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## 5G: IMPACT & FUTURE OF CONNECTIVITY

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**Abstract:** The mobile industry is developing and preparing to deploy the fifth-generation (5G) networks. The evolving 5G networks are becoming more readily available as a significant driver of the growth of IoT and other intelligent automation applications. 5G's lightning-fast connection and low-latency are needed for advances in intelligent automation—the Internet of Things (IoT), Artificial Intelligence (AI), driverless cars, digital reality, blockchain, and future breakthroughs we haven't even thought of yet. The advent of 5G is more than just a generational step; it opens a new world of possibilities for every tech industry. The purpose of this paper is to explore how 5G can enable or streamline intelligent automation in different industries. This paper reviews the impact and applications of 5G technology in different key industries, and highlights its role in shaping the age of unlimited connectivity, intelligent automation, and industry digitization.

**Index Terms - 5G Technology, Augment Reality (AR), Virtual Reality (VR), latency, IoT, automation, smart grids.**

### I. INTRODUCTION

The next generation of wireless technology 5G could affect a wide range of industries, from healthcare to financial services to retail. The 5G technology enables faster data transfer speeds — up to 10x faster than the speeds achievable with older standards — lower latency, and greater network capacity. As a result, 5G creates a tremendous opportunity for numerous industries, but also sets the stage for large-scale disruption. Even as the momentum builds to deploy 5G networks the world-over, there is widespread anticipation about the transformative capabilities of the next-gen wireless phenomenon. It's a given that the 5G era will deliver higher speeds and expanded connectivity on multiple devices— reasons why it will change lives forever. According to a recent forecast, the global 5G core market size is projected to grow from USD 630 million in 2020 to USD 9,497 million by 2025.

### I. WHAT IS 5G?

5G is the next generation of wireless cellular technology. It will provide speeds faster than any previous generation — up to 3000 Mbps (3 Gbps) in the real world, depending on the conditions and the tech being used — competing even with those delivered via fiber-optic cables. Movies that took minutes to download with 4G will take seconds with 5G. While smartphones and other mobile devices are the obvious use cases for 5G, there are many other applications for the technology. The internet of things (IoT), for example, will benefit tremendously from the speed and bandwidth provided by 5G, especially as the industry grows. In 2020, there were an estimated 12B IoT connections globally, according to IoT Analytics. By 2025, it's anticipated that there will be more than 30B IoT connections around the world, more than 4 IoT devices for every person on Earth. Autonomous vehicles, robotic surgery, and critical infrastructure monitoring are just a few of the potential applications of 5G-enabled IoT.

### II. INDUSTRIES BEING DISRUPTED BY 5G

5G's quantum leap in connectivity creates tremendous opportunities for numerous industries but also sets the stage for large-scale disruption. Industries such as healthcare, manufacturing, and auto are already adopting technologies and becoming more connected. Once 5G becomes widespread, the effect on these industries could be transformative for 3 main reasons:

1. 5G offers **lower latency**, enabling faster transmission of larger data streams
2. 5G is **more reliable**, enabling better transmission of data in extreme conditions
3. 5G is **more flexible** than Wi-Fi and can support a wider range of devices, sensors, and wearable's

Let us look at how 5G can create significant economic impact across key industries by unlocking multiple use cases:

### 1. Manufacturing (Accelerating Industrial Automation in Manufacturing)

The impact of 5G on manufacturing could be huge. It's estimated that improved connectivity through 5G will create \$13T in global economic value across industries by 2035, according to IHS Markit. A third of that total is projected to come from the manufacturing sector alone.

The manufacturing industry has already started adopting artificial intelligence and IoT technologies to increase efficiency, improve data collection, and build better predictive analytics. With 5G, manufacturers gain a faster, more reliable means of collecting and transmitting that data, as well as a broader range of sensors and devices they can integrate into their factories and workflows. 5G technology could help production operations in the manufacturing industry become more flexible and efficient while enhancing safety. This would enable manufacturers to build "smart factories" that rely on automation, augmented reality, and IoT. And with 5G powering large amounts of IoT devices and sensors around the factory, artificial intelligence can be integrated more deeply with operations.

