The Global Language of Business

Trend Research 2023-2024

Innovation in a world of continuous disruption

Authored by the Innovation Board

Table of Contents

Innovation in a world of continuous disruption

Uncertainty. That one word captures the continued disruption we've seen over the past few years, despite a waning global pandemic: global inflation worries, climate change driven extreme weather events, financial instability due to inflation and interest rate fluctuations, as well as increased geopolitical tensions. Yet, in light of these uncertainties, there is accelerated investment and commitment to combat climate change and improve corporate sustainability. According to Deloitte in their survey of 2,000 corporate executives across 24 countries, 78% are optimistic that steps being taken can help avoid the worst impacts of climate change and 84% believe economic growth can be achieved while also reaching climate change goals.[1] Complementary to the global focus on sustainability initiatives is an increased emphasis on circular economy practices to improve the collection, recycling and reuse of goods and their materials.

While analysing these and other business trends, the rapid advancement of technologies that can serve to accelerate these business trends is also an essential focus. While 2022 was the year of hype around the Metaverse, 2023 has become the year of massive hype for artificial intelligence (A.I.) after the public launch of ChatGPT 3.0 in November 2022.[2]

As we continue to evaluate trends impacting the future of the industries that GS1 serves and seek to understand ways to improve supply chain transparency and resiliency, the themes of Flexibility, Collaboration and Innovation are strong principles that will guide companies through periods of uncertainty.

Flexibility

Up and down the supply chain, companies need to continue to look for new ways to be nimble against small and large disruptions. Supply chain digitalisation – a new trend featured in this report – is key to gaining visibility into new insights that allow companies to adapt and compete in an ever-changing global landscape.

GS1's approach to digital interoperability for both identity and data sharing can be an important enabler to aid in supply chain resilience and is core to the success of supply chain digitalisation.

84% of corporate leaders believe the world can achieve global economic growth while also reaching climate change goals.

– Deloitte, 2023

Collaboration

Distributed hybrid and remote workforces have challenged companies to evolve their approaches for ensuring strong collaboration. Additionally, workforce demographics are shifting dramatically: Generation Z workers (those defined as being born after 1997) will make up 30% of the global workforce by 2030.[3] Throughout the COVID-19 pandemic, proficiency in leveraging connectivity and cloud-based tools aided in connecting people-to-people, systems-to-systems and people-to-systems.

GS1 continues to lead the way in creating collaborative communities where organisations can come together to solve problems and utilise connected systems to unlock the value of data about products, places, assets, shipments and entities.

Innovation

Continuous improvement and reinvention through innovation has never been more important. In fact, over 50% of the Fortune 500 companies in the year 2000 have either gone bankrupt, been acquired or ceased to exist.[4] But how can you innovate effectively and stay ahead when everyone else is doing it too? It all comes down to effective problem-solving: knowing how to choose the right problem, deciding what impact solving that problem will have and, most importantly, leveraging internal and external talent, resources and solutions to create new opportunities for innovation and growth.[5]

GS1's innovation activities are grounded in the founding principles of designing standards and solutions that aid companies in solving new emerging business problems.

In this third edition of the GS1 Trend Research Report, we continue to evaluate and comment on the top trends and technologies that will support industry transformations today... and into the future.

1 *Deloitte 2023 CxO Sustainability Report.* https://www.deloitte.com/global/en/issues/climate/content/deloitte-cxo-sustainability-report.html

2 Rascoe, Ayesha and Kerr, Dara. (2 April 2023). *Amid AI hype, tech companies are taking a step back from the metaverse.* [Radio broadcast]. NPR. https://www.npr.org/2023/04/02/1167645442/amid-ai-hype-tech-companies-are-taking-a-step-back-from-the-metaverse

3 Kumar, Vibha Sathesh. (18 April 2023). *Gen Z In The Workplace: How Should Companies Adapt?* https://imagine.jhu.edu/blog/2023/04/18/gen-z-in-the-workplace-how-should-companies-adapt/

4 When Digital Disruption Strikes: How Can Incumbents Respond? (July 2017). Capgemini Consulting. https://www.capgemini.com/consulting/wp-content/uploads/sites/30/2017/07/digital_disruption_1.pdf

5 *Author Talks: Why problem solving is the key to innovation.* (6 June 2023). McKinsey Featured Insights interview with Dr. Sheena Iyengar. https://www.mckinsey.com/featured-insights/mckinsey-on-books/author-talks-why-problem-solving-is-the-key-to-innovation

Adjustments to the trend report

The team responsible for the research reached out to GS1 Member Organisations and worked with the Innovation Board to evaluate the relevance of the business trends and technology enablers that were highlighted in the 2020-2021 Trend Research Report. In revisiting these trends and technologies, the team has adjusted or shifted the status of some of the trends and technologies.

