



2021 Research Trend Report



Executive Summary

Throughout 2021, GS1 US[®] conducted research that has revealed several new market and technology trends, namely: automation, artificial intelligence (AI), e-commerce, and advances in supply chain technology, sustainability, and emerging technology.

One major ripple from the pandemic, even as most of the country returns to some level of normalcy, is the need for automation in the face of both the ongoing contactless customer experience and the massive labor shortage that faces the retail and restaurant sectors. Robotic solutions are being leveraged through micro-fulfillment centers (MFCs) and dark stores, while AI is serving to automate customer service with conversational commerce and to improve online operational logistics with predictive analytics. Non-fungible tokens (NFTs) continue to evolve as their technology and market matures past the initial hype cycle, with work being done to better tie them to physical products for authentication and further develop nascent forays into the metaverse. The circular economy continues to grapple with the issue of persistent identification and recyclability of products, turning to QR codes and computer vision as the main solutions. In addition, sustainability initiatives are seeing an increased interest around tracking both food waste and the carbon footprint (CO2 emissions) of products and providing that information to consumers so they can understand the true environmental impact of each purchase. Two major market areas that have seen astronomical growth during this time are cashierless checkout options, both computer vision based and those that utilize other technologies like smart carts, and e-commerce aggregators that acquire small businesses on Amazon for the express purpose of scaling them into larger enterprises.

Various emerging technologies sit on the far horizon, such as quantum computing, cellular agriculture, digital and physical convergence towards a shared metaverse, nanotechnology-enabled identification tags, and the commercialization of spaceflight. Overall, robotics and AI are becoming more cost-efficient and computationally powerful, strong enough to create fast, autonomous links between the physical and digital worlds to build a cohesive, interconnected technology ecosystem. Disruptive innovation is being spurred on by the pandemic's digitization of the world and consumers' growing sustainability concerns. Supply chains must evolve to meet this new digital future.

Trend Categories

There are six major categories under which each of the research topics falls:

Automation & Robotics

Artificial Intelligence

Sustainability

E-Commerce

Supply Chain Technology

Emerging Technology

Automation & Robotics

Automation and robotics are being leveraged to both perform jobs that are too dangerous, dull, or dirty for human workers and to enhance the everyday management of warehouses, storefronts, et cetera for employees. Cost-effectiveness of the technology has become a major part of the equation, accelerated by the pandemic putting the safety of workers into the forefront of operational consideration.

Fulfillment centers | Automation is proliferating throughout the retail supply chain, primarily in warehouses, automated dark stores, and micro-fulfillment centers to meet the increased demands of e-commerce and issues of supply chain disruptions.

Delivery drones | Delivery continues to grow as autonomous, driverless drone technology becomes more robust, cold chain tracking becomes increasingly vital, and regulations are being approved for more widespread residential usage.

Cashierless checkout | Cashierless checkout is growing as it is adopted by retail and grocery stores through several different technologies such as computer vision, smart carts, mobile apps, and multifaceted combinations thereof.

Warehouses | Manufacturing centers and warehouses are adopting robotic solutions to automate their operations, picking, packing, and aiding their human counterparts through ever-evolving 3D vision technology.

Internet of Things (IoT) | With the advent of 5G, connected devices and wireless communication are evolving in both functionality and ubiquity, powering solutions from retail stores to warehouse operations to cold chain sensors and beyond.



Figure 1: Most automation has been centered on the warehouse, with a good portion on drones for last-mile delivery as well, specifically powered by computer vision as a consistent, accurate means of product identification

Artificial Intelligence

AI provides an underlying algorithmic architecture to a wide variety of technologies that rely on copious amounts of data in order to either optimize current states or predict future states. The physical world is becoming increasingly digitized, with AI necessary to understand how this digital landscape works and translate it, via sensors and statistics, for human consumption.

Data Quality | Bias in AI systems remains a problem, as the robustness of the solution is contingent purely on the quality of the data input into the system; to that end, ethical standards are being created about what qualifies as “good” data.

Standards for machine learning (ML) data are being investigated to allow for enhanced interoperability, collaboration, and ultimately the democratization of AI data for better research and development.

Natural Language Processing (NLP) | Voice technology continues to develop, both within commercial environments as a form of accessibility technology as well as at home, with smart devices that are working to improve interoperability for a better user experience.

Conversational commerce through mobile apps and text is one aspect of omni-channel sales that is becoming more prevalent, especially through systems like WhatsApp, while others replace customer service via chatbots.

Predictive Analytics | Consumer trend AI analysis is being used to empower retailers to place the “perfect” order, one that predicts shopper purchases to optimize inventory, reduce waste, and overcome ongoing supply chain disruptions.

Logistics Data | Between inventory management and demand planning, AI has become an essential component of retail operations, using robotic intelligence (made more robust now due to its failures earlier in the pandemic) to make sense of highly complex supply chains.

