5G Technology in Emergency Services

5G will usher in the age of invention. What will this mean for public safety and emergency services?

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Version: 1.0

Publication date: 19/09/2019

Status of the document: Approved

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INTRODUCTION

The fifth generation of cellular technology is upon us. This technology does not simply represent just another advancement. Thanks to 5G, autonomous cars will be able to function and industrial robots will be able to process any order in real time. This will turn them into efficient and almost human machines, capable not only of replacing factory workers but also surgeons in operating rooms by performing remote operations.

5G will usher in what we call the age of invention. It is a much deeper change than what we saw before with the move to 4G or any previous development. And that’s not an exaggeration: 5G and artificial intelligence will mean billions of connected elements, huge amounts of data and all of them in the cloud. It will change how we share files, make online purchases and reproduce content.

5G will give way to the fourth industrial revolution thanks to leaps of innovation, creating total technological disruption. 5G is designed for a high data rate, reduced mobile internet latency, energy saving, cost reduction, higher system capacity, and massive device connectivity. Connections are 10 times faster (although laboratories have reached speeds 250 times higher) than the current 4G. Thanks to this immediacy, you can see contents with unimaginable quality in virtual reality or on television in 8K.

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5G will represent a great advancement for people working in the emergency services, as it will enable technological developments in public safety. These include telehealth, drones, traffic control, intrusion detection, surveillance, wearables and connected vehicles.

The previous big advancement in network technology helped make technologies like Lyft, Uber, and many more feasible. With speeds upwards of 100 times faster than 4G, 5G can be the same kind of disruptive force, spurring another generation of technological growth in agriculture, transportation, medicine, manufacturing, AI-supported phones, driverless cars, smart grid, as well as governments' access to data and networks essential to their functions, including their military.

	1G	2G	3G	4G
Period	1980-1990	1990-2000	2000-2010	2010-2020
Data Rate	2Kbps	64Kbps	2Mbps	100Mbps
Technology	Analogic	GSM	CDMA, UMTS, Edge	LTE, WIFI
Primary Services	Analogue phone calls	Digital phone calls and messaging	Phone calls, messaging and data	All IP services (includong Voice and Messaging)
key Differenciator	Mobility	Secure mass adoption	Better Internet Services	Faster broadband Internet, lower latency
Weaknesses	Poor spectrar eficiency, major secuurity issues	Limited data rates, Dificult to support demand for internet/email	Failure of WAP services	

Table 1 – Mobile communications technology has seen great progress since its launch in the 80s

Another important feature of 5G is capacity: the number of devices connected with the same number of antennas is multiplied by 100. This solves the problem of coverage in large agglomerations, such as football stadiums and concerts. In addition, it also reduces the battery consumption of the devices (alarms, cells or chips) to a tenth, which gives them much more autonomy.

However, the biggest improvement brought by 5G will be the reduction of the latency - the response time that a device takes to execute an order from the moment the signal is sent to it. The lower the latency, the faster the reaction of the device that we operate from a distance. 5G reduces that delay to one millisecond.

The technical requirements that define 5G technology and the use cases it could bring are related to speed, latency and connectivity.

- **Latency under 1ms**
- **Speed over 1 Gbps downlink**
- **Massive connectivity**

Therefore, only services that demand at least one of these would be considered 5G use cases.