Data security and privacy is now solely focused on Data privacy (as Data security has become a commonplace corporate function), Sustainability now includes circular economy, On-demand logistics and services is replaced by Supply chain digitalisation and Empowered consumers now includes Metaverse as a growing disruptor for how brands interact with consumers. Finally, Mass customisation is no longer a prioritised trend but the related topics of Limited edition products and personalised healthcare were added as trends to watch.

For enabling technologies, Robotics and Autonomous logistics were combined into Robotics and automation. Spatial computing was added to encompass both computer-based interactions with the physical world and the previous technologies of Augmented and Virtual Reality. Additionally, Blockchain and distributed data and Biometrics and voice recognition are no longer top technologies but are highlighted in other interesting technologies to watch. Additive manufacturing was included as another technology to watch.

As before, we worked with the GS1 Healthcare team to incorporate comments on the trends and technologies that are unique to the healthcare sector. Some of these insights are included with the discussion on individual trends and technologies and a callout on page 8 provides broader context for key trends in healthcare.

Finally, with this third Trend Research Report, we look back and illustrate the shifts we have seen across the trends and technologies since the first report was published five years ago.

Revisiting top business trends

The research team revisited the previous 2018-2019 and 2020-2021 Trend Research Reports[6,7] and have refreshed the business trends to highlight those that are impacting the industries that GS1 serves.

Each of them was then researched to explore how they have advanced or evolved, with some being renamed or changed. Additionally, the team noted that some are accelerating in importance faster than others.

Throughout the document, icons show the change in the trends and technologies that are:

- Rapidly increasing in importance
- Accelerating in importance
- Making steady progress, but not accelerating as fast as others

These top current and near-future business trends are:

- Data privacy (previously data privacy and cyber security)
- Sustainability and circular economy (previously sustainability)
- Supply chain digitalisation (replacing on-demand logistics and services)
- Traceability
- Empowered consumers and the Metaverse (previously empowered consumers)
- Smart everything and connected things

Other trends to watch:

- Limited edition products and personalised healthcare (replacing mass customisation)

Rapidly increasing in importance

Data privacy

The cost to businesses for a data privacy breach increased to a new high of US$4.35 million in 2022.[8] To combat the risk to consumers and patients alike, increased privacy regulations for protecting consumer and patient data makes this trend a high priority for companies. Increasingly, artificial intelligence privacy breaches will be a challenge for organisations and will

drive continued investment in cybersecurity measures. Government-led privacy laws are being considered throughout the world and are often being modelled after the 2018 EU GDPR (General Data Protection Regulation), which drives requirements for greater transparency in data privacy and gives the individual more control over their data. Yet, while 83% of consumers understand the value of sharing their data, they will increasingly demand control over their data, creating a challenging balance for companies to monetise consumer data while maintaining consumer trust.[9]

Therefore, the Innovation Board believes that data privacy will continue to be an important topic across the GS1 value chain, from upstream providers through manufacturing and transport, and especially in healthcare, retail and the use of products.

Sustainability and circular economy

While social and environmental sustainability continue to drive high corporate interest, circular economy concepts have taken centre stage in focusing action and regulation. In the EU, the Digital Product Passport initiative is providing a roadmap to increase recycling and recovery of valuable materials, starting with apparel and textiles and with key raw materials like iron and steel.[10] Additionally, goals to achieve net zero emissions by 2050[11] and increase renewable energy resources continues to be a global focus, with rapid acceleration of wind and solar capacity in China and a 50-fold increase in solar generation capacity in India since 2012.[12]

6 *GS1 2018-2019 Trend Research Report: Identifying opportunities for GS1 to address today's industry challenges* https://www.gs1.org/docs/innovation/GS1-Trend-Research-Paper-070219.pdf