This next-gen wireless technology will also result in increased adoption of augmented reality (AR), as 5G networks offer the high bandwidth and low latency required for sustained augmented image quality. In a factory setting, this means AR could support training, maintenance, construction, and repair. Ericsson began testing augmented reality troubleshooting in its Tallinn, Estonia factory in January 2018. With an AR app, technicians can observe a part that needs maintenance and pull up the relevant schematics and instructions within their field of vision, drastically shortening the time it takes to complete the repair. Ericsson has also partnered with MTU Aero Engines, an airplane engine manufacturer, and Germany's Fraunhofer Institute for Production Technology to test 5G tech. Ericsson says that this initiative could lead to savings of around 27M euros for a single factory.



Fig: A technician repairs a circuit board using an augmented reality overlay at Ericsson's Tallinn factory.

### 2. Energy & Utilities (Energy efficient smart grids, meters, street lights)

5G-powered sensors can provide real-time insights into power outages and energy usage. Through 5G-connected smart meters, homeowners will have more information to better manage their energy usage. Using 5G-enabled drones for monitoring, maintenance, and inspections of energy infrastructure will boost efficiency and reduce environmental impact. 5G could lead to innovative solutions in energy production, transmission, distribution, and usage. It is also expected to unleash the next wave of smart grid features and efficiency. With more connected smart grids, energy management will become more efficient, reducing electricity peaks and energy costs overall. Faster connection speeds could result in energy grids being more efficiently managed, which, in turn, could lead to less downtime.

An example of a 5G-powered smart grid can be seen in Hawaii, where a system built in collaboration with Verizon analyses outages and monitors meters. Streetlights connected with 5G technology and equipped with sensors could dim if there aren't any people or vehicles on the road, thus saving energy. This approach could lead to savings of up to \$1B annually in the US, according to a report from Accenture.

Verizon believes that the energy industry will be a key demonstration of 5G's potential, with the company stating that the sector will be one of the "most significant test cases" for 5G technology.

### 3. Agriculture (real time monitoring & automation of agriculture machinery & Systems)

5G could have a major impact on the agricultural sector, especially on improving crop yield - an essential task, given that the world will need 70% more food in 2050 than it did in 2009 due to population growth, per the UN Food And Agriculture Organization. 5G could provide real-time data for farmers to monitor, track, and automate their agricultural systems, resulting in increased profitability, efficiency, and safety. In a high-risk industry such as agriculture, these increases in production and precision are vital, especially as climate change poses new threats to farmers around the globe.

Autonomous tractors, for example, may eventually use 5G to pair with drones to guide their work, like identifying which parts of a field need fertilizer.

Similarly, machinery manufacturer Blue River Technology uses chip maker NVIDIA's 5G-enabled edge platform to power its AI-based "See & Spray" technique. This method equips tractors with cameras that can discern a weed from a crop and can then spray the appropriate solution to kill or nurture the plant. 5G could also drive the adoption of IoT devices for farming, which will improve agricultural processes such as water management, irrigation, livestock safety & maturity monitoring, crop communication, and aerial crop monitoring.

The Food Resiliency Project is an example of an initiative that has brought together different stakeholders to find ways to apply 5G to farming. For instance, the project has combined edge computing technology, IoT deployments, and 5G networks to improve crop yields by continuously analyzing soil conditions.

#### **4. Retail (Real time e-product experience to customers)**

Over the last several years, retailers have invested millions in smart technologies to help customers shop more efficiently and check out faster while also collecting more data on the customer experience. From in-store analytics to visual recognition-driven shelf monitoring, all depend on or benefit from the ability to transmit large amounts of data and access high-throughput connections, which is why 5G stands to have such a large impact on the way retailers operate.

