remote control facility located 60 km away from the construction site. Ongoing tasks were read from a digital twin, which was created online based on actual on-site sensor readings.

Workstation for remote control of an excavator over the 5G network of NTT DoCoMo.



5.6.2. AR/VR in construction

Combining construction video data from fixed on-site cameras, portable UAV-based cameras, and augmented reality glasses into a single 5G virtual network helps the personnel and management get all the information they need for easier, more informed and faster decision making and enables checking ongoing results against design documentation. The corresponding digital development scenario includes:

- An on-site high-speed private 5G virtual network
- 5G cloud infrastructure to create and process the 3D model of the project;
- CCTV management from AR equipment; building AR in real time based on video obtained from portable cameras on glasses and UAVs, fixed systems, 3D models of facilities;
- A 3D model of the future project for topographic surveys at the beginning of construction;
- A 3D model of the project at all stages to control compliance with documentation.

Augmented reality technologies work in combination with remote equipment control, with coordinated communications during the assembly of complex structures, for visualization of quality, including during finishing.

Existing and expected benefits:

- Increased attractiveness of the project during 3D demonstrations to investors
- Trust of investors who clearly see the dynamics and progress on the project via 3D models showing the planned course of construction
- Reduced expenses for adjustments to design documentation
- Increased control over compliance with the design, faster error detection and change decision making
- Reduced risk of damage to hidden communications
- Raising management awareness on the work progress.

Future pipe layout overlaid onto the roof space via an AR headset solution by Trimble

Most popular platform services

Demonstrations of the future construction project at the stage of signing investment contracts, informing the personnel on hidden communications, consumption of fuel and lubricants, scope of work, operating hours, and mileage during the ongoing work

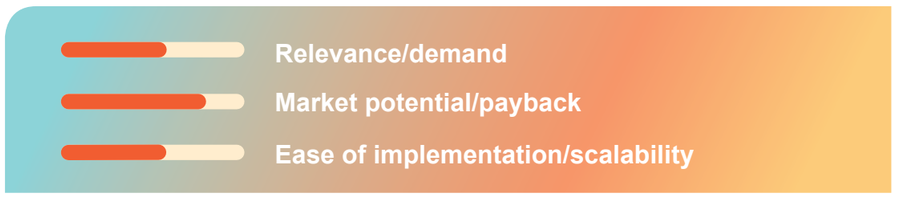
Panoramic camera systems for visual control of construction progress and compliance with design specifications

Drones for visual overview and demonstration of large construction sites, creation and overlaying of AR-enabled 3D images

On-site high-speed data networks, rapid provisioning of virtual networks to increase data transmission speed

Sample cases

Trimble (USA) supplies a portable augmented reality system that displays via a video stream a terrain 3D model of planned facilities and landscapes: construction structures, road infrastructure, residential areas, and utilities. For ease of perception, the system changes the transparency of the virtual development project, displaying individual engineering layers and objects. For data transmission, Trimble uses 4G, with the planned transition to 5G to make images more realistic and reduce transmission latency. Similarly, the product of XYZ Reality (UK), a 3D structural modelling platform for buildings and individual internal systems, overlays them via AR headsets to improve construction productivity and quality of complex installation operations. The company promises to accelerate construction and reduce related costs by 20%.



5.6.3. Smart construction

The use of multiple detectors, sensors, video surveillance systems, construction monitoring systems operating almost automatically based on digital models of facilities and processes is designed to significantly improve their quality, speed, and safety, and to ensure full control over resource consumption.

Necessary components:

- 5G-enabled high-speed virtual network for on-site data transmission
- Monitoring the position of personnel and construction equipment
- Monitoring all construction operations
- Environmental monitoring, noise, dust and other pollution alarm systems
- Predictive forecasting of on-site emergencies
- Predictive forecasting of building materials consumption, automated solutions to ensure their timely delivery to eliminate downtime
- Monitoring on-site equipment movement, automated routing
- Monitoring operating hours and fuel consumption
- Reducing embezzlement of construction materials and resources
- The transition to 5G solves two tasks that could not have been solved by previous generations of communication technologies: 5G enables online monitoring by dramatically reducing the signal latency, and do without on-site physical servers by integrating cloud data centers into the network core.

Existing and expected benefits:

- Increased labor productivity
- Reduced equipment downtime and shortage of materials
- Increased control over the use of construction materials and fuels and lubricants
- Increased level of construction work safety
- Reduced risk of dissatisfaction of residents from adjacent territories with the deterioration of the environmental situation.

Using CAD.42 software on a construction site

Most popular platform services

Collection, processing and analysis of data from sensors installed in vehicles, including data on their location, technical condition, mileage, consumption of fuels and lubricants, amount of work done, and operating hours

Creation of a digital model to control and manage operations, forecast risks, and communicate information

Organization of on-site high-speed data networks, as well as rapid deployment of private networks

Sample cases

CAD.42 and 5G Orange (France) offer construction management software. It is based on the ubiquitous deployment of tracking sensors for digital modeling of facilities and process analysis and control. CAD.42 automatically detects situations that are hazardous to personnel and immediately alerts workforce with audio and visual signals emitted by wearable devices. The system monitors material consumption, equipment wear and tear, and the risks of its misuse.

Similarly, the cloud-based service of ToolSense (Austria) provides guidance and control over the entire construction process and on-site safety via connected machinery and equipment sensors. The platform supports the creation of digital twins for ongoing control, predictive repair, and streamlined resource utilization.

Relevance/demand

Market potential/payback

Ease of implementation/scalability

5.7.

Trade

The implementation of digital networks and the need to handle data from a variety of connected devices are transforming trade business models, changing the appearance of traditional trade enterprises and unlocking immense new opportunities for wholesale suppliers and retailers. In an effort to maintain and strengthen their market position, merchants are implementing IoT, which increases the flexibility and efficiency of business processes and customer loyalty. With the development of 5G, digital trading opportunities are expanding significantly.

Tracking of goods, interactive customer journeys, online marketing, machine analytics of purchases and automatic management of the product range and stocks, mobile payments, as well as other digital services have been in demand for a long time and are actively used in retail. Intelligent machine algorithms are using connected cameras, sensors and tags installed in stores, warehouses, and vehicles to track, for example, the quantity and type of goods in demand. Analysis of data from smartphones of customers enables exploring their consumer experience, predict behavior, optimize the selling space and assortment, and inform each customer about new tailored products, promotions, and discounts.

AR/VR services help the buyer to make purchasing decisions by quickly viewing different virtual product models and the seller to navigate in the warehouse by highlighting the products to accelerate order picking. The development of such services resulted in smart mirrors installed in fitting rooms with visual tips about what products fit the selected items, providing a virtual demonstration of other sizes and color schemes.

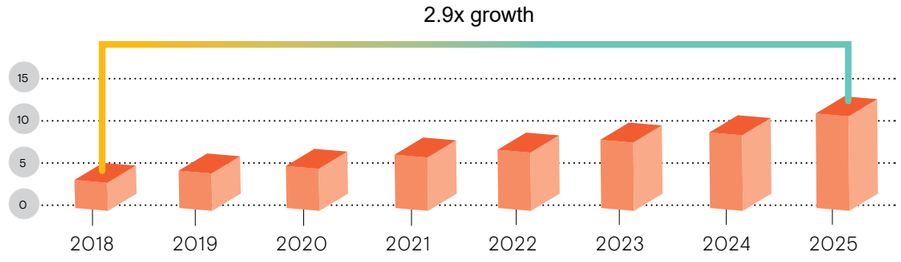
5G provides accelerated implementation of new trading methods, for example, using video analytics to monitor the quality of goods on the shelves, identify the causes for shortage of popular goods, monitor and predicts queues, encourage staff to respond to incidents correctly, improve the level of service, and accelerate the implementation of corrective actions. Total penetration and speed combined with instant analytics of data in 5G create a single steady environment of self-executed processes in any selling area or any marketplace, in which shortages or absence of services are technically impossible.

5G-enabled video analytics ensures correct scanning of goods, conformity of actual and registered weight, the process of taking products from carts to the checkout belt, and in the longer range will enables fully abandoning cashier services through automated 3D-scanning and recognition of goods right in the basket at self-service checkouts. Powerful video analytics is highly valued in smart vending machines, which recognize customers and personalize offers for them via connected digital signage. Implementation of 5G enables a complete robotization of trade for the first time in history, with automated search and delivery of certain goods soon to become a reality. Merchants are already offering robotic assistants to help customers, using them for order picking and loading at warehouses, using drones for delivery.

5G greatly simplifies the interaction between retailers and industry software developers through the transition to platform-based cloud services, ensuring full protection of smart trading solutions against fraudsters and hackers.

Projections and estimates

Capacity of the market for IoT devices in the US retail industry, USD billion.



Byteant, 2019

Key tasks to be addressed:

- Improving customer experience;
- Optimizing all trading processes and spaces;
- Maximizing control over the product range;
- Eliminating queues at fitting rooms and checkouts;
- Reducing the level of personnel's incorrect actions and errors;
- Increasing customer loyalty through offer customization;
- Reducing expenses for personnel, information, electricity, and other resources.

5.7.1. AR/VR for realistic presentation of goods

Augmented and virtual reality technologies are already used to sell home products, apparel, and cars. With AR/VR, customers get more detailed information about the product: without moving away from the mirror, they see what the model looks like in different colors, sets, and sizes, and in different interiors.

The simple way to implement a 5G-enabled AR/VR application is to use a solution that provides data about the entire product range. It is sufficient to direct the smartphone camera at the label, and the screen will display full information on the price, material, specifications, sizes, colors, and similar models available in the store.

AR/VR technologies have unlocked opportunities for creating virtual fitting rooms, smart mirrors that allow you to see the wardrobe element in different colors, choose the size according to your individual measurements, consult with a sales assistant without leaving the fitting room, or control the mirror with gestures. Smart mirrors provide a 3600 view and can record video for replaying.

AR/VR technology is now used across all areas of trade to better present the product and boost sales. Car dealer customers use virtual reality glasses to simulate the appearance of their car by changing its color, configuration and tuning, and examine the design features and technical characteristics of the vehicle.

An excellent example of 5G-enabled AR/VR is the ability to select furniture and other household items in any interiors of the customer's choice. AR/VR-application enables you to see on the display in real time how pieces of furniture can be placed and look in an apartment, change the composition of furniture, and choose the material, color, various models. AR/VR technology is a powerful tool in the hands of a sale assistant as it provides an additional analytical insight into the buyer's in-store behavior. AR glasses can easily build what is known as heat map, reflecting the movement of a potential customer's gaze to understand what exactly attracts their attention. Using this technology, merchants test and improve merchandising, design and usability of their venues, both physical and virtual (i.e. online).

Existing and expected benefits:

- Improve quality of customer service
- Reduced personnel workload, reduced fitting room space
- Business processes streamlined through online analytics
- Expansion and development of personalized offers
- Attracting a new audience to selling areas
- Development of online trading.

Most popular platform services

Monitoring the quality and quantity of goods on shelves, queues, monitoring personnel's reactions, level of service, correction of defects. Creation of personalized offers

In-store navigation in supermarkets, intelligent targeted and personalized advertising. On-shelf navigation for shoppers, search and analysis of goods by seller in store or in a warehouse

Creating a 3D model of shoes to overlay via AR in Cimmerse software

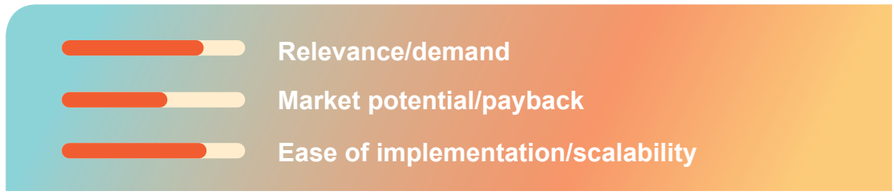
Sample cases

The software solution of Cimmerse (USA) presents a wide range of products in an AR/VR environment on a smartphone screen in 4G. Cimmerse plans to improve image quality and add interactive features with the implementation of 5G providing more bandwidth and lower latency.