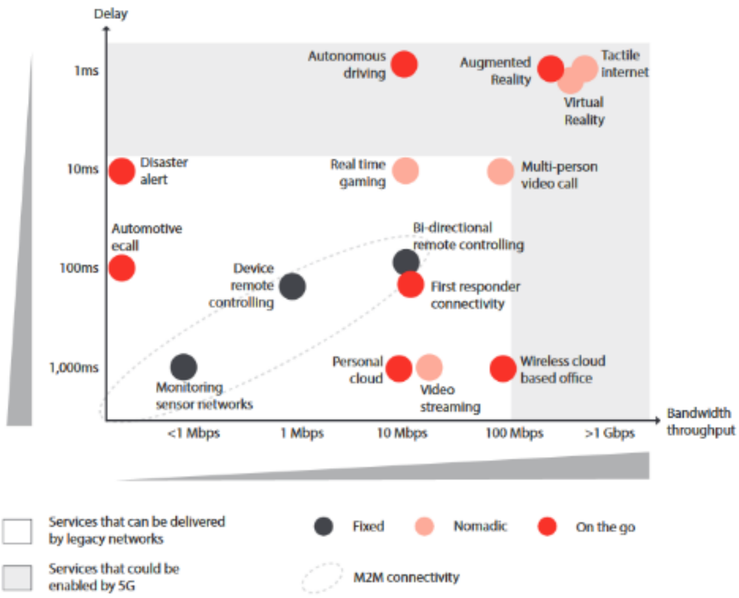

Figure 1: Bandwidth and latency requirements of potential 5G use cases
Source: GSMA Intelligence

Figure 1[1]

[1] Understanding 5G: Perspectives on future technological advancements in mobile – GSMA Intelligence

1 | THE RACE FOR 5G

5G will be a major technology when it comes to creating and enhancing industry digitalisation use cases such as immersive gaming, autonomous driving, remote robotic surgery and augmented reality support in maintenance and repair situations. The largest opportunity will be seen in energy and utilities industries, closely followed by manufacturing and public safety sectors.

Digitisation has pushed the growth of industry across the globe and it’s predicted that digital revenue for ICT players will be worth around USD 3.3 trillion by 2026 across the 8 key industries.

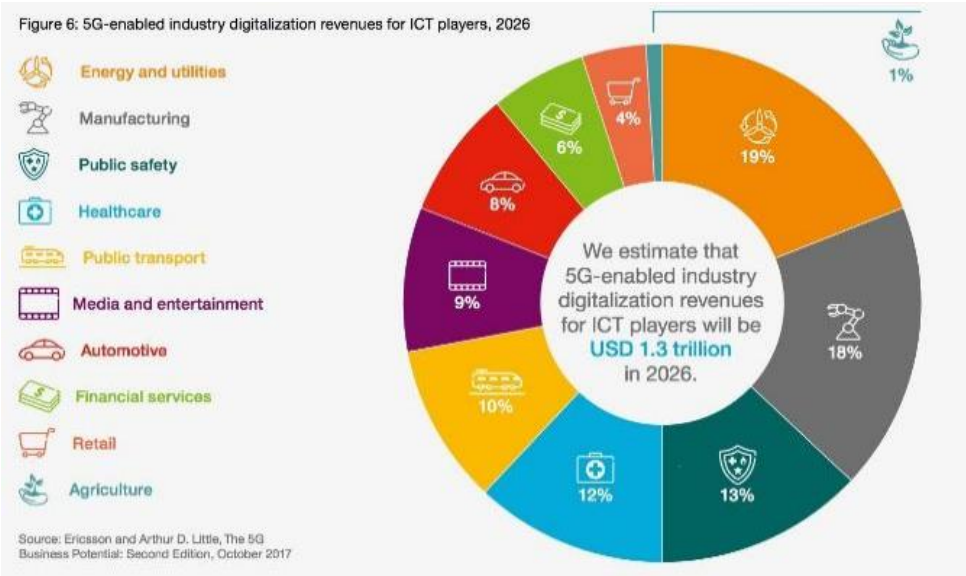

Figure 2[2]

These industry digitalisation revenues are substantial. In fact, revenues reached USD 939 billion in 2016[2]; operators need to consider that this sapling market is already bearing fruit for opportunists to reap financial rewards.

[2] The 5G business potential - Industry digitalization and the untapped opportunities for operators by Ericcson.

There are many different global trends that can account for this dramatic projected growth, including:

- A rise in emerging economies, which are yet to be fully immersed in the digital world.
- The urbanisation of integrated mobility.
- The digital revolution.
- New health and wellbeing demands.
- The scarcity and stability of resources.

