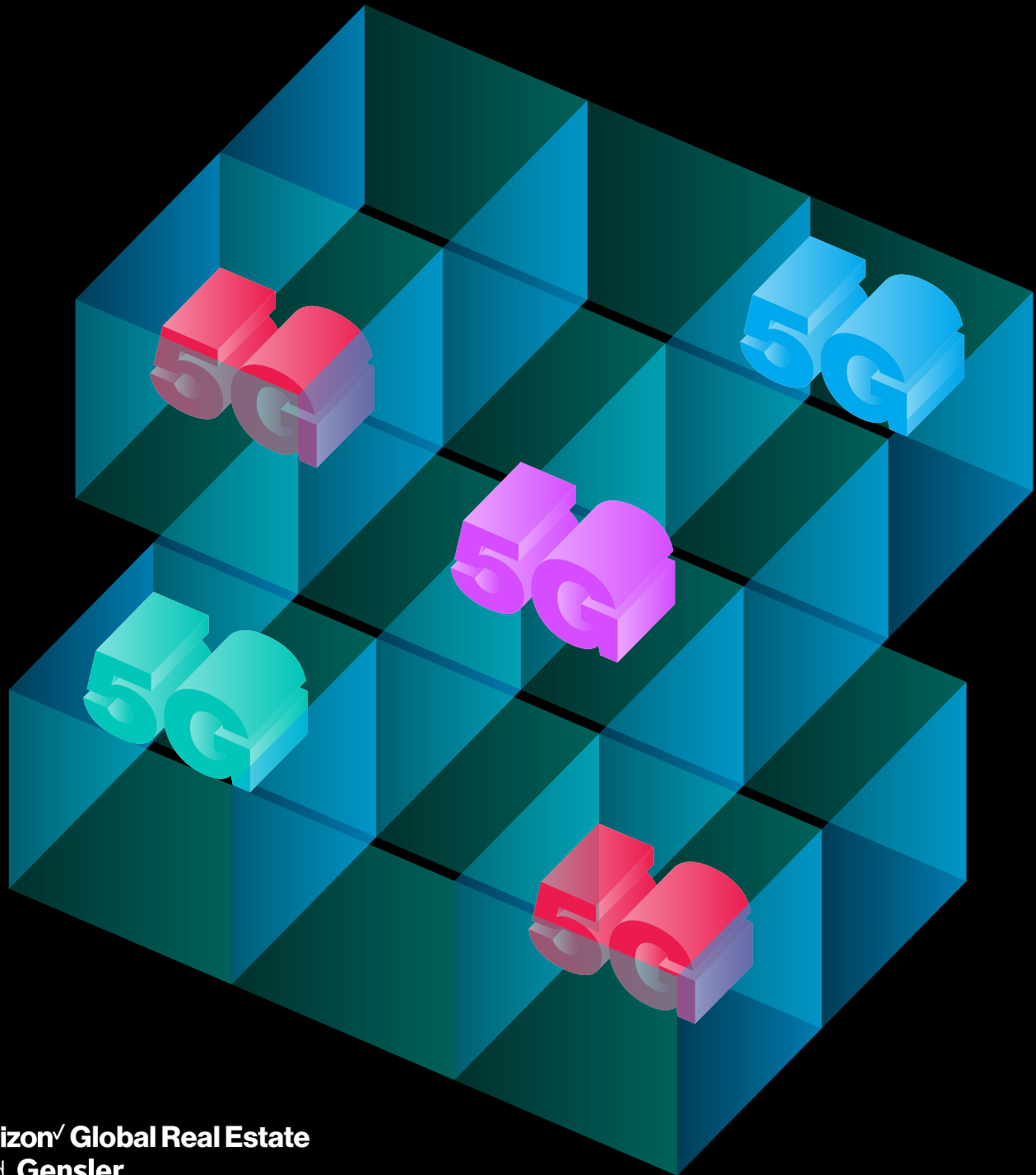


5G^v and the Future of Work



Introduction



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SUMMARY

The world is becoming increasingly connected with advancements in wireless technology. Now in its fifth generation, 5G brings unprecedented speed, reliability, and responsiveness. As 5G wireless technology is further developed and brought to mainstream markets, it will catalyze a paradigm shift for how we connect with our devices, information, and one another.

Verizon partnered with Gensler to explore how 5G will transform the way people work. We started by evaluating the critical capabilities and limitations of 5G. An analysis of 5G disruptions in tangential industries yielded five key emerging trends. Finally, by applying these trends to the workplace, we distilled specific implications that are most likely to shape the future of work.

5G is already impacting a variety of industries—from manufacturing to healthcare to entertainment. 5G technology is enabling the scalability and widespread adoption of autonomous things, intelligent environments, untethered agility, collaborative knowledge, and mixed-reality platforms. Already, assembly line robots are becoming untethered and drones complete last mile deliveries. Many such applications in tangential industries will inevitably permeate the future workplace.

While 5G's impact on the workplace will initially manifest in a few key use cases, it is critical to think bigger. This new generation of connectivity will allow people to have more automated, customized, agile, collaborative, and immersive work experiences. It not only transforms new ways of working for individuals and teams, but also how we build culture, and design and operate physical spaces.

The workplace implications covered in this research are intended to guide workplace service professionals in future-proofing the built environment, strategizing for emerging technologies, and empowering the next generation of employees. This research serves as a springboard into a broader discussion of 5G's impact on the future workplace.

