AIG

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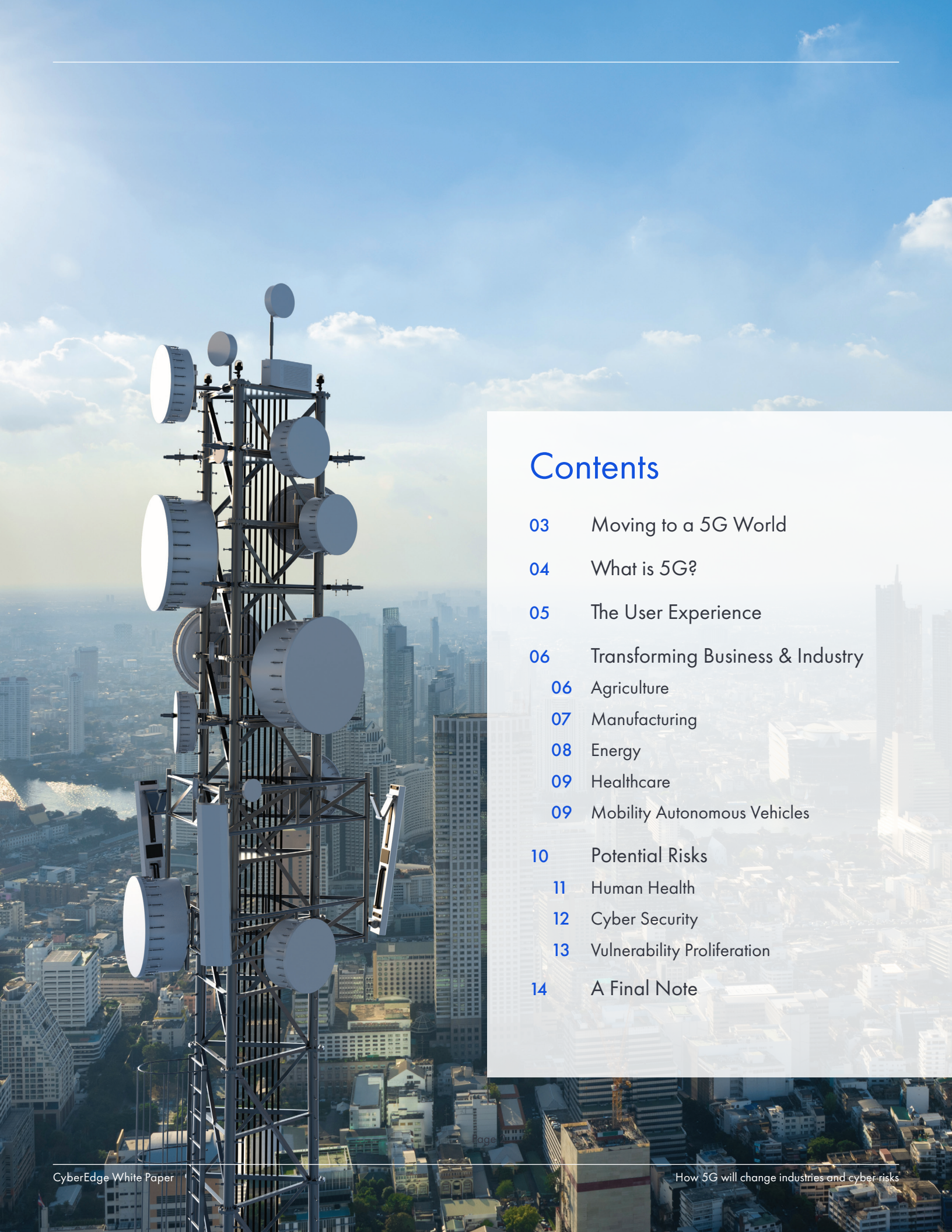
Transformation ahead:

How 5G will change industries and cyber risks



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Moving to a 5G World

5G is likely to usher in a world of new industries, technologies and modern conveniences. It could significantly reshape every aspect of how we live our lives from transportation, to entertainment and medicine.

The year is 2013. Owners of New York yellow taxi medallions – valued at over $1M each – are riding in style and bringing in $2.3 billion across 175 million annual rides[1]. Quietly, 3,000 miles away, employees of a group of unknown companies with names like Uber and Lyft are slouched over laptops, quietly tinkering, perfecting the technology that will upend terrestrial transportation. Slowly, year-by-year, regulatory-slog-by-regulatory-slog, the tide shifts, and five years later the taxis are traipsing the streets of Manhattan, top-lights-lit, looking for passengers and staring at their $150,000 medallions wondering: where did 85% of my fortune go?