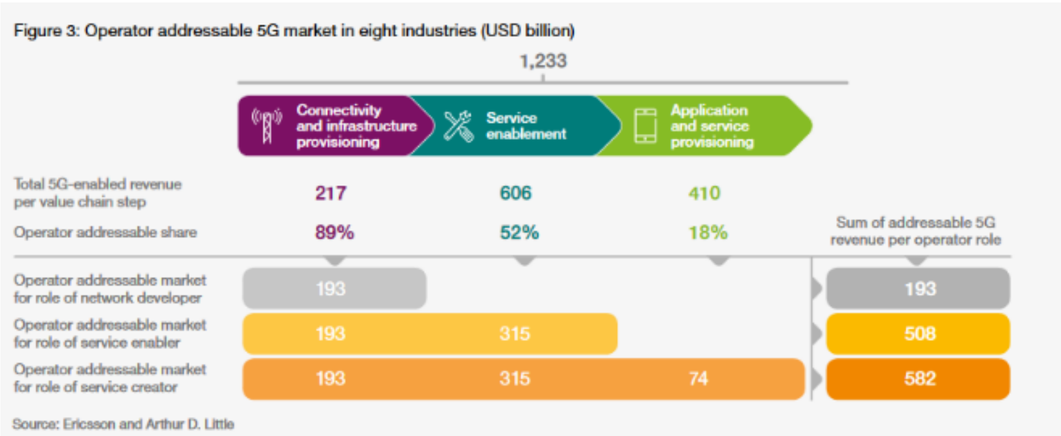

Figure 3[3]

Additionally, business trends such as hyper competition, new customer power and sophistication, the fast-paced change in business ecosystems, and disruptive technological advances all affect vertical industries to different extents.

[3] The 5G business potential Second Edition- Industry digitalization and the untapped opportunities for operators by Ericcson.

Observing the size of the opportunity, no one should be surprised to see companies fighting to increase their presence in the market. Backed by billions from government funding, companies in the European Union, United States, South Korea and China engaged in a silent battle over 5G technology. Last year, China announced that they had acquired the technology and were ready to deploy it – a fact that has led to a crisis on a global scale including espionage accusations.

The damages that this crisis could cause are huge. For example, exports of rare metals essential for mobile phones could be concerned.

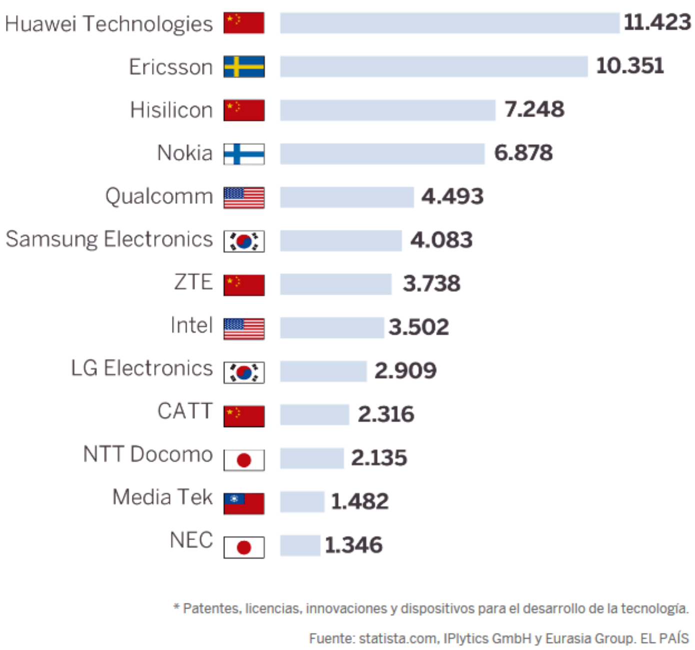

Figure 4[4]

We will have to wait to see how this race ends, hoping it will not lead to a global economic and commercial crisis.

[4] https://elpais.com/economia/2019/05/25/actualidad/1558795538_036562.html

2| TECHNICAL FEATURES

The 5G mobile cellular communications system will be a major shift in the way mobile communications networks operate and are deployed. To achieve this, a totally new radio access network and a new core network are required to provide the required performance. Some of the parameters that will need to be established are:

Cell station size

Smartphones and other connected devices rely on high-powered cellular towers to remain functional and broadcast their signals over longer distances. Millimeter waves, which 5G connectivity will be using to broadcast signals, cannot travel long distances. So small cell base stations will still be needed. Thousands of these small cell, low-powered base stations, will be deployed across the country and over rooftops, light poles, and power poles to transmit millimeter waves.