A solution by InContext Solutions (USA) enables manufacturers and retailers to simulate real store situations by creating, evaluating, and implementing all types of merchandising tools. In fact, InContext Solutions sells an offline store builder in virtual reality. The AR/VR application is able to test new display case designs in virtual reality with real customers, measuring the effectiveness of the live emotional impact of the design, recording the search time for specific products using heat maps of the eye movement. The digital store/display case model is also used for staff training. By early 2020, InContext Solutions has invested USD 42.5 million in the project.

The Wannaby startup (Belarus) develops computer vision and rendering technologies (drawing images from a model using a program) to select products in augmented reality, trying on or displaying the features of the item. Wannaby has developed AR/VR application Wanna Kicks for trying on trainers, Wanna Nails for nail polish samples, and Wanna Jewelry for trying on jewelry. The startup plans to speed up the simulation process using 5G to ensure that textures and colors are as realistic possible. In 2018, Wannaby received USD 2 million from the Belarusian investment company Bulba Ventures and Cyprus Haxus Venture Fund.

Similarly, one of the products of NexTouch (Russia) includes virtual fitting rooms for retail: large interactive screens with built-in AR/VR technology that overlay the image of apparel onto the reflection of the customer in the mirror, giving a realistic, clear and vivid picture of the apparel being tried on.



5.7.2. Smart store

The smart store concept implies 5G-enabled automation of retail sites with integration of a set of technologies, in particular, automatic tracking of product movement and remaining stocks to minimize staff involvement and achieve outstanding customer experience.

Shelf sensors and video analytics in a smart store are enhanced by fast automatic stowage of goods in the virtual shopping cart of the buyer, who is automatically identified at the checkout by a facial recognition solution.

In-store consulting is implemented by retailers in different ways.

For example, when a customer chooses a product, the product's characteristics and potential offer options appear on the digital signage in front of their eyes. Smart and even talking mirrors are also used for in-store consultations. Automatic registration of selected products and face recognition provide almost instant service without waiting in a queue at a self-service checkout. Retailers also use intelligent video monitoring applications to ensure security and prevent theft.

Large stores and shopping centres often use mobile robotic assistants, offering convenient navigation and routes, as well as additional information about goods and services. Robotic systems are also used to deliver goods from warehouses and to organize goods on shelves.

Real data accumulated in a 5G cloud from all systems of a smart store enable carrying out an online analysis and get precise insights: whether the selling space is user-friendly, how it can be optimized, how popular each product is and how to improve in-store consultations.

Existing and expected benefits:

- Improved customer experience
- Personalized services as a result of machine analysis of preferences
- Business processes streamlined through online analytics
- Selling space optimized based on footfall analysis
- Increased online revenue
- Reduced personnel and selling space expenses.

Sample cases

China Real Estate Association, China Mobile, and Huawei jointly launched an intelligent service system for a 12-storey Lujiazui L+Mall hypermarket (Shanghai, China). The system focuses on simplifying navigation and product finding for visitors.

Robot assistants provide information about products and stores, plan personal routes at the request of the visitor, and offer to personally escort them to the selected place. The 5G network deployed at Lujiazui L+Mall also provides self-service location-based navigation in the shopping mall, integrated into a user-friendly mobile app and the Chinese messenger WeChat. Intelligent 5G digital signage panels with 8K screen resolution are spread around the mega mall, broadcasting personalized content to each visitor who approaches them. Video cameras and video analytics system of the hypermarket, also 5G-enabled, recognize visitors, collect online statistics, provide analytical insights to the hypermarket's administration and tenants for retail optimization as well as control security.

A retail automation solution of AWM Smart Shelf (USA) integrates a number of technologies to leverage the shopping experience of a particular customer in online stores to sell them products offline. The solution integrates shelves equipped with LED screens with a powerful multi-layer video analytics system: it recognizes customers and the selected product, offers navigation for customers and sales assistants, monitors the condition of the shelves, determines what advertising needs to be displayed on the screens to attract the attention of specific customers passing by, and collects social and demographic statistical data.

Most popular platform services

Tracking and analyzing customer movements, optimizing selling space

Robot assistants, robotization of goods movement and layout

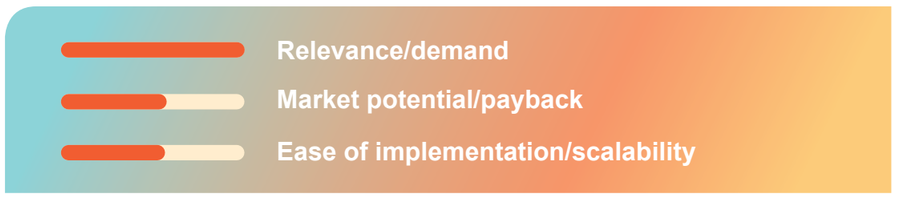
In-store navigation, on-shelf navigation and advertising, searching and analyzing goods in stores and in warehouses for sales assistants

Control of quality and quantity of goods on the shelves, queues, tracking reactions of the personnel, control of corrective action taken, building personalized offers

Intelligence Retail, a cloud service for tracking goods on shelves and in display cases (Russia) based on the recognition of photo and video images enables retailers to fully automate the process of auditing their shelf layout. This computer vision system operates based on a SaaS model via mobile applications and fixed cameras. The service measures shelf layout metrics, shelf share, presence of competing products, and compliance with layout standards in real time. Customers of Intelligence Retail include large retail chains and brands such as Danone, Carlsberg, and Red Bull.

SHUTTERSTOCK/FOTODOM

Operation of an application for visual shelf monitoring



5.7.3. Smart vending machines

Round-the-clock operation, only cashless payment, unmanned operation, increased profitability of the outlet: these are the many advantages of vending machines. They are quickly gaining popularity in Russia. The latest types of vending machines attract customers with high-definition touch screens, and easy communication using voice and gestures. Connection to mobile communication networks ensures remote monitoring and control of these devices. It was network connection that allowed vending machines to go far beyond just selling the goods. Connection to 5G predetermines a number of new trends in the development of smart trading machines. Vending machines interact with smartphones of customers in real time, improving the selection process, level of detail, and relevance of advertising based on collecting and analyzing the preferences of specific people. Vending machine owners are using friendly apps and social networks to interact with customers and inform them about new deliveries of their favorite products, attractive offers, and promotions.

Thanks to its easily available connectivity and high data speeds, 5G makes it easy to recognize customers: an built-in sensor in the vending machine is triggered as the user approaches, the smart camera recognizes regular customers and builds a personal offer for them based on their purchase history. Face recognition prevents the sale of certain goods to minors.

Online remote monitoring of the vending machine enables their owners to easily conduct stocktaking, analyze and manage inventory, and quickly top up the machine with the most popular goods. Sensors monitor the product storage conditions enabling automated optimization of energy consumption.

Network connectivity has enabled designing vending machines that offer buyers who have a bank card or a relevant smartphone application to first take and examine the products they wish to buy. The machine uses sensors and network analytics to understand which products have been taken and only then charges off the customer’s money.

Existing and expected benefits:

- Improved service quality
- Complete control over the point of sale
- Buyers notified about products and promotions via the mobile application
- Optimized multiple retail business processes
- Reducing personnel expenses
- Reduced costs for selling space rental.

Most popular platform services

Tracking and analyzing customer behavior, forming personalized offers, selling space optimization

Customer identification, video control of quality and quantity of goods on the shelves, elimination of shortages and queues

Sample cases

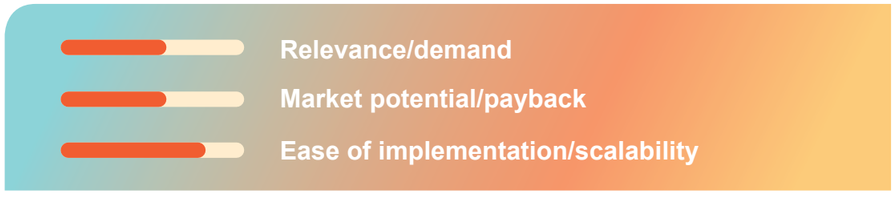
UTStarcom, together with China Mobile (China), has created a vending machine that recognizes faces and works with real customer profiles. The 5G camera of the machine communicates with the cloud video analytics service and identifies the buyer and their solvency. The vending machine lets the identified user open the door and take the products. Sensors detect the actually purchased goods, and the machine makes the calculations. During the purchasing process, customers only make their choice and receive the purchase.

Smart Vending Machines (Australia) produces smart points of sale with built-in digital signage. They display targeted advertisements of their products, answer questions, and take customer instructions.

An example of a booth-format automatic sales system using video analytics from Smart Vending Machines

Machine analytics provides information for automatic product stocktaking while smart cameras identify the customer, welcome regular customers, and offer a choice of contactless payment methods: payment card, smartphone, or online services.

Intelligent terminals Citybox (China) offer customers to simply take out the product – the door opens as customers scan a QR code using their smartphones. As soon as the user takes the purchase and closes the door of the machine, the payment system sends a payment report to the Alipay mobile service. Citybox is equipped with an effective security system, which monitors customer behavior and prevents theft. By 2020, the company has raised about USD 40 million of investments in its vending machines project.



5.8.

Transportation and storage

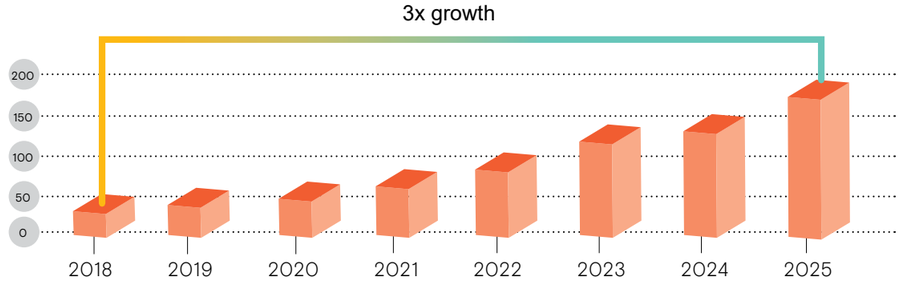
Freight transportation, passenger transportation, and storage of a large variety of cargoes are an important part of the economy featuring numerous processes of communication and interaction between product and service value chains, between manufacturers and retailers, and between stores and customers. Passenger transportation drives workforce mobility and tourism development. Digital transformation processes are evolving fast in this sector. Modern transportation logistics is looking into new opportunities to optimize and improve freight flows, rapidly implementing ICT applications, and creating networks of smart logistics fragments to reduce costs, increase profit, and improve service levels and security. Most digital transportation technologies are based on third and fourth generation communication networks, but their further development requires the use of 5G's breakthrough capabilities.

A 5G network provides a single space to monitor the condition and movement of cargoes, making it indispensable for the digitalization of the industry on the whole. Each segment requires its own original 5G logistics scenarios. For example, in sea, air, and rail transportation, 5G operates using mobile base stations connected via satellite communication links.