“ In the future, everything is going to be transformed by 5G. The pace of technological change in decades past has been fast. The only thing we know for sure is that, in the future, it's going to be even faster. We're going to experience a technological shift that will transform people, businesses and society as a whole. ”

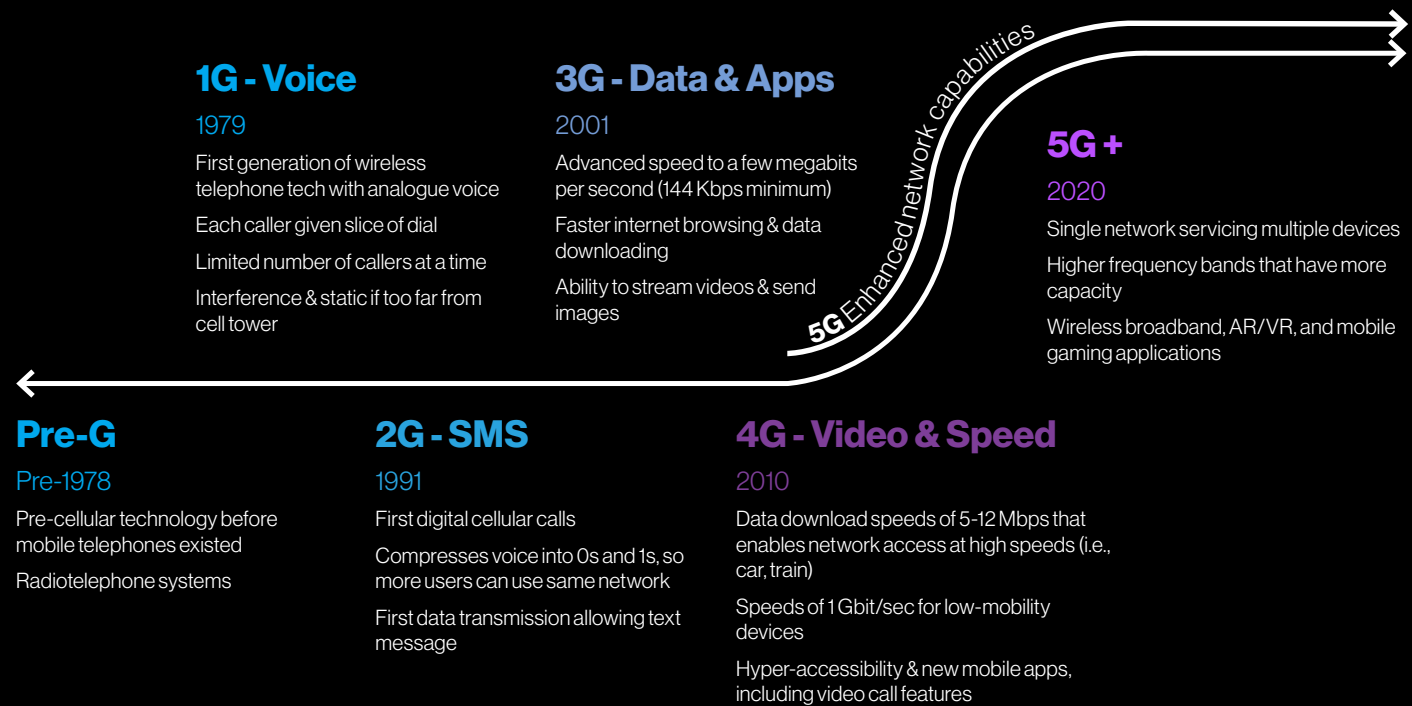
Verizon CEO Hans Vestberg

What are the capabilities and limitations of 5G?

HOW DID 5G DEVELOP?

To grasp the scope of 5G's disruptions, it is important to understand the history of previous wireless generations. 1G enabled the first iteration of wireless telephone technology with analogue voice. 2G made SMS text messages and data transfer possible. In 2001, 3G accompanied the launch of smartphones by improving data transfer speeds to enable internet browsing, content downloading, video streaming, and multi-media messaging. Smartphone mobile apps emerged with increasing download speeds.

In 2010, 4G, with data download speeds of 5-12 Mbps, allowed users to access the network while in motion at high speeds (i.e., car, train). It provided hyper-accessibility, video calling, and a new generation of mobile apps with cross-reality features. 5G promises immense digital transformations and ubiquitous data accessibility through higher frequency bands with more capacity. It will unleash innovations for how we interact with our devices.



WHAT IS 5G?

5G technology enhances network capabilities in many key aspects, such as increased speed, lower latency, and better equipment battery life. 5G is expected to be 100x faster than 4G technology, delivering more than 10 Gbps at peak rates. Currently, users rely on fiber for the fastest internet speeds, which requires installation and wiring within a building, tethering users to their devices.

5G's low latency means the delay between instruction and data transfer is reduced to a fraction of what 4G currently offers. By enabling edge computing, extremely low latency, and higher data transfer speeds, 5G will democratize digital experiences that require expensive equipment and devices with heavy compute capabilities. This will substantially change the way people interact with devices and information.

Before long, smartphones will lose today's relevance and edge-connected wearables will become the primary personal device.

Additionally, 5G delivers massive amounts of data simultaneously, enabling 1 million connected devices per km² at a given time. According to Arne Holst from Statista, the number of 5G connections is predicted to reach 20 to 100 million by 2021. An essential question to ask is how enhanced connectivity challenges the age-old notion that the three most important aspects of real estate are "location, location, location". 5G network will disrupt corporate real estate and many other industries just like how online shopping disrupted brick-and-mortar retail.