New 5G cell stations are not the mega towers of the previous generation and instead can be the size of backpacks in some cases. Regulatory schemes need to consider these changes in order to foster infrastructure investment.

More small cell towers mean better network performance. Best of all, power consumption will be reduced as networks shift from the larger radio towers. These small cell towers will also be able to form a web of broadcasting signals when placed nearby, eliminating signal degradation. As mobile users travel, the device will switch from one small cell base station to another so as not to lose performance or signal.

5G energy efficiency

Peak data rate is the fastest data transfer rate for a device, typically available in short bursts during transfer activity and not sustainable for long periods of time.

The 5G spec calls for radio interfaces that are energy efficient when under load, but also that drop into a low energy mode quickly when not in use. To enable this, the control plane latency should ideally be as low as 10ms—as in, a 5G radio should switch from full-speed to battery-efficient states within 10ms.

5G latency

Latency is a time interval between the stimulation and response, or, from a more general point of view, a time delay between the cause and the effect of some physical change in the system being observed.

Latency is physically a consequence of the limited velocity with which any physical interaction can be carried out. The magnitude of this velocity is always less than or equal to the speed of light. Therefore, every physical system will experience some sort of latency, regardless of the nature of stimulation that it has been exposed to.

The precise definition of latency depends on the system being observed and the nature of stimulation. In communications, the lower limit of latency is determined by the medium being used for communications. In reliable two-way communication systems, latency limits the maximum rate that information can be transmitted, as there is often a limit on the amount of information that is "in-flight" at any one moment. In the field of human–machine interaction, perceptible latency has a strong effect on user satisfaction and usability.

Under ideal circumstances, 5G networks should offer users a maximum latency of just 4ms, down from about 20ms on LTE cells. The 5G spec also calls for a latency of just 1ms for ultra-reliable low latency communications (URLLC).

Connection density

Connection density is the ability to support the successful delivery of a message of a certain size within a certain time, even in space-constrained locations like a football stadium. 5G is expected to support up to 1 million connected devices per square km, compared to around 2,000 connected devices per square km with 4G.

As 5G becomes more of a reality, we will start to see its full potential. For example, potentially life-saving applications that require low latency, high reliability, and continuous availability. Latency-sensitive applications like fire-fighting robots could become a regular practice, saving precious lives. You can just imagine some of the industrial or military applications 5G will enable. Some of these may sound far-fetched, but remember that only a decade ago, the first smartphone was introduced. Look how far that technology has come in just 10 short years.

5G spectral efficiency

Spectral efficiency is typically measured in (bit/s)/Hz per unit area, in (bit/s)/Hz per cell, or in (bit/s)/Hz per site. It is a measure of the quantity of users or services that can be simultaneously supported by a limited radio frequency bandwidth in a defined geographic area.

For example, it may be defined as the maximum aggregated throughput or goodput, i.e. summed over all users in the system, divided by the channel bandwidth and by the covered area or number of base station sites. This measure is affected not only by the single user transmission technique, but also by multiple access schemes and radio resource management techniques utilised. It can be substantially improved by dynamic radio resource management. If it is defined as a measure of the maximum goodput, retransmissions due to co-channel interference and collisions are excluded. Higher-layer protocol overhead (above the media access control sublayer) is normally neglected.

5G's peak spectral efficiency—how many bits can be carried through the air per hertz of spectrum—is very close to LTE-Advanced, at 30bits/Hz downlink and 15 bits/Hz uplink.

5G real-world data rate

Finally, despite the peak capacity of each 5G cell, the spec "only" calls for a per-user download speed of 100Mbps and upload speed of 50Mbps. These are close to the speeds you might achieve on EE's LTE-Advanced network, though with 5G it sounds like you will always get at least 100Mbps down, rather than on a good day, downhill, with the wind behind you.

The draft 5G spec also calls for increased reliability (i.e. packets should almost always get to the base station within 1ms) and the interruption time when moving between 5G cells should be 0ms—it must be instantaneous with no drop-outs.