But the transportation of cargoes and passengers by road, rail, water, or air transport ultimately combine into global transportation channels with hub interconnections at ports, airports, and railway terminals. Tracking the location and condition of cargoes and warehouse automation are critical in each of these logistics segments. Therefore, despite a variety of heterogeneous processes and systems available in the industry, digital transformation needs to be carried out using a holistic approach.

Projections and estimates

Capacity of the global market for smart transportation systems, USD billion



Marketresearchfuture, 2020

Key tasks to be addressed:

- End-to-end monitoring of the position and condition of cargoes throughout the itinerary
- Optimizing transportation and warehousing systems
- Reducing the maintenance costs for warehouses and transportation systems
- Increasing delivery speed
- Reducing personnel and related expenses
- Increasing safety of transportation and storage

5.8.1. Smart warehouse

Concentration of population in cities, urbanization of people's lives, and the rise of e-commerce has sharply increased the volume of goods sent and stored, warehouse space, and capacity of the entire infrastructure for the rapid delivery of the most popular goods.
As warehousing becomes more complex and sophisticated, its optimization and migration to a smart warehouse, i.e. a technology that enables manufacturers, merchants, and operators to handle and automate any logistic tasks as efficiently and quickly as possible. Processes and automation facilities in this segment are inextricably linked with logistics tools.

Warehouse Management Systems (WMS) are widely used for effective management of warehouse processes, and optimization of acceptance, placement, storage, processing, and shipment of goods across warehouses of different types. Receiving and promptly processing data from various connected technological units, WMS manage the operation of warehouse equipment and personnel, control the movement of cargoes and loading equipment, and plan tasks taking into account the ongoing situation. However, the use of sophisticated WMS based on wireless communication technologies of previous generations does not provide the required level of automation.

The spread of 5G greatly simplifies the creation and operation of WMS and increases their efficiency. 5G enables connecting and tracking an almost unlimited number of pallets with goods in warehouses, providing accurate localization, navigation, and synchronization of automated lifts and trolleys, and most importantly, supporting complete robotization of equipment and ensuring the flexibility of any process based on a powerful cloud computing infrastructure and high-speed communication channels. 5G dramatically extends the capabilities of video analytics to recognize small items and cargoes, enabling their fully autonomous processing. 5G provides a host of additional features, such as identification of free space/loading/unloading gates to automatically indicate the best routes to robot loaders.

Existing and expected benefits:*

- Optimization of warehouse and storage facilities
- Precise information about the location of goods in the warehouse
- Speed of order picking and shipping increased by up to 50%
- Increase in order picking accuracy, reduced costs
- Continuous inventory management without stopping the warehouse operation
- Reduced labor costs
- Efficient management of goods with limited shelf life.

Most popular platform services

Keeping track of personnel and goods in the warehouse

Automatic order picking and cargo handling in the warehouse

Sorting and tracking cargoes based on video analytics

Sample cases

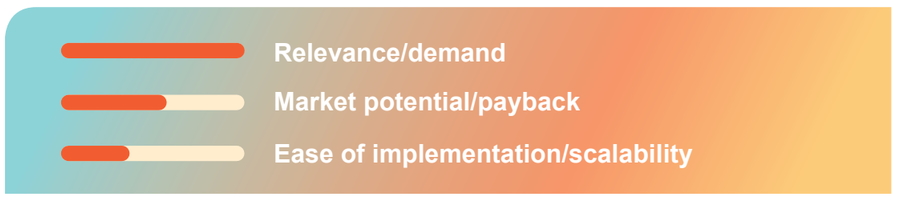
One of the largest online marketplaces in China, JD.com, has started operating a smart logistics park on the outskirts of Beijing. 5G-enabled real-time monitoring of all pallets and goods has been implemented in all company warehouses. The system automatically monitors the movements and reports incorrect transportation. The automatic dispatcher directs the trucks to the closest free gates and monitors the correct loading of pallets.

The Ocado supermarket chain (UK), offering home delivery, has commissioned a smart robotic food order warehouse.

* Quantitative estimates based on Alibaba Group data.

Inside the Ocado robotic warehouse

The Ocado Warehouse is a huge area divided into sections cells by a system of rails used by multiple mini robots with baskets to move around. Robotic manipulators are loading specific goods into baskets after having scanned their bar codes. The system is centrally managed from a cloud platform based on an LTE network (4G), which is scheduled to be replaced by 5G in the coming years. The robotic manipulators and unmanned equipment of the DoraBot smart warehouse (China) support the entire cycle of goods handling: acceptance, sorting, transporting, and loading. The solution is universal: it is designed for warehouses of a wide range of industries – from commerce to industrial production. The solution monitors all warehouse processes and operates via separate and collaboration robots (cobots).



5.8.2 Tracking cargo movement

Integrated digital control of truck traffic is already a common practice in Russia. The implementation of 5G brings a fundamentally new quality to the process – tracking specific containers, pallets, and items with sensors energized via autonomous power sources over LTE-M and NB-IoT radio interfaces. Sensors built into pallets or individual ordered goods identify their location and transport conditions even outside the ICT monitoring system. Individual sensors can be installed on any parcel, cargo, or item using 5G to control humidity, temperature, and integrity of packaging on their way from plant to consumer. This is especially important when transporting perishable products and pharmaceuticals.

5G significantly improves monitoring accuracy, which means it can optimize the delivery route, and speed up loading and unloading without downtime. 5G unlocks new opportunities such as delivery by unmanned aerial vehicles and cars. 5G-enabled UAVs are forecast to be the first to gain popularity. Short distance delivery will be carried out by autonomous trolleys moving via walking and cycling paths.

Existing and expected benefits:*

- Cost of transportation reduced by 15%–20%
- Goods tracked in real time
- Complete information about the condition of the cargo (coordinates, weight, temperature, humidity)
- Simplification, increase in loading and unloading speed
- Enhanced protection against theft and damage in transit
- Use of unmanned delivery technologies.

* Quantitative estimates based on data from The Descartes Systems Group Inc.

Most popular platform services

Tracking goods and vehicles with connection to sensors and navigation systems

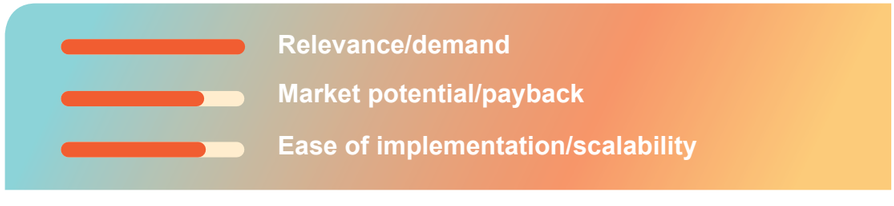
Unmanned truck traffic on public roads

Sample cases

AT&T (USA) provides a comprehensive vehicle tracking, delivery and unloading service with 4G and 5G-enabled control. It includes monitoring of the cargo movement, their transportation conditions, vehicle condition, and fuel consumption, as well communication between drivers and dispatchers, group communication, control of delivery and unloading, and remote video monitoring.

BeWhere (Canada) offers proprietary solar-powered sensors with a lifetime of about ten years to monitor the location, storage temperature and mechanical impact on goods. The devices provide frequent short transmission of data about the cargo and environmental conditions via 5G LTE-M and NB-IoT radio interfaces to a cloud where route optimization is performed. Customers monitor the movement and condition of the cargo in real time from a thin client on their devices.

Transport containers with AT&T LTE-M trackers



5.8.3. Smart port

The increase in global trade requires increased port capacity. Given the extremely limited coastal space and the cost of ship time in port, ICT that accelerate loading/unloading and all other port processes play a key role in this industry. The smart port concept involves automated optimization of logistics, and eventually full automation of all port processes, with maximum energy efficiency and sustainability. Today, large ports require well-coordinated operation of many sophisticated technological systems: navigation, transportation, loading, warehousing, monitoring, and communication systems. 5G makes it possible to combine and synchronize them within a single network, provide a complete picture of the movement of ships and equipment, availability of free berths and storage areas, readiness for receiving or dispatching cargoes of any transport system in real time based on accurate and up-to-date digital models of port processes.

5G enables instant connection of sensors on all containers onboard any ship and in port storage facilities, automatically organizing a fast and accurate delivery of cargoes with optimal remote logistics and immediate notification of the ship's and cargo's owners. Sensors and cameras installed on the protective equipment of the personnel makes it easier to track the movement of people, equipment, and cargo, quickly reorganize work, or predict dangerous situations.

The water area of any port has limited throughput capacity, among other things due to the need to ensure safe maneuvering. 5G provides a fast transition to unmanned operation of ships and tugs. Transition to centralized unmanned operation reduces berthing intervals, and increases the speed of maneuvers and port services in general.

Existing and expected benefits:*

- Ship unloading in port accelerated by 30%
- Headcount reduced by up to 85%
- Ability to handle more ships
- Increased cargo turnover

Most popular platform services

Tracking employees and vehicles with connection to sensors and navigation systems Centralized automated management of all port systems

Remotely operated cranes for container unloading and loading

Management of unmanned aerial loaders and other equipment in port

Tracking of cargo movement and monitoring of dangerous situations

Unmanned vehicle movement within port territory

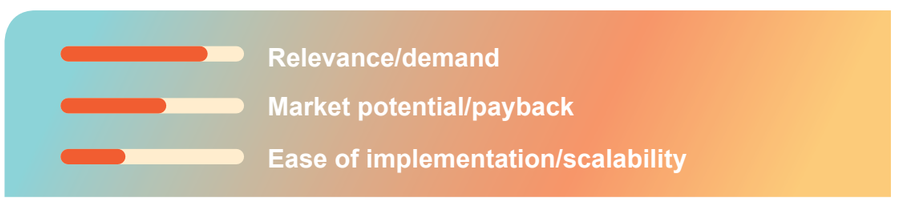
High speed radio data networks to support automation

* Quantitative estimates based on Huawei data.

5G-enabled unmanned trucks in the Port of Qingdao

Sample cases

The Port of Qingdao (China) jointly with Shanghai Zhenhua Heavy Industries Co. Ltd (a port equipment manufacturer), Ericsson. and China Unicom have launched a 5G-emabled pilot port automation project. The project provides for remote operation of cranes and unmanned aerial vehicles to track all container movements in real time based on HD video analytics. Tests have shown a reduction in port personnel expenses by up to 70%. The 5G-driven digital transformation of the Port of Livorno (Italy) is carried out jointly by the Italian Port Authority, the national inter-university consortium CNIT, Ericsson, and TIM (a mobile operator). Connection of cranes and ground loaders to a network and a 5G cloud platform has ensured their fully coordinated operation, including through automatic cargo recognition and tracking. To further speed up loading/unloading, and increase safety and accuracy, the project is planning to introduce further robotic processes based on 5G.



5.8.4 Smart airport

Air transportation is the fastest and most expensive type of transportation services, as it involves costly operation and maintenance of airliners, their takeoffs and landings, complex regulations for the organization of the movement of cargo, passengers, and luggage, border and customs control, multi-level security systems, as well as construction and maintenance of airport infrastructure. Minimizing service time, improving quality and safety, and reducing service costs across the board are the top priorities in air transportation.

The advantage of using 5G networks in air transportation consists in their wide coverage, versatility, and ease of interconnection between many different sophisticated systems. A smart airport automates the operation of all land and air transport management services, providing online supervision, monitoring, and control of aircraft and special equipment movements, robotized loading / unloading, and a range of passenger services such as self-service kiosks, electronic check-in, and navigation beacons on personal luggage. To increase comfort and security in airports with 5G it is easy to organize worldwide video surveillance and automatic analysis of video streams, identification, identification of abandoned luggage.