Fortunes are made and lost by the continuous march of technology. Just ask Blockbuster Video stockholders. In September 2010, Blockbuster declared bankruptcy, rendering the value of its stock worthless. Since then, a different group of stockholders – those of Netflix – are doing much better. The value of $1 invested in 2010 grew to around $20 in 2020[2]. Now, many companies, like Apple, Amazon, Comcast, and Disney, are aggressively battling to own the delivery of digital content knowing that their futures could depend upon it.

What do these two stories have in common? Both were enabled by a seemingly small change to wireless technology – the shift from 3G to 4G. Now, we're on the doorstep of the next big shift – the move to 5th generation wireless or "5G." And, the disruption will likely be *far more dramatic and widespread* than yellow cars or the company that serves up your favorite Nicolas Cage movie. 5G could revolutionize *all industries* ushering in a future we can't even imagine – the hyper-connected, device and sensor rich one that's been promised but hanging stubbornly out in the distance.

What's so different about 5G? In short, it is *massively* faster than 4G. This speed will spawn new industries, companies, services and conveniences. In a 5G future, soldiers injured in war may be operated on by doctors that are thousands of miles away (until they're completely replaced by remote controlled robots). Gamers in Los Angeles could inhabit a virtual world with teammates from Madrid, Singapore, Stockholm and Tokyo to battle the forces of evil and save planet Earth – at least in their minds. Autonomous trucks should achieve previously unheard of levels of fuel efficiency, reliability, durability and – most importantly – *safety*.

This last point can't be underemphasized – auto accidents are the second leading cause of injury death in the United States[3], and a significant cause of injury death in many other countries. The move to autonomous vehicles should dramatically reduce human suffering and reshape mobility – *again*.

As with all technological advancements, the benefits are balanced by the risks. As 5G ushers in a highly connected and efficient world, it will dramatically increase the cyber "attack surface." It will also expose us to higher frequency radio waves that have been the focus of some concerned citizens. But, as with all new risks, science and data must be brought to the table to separate the wheat-from-the-chaff (teaser we think the cyber risk is much greater than the human health risk...read on).

What is the Risk Manager's role in this transition? It is to aid the executive team in analyzing and understanding the shift to 5G. Data, facts, and analysis will allow executives to shape new business strategies, and, most importantly, prepare for the potential unforeseen, unintended or accidental consequences. This will support business success in a 5G world. In short, proactive risk managers will heed the advice of management guru Peter Drucker and "prepare for the future that has already happened" today. We hope that this paper helps move Risk Managers one step closer to that goal.

1. 2014 Taxicab Factbook: www1.nyc.gov/assets/tlc/downloads/pdf/2014_tlc_factbook.pdf
2. Adjusted close price of $22.92 on 9/23/10 vs. $470.61 on 9/23/20 as reported by Yahoo! Finance.
3. www.cdc.gov/injury/images/lc-charts/leading_causes_of_death_by_age_group_unintentional_2017_1100w850h.jpg

What is 5G?

Since the introduction of 1G in 1982, each new generation of cell phone technology has improved and optimized *data transmission speeds*. 5G, the fifth-generation of cellular technology, is expected to be 20 times faster than its predecessor. It will also markedly increase capacity, allowing one million devices per square kilometer to connect and transmit data. Its biggest differentiator, however, is *decreased latency* – or the time it takes for data to connect to another device. Under ideal circumstances, 5G networks should offer users a maximum latency of 4 milliseconds; 4G has 5 times as much "lag time."

To achieve these improvements, 5G accesses higher frequency bands of the radio wave spectrum (see Figure 1). Mobile phone operators use a portion of the spectrum and different devices, including cell phones, operate at different frequencies. As more devices operate on a certain frequency, the amount of capacity decreases. There is also increased risk of interference among radiofrequency waves. To remedy this, additional radiofrequency ranges – called bands – are opened up and allocated over time.

The International Telecommunications Union (ITU) is the United Nations Agency responsible for coordinating the shared global use of the electromagnetic spectrum including 5G bands. The ITU indicates that 5G should have *no mobility interruption* and *greater spectral efficiency*, allowing more data to be transferred across a network without error. Devices should work seamlessly within, and transferring to other networks. The trade-off, however, is that *higher frequency* waves travel shorter distances and face *greater interference* from man-made and natural structures and weather. A large number of signal boosting antennae will be installed to facilitate signal transmission. Several carriers, including Verizon, AT&T and T-Mobile, are building 5G networks across many U.S. test cities, and many other telecommunications companies are doing the same across the globe.