KEY FEATURES OF 5G



High Speed

100x faster than 4G technology, delivering data at speeds from 100 Mbps to >10 Gbps at peak rates



Low Latency

Less delay between instruction and data transfer, at <1ms, allowing information to be processed closer to the end user



Massive Bandwidth

Delivers massive amounts of data and connects 10-100x more devices on a network, up to 1 million per km²



Higher Frequency

Relies on a higher frequency wireless spectrum to enhance speeds by incorporating the use of millimeter wave



Small Cells

Small cells that are placed closer to end users provide improved signal penetration and coverage



Improved Reliability

Serves many devices simultaneously with improved reliability and more stable connections

BENEFITS AND CHALLENGES

5G promises improved communication across new mediums of wireless networks. The ability to transfer massive volumes of data with low latency will enable the connectivity required by the Internet of the Things (IoT), Augmented Reality (AR) and Virtual Reality (VR) experiences, and Artificial Intelligence (AI). What may be high-tech experiences now will become much more commonplace.

5G involves significant investments to start up. It requires denser small cell deployment and a strong fibre infrastructure to meet performance goals. If deployed at higher wave frequencies, 5G requires careful planning for indoor applications. Device compatibility is another challenge. The success of 5G implementation hinges on the ability to create an ecosystem of networks and devices.

Benefits
<ul style="list-style-type: none"> • Enhanced Communication: 5G helps eliminate dropped calls, unstable video, and poor network coverage, due to its enhanced reliability and massive bandwidth. • Internet of Things (IoT): 5G's low latency and ability to handle massive data volumes enable the connectivity of millions of IoT devices, paving the way for smarter buildings and cities. • Immersive Data Experiences: AR and VR technology benefit from lower latencies, enabling more seamless and wireless user experiences. • Network Slicing: 5G providers can segment service for specific needs or business units, enabling customized connectivity, expanded mobile broadband, and improved network security. • Multi-Access Edge Computing (MEC): When 5G is paired with edge computing, data processing can take place closer to the end user instead of transferring the data to the cloud and back, enabling quicker response rates.

Challenges
<ul style="list-style-type: none"> • Start Up Costs: 5G requires investments in new infrastructure and installation for small cells that have better signal and coverage. • Denser Deployment: 5G implementation at millimeter wave frequencies requires that we work closely with local governments in order to achieve denser small cell deployment at large scales. • Fibre Infrastructure Backbone: 5G relies on a strong fibre network infrastructure in order to meet its performance goals and transfer all the gigabits of data needed. • Customized Indoor Deployment: When deploying 5G at higher millimeter wave frequencies, it is challenging for signals to penetrate solid surfaces such as walls and glass. Detailed planning is necessary. • Device Compatibility: 5G can only operate on 5G-enabled devices, placing a cost on the end user or corporations to replace non-compatible devices. Device compatibility is an important part of building out the 5G technology ecosystem.

How is 5G disrupting tangential industries?

FROM DISRUPTIONS TO TRENDS

5G capabilities will drive disruptions across many industries. With advancements in network speed and latency, transportation is more autonomous, supply chains are more agile, and retail is more personalized — to just name a few examples. 5G connectivity will make business management and operations more efficient, accurate, and responsive, saving resources and cutting costs while delivering better results. By taking a panoramic view of 5G applications across a diverse cross-section of industries, we can distill the shared trends that will then drive transformations in the future workplace.

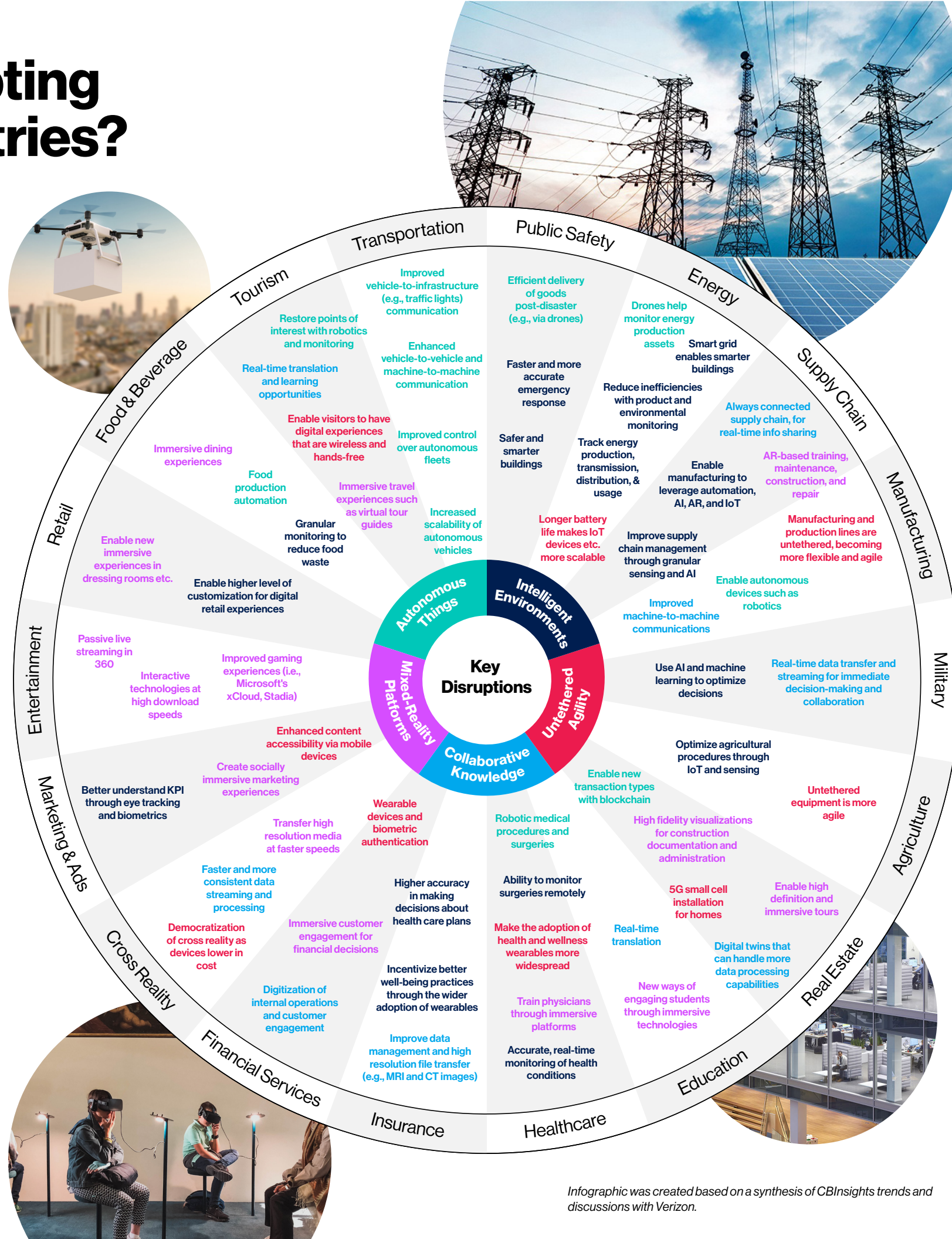
5G connectivity will make business management and operations more efficient, accurate, and responsive, saving resources and cutting costs while delivering better results.