Existing and expected benefits:

- Streamlined flight schedule and reduced delays
- Increased airport throughput
- Reduced or no queuing at the check-in area
- Reduced number of luggage reclaim errors and mitigated risk of luggage loss
- Increased passenger satisfaction
- Improved security

Most popular platform services

Tracking airport personnel, cargo, and vehicles with connection to sensors and navigation systems. Optimization of the aircraft departure/landing schedule

Management of luggage movement, airfield traffic, and unmanned aerial vehicles, for maintenance and cleaning

Identification of passengers and abandoned luggage, predictive analysis of emergency situations at the airport

Movement of unmanned aerial vehicles at the airport

High-speed data radio networks for airport system automation

Sample cases

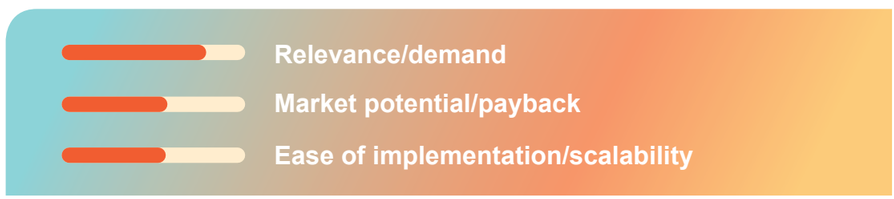
Helsinki Airport (Finland) together with Telia Finland and Nokia have deployed a dedicated 5G network and tested smart airport services. The airfield has in place smart video surveillance integrated with machine vision algorithms to ensure taxiing control and aircraft parking, track luggage trolleys and vehicles near the airport, and monitor the availability of parking spaces. Inside the airport there was a video analytics system integrated via 5G with mobile robots

In particular, the Tellu robot detected suspicious activity and forgotten luggage, and assisted passengers in finding departure terminals.

Passenger face recognition and AR headsets used at Daxing Airport

Huawei has introduced a 5G automation system operated by China Unicom at Beijing's newest and largest airport, Daxing. 5G integrates the airfield, multiple terminal devices in check-in and waiting areas with a network data center, integrating and aligning operations in different parts of the airport.

Based on virtual networking technology, the 5G architecture provides dedicated layers for different airport automation segments: operations, flight management, security, integrated and external airport service networks. The virtual isolation of all subnetworks ensure their complete information security.



5.9.

Public security

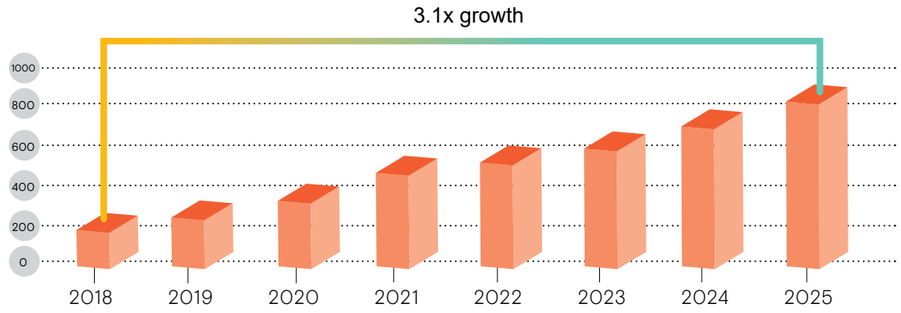
Safety of life, health, and property of people, preventing and countering violations of public order in everyday life, at mass public events, local or wider civil disturbances, in case of natural or man-made disasters, control and preparedness to repel terrorist acts in the new digital world are impossible without the use of the most modern ICT systems and solutions.

Therefore, the digital transformation of law enforcement and public safety consists in organizing 24/7 operation of emergency services using automatic systems for monitoring the public order and environment, incidents, forecasting the behavior of groups of people via digital models and algorithms, conducting automatic analysis of big data from intelligent video surveillance and various control security devices, as well as applying rapidly deployable data transmission and analytics networks in addressing irregular or emergency situations.

Narrowband, including digital, professional mobile radio networks, which were previously one of the main ICT tools used by law enforcement and emergency services, cannot support the implementation of the above functions. 5G capabilities are indispensable to fully implement the digital government's public security functions. In addition to new outstanding capabilities for field work to address security threats, 5G provides the highest level of information security.

Projections and estimates

Capacity of the market for IoT devices in the US retail industry, USD billion.



Marketsandmarkets, 2019

Key tasks to be addressed:

- Improved overall level of public security
- Forecasting of irregular or emergency situations
- Emergency public address systems
- Emergency management.

5.9.1. Mobile and rapidly deployable surveillance systems

The use of intelligent video surveillance systems with connected portable and mobile video cameras operating over a rapidly deployable private virtual 5G has proven highly effective at places where an emergency, social event or disturbance has been localized by law enforcement and emergency services.

Their organization requires:

- network systems and regulations for the rapid allocation of a segment of a public 5G network in the form of a virtual isolated high-speed private network used by special services for the transmission of data at places where an emergency or mass gathering has been localized
- portable special equipment with built-in video cameras, including for facial recognition and augmented reality solutions
- monitoring the movement of each officer and vehicle operating on-site
- transmission of real-time video data, data on the location, physical condition of any officer or special equipment during the operation to the situation center
- providing officers with additional information about surrounding objects and the overall situation by transmitting images to AR glasses/ headsets, especially in low visibility conditions.

Existing and expected benefits:

- Improved safety of emergency service officers
- Higher awareness and effectiveness of emergency services in case of emergencies or public events
- Minimized risk of casualties among the officers
- Reduced damage during rescue or special operations

Sample cases

Qwake Tech Inc (USA) has developed an augmented reality video monitoring system for firefighters. The first version of its C-Thru product captures and overlays silhouettes of people and objects onto augmented reality glasses in firefighter's helmets while the image is simultaneously transmitted to the firefighting control station. In the next version of the product, the developer together with Verizon (a 5G operator) will implement a cloud-based image distribution technology AR/VR-based routing for firefighting operations conducted at night and in highly dense smoke.

Qwake's AR-based indoor navigation system for firefighters

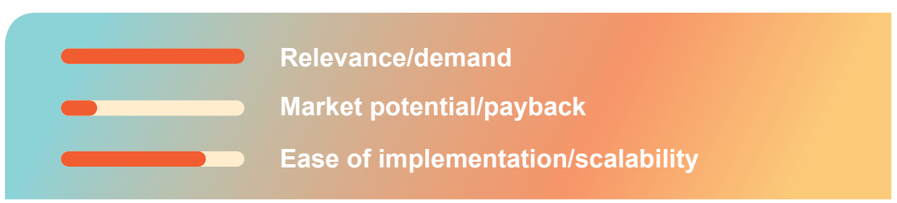
Most popular platform services

Monitoring public security using video surveillance based on rapidly deployable systems and special vehicles and portable cameras built into officers' equipment or cameras mounted on UAVs

Providing officers with portable augmented reality equipment for improved navigation Facial recognition and information display to detect, prevent, and solve crimes

High-speed data networks for the use by intelligence agencies, emergency organization of high-capacity virtual networks for data transmission to support intelligence operations

The Chinese police started testing AR/VR glasses with video transmission to a cloud for face recognition. While these cameras are still being tested, they are planned to be implemented everywhere as 5G evolves.



5.9.2. UAVs to secure public order

The use of UAV-based (particularly drone-based) CCTV systems for surveillance over large gatherings of people during mass events, local or wider civil disturbances is now widespread worldwide.

Their productive and effective operation requires:

- a quickly deployable high-speed private virtual 5G network
- 360° HD CCTV cameras
- collecting ongoing data on the number of people and congestion of urban facilities
- a forecast of urban occupancy based on existing data
- face recognition to identify dangerous or wanted people
- collection and analysis of data on the movement and behaviour of people and groups in masses in order to predict provocations, illegal activities, or the likelihood of civil disturbances
- monitoring of the location, movement, and actions of intelligence officers

- informing citizens about obstacles and optimal routes to choose based on existing and forecast data
- a public address system to inform people about dangers, measures taken, possible street closures or transport interruptions

Existing and expected benefits:

- Improved public safety
- Convenient routes and logistics organized for people
- Prevention of local or wider civil disturbances
- Responding to riots without negative implications for public infrastructure, health, or assets.

A police drone for aerial surveillance

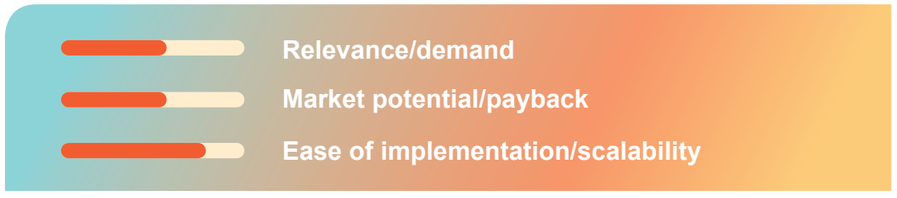
Most popular platform services

UAV-based video monitoring, face and threat recognition, crowd behavior analysis

High-speed data networks, system for emergency organization of local virtual networks with increased data speeds for the use by special services

Sample cases

Kiana Analytics (USA) with 5G operator Verizon is developing behavioral analytics systems for public security services, maintenance organizations and facility owners in crowded and large areas. The technology helps them make informed decisions when planning and holding major events and respond quickly in emergencies. Kiana Analytics's solutions enable using wireless communication and drone-based surveillance cameras to identify people and track their movements in real time. Kiana Analytics offers different public security solutions for airports, exhibition centers, hypermarkets, student campuses, major parks, and entertainment centers, including integration into smart city systems.



5.9.3 Monitoring and emergency alerts

The use of detectors and sensors, analytical systems to control and monitor the environment, environmental parameters, collect and analyze data from security systems enables predicting and preventing the negative implications of natural and man-made disasters.

Build a modern emergency response system requires:

- installing digital sensors at facilities to monitor environmental parameters such as temperature, humidity, seismic parameters, noise level, chemical and radioactive air, water or soil pollution, water and soil
- data collection and analysis, forecasting of critical changes in parameters; control and prompt response to sudden changes in readings, prompt notification of special services and the population in the area of a potential emergency

Sensors and detectors are connected via 5G LTE-M and NB-IoT radio interfaces, while the cloud infrastructure in the 5G core provides data collection, storage, and processing. Digital models of environment and facilities based on online processing of data from sensors enables clear and distinctly visualization of emergency risks within specific monitoring areas, as well as predicting catastrophic changes and providing prompt response.

An example of NB-IoT-based vibration sensors installed on a bridge by Arbor Technology to monitor its integrity

Most popular platform services

Collecting environmental data from all systems within a single center Emergency decision making systems based on actual real-time data A shared cloud service platform for government agencies and special services

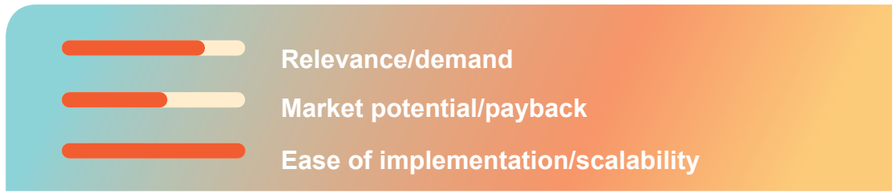
Existing and expected benefits:

- Improved preparedness for emergency prevention and response
- Improved public safety
- Reduced losses during emergency response

Sample cases

Arbor Technology (Taiwan) offers an integrated environmental monitoring solution, which includes sensors with a NB-IoT radio interface and a cloud platform using online anomaly and disturbance detection algorithms. The service is also available via a mobile application. The platform monitors temperature, air quality, noise, vibrations, seismic activity, ground movement, and building integrity.