7 *GS1 2020-2021 Trend Research Report: Navigating the next normal* https://www.gs1.org/docs/innovation/GS1-Trend-Research-2nd-edition-101320.pdf

8 Gobardhan, Astrid. *Data Privacy Trends To Follow for 2023.* (26 January 2023). Information Week. https://www.informationweek.com/big-data/data-privacy-trends-to-follow-for-2023

9 Joseph, Jonathan. *Yes, Consumers Care About Privacy; And They Vote With Their Wallets.* (25 October 2022). CPO Magazine. https://www.cpomagazine.com/data-privacy/yes-consumers-care-about-privacy-and-they-vote-with-their-wallets/

10 Gumbau, Anna. *Digital product passports become the norm in EU's green economy plan.* (21 November 2022). EURACTIV. https://www.euractiv.com/section/circular-economy/news/digital-product-passports-become-the-norm-in-eus-green-economy-plan/

11 *Race to Zero.* The Consumer Goods Forum. https://www.theconsumergoodsforum.com/environmental-sustainability/carbon-solutions-hub/race-to-zero/

12 Gurugram, Mundra and Pune. *Will India become a green superpower?* (20 October 2022). The Economist. https://www.economist.com/briefing/2022/10/20/will-india-become-a-green-superpower

In healthcare, initiatives such as the UK National Health Service (NHS) Net Zero[13] highlight the intent of this sector to support sustainability goals, while also delivering high quality healthcare outcomes. As noted in the latest GS1 Healthcare Strategy, sustainability and effective use of medical products involves both maximising healthcare resources and minimising waste.

Initiatives include the use of green packaging, electronic leaflets and renewable energy in manufacturing as well as efficient, traceable logistics – both forward and in reverse.

The Innovation Board believes this increased emphasis on sustainability by industry will be important as companies embrace ESG (environmental, social and corporate governance) principles and find new ways to make their supply chains more transparent, flexible, adaptable and humane. GS1 must therefore ensure their work supports these escalating drivers.[14] Additionally, the Innovation Board sees significant promise in the use of next generation 2D barcodes powered by GS1 (such as GS1 DataMatrix and QR Codes with GS1 Digital Link syntax) to act as catalysts for connecting physical products with online information. Doing so will accelerate consumer empowerment of greener choices and patient trust through initiatives like access to electronic patient information leaflets (ePIL) and will support many other regulatory compliance requirements.

Accelerating in importance

Supply chain digitalisation

While on-demand logistics and services previously reflected the increasingly agile systems required for resilient supply chains, we've replaced this topic with the driver of supply chain digitalisation. This trend more accurately describes how businesses are working to improve supply chain visibility through increased investment in digital transformation – enabling companies to better understand their strengths and weaknesses and apply analytics and machine learning tools to optimise and increase their supply chain resilience and flexibility.[15] Further, supply chain digitalisation can assist in realising opportunities such as automated smart warehouses and can be a catalyst for implementations of increasingly-advanced traceability solutions. Additionally, supply chain digitalisation can help with the measurement of sustainability and environmental factors to meet increasingly important ESG (environmental, social and corporate governance) corporate goals.[16]

The Innovation Board believes that maintaining all of the GS1 identifiers licensed around the world in a global set of interoperable registries (the Verified by GS1 service) is an essential enabler for the digitalisation of supply chains. This is especially the case as these GS1 identifiers (which identify products, locations, parties, assets and things) are increasingly used to connect to additional sources of data relevant to everything from provenance and logistics data to sustainability and ethical sourcing information.

Traceability

While traceability continues to be a topic of high interest for many industries and sectors, implementation is primarily driven by regulatory demands. Food safety initiatives in the US driven by the US Food and Drug Administration have led to new traceability requirements to help proactively identify and remove contaminated products before they reach the shelf, thereby improving consumer safety and trust through transparency of product data.[17] Another example is the recent food safety and traceability initiative in the Zhejiang Province of China which has enabled rapid adoption of QR Codes powered by GS1, leading consumers to access more product information through 111 million consumer scans of over 180,000 products in 2022.[18] Additionally, collaborations such as the Verification and Traceability Initiative (VTI) enable digital vaccine traceability using GS1 standards to provide access to authentic and safe vaccines in a range of healthcare markets across lower middle-income countries (LMICs).[19] Finally, circular economy goals (see earlier section) are driving interest in B2C solutions to provide guidance to consumers for recyclability and also enable B2B solutions to track and trace upstream raw materials for textile production.[20]

The Innovation Board reaffirms the important impact that GS1 standards have in enabling trust and safety in traceability systems which operate across interoperable supply chains.