Current “smart shelves” incorporating RFID technology, for example, can tell a business owner the ratio of item pick-ups to sales and display dynamic prices. With 5G technology, shelves equipped with sensors could determine low stock on a product, ping a distribution center to restock its inventory, and dynamically monitor the progress of that shipment. The amount of data needed to move over the mobile network is too great for existing infrastructure, according to AT&T. Today, companies like Sephora use virtual try-on technology to help in-store customers see what a particular makeup would look like on them before they buy, but the product is constricted by data streaming limits. 5G technology eliminates such limit, we could one day be using data-heavy applications like trying on clothes in augmented reality with photo-realistic accuracy.

In February 2021, Verizon Business announced a new 5G-enabled mobile edge computing (MEC) platform developed in partnership with Deloitte and SAP. The platform promises to offer retailers real-time analytics on in-store consumer behavior via sophisticated sensor networks combined with augmented reality and artificial intelligence. Verizon’s platform could also solve some common retail challenges, such as real-time inventory management.

Verizon is also investing in startups working to bring new wireless technologies to the retail sector. In June 2021, Verizon partnered with British digital agency Digital Catapult to launch the Verizon 5G Immersive Retail Accelerator. The program will nurture early-stage telecommunications startups to develop new technologies for use in the retail and customer experience spaces.

#### **5. Real time Financial Services**

5G’s faster data transfer speeds mean more efficient, real-time financial services, from processing payments to credit checks to placing trades. 5G will drive a better user experience on mobile devices and increased adoption of applications like contactless payments and mobile wallets. It will allow improved privacy and security through rapid biometric communications and more efficient fraud detection.

5G connectivity could also allow wearable devices to share biometric data with financial services to authenticate user identity instantly and accurately. This will cut down the time it takes to on board new customers, approve loans, and more. On the back end, fraud detection tools will have access to more data and will be able to work more quickly.

Faster data transfer using 5G in financial services means more seamless transactions and processing, whether that be conducting a credit check, processing a payment, placing a trade, or transferring funds.

#### **6. Media & Entertainment (emerging synthetic media forms, such as holograms, avatars, and synthetic voices)**

5G is set to disrupt media and entertainment on many levels, including mobile media, mobile advertising, home broadband, and TV. It will also be crucial for improving experiences across emerging interactive technologies such as AR/VR.

Faster data transfer speeds and lower latency will support varied entertainment experiences from streaming to mobile viewing to VR. On a 5G network, movie downloads will decrease from an average of 7 minutes to just 6 seconds. 5G will save people an estimated average of 23 hours of loading time per month while browsing social media, gaming, streaming music, and downloading movies and shows. For media & entertainment companies, this amounts to a \$1.3T revenue opportunity by 2028, per an Intel and Ovum study. VR also opens up the possibility for better shared viewing experiences with others even when not in the same physical space, as well as more interactive types of viewing like immersive 3D experiences.

5G will power new types emerging synthetic media forms, such as holograms, avatars, and synthetic voices. 5G could even bring big changes to how sports are played. For instance, the NBA’s Phoenix Suns are working with Verizon on a 5G-fitted practice facility that features a system of HD cameras and sensors that pick up on everything from shot arc and direction to players’ limb lengths and movements. Trainers can then use these insights to fuel strategy, player development, and more.

#### **7. Healthcare (Wearable’s and remote patient monitoring (RPM))**

With the goal of reducing costs and improving health outcomes, healthcare spending is shifting towards preventative care. 5G offers an enormous opportunity for expanding preventative and monitoring practices via wearable devices. Such devices are already being used to track everything from sleep to blood glucose levels to physical activity, among other things. 5G’s faster speeds and greater network reliability will allow for the development of more complex devices, including those implanted directly into a human body rather than worn externally.

Microscopic cameras equipped with 5G will be able to provide real-time video streaming in and out of patients’ bodies, setting the groundwork for more remote diagnoses and other more complex telehealth practices.

5G will enable the widespread use of AI in healthcare and more automated workflows, while the adoption of 5G-supported AR/VR in care settings could improve training and procedures.

Better telemedicine services could contribute to more affordable and accessible care. The high throughput and low latency of 5G networks could mean potentially life-saving decisions can happen more quickly in care settings, whether inside of a hospital or remotely. A broad range of steps on the care journey can benefit from improved data transfer speeds, from high-definition telehealth video streaming to imaging diagnostics to sharing results with health care teams.