Autonomous Things

Low latency, hyper connectivity, and high data transfer speeds will make autonomous vehicles, robotics, and drones increasingly ubiquitous. 5G will transform machine-to-machine (M2M) communication and machine-to-infrastructure (M2I) communication, improving scalability, efficiency, and accuracy of autonomous devices. Real estate programming and space allocations, such as parking and storage, will need to be reevaluated. From robotics in medical procedures to food production to assembly lines to building preservation, 5G will allow machines to do more, at both microscopic and macroscopic scales. By taking advantage of airspace in urban and rural areas, drones can streamline last mile deliveries and monitor disasters, valuable assets, and other high-stake scenarios.

Intelligent Environments

As the backbone of advanced applications in Internet of Things (IoT), Multi-Access Edge Computing (MEC), and machine learning, 5G will pave the way for human-centered smart buildings and cities. The combination of wearables and real estate IoT technology means that anything, from products to spaces, will become customizable to individuals and groups. Buildings and cities will become more responsive, efficient, and sustainable, challenging the status quo of building management and operations. The ability to collect granular data about assets and environments will reduce losses, inefficiencies, and costs.



Untethered Agility

5G network slicing allows operators to create customized network segmentations to improve service quality, latency, and security, particularly relevant for making machines and devices more flexible. Powered by cellular data, machines can speak to each other and the network without cabling limitations, rendering machines more agile, multi-functional, and adaptable to future needs. Increased data transfer speeds mean that more content can be streamed on wireless, personal devices, allowing users to access information faster, anywhere, and even hands-free. Discrete, distributed 5G hotspots and antennas make data processing and servers more secure, reducing risks to cyber security.

Collaborative Knowledge

Enhanced reliability and massive bandwidths close the gap between people and what they need to know. Significant improvements in data management and high-resolution file transfer speeds eliminate the need to limit file sizes for saving and sharing media content. Higher upload and download speeds permit multiple users to simultaneously share and create content on a single platform. With real-time data processing, information from disparate sources can easily be processed together, allowing decision-makers to execute with greater speed and accuracy. Language translation and computer vision can take place instantaneously and be augmented by cross-reality tools.

Mixed-Reality Platforms

Low-latency streaming and lightning-speed information transfer will allow us to engage with cross-reality and multi-sensory worlds with a seamless user experience and uncompromised content fidelity. The way people play, buy, and understand information will shift entirely. The proliferation of cross-reality experiences, especially as wearables lower in cost and become more compact in size, will transform the way users interact with their surroundings. Human relationships in digital environments will be redefined as it becomes easier to mimic natural physical behaviors and language patterns. Leaders in all industries can use high-fidelity visualizations and virtual prototypes to make decisions about the unknown with greater certainty, reducing wasted resources.

"By 2035, 5G will enable \$12.3 trillion of global economic output and support 22 million jobs worldwide. Much of that growth will come from the digitization of transportation, agriculture, manufacturing and other physical industries."

Ronan Dunne, Executive Vice President and Group CEO, Verizon Consumer Group

How will 5G transform the workplace experience?

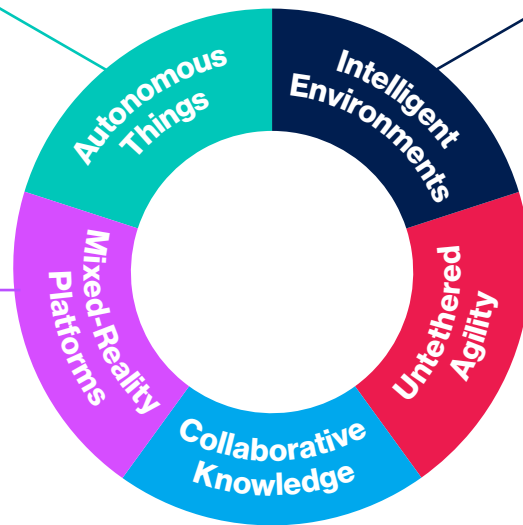
TRANSFORMING THE FUTURE OF WORK

5G's key disruptions on other industries will impact the future of the workplace in terms of automation, customization, agility, collaboration, and immersive work experiences. Autonomous vehicles and robots will help simplify mundane tasks. Shared workspaces can be customized to individual and team preferences. The ability to access wire-like speeds wirelessly gives employees more options for where they work. New ways of collaboration are unleashed with faster data transfer speeds. Digital, mixed-reality experiences and content are better integrated into the physical workplace. All

of these transformations will challenge the way we empower workers with the right tools, culture, and spaces.