SPOTLIGHT

The Evolution of Mobile Technology

The first generation of cellular devices, introduced in 1982, operated on analog signals – or audio signals translated into electronic pulses – and was voice calls only.

In the early 1990s technology allowed for digital signals, enabling packet-switching, when small units of data combined in "packets" are routed through a network based on the packet's destination address. This allowed for more efficient movement of data and additional services, such as text messages.

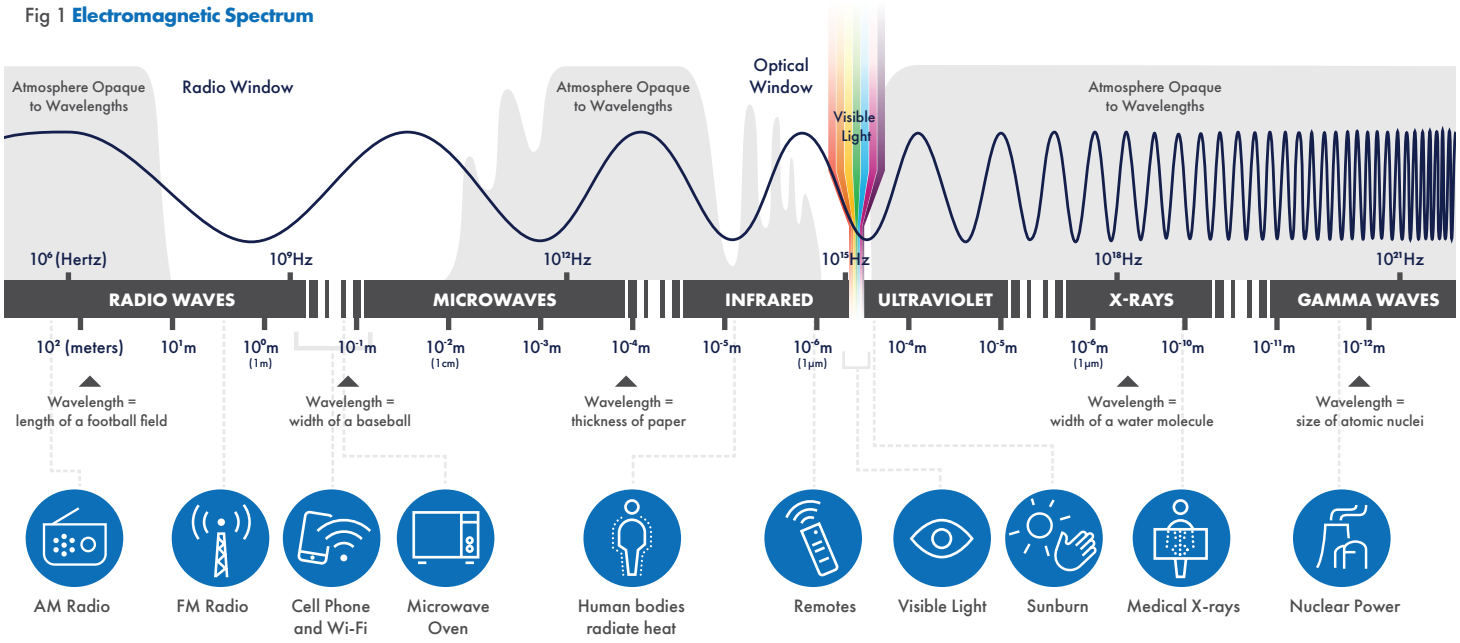
With the number of cell phones increasing drastically by the late 1990s, the ITU stepped in and created standards. 3G High Speed Packet Access (HSPA), which further increased data speed and capacity and decreased latency. HSPA allowed for wireless internet access and the creation of smart phones.

In 2008 the ITU released standards for 4G which differed from previous generations in two important ways:

- The adoption of a Long-Term Evolution (LTE) network. LTE consolidated previous networks to create a largely unified system across the world.
- Multi-input, multi-output (MIMO) technology. Older wireless communications used a single antenna at the source of the communication and another single antenna at the destination. Multi-input, multi-output (MIMO) technology allowed for the use of multiple antennas at both the origin and destination points.

Like its predecessor, 5G will rely on packet-switching technology, which has advanced beyond its previous capabilities. 5G will likely utilize a new variation of MIMO technology, known as massive MIMO.