Other features of the 5G technologies are:

Millimetre-Wave communications: Using frequencies much higher in the frequency spectrum opens more spectrum and also provides the possibility of having much wider channel bandwidth - possibly 1 - 2 GHz. However, this poses new challenges for handset development where maximum frequencies of around 2 GHz and bandwidths of 10 - 20 MHz are currently in use. For 5G, frequencies of above 50GHz are being considered and this will present some real challenges in terms of circuit design, technology, and the way the system is used as these frequencies do not travel as far and are absorbed almost completely by obstacles. Different countries are allocating different spectrum for 5G.

Waveforms: One key area of interest is that of the new waveforms that may be seen. OFDM has been used very successfully in 4G LTE as well as several other high data rate systems, but it does have some limitations in some circumstances. Other waveform formats that are being discussed include: GFDM, Generalized Frequency Division Multiplexing; FBMC, Filter Bank Multi-Carrier; UFMC, Universal Filtered Multicarrier. There is no perfect waveform and it is possible that OFDM in the form of OFDMA is used as this provides excellent overall performance without being too heavy on the level of processing required. At this moment, CP-OFDM and DFT-s-OFDM are more likely to be selected.

Multiple Access: Again, a variety of new access schemes are being investigated for 5G technology. Techniques including OFDMA, SCMA, NOMA, PDMA, MUSA and IDMA have all been mentioned. As mentioned above, it appears that the most likely format could be OFDMA.

Massive MIMO with beamsteering: Although MIMO is being used in many applications from LTE to Wi-Fi, etc., the number of antennas is limited. Using microwave frequencies opens the possibility of using many tens of antennas on a single equipment, which becomes a real possibility because of the antenna sizes and spacings in terms of a wavelength. This would enable beams to be steered to provide enhanced performance.

Dense networks: Reducing the size of cells provides a much more effective overall use of the available spectrum. Techniques are required to ensure that small cells in the macro-network and deployed as femtocells can operate satisfactorily. There is a significant challenge in adding huge numbers of additional cells to a network and techniques are being developed to enable this.

Full duplex: Current cellular base stations can only either receive or transmit signals at a time. They cannot commit to doing both things simultaneously. Think of this operation as a walkie-talkie scenario, where two people need to take turns in sending and receiving data. This is where full duplex is going to change things. It will be able to re-route data in such a manner that receiving and transmitting data will be done nearly at the same pace, improving speed and efficiency.

Network Slicing: One of the key capabilities of 5G is the ability to 'slice' the network. Network slicing allows a physical network to be divided into multiple virtual networks, enabling operators to provision the right 'slice' depending on the requirements of the use case. 5G network slicing brings the adaptability needed to meet the performance expectations for these new telehealth use cases and emergency services.

Mobile Edge Computing (MEC): MEC is regarded as a key enabling technology, which provides the capability for a high-performance virtual environment residing at the network's edge. By being adjacent to the IoT environment, MEC can support applications and services with increased bandwidth, low latency and improved QoS.

The network architecture for 5G emergency services can create and manage virtual instances of network access, hence providing customised network resources to each emergency service agency (i.e., police, ambulance, fire-brigade).

We can also expect newer technologies to be introduced down the road.

3| USE CASES

In the previous sections of this document we had the chance to observe the changes in the technology brought to us by 5G. In this section we will see what this technology means for people and what are the main use cases related to emergency services.

Figure 5[5]

When talking about 5G use cases we refer to those that will be developed or improved after this technology appears.

3.1 INTRUSION DETECTION AND SURVEILLANCE

'There is no place like home' and it is important for everyone to feel safe there. In the past, the only way to improve the level of safety in our houses was to invest in better doors, better locks or expensive (and not very reliable) alarm systems.

With the introduction of high-speed connections like 5G there is a new opportunity to access cameras, sensors and other devices that would allow us to receive information about our homes even when we are far away.

At the same time, the information from these devices can be shared with security services in real time. Thanks to the massive broadband networks, security services can receive richer information including audio and video. In this context, the Internet of Things (IoT) ecosystem

5 https://www.new-techeurope.com/2018/01/18/5g-not-yet-closer-think-race-define-5g-may-ending-process-design-deploy-5g-technology-just-beginning-2/)

will need to evolve to the Internet of Public Safety Things (IoPST). Communications will in fact require a mix of speed and security.