An environmental monitoring service was launched in 2019 by MegaFon, a Russian mobile provider. The operator's platform processes data on emissions from enterprises, analyses information from multiple sensors and transmits it to the operational monitoring center. The project is piloted in 12 Russian cities with poor environmental conditions, including Magnitogorsk, Norilsk, Chelyabinsk, and Cherepovets.



5.9.4 Drone-mounted base stations

UAV-mounted base stations can be used to organize high-speed local data transmission networks across many industries.

Natural or man-made disasters can completely destroy or damage the communication infrastructure to such an extent that it will not be fit even for use by special or emergency services. Earthquakes and floods cause significant damage to transportation routes, preventing delivery of necessary communication equipment to the emergency location by road or rail. A network of high-speed data transmission in such emergencies can now be quickly deployed using remotely or automatically piloted drone-mounted base stations deployed above the area.

The use of drones to organize a data transmission network in emergencies has many advantages, as they operate within the users' line of sight, increasing the speed of data transmission, network capacity, and reliability of connection.

Another application of UAV-mounted base stations includes the ability to promptly organize additional provisional network capacity during mass events. A UAV-mounted base station can serve as a segment of an existing network or a separate local data network used exclusively by public security services, without creating any excessive burden for the overloaded public network.

Existing and expected benefits:

- Improved public security and emergency localization
- Prompt organization of communications in case of destroyed network infrastructure
- Prompt organization of a network near damaged road infrastructure
- Organization of a data transmission network in hard-to-access areas
- Prompt creation of an additional network or an extension of an existing network

Sample cases

With the transition of the UK public security services to public LTE-networks for special services with high-speed data transmission, EE (a UK operator) and Nokia developed and tested drone-mounted base station for the deployment of a communication network in emergency areas. Their tests in Scotland have shown a high operational effect of deploying networks in particularly difficult areas and confirmed the possibility of creating a cell with a radius of up to 50 km using one drone.

AT&T (USA) has developed and tested a variant of a mobile base station mounted on a rotary wing drone being as part of a motorized emergency system to replace telecom towers in emergency areas. The drone flying at an altitude of 150–200 meters is supplied with power via a cable from a vehicle-based generator to ensure its round-the-clock operation in the air. Tests in the area affected by a hurricane in Puerto Rico have proved that the solution can rapidly provide coverage of tens of square kilometres in an emergency.

Similarly, KT operator (South Korea) is developing a special UAV to deploy 5G segments for emergency services. In South Korea, special services have already switched to 4G and are planning to switch to 5G. UAVs will serve as a base station of a communication network and a command center for other unmanned equipment involved in operations.

Back in 2017, Baicells (USA) and China Unicom installed a portable base station on a drone to deploy an additional segment of a mobile network. Such technical solutions are also planned to be used in emergency rescue operations after earthquakes, tsunamis, or other natural disasters.

The partners use the UAV with a portable base station to organize search and rescue operations for victims isolated in inaccessible places providing them with an opportunity to connect their phones to the drone network to identify their location and contact the rescue team.

Most popular platform services

Automatic coordination of UAV-mounted base stations, creation of high-speed lines in 5G

High-speed data networks for emergency services, rapid deployment of virtual networks to support them

Drone with a 5G base station of KT

Relevance/demand

Market potential/payback

Ease of implementation/scalability

5.10.

Culture and leisure

Digital technology is making cultural, leisure and tourism entertainment services much more accessible for millions of people. The widespread adoption of 4G has shown that the segment is the most receptive to the implementation of new digital network services, quickly leading to the adoption and consolidation of new ways of consuming entertainment content. 5G and new audiovisual technologies based on it promise a rapid development of this trend.

In most cases people are already searching for interesting cultural events, leisure activities, entertainment and educational programs using online services. The next step is to expand the range of capabilities to provide cultural and leisure services based on 5G platform solutions.

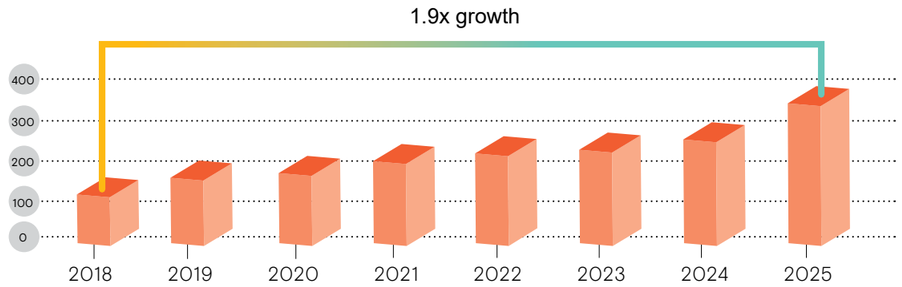
Russia is actively creating a single electronic knowledge base from digitized books, archives and museum collections. Many paid and free cultural and educational services are already available online. Supplementing and developing them with high-quality AR/VR images will radically improve the quality of remote service consumption.

In order to develop virtual tours of museums and historical places in Russia, we are developing a simple, user-friendly, and exciting AR/VR-based format of presentation for all remote online users. It is 5G that will ensure the transition to high-quality 360° video, an AR/VR-enabled environment with an immersive effect for all users, including mobile users.

Augmented reality applications for travelers help expand the inflow of guests to all Russian regions and contribute to the development of international tourism. With the widespread distribution of 5G, the development of AR/VR applications will be accelerated: with their help it will become easier to plan trips, book tickets, book hotels, or navigate in an unfamiliar place. An automatic guide will tell you about any attraction, you just need to simply direct your AR headset or smartphone at it. AR/VR technologies will be widely used for watching sports events, especially live broadcasts. There is a strong potential for creating smart stadiums, which will enable following the course of the game in detail, from different angles, with text and audio comments, and any information about games, teams, or players.

Projections and estimates

Estimated revenue of the global media market, USD billion



How 5G will transform the business of media & entertainment
Ovum, 2018

Key tasks to be addressed:

- Ensuring access to high quality legal media products, including Russian
- Increasing availability of cloud media products and entertainment services
- Expanding the audience that prefers digital content
- Developing new domestic and foreign travelling destinations
- Developing the infrastructure for cultural institutions
- Implementing smart systems for accounting and analysis of visits and ticket sales

5.10.1. Cloud based gaming

In the internet industry, computer entertainment is growing faster than other segments, reaching people of all ages and social groups, primarily with the spread of mobile gaming platforms. The main obstacle to the growth of gaming and emergence of new advanced mobile games, including AR/VR-enabled, is the cost of end devices, whether they are flagship smartphones, game consoles, or powerful gaming computers.

Experts predict the rapid growth of cloud gaming, eliminating the need to buy expensive equipment, as all gaming programs and calculations are performed on a remote server. That is, the computational load from the local device is transferred to the cloud. Computer images (rendering) of the game image takes place in a powerful data center and are sent to the user via a high-speed video stream, while the game itself with high-quality realistic 3D images and the AR/VR-enabled immersive effect runs on a local device – a desktop computer, tablet, or smartphone using a thin client model.

However, cloud gaming has not yet become widespread, primarily because the necessary quality of the link between the data center and the user device in terms of data transfer rate and latency has been unattainable in existing mobile networks. The new high requirements of cloud gaming for communication channels and information infrastructure will be met by 5G in the near future.

5G network operators will be key partners for gaming platforms in this segment of the gaming industry. According to forecasts, during the first years of widespread implementation of 5G, while many other, including industrial, digital services and systems will not yet be dominant in the economy, the share of cloud gambling traffic will reach 25%–50% of 5G traffic.

Existing and expected benefits:

- Access to high quality online games from all gadgets and smartphones - Reduced user spend on expensive equipment
- Growth of the legal gaming market, reduction in pirate consumption
- Increased coverage thanks to cloud neutrality and a cross-platform model
- High profitability and fast 5G monetization

Most popular platform services

Delivery of content to user devices and digital signage

Transferring content processing to remote servers, with games running on inexpensive devices with poor computing capacity

Effective content transmission and generation, feedback from AR/VR devices in interactive educational and entertainment applications Synchronization of multi-user AR/VR applications

Ability to run desktop games on a smartphone based on a cloud service by LiquidSky

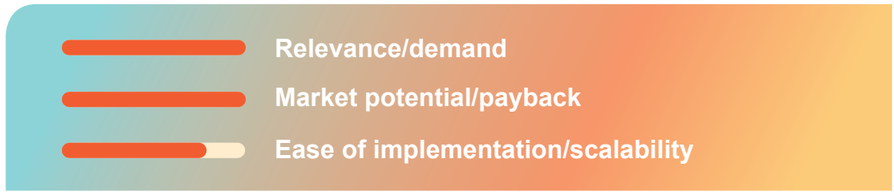
Sample cases

With the massive launch of 5G, technology giant Tencent (China) in partnership with vendors Huawei and Qualcomm is launching its own 5G-enabled cloud gaming platform. At the same time, ahead of the launch of a competing platform by of Alibaba Group, 5G China Unicom and China Mobile are working on their own cloud-based gaming infrastructure. According to a number of analytical agencies, there will be 600 million cloud gamers in China by 2023.

Microsoft Corporation (USA) is working on the creation of cloud gaming service, Project xCloud. Developers from Microsoft Research achieve minimal latency by applying innovations in network topologies, video encoding, and decoding. The service will be able to work with streaming games already in 4G, expanding the capabilities in 5G as their application expands around the world. Project xCloud works through 54 Microsoft Azure cloud data centers located in 140 countries. The full-scale launch of xCloud is scheduled for 2020. So far, the project's test speed has reached 10 Mbps, and only 5G will enable reducing the latency and increasing the game speed on smartphones.

Cloud gaming provider LiquidSky (USA) is launching its latest games for Windows with Full HD video streaming, 120 FPS and ultra low latency over 5G networks of Verizon. The partners are experimenting with streaming games on mobile devices, reaching an image speed of 100 frames per second. LiquidSky has raised about USD 16 million for the project.

Russia's first and largest cloud gaming service Playkey supports gaming on low-capacity computers using channels with bandwidths starting from 10 Mbps. Players from 15 countries use this cloud gaming platform. By early 2020, the Playkey database had about 100,000 active players per month. The company has partnership agreements with 15 leading game publishers, including Ubisoft, Bandai, and Wargaming. In 2017, IIDF invested USD 2.8 million in Playkey.



5.10.2. Guides and travel services with AR/VR

There are many online applications that combine electronic maps with booking services, booking tours, and guidebooks. Most services are used for travel planning.

While creating realistic images of any object, augmented and virtual reality (AR/VR) provide valuable visual information about new places and surrounding attractions in an easily accessible and quick way – right on the spot. With AR/VR applications, tourists feel more comfortable abroad, easily getting access to transport schedules and routes, information about local prices and special offers of local institutions, as well as about popular destinations, all in real time. Combined with machine translation systems, they enable people to easily overcome the language barrier in communication or read in an unknown language by simply pointing a camera at the text.

In many museums around the world and at exhibitions, AR technology has greatly expanded the capabilities of electronic guides, presenting exhibits and any information in a more vivid and impressive way. For example, artifacts that have been partially lost or completely destroyed can be viewed in their original form using AR projection.