Fig 1 **Electromagnetic Spectrum**



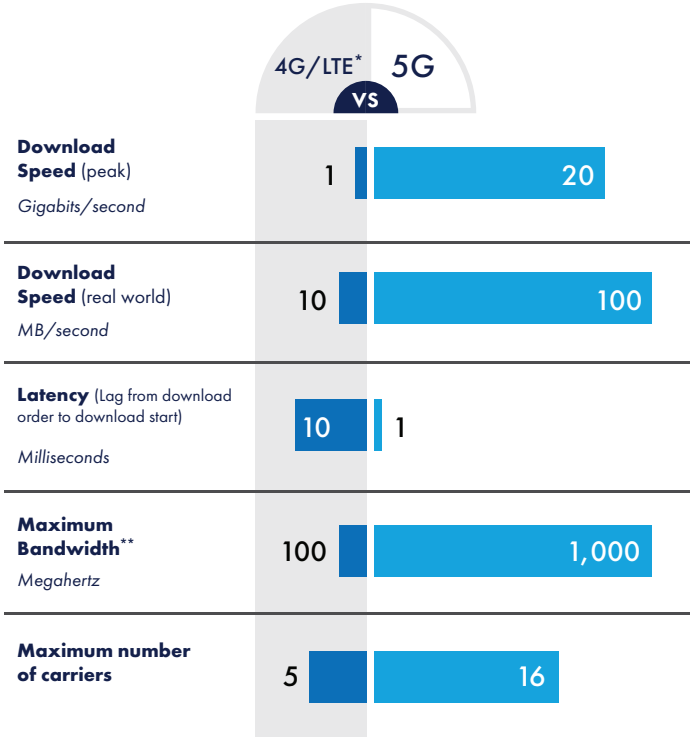
Source: NASA

The User Experience

Reduced latency will be the biggest change in user experience. Service should be seamless: if working properly, a user will never notice a gap in coverage or slow speeds. Initially, the 5G benefit will likely manifest as increased convenience and fewer frustrations. But, latency problems are not just inconvenient; they are an obstacle to *rolling out transformative technology*. For example, 5G-enabled virtual reality can be used in critical applications such as medical operations. Reducing lag time would allow surgeons to operate on patients thousands of miles away. This would broaden access to life saving medical procedures for millions of people in remote areas.

5G can also enable exponentially more connected devices. The world is already highly device-rich and interconnected. Doorbells, smart speakers, watches and thermostats – the number of such devices can grow materially with 5G. It will likely also bring more convenience and greater safety. For instance, autonomous vehicle safety features could eventually reduce the nearly tens of thousands of traffic fatalities worldwide. 5G will support taking autonomy to scale by enabling real-time data tracking and communication between cars, roads and other devices.

Fig 2 **Comparison of key performance specs of 4G and 5G networks**



* specs for LTE-Advanced, release 10-12
** used to distribute the signal through the air

Source: StatistaCharts / Android Authority

Transforming Business & Industry

5G has the potential to transform not only our daily lives but also virtually every industry. Here's how it could impact a few.

Agriculture

In 2006, the UN Food and Agriculture Organization estimated that feeding a world populated by 10 billion people in 2050 will require farmers to grow 70% more food[4]. "Smart Farming," powered by connected sensors, will dramatically move us toward this goal. Smart farms collect information such as soil moisture, fertilization levels, and weather patterns and transmit it to a central hub. At the hub, software programs using artificial intelligence analyze the data and recommend short- and long-term operational performance improvements.

Smart Farming with 5G could move beyond "end-of-day" analytics acting on data in real-time, boosting productivity and optimizing management of crucial resources. Two examples are water management and food waste:

- Water Management: Climate change is driving disparities in local water supplies and making rainfall patterns unpredictable. Proper water management is essential to sound, stable and sustainable farming. Sensor technology has already enhanced the ability to deliver the right amount of water to crops. With 5G connectivity, farmers and watering systems could more precisely track which crops need water and how much improving use of this highly valuable, increasingly limited resource.

- Food Waste: The U.N. notes that 1/3 of food produced globally is not consumed[5]. This tremendous waste creates environmental and human impacts. Much of the waste comes from inefficiencies in the food supply chain which can occur from delays in shipping promptly from the farm, through the distribution system, on to the end consumer. 5G sensor technology and connectivity could allow more precise and prompt matches between farmer and buyer, better tracking of temperatures and humidity throughout the supply chain, and stronger inventory management to help shipments get to the right place at the right time.