5G networks could facilitate remote surgery procedures as they enable lag-free and ultra-fast connections. Wearable’s and remote patient monitoring (RPM) drive a more proactive approach to diagnostics and treatment, leading to improved health care outcomes and decreased costs.

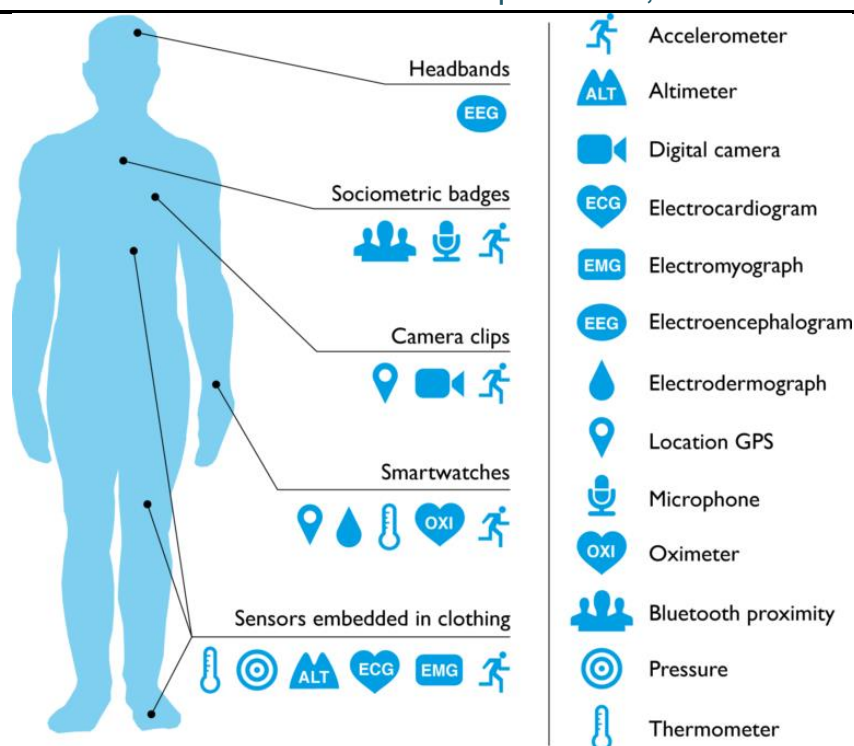


Fig: Examples of wearable's and the associated medical capabilities. Source: Plos Medicine

## 8. Transportation – Automotive (cellular-vehicle-to-everything – C-V2X)

5G will be critical to enabling autonomous vehicle operations, including handling the massive data requirements of cellular vehicle-to-everything (C-V2X) communications. 5G Automotive Association (5GAA), began work on “cellular-vehicle-to-everything,” or C-V2X, technology in 2016. Rather than cars determining individually how to act, in the C-V2X system, driverless vehicles communicate with one another and with parts of the physical environment like traffic lights and construction signs in order to coordinate movements safely and efficiently. The system is in a testing phase today, but researchers believe 5G could help enable truly autonomous driving in the future. The average autonomous car of the future could produce as much as 2M gigabytes of data per week, and moving all of that data to the cloud or a regional server isn't feasible today with Wi-Fi or 4G.

Public transit systems could become more efficient and flexible through real-time route planning and high-speed communications. Smart city functions such as smart traffic management, powered by 5G connectivity, could save time for drivers and cut down on fuel emissions. Connecting public and private vehicles with 5G could change the way people and goods travel around the world. 5G technology could provide increased visibility and control over transportation systems, from public buses to private logistics fleets.

As per a Carnegie Mellon University study, traffic lights that integrate real-time data on traffic patterns were found to reduce traffic stops by 40%, emissions by 21%, and commute time by 26%. As of May 2021, China is the only country in which vehicular technologies such as C-V2X are already commercially available. FAW Group Corp., a state-run automotive manufacturer, and BYD Co. Ltd. began offering vehicles featuring C-V2X technology in 2020, giving Chinese automakers a substantial head start on their American counterparts. Huawei, has been working with several European automotive companies, including Audi and BMW, to test experimental technologies such as remote-controlled driving capabilities using 5G.