The transition from the previous slow video projections from a smartphone to a realistic environment in AR/VR glasses turns every visit to a museum into an exciting adventure. However, the new AR/VR quality requires a huge increase in the volume of images, low latency in their processing and transmission, i.e. It requires 5G. The cooperation between 5G operators and city authorities, travel agencies, services, museums, and exhibition halls will allow application developers to create new cultural and entertainment services without the previous restrictions and within a shared technology environment.

Existing and expected benefits:*

- Increase in the tourist inflow to Russian regions by up to 30%
- Higher attractiveness of Russian cities for international tourists
- Increase in visitors' mobility and tourist footfall
- Quick and easy access to tourist information
- Analysis of site visits to identify the target audience
- Reducing staff costs for tour operators and local institutions

Most popular platform services

Content transmission and generation, feedback from AR/VR devices in interactive applications for educational and entertainment services. Synchronization of multi-user AR/VR applications

Sample cases

The Hubei City Museum is the first museum in China, whose exhibits have been fully converted to AR/VR objects. The project was implemented jointly by Huawei and China Mobile, which provided 5G museum coverage and connection to the AR/VR cloud platform.

* Quantitative estimates based on Piligrim XXI data.

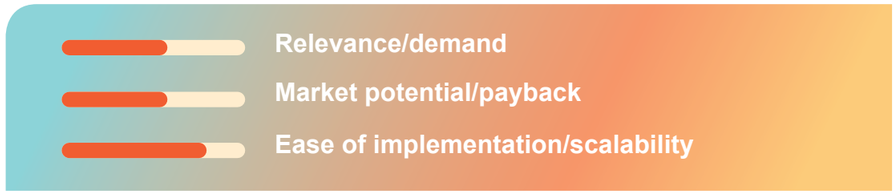
Use of AR images for historical reconstruction of architectural complexes based on a solution by Piligrim XXI

Every object of the Hubei Panopticum can now be viewed on your smartphone in a complete historical interactive AR/VR environment. Visitors can try on costumes from different eras using a 5G-enabled smart holographic mirror of the museum. The experience of the provincial museum is now rolled out to one of China's main attractions, the Forbidden City.

To increase the competitiveness of the UK tourism industry, 5G with AR/VR applications has been tested with the support of the UK government. The pilot project of virtual interactive tours features animated AR tours of Roman baths in the vicinity of Bristol in different eras.

Nimest Tech (Portugal) has presented electronic guides enabled by augmented reality, artificial intelligence algorithms, and geolocation technologies. You can use your smartphone to see 3D images of Portuguese kings and poets and hear stories from participants of historical events live. The platform is developed bearing 5G opportunities in mind to increase the library of 3D models, transfer information processing to the cloud with a transition from static AR/VR world to dynamic models. Nimest Tech plans to expand the capabilities of the platform by creating tools to record the experience of AR/VR-enabled immersion into historical events, and to share them online.

Startup Piligrim XXI (Russia) is developing AR/VR tours of historic parks via smartphones, enables the users to see the sights at their historical heyday. Classic tours supplemented with AR visualization show a ten percent increase in park attendance. Eight Piligrim XXI augmented reality parks have already been launched: three in Russia and five in EU countries (Latvia, Bulgaria, Italy, France, and Estonia). The project is still using pre-installation of applications, with plans to switch to 5G.



5.10.3. Smart stadiums and broadcasts

Progress in video processing, increased bandwidth of communication channels, availability of 4K/8K TVs with large diagonals, and 360° video VR helmets have significantly improved the quality of broadcasts of sports and other entertainment events, and ensured the immersive effect outside stadiums and concert halls. So far, such broadcasts are only possible via wired and satellite channels, but with the advent of 5G they will also be available over mobile networks. A real revolution will take place in sports content broadcasting.

The technological advances encourage event organizers to open large-scale access to new content for visitors and remote participants of shows. The former will get a realistic AR/VR immersive effect, the latter will be offered fuller and higher quality additional content that is not available to TV viewers.

The Smart Stadium concept involves the transfer of all media content about the competition or show to 5G-enabled smartphones of visitors via a user-friendly application with minimal latency. HD video content is delivered to fans' gadgets via a high-speed 5G private network, specifically dedicated to the stadium. Integration of 5G with local data centers at or near the stadium enables processing video streams and packaging them into the application format on-site. This eliminates latency and disalignment with the event's timing, minimizing the need for additional broadband transport links.

Thanks to 5G, the viewer can use even an inexpensive smartphone to access streams from all video cameras, connect to any of them, even those installed on the player's clothes, move around the stadium, or watch the game from anywhere. Using an augmented reality application, the viewer can access to the game's current statistics, see replays of any selected moment, get additional explanations from commentators, or infographics from previous competitions. AR/VR services help the visitor to quickly find a convenient place to park, a seat, or the nearest entrances and exits from the stadium.

5G enables tracking visitors' consumption patterns to find out the real popularity of seats in the stands, increase the sensitivity and efficiency of security systems, and remotely manage the infrastructure of the stadiums.

Experts predict that AR/VR content in smart stadiums will first be fully available only to visitors during the events. With the development of 5G and the expansion of backbone channels, exclusive video services will also be offered live by operators through 5G premium subscriptions.

Existing and expected benefits:*

- Increase in the number of attracted advertisers by 200% - Increase in advertising and sponsorship revenues by 300%
- Increased interest in attending events and activities
- Quick and comfortable access to services and information at stadiums
- Collection of statistics on viewers, performances and interactions
- Increase in security, optimization of event management
- Emergence of new broadcast formats and immersive effects
- Increased demand for and profitability of live broadcast content

Most popular platform services

Delivery of content to user devices and digital signage

AR/VR content for viewers on the stands: match statistics, data on athletes

Stadium system management based on information from sensors

* Quantitative estimates based on CROC data.

SHUTTERSTOCK/FOTODOM

Access to streams from any camera to the smartphones of visitors present at the stadium

Sample cases

The Sacramento basketball team partnered with Verizon to upgrade their Golden 1 Center by installing a large number of 360° cameras to broadcast games via AR/VR headsets. So far, the service is only available to visitors of the basketball arena, but the partners are planning to launch AR/VR shows of games for Verizon 5G subscribers. Similarly, there are many 360° cameras at the Camp Nou stadium in Barcelona (Spain) for broadcasting via AR/VR headsets. The participating Telefonica operator is planning to broadcast streams from all cameras not only at the stadium, but also in the nearest cafes, restaurants, and fan zones, complementing the friendly meetings with the immersive effect of the game.

The integrator CROC (Russia) has designed, assembled, and configured the ICT infrastructure of FC Krasnodar's stadium in Krasnodar. The project has achieved 100% coverage of the stadium with high-speed High Density (HD) Wi-Fi, simultaneously connecting 12.5 thousand spectators to the internet. 1,000 CCTV cameras have been installed to cover the pitch, the stadium's interiors and surrounding areas, which can be used for face recognition. IP-TV systems and technology for centralized management of the Digital Signage screen network are broadcasting the game and advertising messages on 300 digital screens of the stadium. The mobile application of the football club shows the best moments of the matches online, enables commenting on the game, viewing the lineup and positioning of players, participate in competitions, and get access to news and special notifications.

5.11.

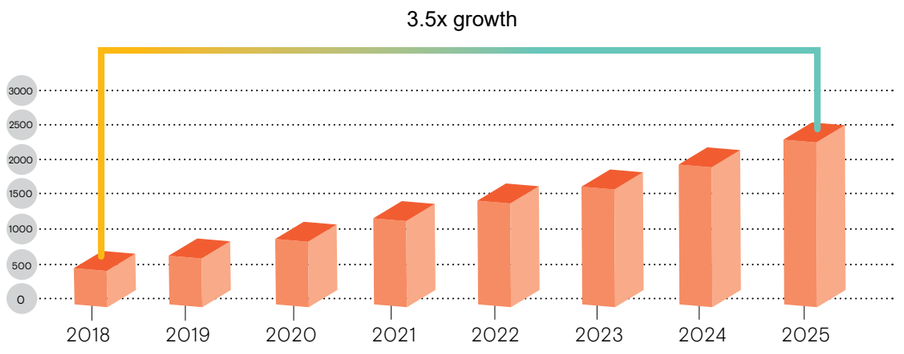
Municipal services

The digital transformation of municipal services under the smart city concept implies the implementation of a set of technical solutions and organizational measures to quickly achieve a new level of quality of urban services and resource management, create sustainable favorable conditions for living and working in a metropolis, and increase its competitiveness. The concept is based on the following key principles: focus on human needs; flexible urban infrastructure; better quality of urban resource management; safe and friendly environment; cost effectiveness.

Building a smart city requires a distributed infrastructure of sensors, video monitoring, transport control and safety solutions, and interactive interaction with residents. The most efficient and cost-effective way to create and maintain ICT infrastructure addressing a huge range of diverse tasks is to deploy 5G networks in cities. Moving urban services to the cloud network infrastructure, as well as the flexibility and capacity of 5G channels enable municipal authorities to focus on the development and debugging of applications without large initial investments in infrastructure.

Projections and estimates

Estimated capacity of the global market for smart city systems, USD billion



Marketsandmarkets, 2019

Key tasks to be addressed:

- Sustainable improvement in the quality of life of the residents
- Improving the quality of urban services
- Improving the efficiency of urban management
- Saving resources through streamlining urban services

5.11.1. Road traffic management and road safety

Road traffic safety in a smart city is increased through the implementation of an intelligent self-adjustable transport system featuring continuous automatic monitoring of all road infrastructure and management of all public and personal traffic. Its overall operation is based on data collection and processing supported by a number of automated systems.

The Intelligent Transportation System (ITS) of the city analyses all traffic routes and assesses the level of congestion in the transportation network for traffic optimization. Collection of data on traffic congestion and video analytics can be fully implemented only through 5G.

For example, a special radio interface C-V2X for 5G networks supports the communication between traffic lights and vehicles and pedestrians in Smart Traffic Lights, an automated traffic control system depending on the increase/decrease in traffic congestion.

Vehicles equipped with autopilots and/or active safety systems are designed to reduce the number of accident victims by eliminating certain human factor accidents. The key component of the solution is the C-V2X 5G radio interface that supports the communication between cars and notifications from road infrastructure.

The Parking Space Management System, which helps quickly find parking spaces to reduce fuel consumption and emissions in real time, provides online information on the availability of parking spaces in public parking lots and informs about their operating time and payment terms.

Combining all these elements via 5G radio interfaces will create a single information space for interaction between authorities, car owners and pedestrians, connecting all city resources and infrastructure as efficiently as possible.

Existing or expected benefits:*

- Higher safety of drivers and pedestrians
- 90% reduction in traffic accidents
- Reduced utilization of transport infrastructure, reduced congestion
- Informing road users about the current traffic situation, and optimal private and public transport routes
- Uninterrupted movement of urban land passenger transport
- Movement of emergency services transport prioritized in real time.

Most popular platform services

Collecting information on the condition of road infrastructure, traffic tracking

Road traffic management, improvements to road safety

* Quantitative estimates based on data from Spiegel Online.

SHUTTERSTOCK/FOTODOM

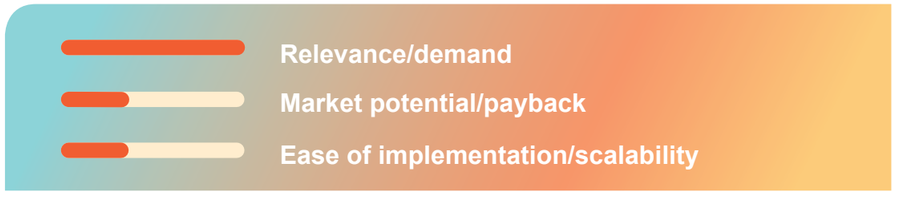
C-V2X used to transmit the switch time from a smart traffic light to cars

Sample cases

Chinese authorities, China Mobile (operator) and Huawei (vendor) are implementing the largest urban 5G project in Wuxi (China). Over the next few years, the project is to become a testing ground for developing future models for managing urban traffic via a C-V2X radio interface to be further rolled out to other cities and highways. The system is based on 5G fully covering 170 square kilometres of the city's area, and includes 400 junctions equipped with intelligent sensors and traffic lights controlled from a common cloud platform.