4. www.wri.org/publication/creating-sustainable-food-future
5. www.fao.org/3/i3347e/i3347e.pdf

Manufacturing

Automation and robotics have dramatically changed manufacturing, increasing worker productivity, changing workforce dynamics and improving worker safety. With 5G, we can expect further advances of "Industry 4.0." The National Institute of Standards and Technology defines "Industry 4.0" or "Smart Manufacturing" as "fully-integrated, collaborative manufacturing systems that respond in real-time to meet changing demands and conditions in the factory, in the supply network, and in customer needs."

5G can push smart manufacturing beyond simply using sensors to help an automated system work better and smarter. 5G's instant connectivity and enhanced sensors bolster the "digital thread" that circulates information throughout all parts of the manufacturing system. Today, sensor technology allows stronger tracking of product, process, and workflow within a facility. 5G can allow seamless connectivity for multi-facility operational and safety management – taking the "digital thread" outside the factory walls to multi-company manufacturing operations. Industry 4.0 systems could track materials and ingredients upstream and downstream through the entire supply chain and to and from customers. This would allow further efficiencies and complexities throughout already intricate and globalized supply chains.

SPOTLIGHT:

5G Manufacturing Examples

5G's capabilities should enable manufacturers to leverage automation, machine learning, artificial intelligence, augmented reality (AR), and IoT.

Robotic assembly lines could be controlled, monitored, and reconfigured remotely over the 5G mobile network. AR capabilities would be expanded leading to support for training, maintenance, construction, and repair. It can enable companies to conduct remote operations – identifying and tracking goods, inspecting situations, and monitoring machine operations in real time.

Energy

The importance of reliable energy cannot be overstated. Outdated energy infrastructure, and costly upgrade and maintenance costs are common across developing and developed economies. Moving to a "smart grid" could revolutionize energy management, generation, distribution and consumption in the coming years – and 5G will support a more reliable and efficient energy infrastructure.

Monitoring and controlling energy production and consumption is key to reliability and efficiency. This requires better tracking and control of energy flows from point A to point B, and management of energy flow into the grid. With sensors distributed across the infrastructure, automated and human-managed systems could better adapt to changing conditions. For example:

- Tracking energy use in real-time can allow utilities to better match energy production to use rather than relying on historical information;
- Energy usage data can be combined with weather and other environmental data, allowing utilities to maximize alternative sources – like wind and solar – where and when conditions allow. Shifts to backup natural gas and other sources could compensate for shortfalls before the wind stops blowing or sun is obscured by clouds;
- Better data and analysis on usage and production could allow for more dynamic reporting, motivating energy conservation while encouraging investment in production especially alternative sources.

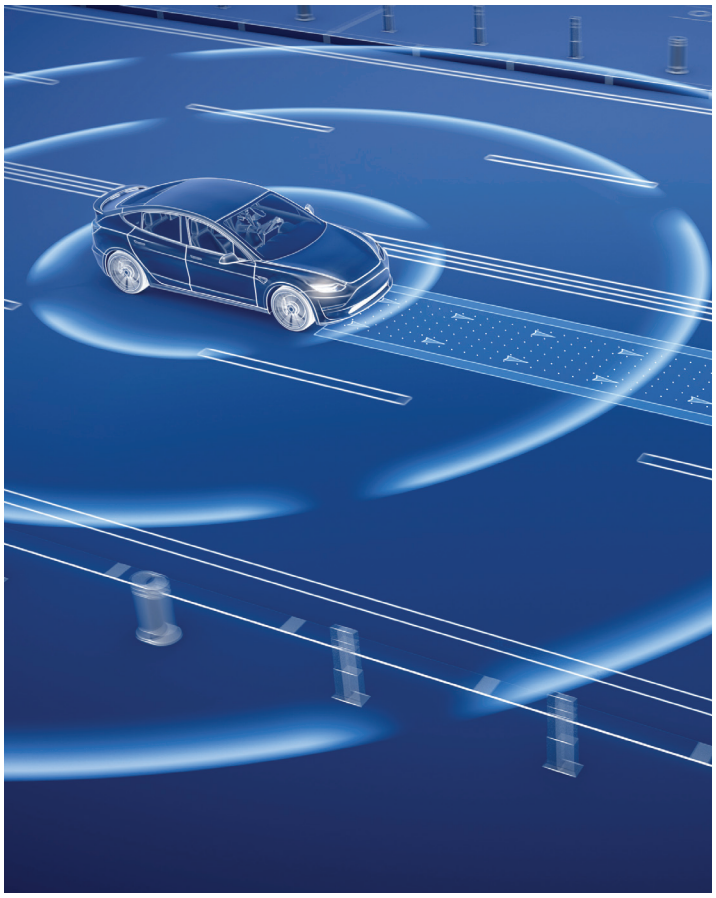
Capturing data via sensors would allow energy companies to proactively decrease energy consumption – both at the individual and system levels. Companies and municipalities would also benefit – understanding their usage data, adjusting and achieving cost savings and efficiencies. Innovative new risk transfer products – such as parametric weather bonds – may also emerge as richer data sets would be available on energy trends. These benefits must be weighed against the cost of inadvertently opening up the grid to excessive cyber vulnerabilities.