It is also necessary to ensure technical compatibility between the future implementation of 5G public communication networks and public warning systems, by achieving an optimal technical and operational legal framework for the interconnection of public mobile communication networks with public warning systems. It is also necessary to ensure that 5G terminals existing on the market are compatible with public warning systems.

3.2 TRAFFIC CONTROL

One of the most important things when attending an emergency is the time needed to deploy help. Having an intelligent system that can give priority to emergency vehicles, so that they can move faster in a city, could save many lives. This "smart -traffic" system should be connected to every vehicle using a 5G connection, or even by constructing mesh networks, using vehicles as nodes.

Using high speed wireless communications systems to communicate, emergency service vehicles would be able to alert traffic management systems of their approach. It will also enable them to modify traffic to provide an optimal route for the emergency service vehicle to its destination. Emergency service prioritisation like this occurs today but on a smaller scale than would be possible with 5G.

3.3 PUBLIC SAFETY AND SURVEILLANCE

There is no doubt that the threats that modern cities need to face are more and more sophisticated and difficult to manage. Millions of people live their lives sharing space, transports and other resources. Surveillance systems are one of the technological solutions that can improve safety in the cities of the future. Fast and massive networks will be needed to connect databases, cameras, sensors and other devices.

When talking about cameras, the issue to consider is how to process that raw data to provide useful information to the right people at the right time. 5G could support more real-time video, as well as additional processing resources in the form of edge computing to make sure that only useful information gets transmitted immediately. The rest could be stored and transmitted intermittently or only if needed.

3.3 WEARABLES AND CONNECTED VEHICLES

The automotive industry is characterised by the early adoption of a variety of connectivity solutions to improve vehicle experience, road safety, intelligence, vehicle performance or maintenance needs, while being considered as one of the industrial sectors that benefits the most from the performance of 5G. Thus, it is anticipated that the role of 5G in the automotive industry will head in several different directions: including improving on-board information services in cars and facilitating the collection and processing of more data needed to provide innovative services. 5G performance is also critical to completing today's short-distance

communication requirements through the ultra-reliable V2X (vehicle-to-everything) communication, which is needed to improve car autonomy.

Wearables will enable the provision of enhanced patient insights. The goal is for all paramedics to have wearable clothing that can provide real-time video feeds as well as other sensor related data pertaining to the immediate environment. 567 million wearable devices will be employed in Europe in 2030. It is also important to consider that 86% of doctors agree that wearables increase patient engagement with their own health. Additionally, wearables are predicted to decrease hospital costs by 16% percent in the next five years. Both figures are likely to increase further in the coming years.[6]

The availability of patient-related real-time video stream for the awaiting emergency department will enable more intelligent decision support for the paramedics attending the patient. Real-time video streaming will enable the awaiting emergency department professionals to remotely monitor the patient for conditions that are not easily sensed, such as skin pallor and patient demeanour. In a more ambitious scenario, life-saving remote assistance might be required on the ambulance, supervised by a specialist located elsewhere and connected to the same platform.

Clearly, some of these uses will require high-resolution video capabilities, e.g. the remote assistance will require ultra-high-definition video streaming from the ambulance to the remote site where the specialist is located.

This enhanced and interactive communication between the medical professional teams and the remote paramedics attending to the patient will lead to fundamental improvements in emergency medical care and improve the probability of better patient outcomes.

[6] https://www.anthem.com/blog/living-healthy/top-4-trends-in-health-care-technology/

3.4 DRONES AND 5G

Extinguishing a fire, locating a missing person, and the subsequent control of the perimeter require having global information about the affected area, as well as knowing the position of the different personnel involved. For this type of task, it is very useful to use a drone, which provides aerial vision, together with processing information for the geolocation of the fire and firefighters in the field.

The availability of images in real time, both by the personnel deployed in the field and by the rest of the security forces, is essential for efficient emergency management and to protect the lives of firefighters and other resources.

The mission begins by activating a flight plan for the drone, defining the area of action and parameterising the information to be received. The sensors installed on board the drone (high resolution and thermal imaging cameras) can detect temperature and record video in high resolution. This information is sent to the base station, which is responsible for processing it to add the georeferencing of the images, the temperature scale and the position of the available personnel in the field.

