WIRELESS 2025

PROVIDING SECURE AND RELIABLE COMMUNICATIONS FOR THE FUTURE

INTRODUCTION

SIMPLY PUT, TODAY'S communication universe is divided into two worlds. The big one is where you send e-mail, stream music, watch movies and upload cat videos to Facebook. It's large-scale, commercial, cost-efficient and reasonably tolerant of lags and downtime.

The small world, on the other hand, is the one that keeps you alive. It's public service, obsessed with safety, security and integrity, and relentlessly reliable. It's the system that keeps communication lines open in disaster zones, operates machinery in toxic environments and will allow doctors to perform remote surgery.

Due to the free-market emphasis on cost-effectiveness, these two worlds are not likely to merge in the future. If anything, the divide between them will become more pronounced. But while the big world has a well-defined business model up and running, the small one has some critical challenges to face in the coming years. How it manages those challenges is the focus of this paper.

UNDER NORMAL CONDITIONS, letting thousands of users simultaneously stream high-resolution video is not a problem. Repeating this in a region where all fiber-optic cables have been severed and 90 percent of masts are down would be forbiddingly expensive for a commercial operator. Disaster-proofing commercial networks on this level has never been part of the industry's business plans.

But for citizens stranded in disaster areas, access to reliable information very quickly becomes a top priority. What is happening? Where is it safe? When is help arriving? This is where the small world comes in, equipped with radio links, mobile masts and backup power generators. Maintaining broadband access during relief efforts is crucial, both for emergency workers and for the people affected.

THIS SMALL WORLD also has an important role to play under normal circumstances. Technology has always played a role in relieving mankind of strenuous labour. Now it is ready to take the final step – letting humans monitor operations from the safety and comfort of air-conditioned offices while machines do all the hazardous work. For this to be feasible, though, response times between machines and their remote operators must clock in at below one milli-second. Engineers call this "extreme real-time communication," and its real-world benefits are fewer industrial accidents, healthier working environments and cleaner jobs.

« Now it is ready to take the final step – letting humans monitor operations from the safety and comfort of air-conditioned offices while machines do all the hazardous work »

JUST AS WITH communication networks in disaster zones, however, these super-fast systems are extremely expensive to build and maintain, and no commercial operator will have the incentive to provide them to society.

THE HEALTH SECTOR faces challenges on multiple fronts. For example, with the help of modern communications technology, patients can increasingly receive advanced medical attention in their homes instead of at hospitals. Naturally, this requires some modification of patients' residences, but these services do not need to carry large amounts of data. Nor must they be available to large segments of the population, or transmit instantaneously. What they do need to be is reliable, even if all they send is a patient's heartbeat. And it goes without saying that this connection must be ultra-reliable. A pulse signal can afford to lag a few seconds, but not minutes.

Also, both home-monitoring systems and the remote-surgery systems envisioned for the future must be immune to power fluctuations or network failures that put other systems offline. They also need to be reliable from an integrity viewpoint, since they deal with sensitive medical information.

IN SHORT, the future holds a vision of enormous amounts of information, and different ways of disseminating them. In addition, some of this information is sensitive and critical for the lives and well-being of real people.

But this level of reliability costs money, and the commercial sector, for all its accomplishments, is for pure business reasons not suitable to take on this role. The only system that can deliver this tall order is a single, reliable nationwide network, dedicated to serving public needs for security, safety and integrity.

The effects of catastrophic events are often compounded by the disruption of communication networks.

[SCENARIO A:]
SECURING COMMUNICATION IN A DISASTER ZONE

IT IS A UNIQUE DAY, but for all the wrong reasons. Rebecka leans out the window of the Hägglunds all-terrain vehicle to survey and record the damage. For as far as her eyes can see, there is devastation – trees broken like matchsticks, burnt-out houses and smashed, abandoned cars. People are walking among the remains of their former lives, picking at their ruined belongings, not knowing where to start.

Leaning back in, Rebecka shows her tablet to her colleague. On one part of the split screen, reactions to the high-resolution video she has just shot are coming in from HQ. Helicopter pilots circling overhead want to know if there are still people near the smouldering textile factory or if they can waterbomb it. Rebecka gives a clear signal and orders the caravan of Hägglunds to move out of the way. Rain is coming.