Healthcare

5G can enable the full possibilities of telemedicine- connecting healthcare providers and patients across distances. The need for telemedicine became evident during the early stages of the coronavirus crisis, and occurs not just when there are concerns about communicable disease, but also in rural areas, warzones, or any place where patients can not physically access doctors.

Using IoT devices, healthcare workers can accurately assess patients and provide better care. Wearables can provide reliable, real time monitoring for preventative care. Medical data including high resolution MRI and CT images can be captured and transmitted accurately in high resolution via 5G allowing more efficient medical collaboration. With increased reliability and reduced latency, 5G networks would even allow for complex surgical procedures when a specialized surgeon is unavailable locally.

Augmented Reality (AR) is another technology made possible by 5G. Medical imaging has advanced tremendously but the method for displaying the images has not. Doctors are limited to viewing individual, independent, two-dimensional images. AR, a combination of technologies that overlay digital information on the physical world, changes this. Using head-mounted displays, doctors can superimpose images, such as MRI and CT scans, onto a patient's body providing a more accurate and precise representation, and cohesive representation of health issues.



Mobility: Autonomous Vehicles

Autonomous vehicles are already on the road. However, they largely operate as standalone units with minimal input from external sources for geolocation and other data. A fully integrated 5G network could create seamless traffic "ecosystems" with on-board and off-board devices continuously communicating. Each vehicle could share data that would impact decision making beyond its four doors communicating broadly with other nodes in the ecosystem. This will require near-zero latency: a vehicle cannot wait more than a few milliseconds (max 20) to receive information, process it and make the right decision.

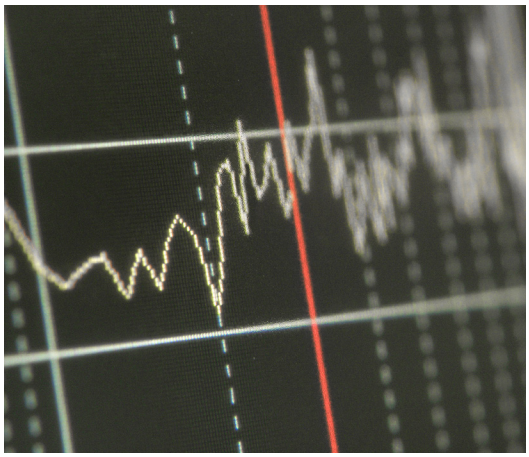
A true 5G network would address another hurdle – promoting standardization in autonomous technologies. The many autonomous vehicle manufacturers will be motivated to work together because their vehicles must. Vehicles from different manufacturers will need a common "language," data standard and "handshakes" to ensure that they understand and don't conflict with each other. 5G will require a degree of collaboration and cooperation that we have not seen before with other technology standards.

Potential Risks

5G benefits will likely significantly outweigh the costs. But, as with all new technologies, the rollout has precipitated warnings of potential risks. Some of the most cited risks include the human health impact of exposure to 5G radio waves and a substantial increase in cyber risks.

5G technology will require many signal boosting antennae that will be installed in high density clusters. There will be many more devices transmitting high frequency 5G signals versus current 4G. This has stoked fears that humans may be harmed by exposure to large amounts of "new" frequency waves. However, the current scientific literature shows no adverse consequences of exposure to 5G waves and devices. While there will be continued studies on human health, any claims that 5G is harmful today are not supported by science and data.

Increased connectivity brings tremendous benefits, but also increased cyber risks. There will be *more* and *new types* of connected devices. The new devices will create new security challenges. And, if the future mirrors the past, it is likely that IoT devices will have substandard or inadequate cyber security. The bar is high for these devices – even seemingly "perfectly" secured devices will exhibit unforeseen security flaws. And, the vast quantity of data produced and transferred will be targeted by thieves seeking big dollars and competitive advantage.