As 5G scales over time with an ecosystem of innovations, we will see its full potential come to fruition. More and more use cases for the workplace will be unlocked to transform the employee experience. In the near term, Wi-Fi and 4G LTE will play an important role in complementing the 5G network. An entire leap forward in connectivity, 5G means that brick-and-mortar offices will only serve a fraction of the holistic workplace experience in the future.

The way we complete work and personal tasks will be aided and amplified by personal devices, robots, and vehicles that enable us to pursue more high-value tasks.



Any work environment will be personalized, responsive, and predictive of preferences and behaviors, becoming smarter over time with zero latency.

Unprecedented immersive experiences will fuse the physical and digital, redefining how we interact with each other and multi-sensory content.

Untethered from traditional networks, people can work in more agile ways, anywhere and at anytime, with a seamless and uncompromised experience.

New ways of learning will be unlocked by platforms that delight users and process increasingly complex information.

"The virtualization of experiences will not only enable different ways of communicating, but also transform the demand for brick-and-mortar, how spaces are designed, and the infrastructure consumed. The workplace will radically change; from the office to the home and anything in between."

Cesar Jeri, Head of Workplace Technology, Verizon Interviews

"The workplace is one of the areas that will be most transformed by 5G and MEC. In the future, it might not even mean a physical space anymore, but a set of technologies supporting our interactions with co-workers, partners, and customers. Can a hotel room or an autonomous car be part of my workplace if it had the same speed, responsiveness, and security as today's office?"

Manuel Zapata, Director of Technology Development, Verizon Interviews

Autonomous Things



The way we complete work and personal tasks will be aided and amplified by personal devices, robots, and vehicles that enable us to pursue more high-value tasks.

ROBOTS AT YOUR FINGERTIPS AND WORKPLACE-ON-WHEELS DECENTRALIZE THE LOCATION OF WORK TO NEW, ALTERNATIVE ENVIRONMENTS

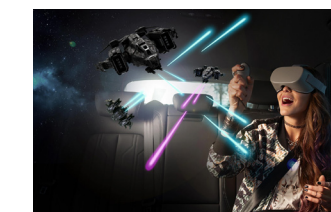
From autonomous vehicles to dry cleaning robots, **autonomous devices will support mundane daily tasks and capture lost hours on the road, giving more productive time back to people.** Improved networks give users the confidence to take conference calls and enjoy infotainment with reliable high-speed connectivity. Autonomous vehicles can become mobile office environments enhanced by immersive AR/VR experiences. Location accuracy makes robots more reliable in urban and interior environments, lending a helping hand to employees anywhere, anytime.

IMPLICATIONS

The physical workplace will need to be "robot-ready" with automated building components, such as doors and elevators. More and more materials, documents, and equipment can be stowed off-site and ordered on demand, reducing the total amount of storage space needed. However, storage to accommodate a surge in delivers as well as on-site charging for robots will need to be considered.

As more tasks are hyper-convenient and can be done without even getting up, **the workplace will need to integrate more proactive health and wellbeing measures.** For example, the workplace can encourage people to meet and brainstorm while walking to a nearby park. Additionally, the expectation of hyper productivity and multi-tasking will challenge workers to maintain a positive work-life balance.

PRECEDENTS



Holoride

Audi and Disney's partnership for Holoride transforms moving vehicles into theme parks, responding to turns and acceleration.



Relay

The autonomous service robot is designed to work around people in busy environments to deliver tools and materials.



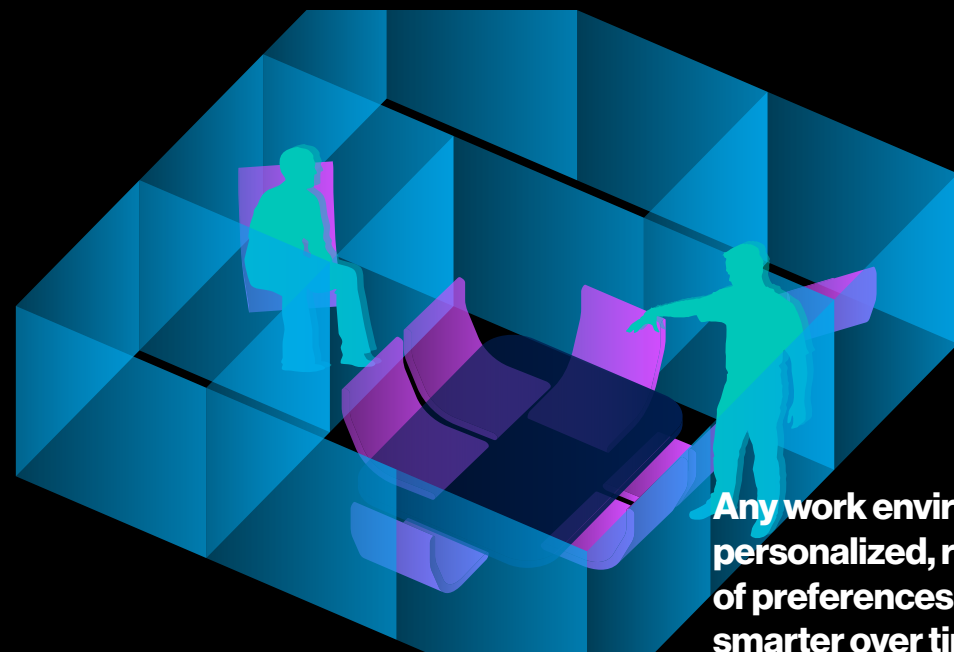
Volvo

Volvo has designed the 360c concept car with a modular interior, full mobile connectivity, and content casting on windows.