Luckily, this was a disaster the experts could predict in advance. A total of 30,000 people were evacuated during the weeks leading up to the blast. No casualties have been reported, but 64 people are still unaccounted

for. As search and rescue leader, it's Rebecka's job to find them. Naturally, each of the 64 have up to a dozen friends and relatives who are also looking for them, all desperate for the latest information. Between these civilians, the military, the police, the Red Cross, air traffic, returning home-owners, well-meaning volunteers, a host of regional and national rescue services, the media and the inevitable looters, the region's communication network is under more stress than ever.

When Rebecka first started working with disaster management, the communication grid was routinely shut down for everybody except emergency services in similar scenarios. There simply wasn't enough bandwidth to go around.

Today, some frequencies are still off limits to civilians, but the full array of handheld devices can be accomodated for both voice, data and image communication. This way, Rebecka and others can benefit from real-time on-the-scene information from civilians, which more than once has proved beneficial to saving lives and property.

REBECKA'S WORKDAY illustrates the coming technical challenges as our use of smartphones evolves further. The increase in mobile video traffic places higher demands on connection speeds, as does the number of devices supported in some rural areas. Rebecka's work in crisis situations depends on digital communication flowing seamlessly along pre-determined lines. Glitches, lag time and insufficient clarity are simply not options. If they are, people die.

This scenario illustrates the importance of "Broadband access in dense areas". The always-connected, always-communicating, always-mobile behaviour puts network resources and network reliability front and centre. And in emergencies, systems are suddenly expected to handle many times more information than usual, often in situations where parts of the existing network has been damaged. This level of activity is highly dependent on improved wireless networks. To meet this future, wireless systems will need 1,000 times the capacity of today to enable large numbers of people to share information and data instantly.

« We need 1,000 times the capacity of today to enable people to connect in a crisis »

[SCENARIO B:]

REDUCING ACCIDENTS THROUGH EXTREME REAL-TIME COMMUNICATIONS

SVEN PUTS ON his hard hat before leaving the local control room, heading for the elevator that will take him down to the thousand-metre level in the Kiruna mine. He is one of only a handful of employees, mostly service technicians, who work at the actual mine, historically the workplace of thousands. Nowadays most of the trucks and drilling equipment are operated from Stockholm, more than 1,200 kilometres away, while the ex-miners have moved on to clean jobs in space technology and solar energy development.

Before leaving the room, Sven checks that all the necessary data streams, such as sensor messages, high-resolution video and some blueprints, are reflected onto his handheld screen. This gives him all the right tools when he reaches the faulting excavator 1,000 metres underground. As a precaution, he activates his own live video stream from the small camera in his hard hat. This live video is viewable from anywhere in the world, just like the information on his screen.

ALREADY TODAY we can see how both mining equipment and forest harvesters are run from a distance. With more reliable sensors, more and more machinery will be remote controlled over mobile networks. Fleets of drones, different self-driving vehicles and robots will put real-time communication to the test, as will the distance between the operator and the machine. This development will place increased demands on networks with extreme reliability, as well as on distribution of computation.

Sven's workplace is an illustration of "Extreme Real-Time Communications," or "Tactile internet". Tactile interaction is referred to as a system where humans will wirelessly control real and virtual objects. Tactile interaction typically requires a tactile control signal and audio and/or visual feedback.

One application falling into this category is the use of software running in the cloud in such a way that the user, interacting with the environment, does not perceive any difference between local and remote content. Robotic control and interaction include countless scenarios, such as those in manufacturing, remote medical care and autonomous cars.

The main challenge in tactile interaction will be real-time reaction, which is expected to be sub-millisecond (i.e. less than one thousandth of a second).

Humans are kept out of harm's way when heavy machinery in dangerous environments can be operated by remote control.

« Tactile interaction is a system where humans will wirelessly control real and virtual objects »

Improved blue-lights communications will lead to faster and more appropriate emergency responses, benefitting victims and minimizing damage to property.

[SCENARIO C:]
ULTRA-RELIABILITY THAT IMPROVES HEALTH AND SAVES LIVES

FIREMAN LEIF'S LIFE is something more than driving a red truck and spraying water on a blaze. He is on call 24 hours a day, seven days a week, 365 days a year, always ready to risk his life to save others in times of disaster.

All Leif's communications equipment is checked on a daily basis to assure it is working properly, because in 2025 firefighting is mainly done remotely through robots and drones. Also, victims injured in emergencies are treated immediately in the ambulance. Paramedics, however, can rely on directions provided by medical experts at the hospital. As a result, information concerning clinical status, such as vital bio signals, test results and a video of the patient can all be constantly available to the experts throughout the transport stage.

ANNA, 82, IS greeted by the smiling face of Marco peering in through the kitchen door.