Location Mapping | Location mapping and geofencing technologies are being used for delivery, for interactive augmented reality (AR) mapping, and to streamline curbside pickup.



Figure 2: Artificial intelligence fuels a vast number of different technologies, all powered by the plethora of data pulled from the physical world into the digital one that needs to be both quality and unbiased to be useful

Sustainability

Sustainability is the overall umbrella term that includes not only the circular economy but also efforts to create more environmentally conscious packaging decisions (even more important now due to the massive increase in direct delivery). In addition to recycling and refurbishment, indoor farming is working to hyper-localize the agriculture supply chain into urban areas and food deserts, reduce the amount of food waste generated throughout the supply chain, and better track carbon emissions.

Circular Economy | Circular economy efforts continue to be pursued across the fashion industry, retail, and construction through a combination of computer vision, recycling, refurbishment, and re-commerce practices.

“Right to repair” is seeing increased support from organizations like the Federal Trade Commission (FTC) to enable third-party entities to repair hardware and improve the designs of consumer electronics to reduce e-waste.

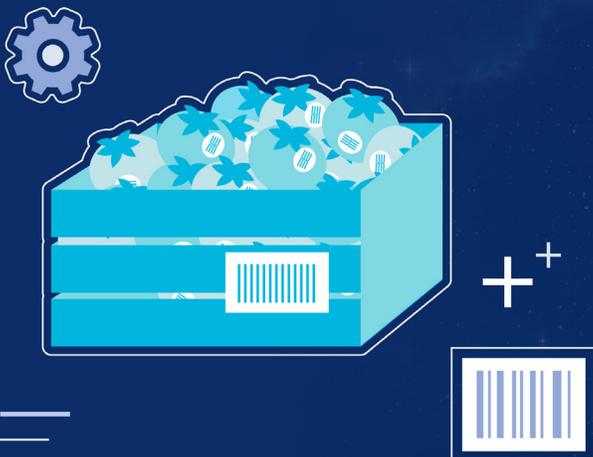
Digital passports, QR codes, computer vision, and other types of data carriers are being used to bridge the gap of post-sale identification.

Indoor Farming | Indoor farming is being used to provide agricultural sustainability, reuse of physical spaces, and localization of the food supply chain into urban environments via AI and robotics.

Food Waste | A growing concern among the food supply chain is the amount of waste generated, with efforts to curb it through specialized produce packaging, AI-based inventory management, and similar efforts.

Carbon Footprint | The carbon footprint of a product is starting to become a concern of consumers, with work being done to calculate the true carbon cost of a product, both to manufacture it and to move it through its supply chain.

Figure 3: Various technologies, from electric vehicles to solar energy to recycled products to the repair and refurbishment process, are finding increased interest from both business and consumers



E-Commerce

E-Commerce has become the primary method of shopping for many customers, leading to growth in both companies that sell within the ecosystem and those that support the overall infrastructure of the digital marketplaces. In this volatile market, there are numerous organizations starting to seek the ability to capitalize on the growth, while bad actors erode customer confidence. Fulfillment networks and website platforms have both evolved to lend logistics and customization capabilities to small businesses, so that they can operate within preexisting marketplaces and utilize direct-to-consumer (DTC) solutions at scale.

Amazon Aggregation | Amazon marketplace is the largest e-commerce platform in the U.S., with a myriad of companies (e.g., Thras.io, Perch, Forum Brands) acquiring smaller businesses on the platform to grow and scale them into larger enterprises.

Fulfillment | Large-scale enterprises (e.g., Walmart, Amazon) are offering their infrastructure of fulfillment and delivery to empower small e-commerce businesses.

Authentication | One primary concern of customers that continues to plague e-commerce is the issue of authentication, questioning whether products are counterfeits or if even the data (e.g., reviews) on authentic products are even real, with a concerted effort from marketplaces to create better customer confidence.

Augmented Reality & Virtual Reality | AR is being used in e-commerce to allow customers to “try before you buy” in the physically untouchable world of the pandemic, while VR is being leveraged for enterprise training and gaming.

Social Commerce | Direct-to-consumer e-commerce solutions are utilizing social commerce and livestreaming to engage more closely with consumers and sell via non-traditional methods, with an emphasis on Amazon and Shopify (along with its extensive developer ecosystem) as key players.

Non-Fungible Tokens (NFTs) | NFTs, cryptographic tokens assigned to digital assets on the blockchain, are being used to create unique, immutable certificates for products sold through e-commerce and have the potential to extend that use case to resale as well.