The final processed video is sent to the broadband network based on 5G technology, specifically designed for emergency management, distribution and viewing by security bodies in real time. This allows effective management of deployed personnel, as well as reducing the possibility of damage.

The system is especially useful both in the fire extinction phase and in the subsequent control and monitoring of the extinct perimeter, since it allows an optimised management of the personnel and guarantees their safety.

5G can also improve the deployment of rescue robots in dangerous situations. Controlled by specialists, these robots can receive orders using low latency communications and carry out work precisely without the need to put any person in danger.

3.5 HEALTH

For people in rural areas, with doctors located several miles away, traveling while ill can be challenging and time-consuming. Nevertheless, with the advent of telehealth and remote home monitoring systems, we could receive care from the comfort of our homes. Doctors could make recommendations after a short video call and even submit prescription requests.

Magnetic resonance imaging and other image machines produce very large files that often must be sent to a specialist for review. When the network is low on bandwidth, the transmission can take a long time or not send successfully. This means the patient waits even longer for treatment and providers can see fewer patients in the same amount of time.

Adding a high-speed 5G network to existing architectures can help quickly and reliably transport huge data files of medical imagery, which can improve both access to care and the quality of care. Regional networks of services could be deployed in order to improve the quality of the assistance.

When healthcare systems utilise this technology, patients can often get treated sooner and have access to specialists otherwise not available. It can also allow doctors and other staff members to collaborate more efficiently.

With 5G technology, which has lower latency and higher capacity, healthcare systems can offer remote monitoring for more patients. Providers can then be confident that they will receive the data they need in real time and can provide the care their patients need and expect.

Low latency is one of the main features of 5G and it could also introduce the concept of telesurgery. Telesurgery is understood as the process in which the doctor can operate on a patient who is in a different location. Achieving telesurgery would be extremely complicated to implement because of the technology involved. Nevertheless, there is no doubt that it would be a major improvement for patients that could be treated by doctors in other cities or countries.

4 | CONCLUSION

5G will not simply be another technological development, but it will represent a significant change in our way of life.

Just as the agrarian and industrial revolutions deeply altered the economic structure of nations and the way in which citizens perform their work, the next technological revolution promises to transform society as we know it.

The technological revolution framed by the evolution of telecommunications, robotics and artificial intelligence will modify the way we live within cities, the way in which we relate to each other and the way we work.

The fifth generation of communication networks promises to introduce a large number of new possibilities unknown today and traditionally associated with science fiction novels: droid, autonomous cars, telepresence, artificial intelligence, Big Data systems capable of anticipating behaviours and trends. It is also to be considered a synergy of these new technologies that leads to new paradigms like real time processing clouds, remote training, real time translation, etc.

Nevertheless, there are also some challenges in the deployment of 5G that need to be considered. One these challenges is the interference between 5G devices and some of the instruments used by scientists to forecast the weather. This problem arises due to the fact that 5G uses a frequency near to that of reflectance of vapor and this could interfere with meteorologists' measurements[7].

We still will have to wait and see how these new technologies evolve, as well as how they affect society and the economic relations between countries. What our future will look like will depend on this.

For the experts working in emergency services, 5G will without a doubt represent a great advancement for how they carry out their jobs, bringing a significant in functionality, efficiency and safety.

[7] https://www.theguardian.com/world/2019/may/04/5g-mobile-networks-threat-to-world-weather-forecasting

GLOSSARY

FBMC – Filter Bank Multi-Carrier

GFDM - Generalized Frequency Division Multiplexing

IDMA - Interleave-Division Multiple Access

LTE - Long-Term Evolution

MEC - Mobile Edge Computing

MIMO - Multiple-Input and Multiple-Output

MUSA - Multi-User Shared Access

NOMA - Non-Orthogonal Multiple Access

OFDM - Orthogonal Frequency Division Modulation

OFDMA - Orthogonal Frequency Division Multiple Access

PDMA - Pattern Division Multiple Access

SCMA - Sparse Code Multiple Access

UDN - Ultra-Dense Network

UFMC - Universal Filtered Multicarrier

URLLC - Ultra-Reliable Low Latency Communications

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