« The main challenge will be to ensure ultra-reliable communication over the entire footprint of the emergency services »

Sensors that monitor patients remotely throughout the day give health workers more reliable data on which to prescribe treatment.

"Are you awake, Anna?" One minute earlier he was identified and admitted by the electronic lock on the front door. Now he steps into the room to help her get ready for the day. During the night, Anna's sensor-filled bracelet has registered her sleep, heartbeat and temperature. Now the data is passed to her online medical record and compiled for the next video check-up from her doctor. Twice during her sleep, the night staff has paid her virtual visits using the connected camera above her bed.

PUBLIC SAFETY SYSTEMS such as these illustrate the use of "ultra-reliable communications". All public safety organisations will need enhanced and secure communications. This will include real-time video and ability to send high-quality images. The main challenge here will be to ensure ultra-reliable communication over the entire footprint of the emergency services, including land, sea, air, in-building and some underground areas such as basements and subway systems. It will also require priority over other network traffic.

Automation will complement human workers, not only in jobs with repetitive tasks but also within public safety. This will require an underlying control network with very low latency and high reliability. For many robotics scenarios in manufacturing, a round-trip reaction time of less than one millisecond is anticipated.

As for e-health homes such as Anna's, this is probably where the Internet of Things (IoT) will be most useful. Sensors, cameras and other smart objects that are capable of identifying, locating, sensing and connecting to one another can be used in ways that reinforce the quality of home and health care. With more effective planning, home care staff will have more time to socialize with their patients. And with closer monitoring of Anna's health, she can cut down on today's frequent visits to the health centre.

A SINGLE NATIONWIDE WIRELESS BROADBAND NETWORK DEDICATED TO PUBLIC NEEDS

WIRELESS AND FIBRE-OPTIC broadband services have a strong presence in densely populated areas, ranging from consumer-oriented mobile apps and voice, ticketing or payment solutions all the way to industrial applications and Machine-to-Machine (M2M) communications. However, remote areas do not benefit from these types of services, mostly due to the high cost related to providing coverage.

The Scandinavian countries (perhaps with the exception of Denmark) have rural areas with low population density but great assets and strong potential growth. For instance, in northern Scandinavia, industries related to forestry, mining, energy and tourism are all strongly contributing to national growth. Moreover, health, safety and transport services are indispensable and must be ensured nationwide unless we want to see rural areas become completely depopulated.

Governments have long requested that commercial operators provide both better services and coverage. This is of course hard to do with any financial profit in sparsely populated areas due to the high cost of network deployments in these regions, combined with low population density. Hence, there is little or no interest from commercial actors in taking full responsibility for providing rural services.

Here is a role which probably only a government-owned network operator can fill – a single nationwide wireless broadband network dedicated to public needs.

Even if the various industries and services outside of urban areas are not directly related to each other, they can benefit from common operations and solutions. Synergies between commercial systems such as 4G and 5G on the one hand, and the GSM-R system on the other, critical for train operations all over Europe, are large. What is missing is the collaboration between involved parties in order to possibly solve each other's issue. The solution is a single nationwide broadband network, dedicated to serving public needs when it comes to security, safety and integrity.

By becoming the neutral host for both commercial and mission-critical government services, security and safety, a government-owned operator may act for the good of society in an affordable way, making mobile services that today are offered in dense populated areas available also for people living in rural areas. They are also entitled to voice, broadcast and broadband services as specified by the European Digital Agenda.

Furthermore, a single nationwide broadband network, dedicated to serving public needs when it comes to security, safety and integrity would be the solution for providing connectivity in all such cases where multiple wireless infrastructures are commercially or technically not feasible.

Four examples could be:

1. Stadiums and festival venues are places which are ultra-densely populated during very short periods of time. One common infrastructure is needed since several parallel ones will be economically inefficient
2. Densely populated rural areas: One common, extremely versatile infrastructure is needed, able of carrying all sorts of public wireless services, commercial mobile broadband, broadcast, blue lights etc. Several parallel infrastructures will be economically inefficient
3. Providing high-capacity passenger internet and connectivity for trains, aircraft, buses and cars. Digital roads may not have parallel wireless infrastructures
4. Mission-critical services such as GSM-R/ERTMS, blue lights, power control systems, public alarms.

Benefitting society, contributing to the public good, keeping us safe. Call it what you will, but this is arguably, and rightly so, the greater calling of the information society.