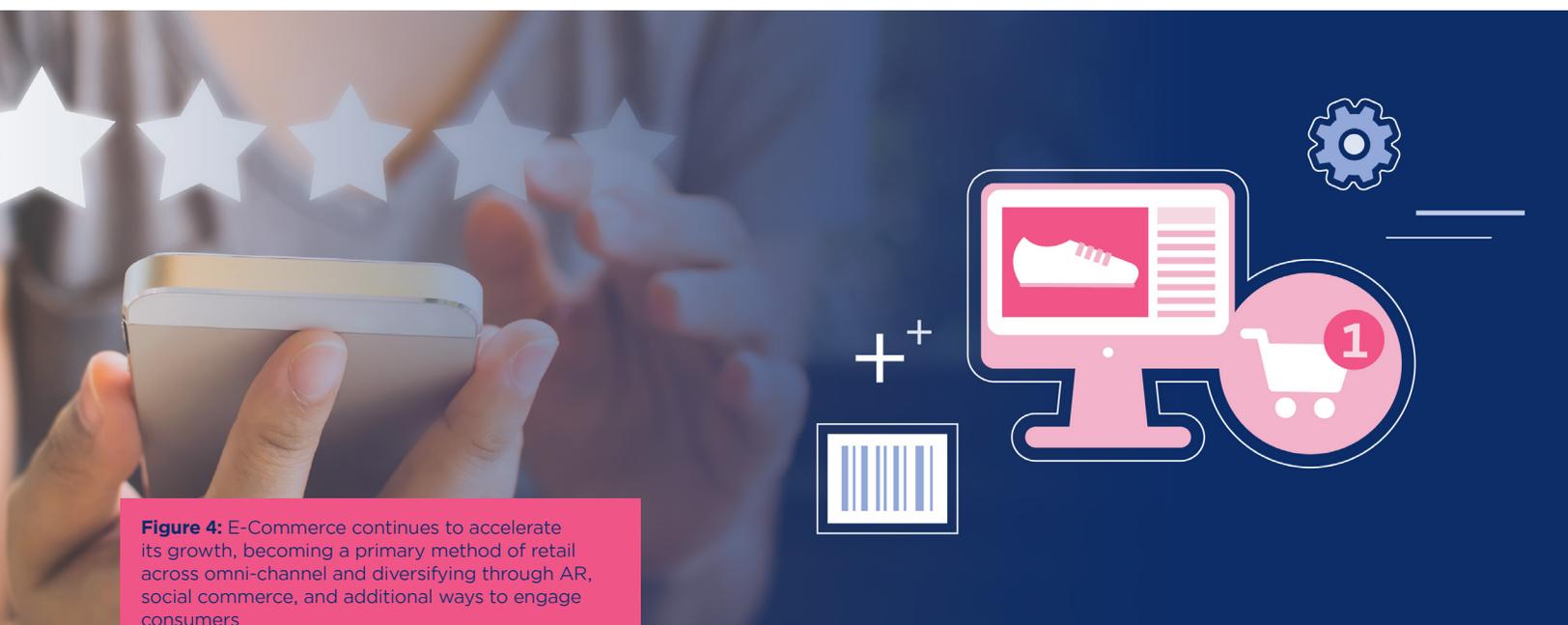


Figure 4: E-Commerce continues to accelerate its growth, becoming a primary method of retail across omni-channel and diversifying through AR, social commerce, and additional ways to engage consumers

Supply Chain Technology

Supply chain technology continues to evolve. As sensor technology continues to develop, companies are more invested in the power of smart packaging, and traceability remains one of the primary concerns of consumers and businesses that want to prove the ethical, sustainable sourcing of their products. From Radio Frequency Identification (RFID) tags to QR codes to Near-Field Communication (NFC) tags, brands are experimenting with different ways to enable traceability both within their operations and for consumer edification as well.

Construction | The construction supply chain is using technology to overcome fragmented processes and improve the ease with which products can move from origin to jobsite, via marketplaces, RFID tags, QR codes, and computer vision.

Traceability | Product traceability evolves with sensor development and requires the digitization of supply chains (digital twins), tags for real-time location system (RTLS) tracking, QR codes, and RFID sensors to track and trace products at scale.

Smart Labels | Packaging is being integrated with sensors to improve its functionality and usefulness within the supply chain, reporting automatically to supply chain systems about location and product status and enabling consumer engagement.

Novel Data Carriers (e.g., DNA) | DNA remains the primary method of persistent identity for products in the agriculture supply chain, work is being done to commercialize spores and “smart dust” as well; and the latter could even integrate with wireless IoT applications.

Verified Credentials | Electronic digital twins that provide certification and authentication (a digital passport) are seeing investment from luxury goods (i.e., wine) and integration with blockchain technology.