“Where 5G becomes valuable is providing wire speed performance with low latency while I'm in motion. And when the car drives itself, I no longer need to pay attention; it becomes a temporary office.”

Brian Peebles, Senior Manager Technology Development, Verizon Interviews

Intelligent Environments



Any work environment will be personalized, responsive, and predictive of preferences and behaviors, becoming smarter over time with zero latency.

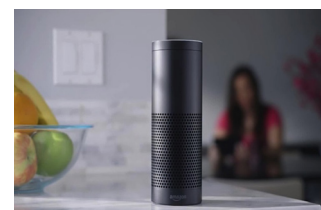
PERSONALIZED AI ASSISTANTS LINKS USER BEHAVIOR AND PERFORMANCE IN ORDER TO OPTIMIZE WORKFLOW AND SPACE UTILIZATION

Voice assistants in homes and checkout-free groceries are examples that real-time predictive analytics will change the way we interact with physical spaces. **5G will be foundational for helping IoT in buildings realize its full potential.** Anything in the environment can become "smart" and facilitate hyper-responsiveness, from immediate screen sharing to furniture layout recommendations. **As sensing technology, such as computer vision proliferates, 5G paired with edge processing makes it easier to anonymize data instantaneously, alleviating personal privacy concerns.** Additionally, calendar optimization taking into consideration work styles, chronotypes, and room availability can enhance employee productivity, satisfaction, and performance in the workplace.

IMPLICATIONS

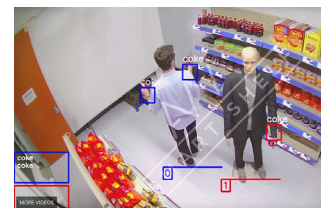
As user needs and preferences are anticipated, **workflows will become more efficient, yet programmed algorithms risk losing an important element of serendipity and diversity,** important human elements of our daily work. For example, the assistant can suggest a change in the white noise track if concentration levels are declining after a long time period. While granular monitoring enables more personalized experiences and gives companies data on performance metrics (i.e., idea quantity, work progress, concentration levels), workers may feel that their privacy and autonomy are compromised. **Fundamentally, algorithms must not only support company efficiencies, but employee needs.**

PRECEDENTS



Alexa Hunches

Amazon's voice assistant, Alexa, has a feature called "Hunches" which predicts a users' future needs within the home.



Smart Shelf

This retail solution offers AI-based inventory, product mapping, content management, and a retail data engine.



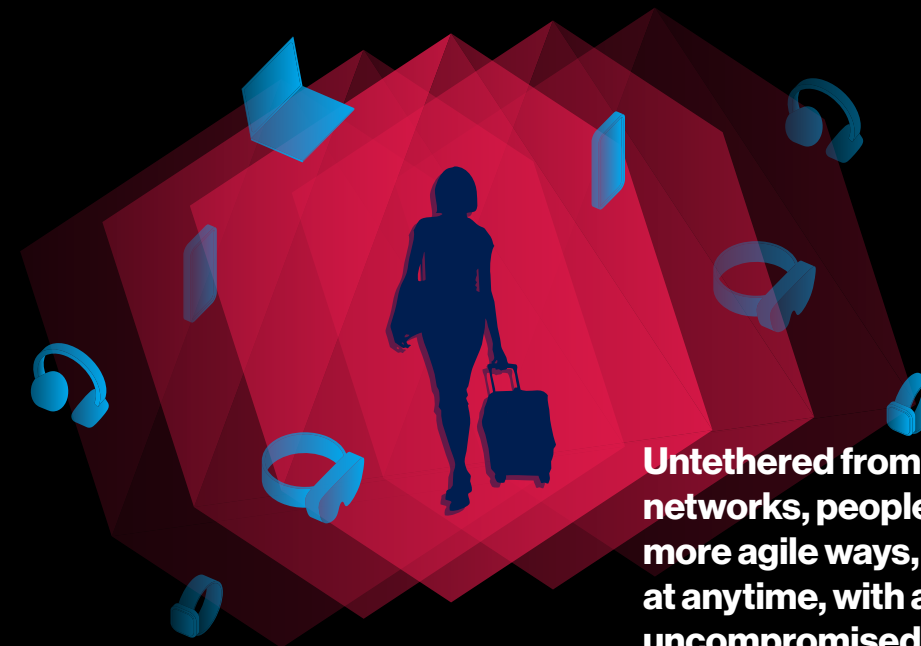
Johnson Controls

The Digital Vault connects building operational tech and external data to deliver a smart headquarters for Bee'ah Partners.

“ Smart buildings will be a thing of the past. Instead, buildings will be fully autonomous, driven by highly sophisticated neural networks. Facilities management will become a data-science. ”

Cesar Jeri, Head of Workplace Technology, Verizon Interviews

Untethered Agility



Untethered from traditional networks, people can work in more agile ways, anywhere and at anytime, with a seamless and uncompromised experience.