Helping us take care of each other is something communication is supremely equipped to assist with. Choosing to leave some citizens behind because it's too expensive or hard to reach them is simply not a viable option.

We can do better than that, and with the help of a humanely erected communication infrastructure, we will.

MEDIA SERVICES

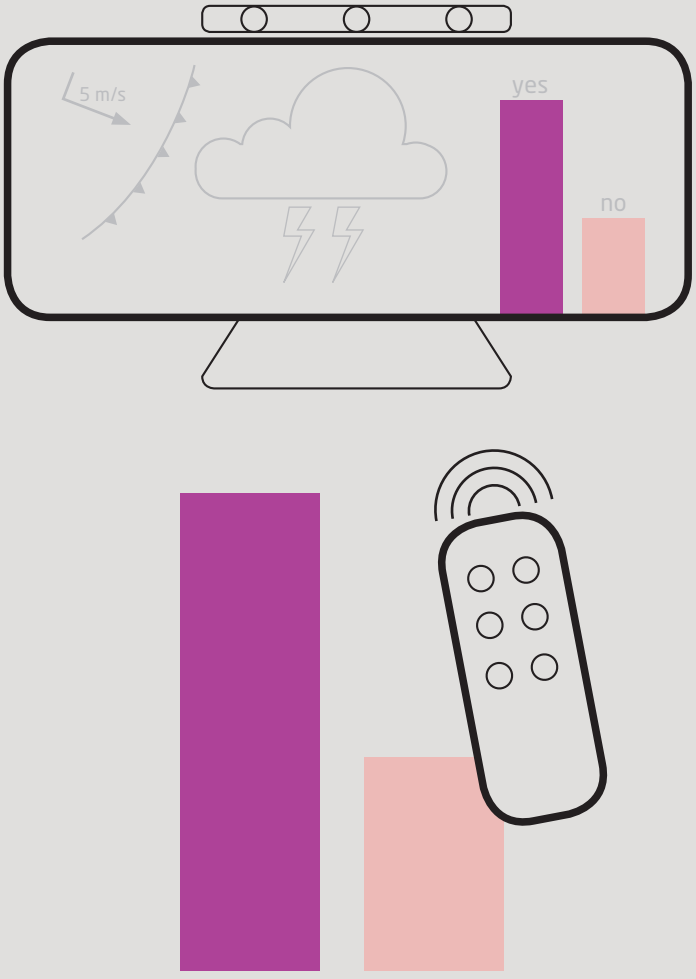
EVEN THOUGH PERSONALIZATION of communication will lead to a reduced demand for legacy broadcast as deployed today, e.g. linear TV, the fully mobile and connected society will nonetheless need efficient distribution of information from one source to many destinations.

These services may distribute content as they do today (typically only downlink), but also provide a feedback channel (uplink) for interactive services or acknowledgement information. Both real-time or non-real-time services must be possible. Furthermore, such services are well suited to accommodate the needs of vertical industries. These services are characterized by having a wide distribution which can be either geo-location focused or address-space focused (with multiple end-users).

News and information
Beyond 2025, receiving text/pictures, audio and video, everywhere and as soon as things happen (e.g. action or the score of a football match) will be common. Customers in specific areas should simultaneously receive appropriate news and information regardless of the device they are using and their network connection.

Local broadcast services
Local services will be active at a cell (compound) level with a reach of for example 1-20 kilometres. Typical scenarios include stadium services, advertisements, voucher delivery, festivals, fairs and congress/convention centres. Local emergency services can exploit such capabilities to search for missing people or in the prevention of, or response to, crime (e.g. theft).