Continental, an automotive systems manufacturer, together with Ericsson, Nissan, NTT DoCoMo, OKI, and Qualcomm Technologies, has successfully tested the Cellular V2X technology in Japan. The partners tested vehicle-to-vehicle (V2V), vehicle-to-infrastructure

(V2I), and vehicle-to-pedestrian (V2P) communication over 5G. 5G was used to provide the communication between the vehicles and the V2N network to deliver cloud services such as traffic forecasting and situation prediction. To assess the performance of the C-V2X radio interface, the systems were tested in different road conditions at speeds up to 110 km/h.



5.11.2. Unmanned and remotely operated urban equipment

Autonomous operation of municipal, road, or any special equipment with integration into the intelligent transport system of the city is based on the collection and online processing of data on real road processes for automated optimal accident-free management. Unmanned municipal equipment is required for a large number of similar operations supervised by an operator with an option to rapidly switch to remote manual control in emergency situations. Remote control of municipal equipment is carried out via a two-way wireless radio channel between the operator and control mechanisms based on ongoing information about the operations submitted by built-in CCTV cameras. Fixed intelligent video monitoring systems assess the scope of work, such as cleaning or removal.

Remote monitoring of the fill-level of public trash bins using radio sensors is one of the ways to improve the collection, removal, and disposal of waste. Using 5G-enabled facilities and unmanned cleaning equipment will increase the accuracy of task setting, and improve and accelerate the ongoing communication between public services in general.

Implementing this scenario requires:

- special equipment with built-in integration and video surveillance systems, and active safety, technical condition and security sensors
- data transmission systems and HD video streams for 5G-enabled control
- integration of special equipment into the municipal ITS.

Existing and expected benefits:

- Improved efficiency of municipal equipment
- Monitoring of tasks, scope of work, parameters, and routes
- Reduced labour and fuel costs
- Reduced solid waste disposal costs

Most popular platform services

Unmanned equipment for routine daily tasks of the utility services

Remote management of municipal equipment, real-time supervision of performance

Collection of information on the condition of municipal infrastructure, tracking the work carried out by municipal services: cleaning up, garbage and snow removal, repair of lighting systems

Supervision of remotely operated and autopiloted municipal vehicles on public roads

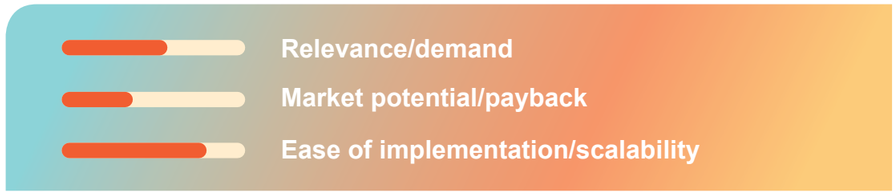
An automated snow cleaner from Left Hand Robotics

Sample cases

In December 2019, a RT-1000-based unmanned snow cleaner by Left Hand Robotics (USA) was used for the first time to remove snow from a 7-kilometer walking path around the Bear Creek Reservoir in Canada. Left Hand Robotics's equipment is highly versatile: the robot can be used to remove snow, treat roads and sidewalks with sand and chemicals, sweep the streets, or cut grass. The machine runs on gas and uses GPS, radar and panoramic cameras. The robot avoids collisions with obstacles following a programmed route. Between 2018 and 2019, Left Hand Robotics raised about USD 7.2 million for the RT-1000 project.

The municipal unmanned aerial vehicle control system by AutowiseAI (China) uses optical sensors (lidars), radars, and cameras. In 2018, AutowiseAI started cleaning streets in the Shanghai Industrial Park in a test mode.

Since 2019, it has been working in Shanghai, Beijing, Xiamen, and Hangzhou. AutowiseAI vehicles distinguish traffic light signals, road signs and markings; detect vehicles, bicycles, and pedestrians, giving way to them, bypass all obstacles; follow their lane, safely pass intersections, use emergency brakes, pull over, start operating at a certain time leaving the garage on their own, independently regulating the force of the brushes and dumping the collected garbage.



5.11.3. Lighting, climate, access to infrastructure facilities

Systems that control outdoor lighting networks monitor their condition, organize energy metering and equipment diagnostics to optimize energy consumption based on real data from sensors within a single transmission environment.

Controlled lighting sources are optimized and adapted for on/off operation in any part of the city, contributing to overall energy efficiency. Remotely and automatically controlled lighting also enhances urban safety: any power failure or underlit area of the street will be immediately tracked and localized, with inspection and repair jobs immediately assigned to deal with the situation. Monitoring data on real energy consumption at the lighting location is fed into an intelligent management system and used to adjust energy consumption. To optimise energy consumption within the management system, light sensors are installed to minimize

electricity consumption during daylight. Sensors are connected and integrated by the lighting management system over 5G networks. In addition, 5G provides a cloud-based lighting automation infrastructure. Lighting management can be extended and integrated into the overall building management system with integrated automation and remote control functions, and smart appliances, applications and services.

The same tasks can be performed via a 5G infrastructure without building a dedicated municipal system. This reduces costs and simplifies scaling-up to other areas and cities.

5G can be used within a single management environment to:

- monitor and adjust air quality and humidity, temperature, lighting, and noise levels
- control ventilation, heating and air conditioning, water and power supply, sewerage and fire safety systems, ICT infrastructure, monitor their serviceability, control elevator facilities, as well as building access management systems and adjacent areas using face and license plate recognition functions.
- report about emergency situations to the emergency services of the managing organization or to special services.

Existing or expected benefits:*

- Power consumption reduced by 40%
- Water consumption reduced by 30%
- Maintenance costs in smart buildings reduced by 10%–30%
- Optimized outdoor lighting
- Faster detection of and response to lighting network failures
- Reduced expenses for field repairs

* Quantitative estimates based on data from the portal of the Smart City Urban Development Agency

Most popular platform services

Collecting information on the condition of municipal infrastructure and smart buildings

Creation of digital building twins to optimize heat exchange and lighting, and save resources

Smart building remote control

Sample cases

The cloud solution of Twilight (Netherlands) is designed to control all lighting systems within a city or building via a single platform. Its software product includes a control interface for visualization and adjustment of lighting. Twilight uses a 2.4 GHz mesh-network or NB-IoT connection. The solution provides integration with products from different lighting system suppliers and interfaces for integration into a common management environment for all urban services. The cloud solution of InteliLight (Romania) also provides street lighting control supported by connected sensors and actuators installed on street lighting facilities over various radio interfaces, such as NB-IoT, as well as lighting network visualization, lighting level monitoring, and automatic on-and-off control. The platform also uses algorithms for energy consumption analysis and optimization and interfaces for its integration into urban infrastructure management systems.

IBM Intelligent Building Management (USA) is an integrated software suite for smart buildings, which combines online facility monitoring functions and an event management system. Its functionality includes data collection from all sensors, optimization based on centralized analytics, and distributed resource management. The enterprise-class solution is designed to help owners and managing companies analyze and reduce operating

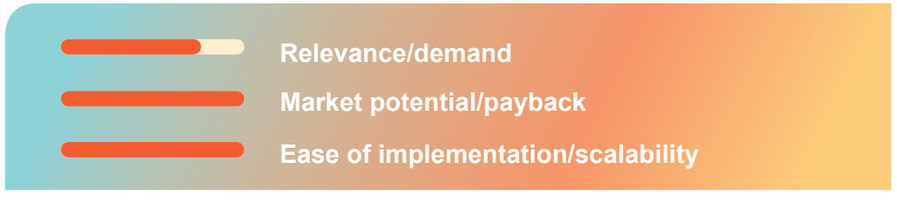
SHUTTERSTOCK/FOTODOM

Illustration of wireless lighting connectivity using NB-IoT

expenses and power consumption, and improve overall resource management, reliability, and stability of utility services.

The cloud-based automated lighting control system Helios (Russia) using the Helios solution of the Institute of the Institute of High Technologies of Belgorod State University is deployed in 26 Russian regions.

Its implementation has reduced energy consumption and reliance on third-party energy supplies, provided flexible lighting, remote control, planning and analysis of energy consumption, increased the quality of supervision via in a single control center, and enabled the prediction of energy consumption.



5.11.4. Digital signage and public feedback systems

Modern ICT public address and feedback services often simultaneously provide e-government services and support civic engagement tools. Interactive digital signage encourages people to personally participate in urban development (via crowdsourcing, electronic voting on public decisions, and awareness raising).

Social networks have become an important channel of communication between the administration and city residents: they enable direct access to large groups of people poorly covered by other channels, as well as high-quality feedback. But such communications do not provide local targeted engagement with people. A new format of feedback to a city's administration from its residents includes digital signage or digital displays installed at public transport stops and public transport cabins, or built into stationary kiosks near particularly intensive pedestrian traffic routes. Digital signage are systems for creating and broadcasting local media content, which typically include data collection, storage and processing equipment, switchboards and communication lines, special software, and interactive screens.

By connecting a digital media platform to digital signage, the authorities provide residents with access to information about official events, cultural and sporting events, as well as the opportunity to leave feedback and suggestions for the administration.

Placing digital signage everywhere in the city, delivering unique, vibrant and meaningful content, and especially organizing interactive communication require flexibility and powerful computing resources and, accordingly, the use of 5G and cloud services based on thin clients, which are easy to create in data centers integrated into the core 5G network.

Urban digital signage by Soofa

Existing and expected benefits:

- Public awareness of urban services and activities
- Increased social involvement in the management of urban development
- Improvements to the quality of urban services.

Most popular platform services

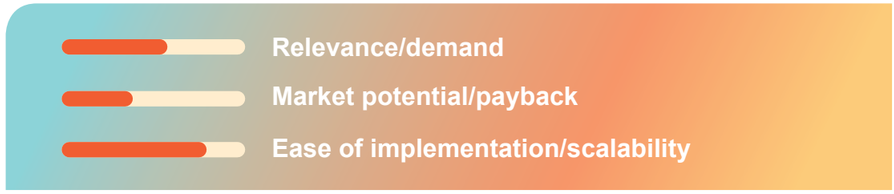
Reception and accumulation of video streams from digital signage for on-site user recognition and video monitoring

Interactive feedback and access to urban services

Sample cases

In 2019, Boston's Mayor's Office of New Urban Mechanics connected the digital media platform of Soofa Signs (USA) to interactive screens. They enable citizens to provide feedback and suggestions to city officials, read and view local news, promoting an image of a smart city among visitors.

SpinetiX (Switzerland) has provided the interactive screens, including content creation widgets and media players for Dubai's city media panel system. They broadcast information and advertisements for citizens on events and services, such as entertainment highlights, nearby bicycle and car-sharing stations, and on public transport movements. Digital signage solutions installed on interactive kiosks conduct weekly polls to get people's opinions and suggestions about how to improve urban life and then display poll results and decisions taken by the authorities.



[6.]