Human Health

5G will open new portions of the electromagnetic spectrum to accommodate the vast number of new devices. Some are speculating that the "new" or increased level of radiofrequency exposure will harm people. However, currently there is no published scientific research within the U.S. National Library of Medicine database linking 5G technology to any negative health impacts.

Some of the health effect allegations are alarmist and unsubstantiated. Claims that 5G will cause cancer because it is a form of radiation are misguided. 5G, like FM and AM radio waves, light bulbs and WiFi, are "non-ionizing," meaning that they do not break chemical bonds (see Figure 1 earlier). X-rays which are used for medical procedures and gamma rays which are used for nuclear power are ionizing and therefore have the potential to cause human harm (thus the lead vests and safety equipment used in such settings).

Electromagnetic hypersensitivity is a hypothesized disease in which people experience debilitating symptoms from exposure to non-ionizing radiation. People have claimed such sensitivities for several decades, but controlled studies have failed to show correlations between exposure and symptoms and little scientific evidence exists. If such a disease exists, the increase in ambient 5G waves could influence this population.

Some of the concern also stems from the fact that we simply do not know exactly if and how the new exposure will cause harm. While not a perfect analogue, there is significant scientific research on the health effects of exposure to cell phones and 4G. Several studies, largely authored by one researcher, have found a correlation between brain cancer incidence and cell phone use. However, the research is highly controversial given that the overall rates of brain cancer have decreased across decades in which cell phone use expanded *exponentially*. Many other scientific studies have found *no relationship* between cell phone use and brain cancer.

5G will continue to attract scientific scrutiny in coming years. One published study hypothesized that human skin – and sweat glands in particular – will absorb higher frequency 5G waves more easily than prior wireless generations[6]. While harm has not been proven, researchers are trying to create a baseline of human exposure to wavelengths to properly assess any changes when more signals are transmitted in the 5G world[7].

6. Betzalel eg al., The Human Skin as a Sub-THz Receiver – Does 5G Pose a Danger to it or Not? Environmental Resources. May 2018.
7. Carlberg et al., High Ambient Radiofrequency Radiation in Stockholm City, Sweden, Oncoll Lett. 2019.

Cyber Security

5G presents noteworthy challenges to cyber security. Most notably, 5G will dramatically increase the attack surface via the significant number of new devices, networks and connections. New devices will inevitably have security flaws and vulnerabilities. Attackers will have more targets and devise new attack types that may be unfamiliar to security researchers. Such attacks have the potential to impact not only data confidentiality, integrity and availability, but also human health and well-being.

Moreover, attackers could leverage the new devices to build "digital armies" or "destructive bots." The world had a preview of this in 2016 when attackers built the Mirai botnet using the computing power of routers, security cameras and other connected devices. The bot launched a crippling distributed denial of service (DDoS) attack on Dyn – a leading provider of Domain Name System (DNS) services – leading to outages across many prominent web platforms like Twitter, Netflix and CNN, among others. The potential for bigger and more destructive bots will grow with 5G.

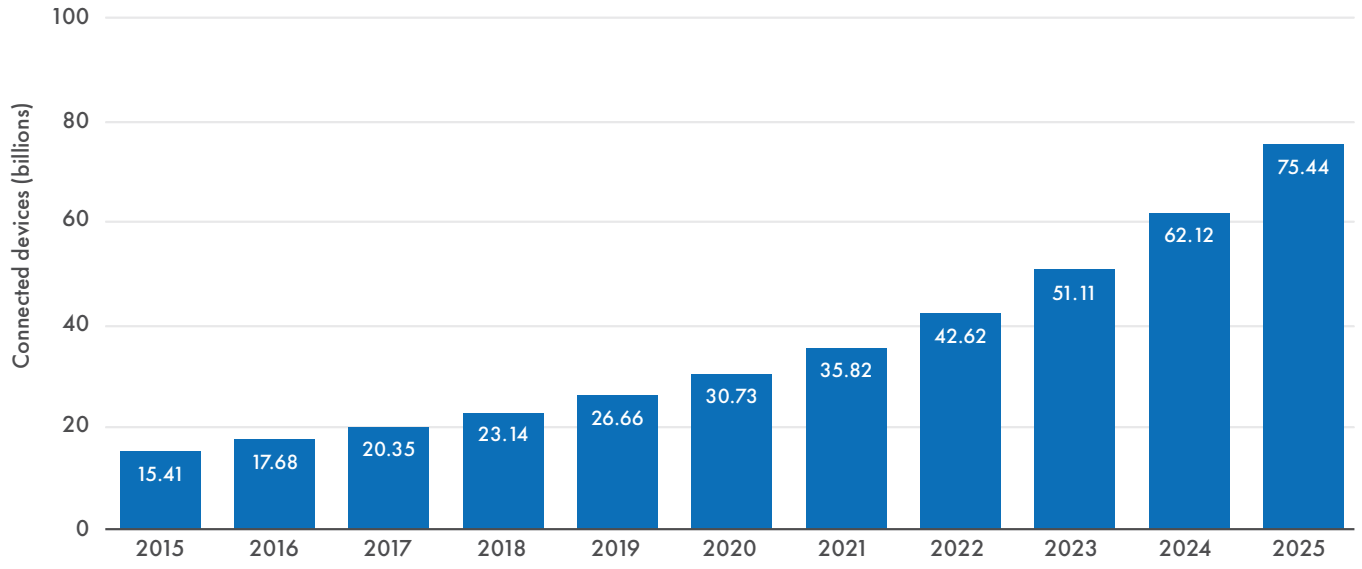
Additionally, 5G will create bigger, richer and highly valued data sets that will be targeted by financially motivated attackers. Attackers will look for ways to steal and monetize the data either by selling it, using it directly to build new products or technologies, or simply "locking it up" and demanding ransom payments (as we've seen lately). Companies will need to up their cyber security game to protect their highly valuable data assets, but also comply with regulatory requirements which are sure to grow with the implementation of 5G.