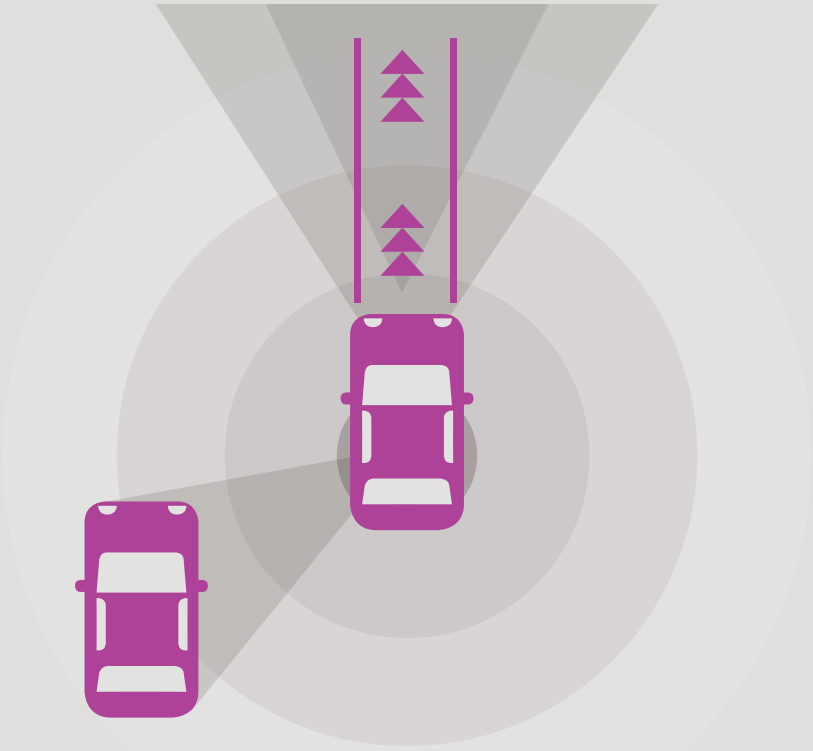
Regional broadcast services
Broadcast-like services with a regional reach will be required, for example within 1-100 kilometres. A typical scenario includes communication of traffic-jam information. Regional emergency notices can include disaster warnings. Unlike the legacy broadcast service, the feedback channel can be used to track delivery of the warning message to all or selected parties.



Real-time kinetic interaction lets viewers talk to their television sets, answer questions by raising their hands and call up stats to see how their neighbors have prepared for the oncoming storm. Just to mention a few future applications supporting traditional broadcasting.

HIGH-USER MOBILITY NETWORKS

BEYOND 2025, THERE will be a growing demand for mobile services in vehicles, trains and even aircraft. While some services are the natural evolution of the existing ones (navigation, entertainment, etc.), others represent completely new scenarios such as broadband communication on commercial aircraft (e.g. by an onboard hub). Vehicles will demand enhanced connectivity for in-vehicle entertainment, accessing the internet, enhanced navigation through instant and real-time information, autonomous driving, safety and vehicle diagnostics. The degree of mobility required (i.e. speed) will depend on the specific use case.

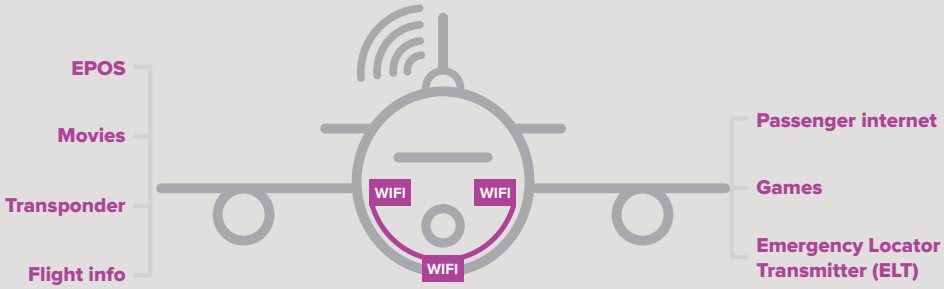


3D connectivity: Connected vehicles and automated driving

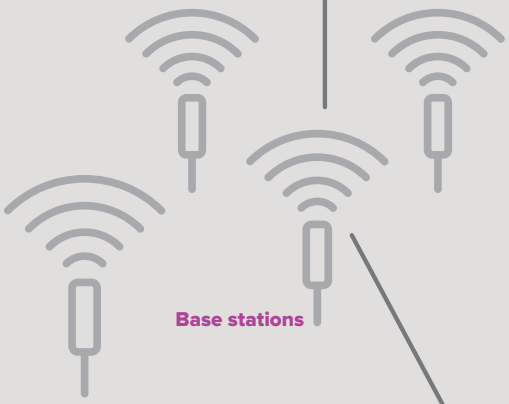
According to Gartner, there will be a quarter billion connected vehicles on the road by 2025, enabling new in-vehicle services and automated driving capabilities. During the next five years, the proportion of new vehicles equipped with this capability will increase dramatically, making connected cars a major element of the Internet of Things (IoT).

The connected car is already a reality, and in-vehicle wireless connectivity is rapidly expanding from luxury models and premium brands like Tesla, to high-volume midmarket models. The increased consumption and creation of digital content within the vehicle will drive the need for more sophisticated infotainment systems, creating opportunities for application processors, graphics accelerators, displays and human-machine interface technologies. At the same time, new concepts of mobility and vehicle usage will lead to new business models and expansion of alternatives to car ownership, especially in urban environments.