HYPER-FLEXIBLE WORKPLACE PLATFORM WITHOUT WALLS WHERE WORKSTYLE AND SPACE COMBINATIONS ARE LIMITLESS

The future appears wireless as agile manufacturing and wearables take center stage. **Improved wireless network access means that work activities no longer need to take place in specific spaces.** The fiber-like performance of 5G unwires network access, making mobile and flexible working the norm. Devices, especially wearables, can do more with 5G because they will require less native compute power and can leverage intelligence in the cloud and edge. Additionally, with consistent coverage, users will no longer experience broken networks when transitioning from Wi-Fi to cellular.

IMPLICATIONS

As 5G untethers workers, the link to a physical desk will be fully broken, allowing **the 'home base' to assume a variety of settings in lieu of a single workspace.** Furniture specifications will need to find a balance between prescriptive and adaptive. Less prescriptive spaces, while more flexible, need to be designed intuitively to cue specific user behaviors (e.g., recommended furniture layout). **Improved tools for global collaboration and work-from-home allow companies to tap into new talent markets without being burdened by expensive real estate.**

If high frequency millimeter waves were deployed for interiors, careful planning is required because the signal cannot penetrate solid surfaces such as walls. With fewer solid walls, the workplace is more adaptable to changing needs but **it becomes imperative to incorporate visual and audio privacy elements into the design.**

PRECEDENTS



Ericsson Factory

Ericsson's smart factory in China leverages cellular technology for a flexible and modular production line.



HoloLens 2

Wearables are becoming more prevalent, offering new immersive capabilities that can be experienced hands-free.



Tap

Tap is an information input wearable that allows users to type on a keyboard or click on a mouse without a traditional device.

“ Rushing from meeting to meeting, you can immediately be on the next meeting and show up virtually... I can turn garages into an office and set up a meeting room with a virtual hologram for facial contexts and reactions. ”

Brian Peebles, Senior Manager Technology Development, Verizon Interviews

Collaborative Knowledge



New ways of learning will be unlocked by platforms that delight users and process increasingly complex information.

A SPATIAL VIRTUAL "PALACE" FOR COMPLEX INFORMATION THAT ENHANCES LEARNING, RECALL, AND FILE MANAGEMENT

Immersive events, real-time translations, and design collaboration in virtual space are examples that **5G's capabilities will change the way we learn, recall, and share information with one another.** AR, VR, 360 video recording, and high fidelity 3D rendering capabilities contextualize and spatialize information, giving employees a much more immersed way of understanding content. Additionally, 5G's improved speed and latency allows massive amounts of data to be geographically tagged, so people can have more reliable location references.

IMPLICATIONS

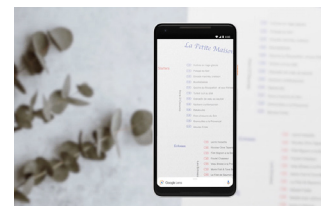
Virtual reality researchers at the University of Maryland demonstrated that people can learn better when information is presented in an immersive environment instead of 2D desktops or hand-held devices. A "virtual memory palace" can be created by linking information to spatial locations in AR and VR. **The conventional nested filing structure on a 2D desktop screen will be replaced by an organizational system linked to spatial and experience triggers, improving information recall.** Voice recordings, notes on a whiteboard, and comments to a presentation can all be captured, tagged, and stored in a digital database with spatial references. Physical rooms can be designed with distinctive wallpaper and furniture to prompt specific memories. However, as data management becomes more personalized, it can be a challenge for those unfamiliar with the content to understand the file structure, thus a consistent organizational logic will still need to be maintained.

PRECEDENTS



360 Immersive Mapping

This Verizon product combines 360 video capture and image stitching technology to create immersive, virtual events.



Google Lens

Google Lens leverages AR and image recognition technology to translate text and identify objects in real-time.



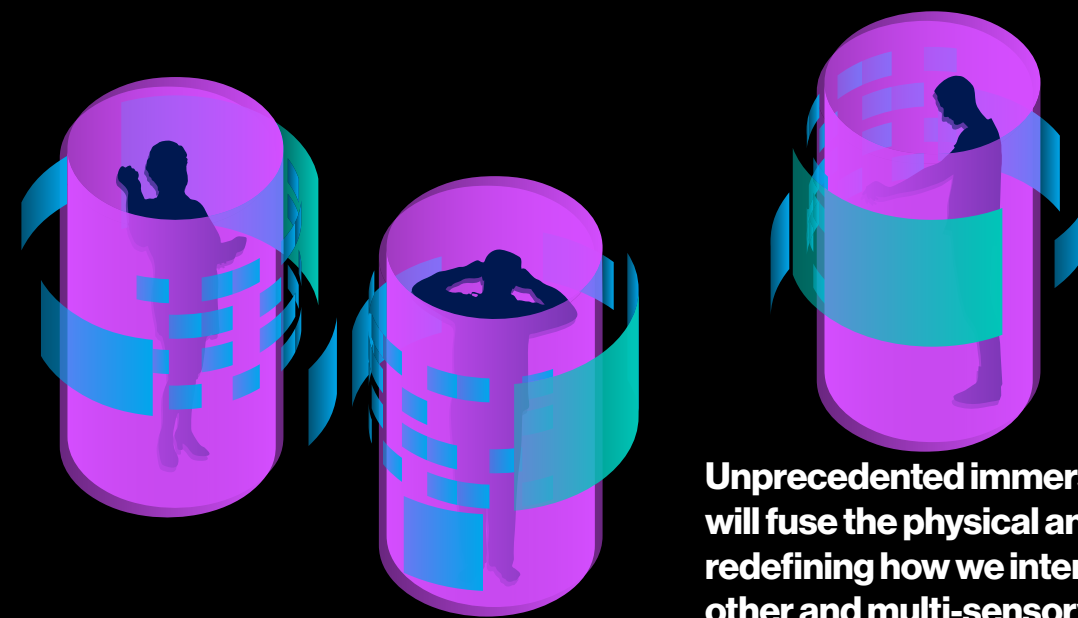
The Wild

Integrated with BIM, the Wild allows multiple users with different devices to make design decisions in AR and VR.