Results of sectoral use analysis

The use of 5G platform services enables simplifying and automating many processes across almost all industries. Even when modern wired technologies or other wireless solutions can be used to optimize the operations of enterprises and organizations, the transition to 5G provides a much simpler and easier scale-up and rollout of solutions, faster exchange of experience with new enterprises, and a noticeable reduction in the cost of initial investment in infrastructure.

The list of 5G scenarios in this review is not exhaustive. It only illustrates the main trends in technology and services, indicating the short term outlooks. Our sample enables us to estimate the scope of applications of a specific platform service, its potential and relevant demand for various industry-specific applications.

Fig. 5 shows an estimate of demand for platform services based on the 33 use scenarios analyzed in the review. Use scenarios for platform services the same industry significantly vary by application. A number of use scenarios are in high demand due to their short payback periods and scalability. Many of mature related technologies have passed or are on their way to the commercialization phase. However, sometimes even when there is high demand, the payback period is long and scalability is low, as in the case of smart factories. Implementations in such cases are generally rare, but each implementation is a large-scale project. In order to gain a deeper and more detailed understanding of each scenario, they have been peer reviewed by peer experts. The peer reviews are summarized in Table 1.

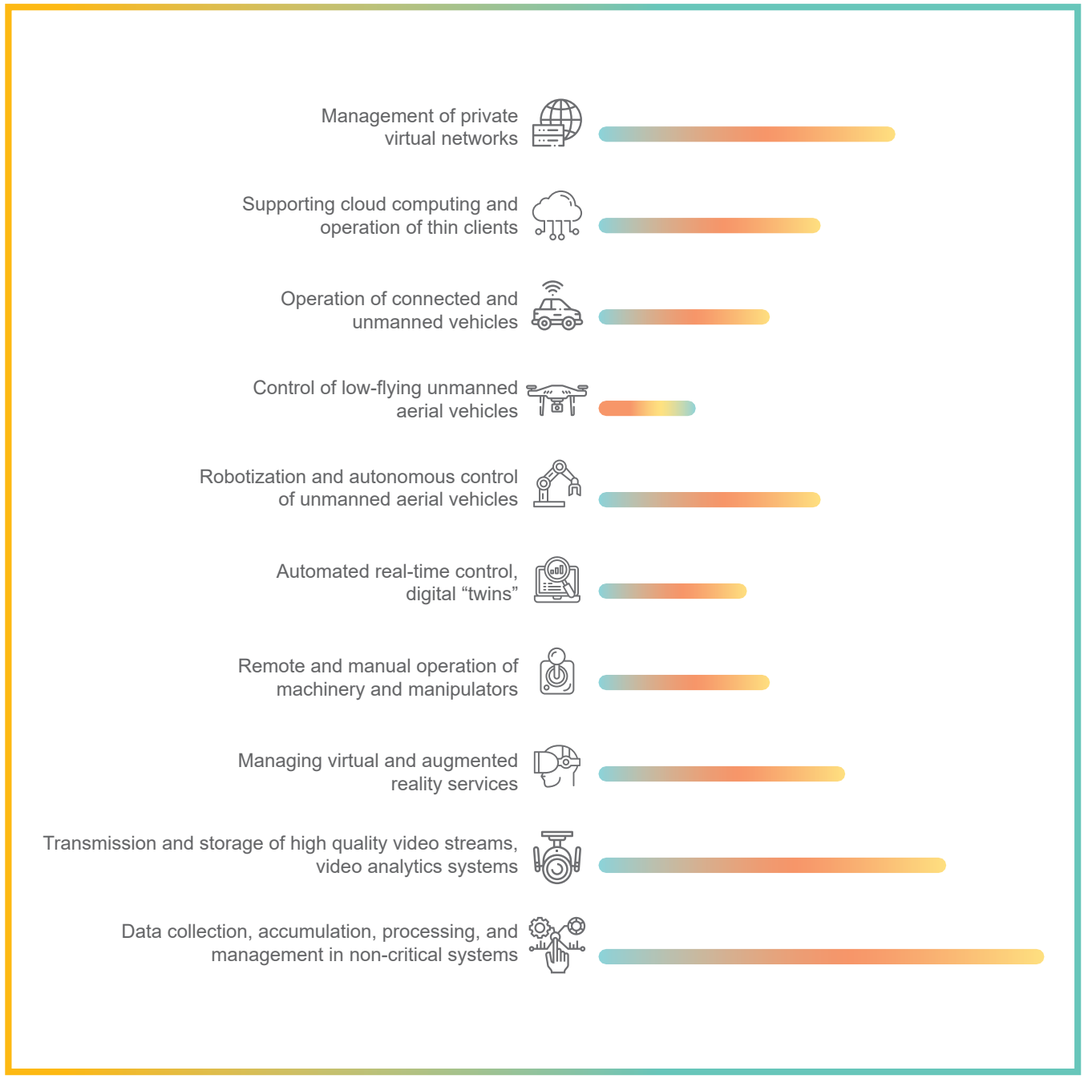


Fig. 6.1 Review of platform services use in the scenarios analyzed

Table 1. Expert review of the potential of the scenarios analyzed

Sector	Use case	Relevance/demand	Market potential/pay-back	Ease of implementation/ scalability	Medium
Agriculture	Smart field	3	3	4	3.3
	Smart farm	4	4	4	4.0
Industry	AR for production and repair work	4	5	2	3.7
	Production and predictive repair sensors	4	5	3	4.0
	Smart factory	4	4	1	3.0
Healthcare	Remote monitoring and health diagnostics	4	3	4	3.7
	AR/VR for diagnostics and surgical operations	5	3	3	3.7
Mineral extraction	Automation and optimization of open pit mining	4	4	2	3,3
	Mine automation, robotization, and safety	4	4	2	3,3
Water supply and electricity	Energy and water consumption data collection and metering	4	4	4	4,0
	Smart Grid	4	4	2	3,3
	Drones for transmission line monitoring	3	2	4	3,0
Construction	Remote control of construction equipment	4	4	5	4,3
	AR/VR for construction	3	4	3	3,3
	Smart construction	4	4	5	4,3
Trade	AR/VR for realistic presentation of goods	4	3	4	3,7
	Smart store	5	3	3	3,7
	Smart vending machines	3	3	4	3,3
Transportation and storage	Smart warehouse	5	3	2	3,3
	Tracking cargo movement	5	4	4	4,3
	Smart port	4	3	2	3,0
	Smart airport	5	3	3	3,7
Public security	Mobile and rapidly deployable surveillance systems	5	1	4	3,3
	UAVs to secure public order	5	1	5	3,7
	Monitoring and emergency alerts	4	3	5	4,0
	Drone-mounted base stations for rapid infrastructure deployment	3	1	5	3,0
Culture and leisure	Cloud based gaming	5	5	4	4,7
	AR/VR based travel services	3	3	4	3,3
	Smart stadiums and broadcasts	3	3	3	3,0
Municipal services	Road traffic management and road safety	5	2	2	3,0
	Unmanned and remotely operated urban equipment	3	2	4	3,0
	Lighting, climate, access to facilities	4	5	5	4,7
	Digital signage and resident feedback systems	3	2	4	3,0

Table 2. Consolidated platform services usage data

Sector	Use case \ Platform service	Data collection, accumulation, processing, and management in non-critical systems	Transmission and storage of high quality video streams, video analytics systems	Managing virtual and augmented reality services	Remote and manual operation of machinery and manipulators	Automated real-time control, digital "twins"	Robotization and autonomous control of unmanned aerial vehicles	Control of low-flying unmanned aerial vehicles	Operation of connected and unmanned vehicles	Supporting cloud computing and operation of thin clients	Management of private virtual networks
Agriculture	Smart field	✓	✓		✓		✓	✓		✓	
	Smart farm	✓	✓							✓	
Industry	AR for production and repair work			✓							✓
	Production and predictive repair sensors			✓		✓					✓
	Smart factory			✓		✓	✓			✓	✓
Healthcare	Remote monitoring and health diagnostics	✓								✓	
	AR/VR for diagnostics and surgical operations			✓	✓						
Mineral extraction	Automation and optimization of open pit mining	✓			✓	✓	✓		✓		✓
	Mine automation, robotization, and safety	✓			✓	✓	✓		✓		✓
Water supply and electricity	Energy and water consumption data collection and metering	✓								✓	
	Smart Grid	✓				✓				✓	
	Drones for transmission line monitoring		✓					✓			
Construction	Remote control of construction equipment	✓			✓		✓				✓
	AR/VR for construction		✓	✓							✓
	Smart construction	✓				✓					✓
Trade	AR/VR for realistic presentation of goods		✓	✓							
	Smart store	✓		✓			✓				
	Smart vending machines	✓	✓								

Table 2. Consolidated platform services usage data (continued)

Sector	Use case / Platform service	Data collection, accumulation, processing, and management in non-critical systems	Transmission and storage of high quality video streams, video analytics systems	Managing virtual and augmented reality services	Remote and manual operation of machinery and manipulators	Automated real-time control, digital "twins"	Robotization and autonomous control of unmanned aerial vehicles	Control of low-flying unmanned aerial vehicles	Operation of connected and unmanned vehicles	Supporting cloud computing and operation of thin clients	Management of private virtual networks
Transportation and storage	Smart warehouse	✓	✓				✓				
	Tracking cargo movement	✓							✓		
	Smart port	✓	✓		✓		✓		✓		✓
	Smart airport	✓	✓				✓		✓	✓	✓
Public security	Mobile and rapidly deployable surveillance systems		✓	✓				✓			✓
	UAVs to secure public order		✓					✓			✓
	Monitoring and emergency alerts	✓								✓	
	Drone-mounted base stations for rapid infrastructure deployment							✓			✓
Culture and leisure	Cloud based gaming		✓	✓						✓	
	AR/VR based travel services			✓							
	Smart stadiums and broadcasts	✓	✓	✓							
Municipal services	Road traffic management and road safety	✓	✓						✓		
	Unmanned and remotely operated urban equipment	✓	✓		✓		✓		✓		
	Lighting, climate, access to facilities	✓			✓					✓	
	Digital signage and resident feedback systems		✓							✓	

Section 4 provides an assessment of use scenarios and details the potential for platform service usage in each specific industry scenario. Consolidated data on platform services usage is shown in Table 2. Importantly, the presented overview refers to the specific use scenarios. The diversity of 5G capabilities often enables solving a specific business problem using different combinations of platform services.

7.

Conclusions

The experience of implementing 5G-enabled platform services to digitally transform industries reviewed in this paper shows that in the overwhelming majority of cases their market will grow by tens of percent immediately after their launch and will keep growing at this pace at least for the next three to five years.

But in the end of the day, the most important thing is the improvements in the performance by enterprises, industries, and the economy on the whole. With the spread of 5G in industry projects there are more and more real cases of a boost in production efficiency and implementation of new business solutions.

This review uses 5G use scenarios and specific real-life cases from industry leaders to engage and inspire Russian enterprises, operators, and developers and help them implement similar projects taking advantage of this advanced technology platform.

With the same goal in mind, we will soon release an overview of measures, methods, and models to provide institutional support to enterprises developing solutions and services for industry needs that can dramatically improve efficiency through 5G. Based on this new review, we are planning to provide guidance on how to organize, develop, and support 5G developer communities via cloud infrastructure.

Project team

This study, Global Trends, Potential 5G Development and Use Scenarios across Different Sectors, has been prepared by the Digital Economy Projects Office of PJSC Rostelecom. As the Centre of Excellence within the Federal Project Information Infrastructure under the Digital Economy of the Russian Federation nationwide programme coordinates projects on digital economy and related areas, and is also responsible for implementing the agreement on development of high-tech area, Fifth Generation Mobile Communication Networks.

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