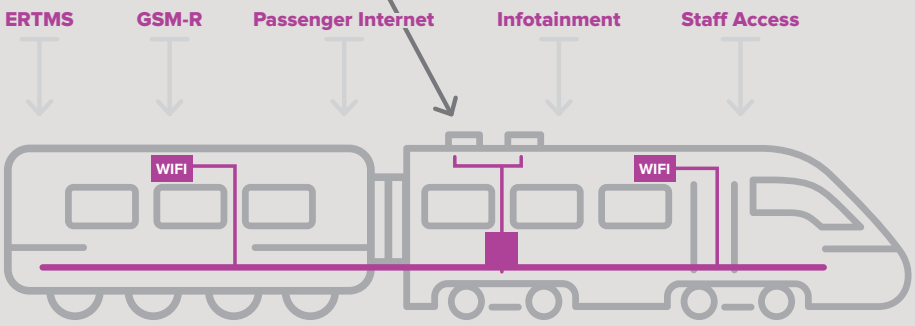
However, in order for this forecast to come true, substantial investments in roadside wireless connectivity, so called digital roads, need to be conducted all over Europe.



3D connectivity: Aircraft
Civil aviation will implement commercial connectivity services in 2025+, and the passenger services offered will comprise applications similar to those available on the ground. Typical aircraft routes are up to 12 kilometres in altitude, while objects like helicopters will usually fly at much lower altitudes.



3D connectivity: High-speed train
High-speed trains are used in various regions for inter-city transport and will evolve further beyond 2025; these high-speed trains can reach speeds greater than 500 kilometres per hour. While travelling, passengers will use high-quality mobile internet for information, interaction, entertainment or work. Examples are watching a HD movie, gaming online, accessing company systems, interacting with social clouds or having a video conference. Providing a satisfactory service to up to one thousand passengers at a speed of 500 kilometres per hour may be a great challenge. In addition, providing an acceptable end-to-end latency will become a challenge for office-like applications.



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EXECUTIVE SUMMARY

THE WORLD OF digital communications is split in two. The big, commercial world encompasses most of what we do online. The small world reaches out to us when things go wrong.

The future will have room for both these worlds, but the smaller and arguably more important part will be the one that serves the greater good of society.

Because technological progress will not only provide us with services such as high-resolution streaming video to mobile devices. It will also help us monitor our health, keep us out of harm's way in traffic, save us from hazardous and tedious work; maybe even save our lives in an emergency. And it will be nationwide so we can be reached wherever we are.

In technical terms, demands for high-speed applications delivered to moving vehicles will only increase, as will delay-sensitive video applications with high data rates. The ever-growing complexity, variability and sheer volume of smartphones and wearable devices will place high performance requirements on supporting delivery networks.

More professional users will demand ultra-low latency and mobility-on-demand for connected objects. A best-effort delivery will suffice for some users, while health and safety applications will demand reliable and ultra-reliable performance. All these will need to be delivered across a wide range of devices and machines, as well as across a variety of environments.

The Next Generation Mobile Networks Alliance (NGMN) has grouped more than 25 future envisioned use cases into the eight families above.

IT IS IMPORTANT to understand that no currently existing infrastructure can support all these services. A new system is necessary, where mobile, wifi, trunked and broadcast networks merge into the same joint wireless infrastructure: 5G. Efforts to develop this system are already underway.

BACKGROUND

THIS IS A white paper from Teracom. Its objective is to peek into the future of our industry, not primarily to seek out business opportunities, but to find ways in which we can make ourselves useful to society.

We won't look too far ahead. Predictions tend to get fuzzy when you look farther than ten years, so that is as far as we go. Nevertheless, enough amazing things will happen in that time span to keep us excited, and hopefully you too.

Imagine your kids playing virtual catch with a cartoon character on your television screen. Or you clearing away debris from a mine 12,000 kilometres away. Imagine being saved from a burning building by a remotely controlled, flame-resistant robot.

All these scenarios are on their way to our lives, but they will require an extensive upgrade of the wireless systems we have in place today. Systems will need to be lightning fast, ultra-reliable and/or handle massive amounts of data.

Companies and organisations like to talk about how quickly they react to the demands of the market. We think a little differently. We don't mind making money, but we also want our efforts to mean something. We want to matter to the safety, security and well-being of everybody we serve.

If our actions didn't contribute to that, the future wouldn't feel quite as bright.

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