“ When it comes to 5G in the workplace, it is not just a single product, but an ecosystem that works together so people using it have an experience that is very fluid and intuitive. ”

Neel Sen, 5G & Emerging Technology Incubation, Verizon Interviews

Mixed-Reality Platforms



Unprecedented immersive experiences will fuse the physical and digital, redefining how we interact with each other and multi-sensory content.

GAMING INNOVATION APPLIES TO WORKPLACE MEETINGS AND COLLABORATION, RESULTING IN MORE SPACES FOR VIRTUAL EXPERIENCES

5G will make the user experience of cross-reality technologies more seamless, consistent, and scalable. Virtual meetings, 3D collaboration, and digital pin-ups in AR and VR will have **real-time responsiveness and multi-user capabilities enabled by low latency and increased speeds.** As the network takes the pressure off the compute power of devices, the hardware will become cheaper, more compact, and more accessible to users, soon becoming standard IT equipment for employees, just like mobile phones today. Concurrent hardware developments in virtual glasses, headsets, and VR booths offer users increasingly immersive and hands-free experiences.

IMPLICATIONS

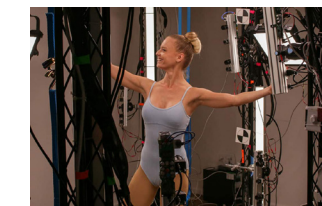
New work settings will arise, such as **dark AR/VR studio booths with flat, blank wall surfaces to easily focus headsets** and enclosures to give users a heightened sense of security and safety while using devices. For virtual interactions, **life-like avatars via volumetric capture**—just like how profile photos are taken for ID badges—will quickly learn to mimic users' expressions and reactions with AI in real-time. VR meeting rooms will become so realistic and productive that employee engagement is enhanced and business travel frequency will decrease, ultimately reducing carbon footprint. Those that embrace these seismic shifts early will have an edge. While the workplace needs to accommodate new digital experiences, potentially replacing some team and war rooms, it is imperative that spaces for in-person engagements are not compromised.

PRECEDENTS



Otherworlds

Visitors can engage in single or multi-user experiences and games at this virtual reality arcade.



Mantis Vision

Any person, object, or place can be digitized as three-dimensional, high resolution content in real-time.



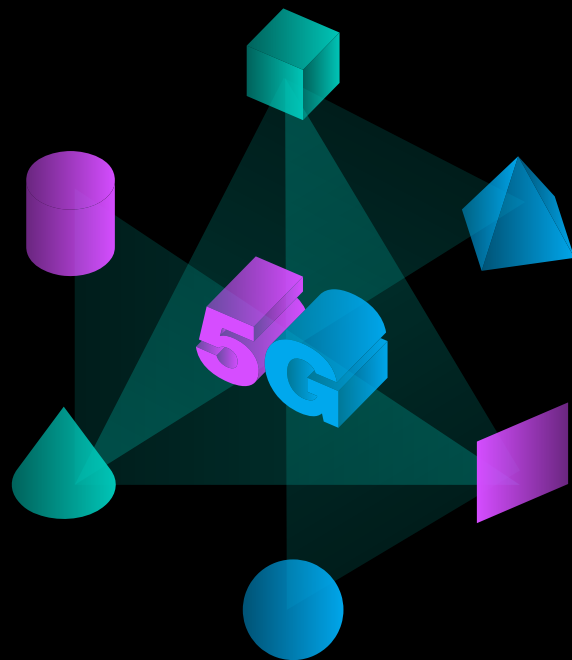
MeetInVR

Meetings and collaboration can take place in virtual reality with an increasing level of interaction for multiple users.

“ For anything that has to do with real-time experiences in AR/VR, the ability to compute and render at the edge will democratize and lower the cost of user devices. It can be a dumb piece of equipment. ”

Winfred Chao, Senior Manager Technology Development, Verizon Interviews

What's next beyond 5G?



CONCLUSION

5G's speed, reliability, and responsiveness, paired with edge computing, will unleash an entire ecosystem of experiences that offer employees more choice and variety in their workstyles and workspaces. From “on-the-go” offices using autonomous vehicles to personalized AI assistants that optimize the experience, 5G will disrupt the future of how and where we work. While this research primarily explores five key areas of disruptions—autonomous things, intelligent environments, untethered agility, collaborative knowledge, and mixed-reality platforms—the possibilities of 5G are infinite.

As 5G networks, products, and devices develop over the next few years, new workplace experiences will become more accessible and scalable. 5G's implications on the workplace call for a thoughtful approach to the design of the technology, physical space, and the culture for all employees. With this revolution in connectivity and digitization, **it is imperative that we are deliberate about technology equitability, human engagement, and work-life balance.** Each new generation of wireless brings about transformations in how we communicate with each other and manage information in the workplace, ultimately influencing workstyles and the physical work environment. The handshake between physical and virtual experiences to activate employee engagement will naturally be reimagined.

“ Products, devices, and the network are the 3 parts of the ecosystem that need to come together. If you have a great network without the ecosystem, the network becomes useless.”

Anand Shah, Director of Technology Strategy and Architecture, Verizon Interviews

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