Figure 5: Supply chain technology has rushed to solve the myriad of problems caused by the pandemic, many of which continue to plague various supply chains (e.g., semiconductor chips) with massive impact on several different industries



Emerging Technology

Various technologies and trends are on the far horizon, primarily the concern of high-level technology venture capitalist firms, but we have seen recent developments as well. The commercialization of spaceflight has made the space supply chain an attractive market for new entrants and opened up the possibility for companies to enter into that arena via microsattellites to augment GPS for terrestrial tracking. Quantum computing is a lofty computational technology that could revolutionize how complex problems (i.e., supply chain logistics) are modeled and solved in a matter of seconds instead of years.

Quantum Computing | Quantum computing will be utilized for simulation modeling and complex optimization problems, specifically those around logistics and supply chains.

Space Tech | Space commercialization continues to accelerate, with private companies creating both satellites for terrestrial monitoring as well as shuttles and rockets for space supply chains, with the potential for zero-gravity manufacturing to develop into its own nascent industry.

Cellular Agriculture | Cellular agriculture is edging towards commercialization and scalability to change the food supply chain from farms to laboratories and reduce the detrimental environmental impact of the traditional meat industry.

Metaverse | The metaverse is a virtual world expected to grow out of the convergence of physical and digital experiences, born from the combination of AR/VR, video games, and purely digital assets (like NFTs) that create a new method of retail, new avenues of consumer interaction, and new types of products to buy.

Nanoscale Identification | Nanoelectromechanical tags, microbial spores, and the re-engineering of silk on the protein level have all grown from advances in nanotechnology to create persistent, unclonable, and covert identification tags for physical products.

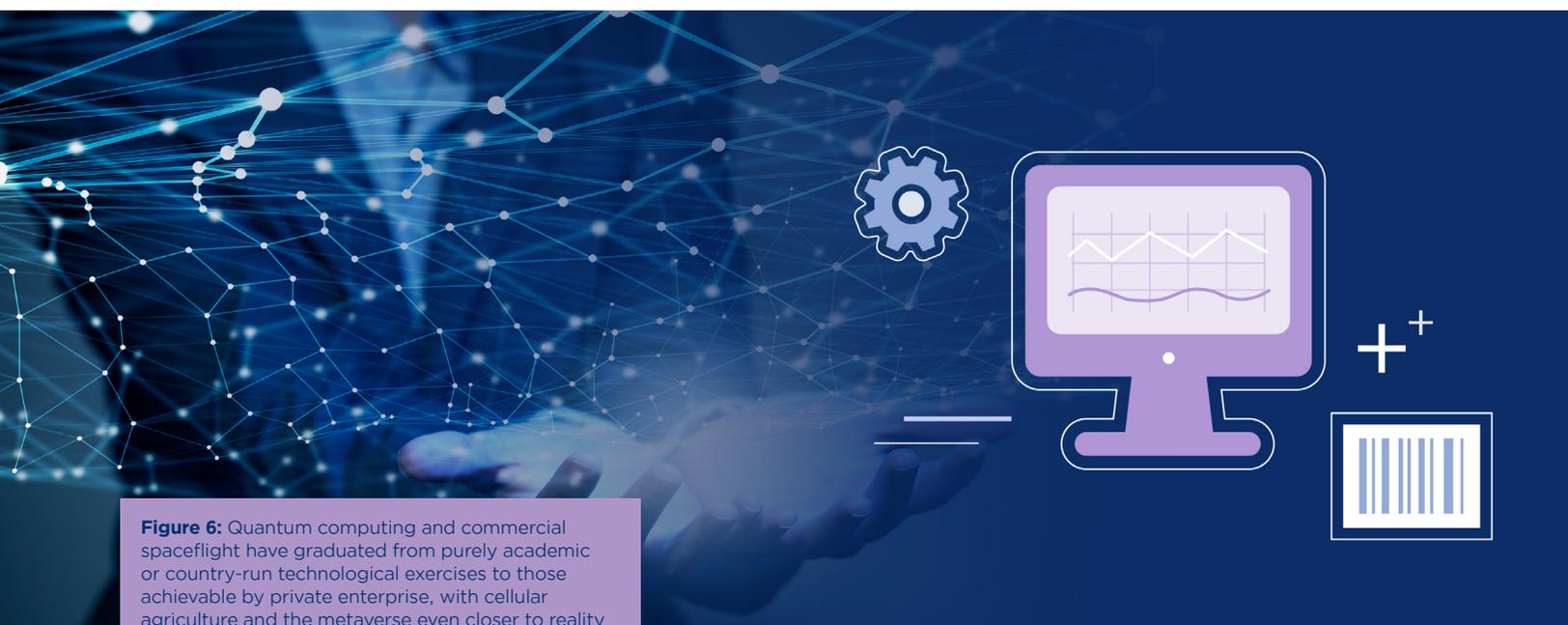


Figure 6: Quantum computing and commercial spaceflight have graduated from purely academic or country-run technological exercises to those achievable by private enterprise, with cellular agriculture and the metaverse even closer to reality

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