IoT DDoS Attack Liability

On October 21, 2016, Dyn, an internet service provider, was the target of a DDoS attack. The attack caused major internet platforms, including Amazon, Netflix, and Twitter, to be unavailable to millions of customers for several hours. The primary source of the attack was a malicious malware called Mirai, which targeted IoT devices, converting them into "botnets," networks of malware-infected connected devices that can be used to send an overwhelming number of requests to the target's server. Hundreds of thousands of devices were targeted, including security cameras and DVRs used in home or office settings.

The IoT explosion enabled by 5G will also provide attackers with an opportunity to hack into vulnerable connected devices for the purpose of building botnets, similar the Mirai DDoS attack. While the legal liabilities are unclear, Companies who suffer financial losses due to a DDoS attack could potentially sue the manufacturers of the IoT devices used in the attack.

Fig 3 **Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)**



Source: Statista

Vulnerability Proliferation

5G will also expand the number and nature of critical security vulnerabilities. It will depend on new software and hardware products that will be produced quickly to capitalize on the 5G opportunity. In some cases, developers will sacrifice security for speed which may lead to negative outcomes. The track record of securing existing IoT devices bears this out – as some manufacturers have cut corners on security allowing Mirai-like attacks to occur.

This trend may grow as smaller and more specialized technology companies look to capitalize on the 5G opportunity. Often smaller companies have more limited security expertise and / or smaller cyber security budgets than major cell phone or computer manufacturers. Further, economic incentives may not exist to properly nudge companies to do the right thing and secure devices at the design stage. This calls for industry leadership in setting common device standards and adhering to sound principles and practices in the design of connected devices.

Lastly, the potential for "accidental" failures should not be overlooked. The 5G ecosystem will consist of hardware and software processing data across a distributed network. Research is needed to fully understand the interaction of devices across the network, identify failure points and proactively implement risk controls to minimize the chance of failure. Such accidents could be caused by simple human errors, a lack of understanding device interactions or data transmission, or even simple external factors such as weather or natural disasters.

Nation State Security Concerns

Cyber security is increasingly a national security concern and this is the case with 5G. Many countries are taking measures to manage potential national security / cybersecurity risks involved with 5G. The European Union has proposed coordinated risk assessment and risk management procedures across the EU. The United States has expressed concerns over Chinese telecommunications companies involvement in 5G infrastructure. Built-in back doors in 5G equipment and software could expose countries and companies to cyberattacks and/ or espionage.

A Final Note

The world is likely on the precipice of a revolutionary change. 5G could dramatically improve the quality of life, health and well-being, but also open us up to new risks. Proactive risk managers need to begin to prepare today for the "future that has already happened."[8] On one hand, companies stand to dramatically reshape their business models and improve profitability – like Uber and Lyft did several years ago. On the other, company risk profiles will change resulting in a need to reassess risk assessment, controls and investments.

AIG looks forward to partnering with companies as they work through this risk evaluation. We are committed to providing support, and working with companies, universities, researchers and governments to ensure that the move to a 5G world happens safely, securely and expeditiously. This is at the very heart of our mission – "helping clients prepare for what's next."

8. https://hbr.org/1997/09/looking-ahead-implications-of-the-present

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