Researchers believe 5G could help enable truly autonomous driving in the future. The number of automotive 5G connections is expected to reach 96M by 2027, according to telecoms consultancy Analysis Mason. 5G availability would mean a greater density of sensors in the environment and faster data transmission from centralized servers to those sensors and vehicles & equipping AI tools with the real-time data needed to keep things running smoothly.

## 9. Insurance (pay-how-you-drive policies)

With 5G, wearable's will instantly share health information with health insurers to inform policy decisions and create new products. As wearable 5G-connected healthcare devices gain popularity, health insurers could offer “positive reinforcement” policies, where premiums would be reduced if a certain level of activity or fitness is maintained.

As 5G ushers in a new era of autonomous vehicles, real-time data and reports could also be instantly sent to car insurance companies following an accident. Similarly, sensors that detect how safe someone is driving could play into an insurer's pricing decisions and allow behavior-based policies like “pay-how-you-drive.” With greater connectivity and improved data granularity, insurers can offer more to customers while making operations more efficient. Meanwhile, being able to access data from remote locations, provided by 5G-enabled devices like drones, will lead to more granular risk pricing and predictive analytics. The damage from a natural disaster could be more accurately and quickly assessed by mapping areas in advance using autonomous drones and then rescanning them soon after an incident.

## 10. Education (Live Classes, VR/AR)

With the explosion of remote learning amid the pandemic, a lot of education now takes place online, from streaming live classes to collaborating on group projects. In real-time applications like these, 5G promises to make learning more seamless, efficient, and engaging. It can also help bring immersive educational experiences to mobile devices, increasing flexibility in how teachers and students approach learning.

The remote learning boom has already accelerated the use of technologies like AI for everything from personalized curriculum planning to prevent cheating at home. These technologies will be able to operate more efficiently and effectively

through 5G's bandwidth and latency improvements. As 5G paves the way to better AR/VR experiences, teachers could use these technologies for futuristic education approaches. Universities are already looking to adopt 5G to boost their education offerings. For example, the University of Miami joined forces with AT&T in 2019 to install 5G on campus in order to create more experiential forms of learning, particularly through using AR developer Magic Leap's mixed-reality platform and headsets. These kinds of immersive learning experiences require the ultra-low latency afforded by 5G.

For students in high-stakes fields such as medicine and aviation, VR learning experiences could prove to be especially useful, as students can simulate intense situations without real danger to themselves or others.

### 11. Cloud & Edge Computing (cloud based smartphone apps)

With 5G, cloud computing's latency and throughput could be on par with local area networks (LAN). 5G in combination with edge computing will enable near-real-time communications and data processing in critical circumstances like autonomous driving. 5G's ultra-low latency and high throughput would allow the cloud computing experience on mobile devices to rival corporate LAN connectivity for desktops. Cloud-based smartphone apps, for instance, will function more consistently across settings.

This will catalyze further cloud computing adoption, which can be a boon for businesses, serving to lower infrastructure costs, accelerate software deployment, and increase operational flexibility. The cloud computing market is expected to grow at a 13% CAGR to reach \$938B by 2027, according to CB Insights' Industry Analyst Consensus.

### 12. Gaming (E-sports, MMO games)

5G will increase online gameplay's bandwidth and cut down on latency, reducing delay by up to 5x and making large-scale multiplayer experiences, i.e. from MMOs to e-sports more feasible. VR gaming will gain mainstream appeal as 5G makes VR use more accessible, enjoyable, and realistic.

In gaming, milliseconds of delay matter. By cutting down on latency, 5G can reduce the effects of nuisances like lag — the time taken for a player's command to be reflected in the game itself — making games more engaging. Gaming will benefit from flawless streaming quality and low latency, as well as ever-more immersive experiences including more responsive simulations, life-like audio, advanced haptic feedback, and more.

In E-sports, where fans tune in to watch players participate in competitive video games, will also benefit from 5G technology, as ever-increasing numbers of viewers stream the action live. The same applies to MMO games like Fortnite, where large numbers of users play with each other at the same time.

### 13. Real Estate (Virtual home tours)

Real estate agents could begin offering more virtual home tours — already a growing trend due to the Covid-19 pandemic. Prospective buyers could use virtual reality to view several homes without ever having to step outside of their homes. For those looking to purchase or rent property in a different state or country, accessing VR tours via a mobile application is especially useful. 5G technology would allow for these applications to run more efficiently and reliably than any existing process today. Additionally, using AR in home tours could allow customers to visualize what spaces would look like with different sets of furniture in them.

As remote work continues to gain popularity as a long-term arrangement, some workers will be able to use 5G to do their jobs on the go — from cars to hotels to cafes, and so on — while maintaining a strong connection for data-heavy, cloud-based software and reliable video calls.

### 14. Public Safety (real time video sharing from body cams, drones, etc)

5G will improve situational awareness in threat and emergency situations, powering threat detection technology, real-time alerts, and more. Connected devices like wearable's and home sensors could use 5G to send immediate notifications to first responders in the event of an emergency.

5G could enhance public safety capabilities, thereby improving emergency response times. Through 5G networks, applications such as real-time video, security communications, and media sharing could be used to assist first responders in emergency situations. In connected automobiles during collisions: not only could a car's sensors alert police of an emergency, but also emergency vehicles could tap into 5G-enabled vehicle communication networks in the area to receive real-time updates on the fastest route there. 5G networks could also improve information-sharing within the public safety community, with secure and reliable video-sharing from bodycams, drones, group chats, file-sharing, and location-sharing.

### 15. Military (battle field simulations using AR/VR)

Communication is key when it comes to military strategies. Real-time data collection and transmission to devices within communication networks are crucial, and 5G technology could greatly increase the speed of data transmission. 5G could offer improvements over today's command-and-control systems, which rely on satellite networks for long-range communications by accelerating signal transmission.

For example, in March 2021, aerospace and defense company Lockheed Martin entered into a strategic agreement with Omnispace, a connectivity provider, to jointly develop a hybrid 5G solution that combines terrestrial and satellite networks. The use of AR/VR could bolster training in the field by creating life-like simulations without the danger of real-life situations. Eventually, 5G could power futuristic military use cases like virtual representations of battlefields, autonomous military vehicles, connected weapons, and more.

## III. Conclusion:

From above use case, the macroeconomic impacts of 5G through different methodologies conclude that the economic value at stake is significant and the job creation potential is large.

This use-case-driven analysis reveals that the way 5G will primarily contribute to industrial advances is by enabling faster and effective inspections through predictive intelligence, improving workplace and worker safety, and enhancing operational

effectiveness. On a social level, 5G technology will immensely affect how humans interact with each other, surroundings, environment and other social factors.

5G could transform certain industries in to altogether different format and generate greater impact on the society. As 5G deployment will take place in phases, certain use cases will only be enabled as the networks and will be expanded as the technology components mature, hence the importance of fostering innovation and collaboration to accelerate 5G deployment and to achieve its benefits. These phases will also mean that 5G will coexist with other networks and connectivity solutions. 5G could be the ideal technology for certain solutions, but others might be sufficiently served with WiFi, 4G or even earlier generations. Additionally, 5G has the potential to provide quality internet access to geographical areas that are currently underserved by the telecommunications network. This could unlock significant social impact through use cases related to tele-education.

To ensure that 5G deployment will accelerate and its components and interdependencies are understood, strong collaboration between stakeholders is needed. Many of the current use cases are technically supported by the functional drivers of 5G and activated through multi-stakeholder cooperation and collaboration. Regulators, industry associations, network operators, service / technology providers and public-private partnership organizations must engage in continuous dialogue to address the challenges facing widespread 5G adoption worldwide and to maximize the opportunities it will bring across sectors. Defining collaboration frameworks and models to initiate and sustain cooperation more effectively will be increasingly important moving forward.

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