---

13 *Delivering a new zero NHS.* NHS England. https://www.england.nhs.uk/greenernhs/a-net-zero-nhs/

14 *Impact of international, open standards on circularity in Europe.* Deloitte. https://www2.deloitte.com/content/dam/Deloitte/pl/Documents/Reports/pl_Deloitte_I_GS1_I_Impact_of_international_open_standards_on_circularity_in_Europe_.pdf

15 Riley, Sean. *Top 10: Ways supply chains can meet customer needs.* (26 February 2023). Supply Chain Digital. https://supplychaindigital.com/top10/top-10-ways-supply-chains-can-meet-customer-needs

16 *Why digital transformation and non-financial reporting go hand in hand.* (9 January 2023). World Economic Forum. https://www.weforum.org/agenda/2023/01/digital-transformation-new-it-esg-davos-23/

17 Civitillo, Wiggs. *Under FSMA Rule 204(d), digital traceability can save lives by saving food supplies.* (14 November 2022). IBM. https://www.ibm.com/blog/fsma-rule-204d-digital-traceability-sustainability/

18 *2D barcodes case study: Better food safety and supply chain efficiency in Zhejiang Province, China*. (August 2023). GS1. https://www.gs1.org/insights-events/case-studies/case-studies/better-food-safety-and-supply-chain-efficiency-zhejiang-province

19 Brydon, Edward. *Digital Tracking of vaccines is boosting health system oversight.* (7 December 2022). VaccinesWork. https://www.gavi.org/vaccineswork/digital-tracking-vaccines-boosting-health-system-oversight

20 *The new EU sustainability textile strategy – the EU Digital Product Passport and what it means for apparel and textile industries in 2022-2023.* (March 2023). GS1 in Europe. https://gs1.eu/wp-content/uploads/2023/03/The-DPP-ApparelTextile-Industry-Briefing-Document.pdf

Continued importance

Empowered consumers and the Metaverse

Post-pandemic, consumer behaviour continues to make rapid changes, with consumers placing a greater emphasis on timely product fulfilment over in-store experiences. Additionally, social media is playing an even stronger role in connecting consumers to new brands: 6 in 10 Gen Z consumers have discovered a new product or brand via social media.[21] A big challenge for brands will be whether consumers trust influencers more than the brands themselves. And an even bigger disruptor may be on the horizon, as companies explore new ways of interacting with consumers virtually as metaverse concepts evolve.[22] Here still, any metaverse experience will be centred on consumers – allowing them to define how their virtual avatars interact with their virtual products.

The Innovation Board continues to emphasise the importance of companies continuing their digital transformation and focusing on bridging physical and digital commerce. GS1 needs to continue to explore and understand these seismic shifts so that the work of connecting physical products to their digital and virtual counterparts can continue at pace, leveraging data useful to consumers, brands, retailers and marketplaces alike...both in and outside virtual metaverse platforms.

Smart everything and connected things

While futuristic visions of smart homes have been around for over 50 years, this promise has led to only a few common "smart" devices finding their way into households, such as smart speakers, switches that can turn lights on and off and thermostats that automatically adjust temperature settings.[23] While smart home interest was anticipated to rebound in 2021, worldwide shipments of these devices continue to decline in 2023.[24] Yet while the consumer-driven smart future hasn't yet materialised, technology advances that leverage IoT technologies to improve productivity in industrial applications continues to advance in both agriculture and energy. All of this has contributed to over 15 billion connected IoT devices in 2023.[25] Likewise in healthcare, connected devices are becoming essential. Those new devices are providing comprehensive information about patients' health and will play a key role in personalised medicine.

Traceability initiatives in China have enabled 111 million consumer scans of QR Codes powered by GS1 in 2022... putting important product information easily in the hands of consumers.

While it still may take time to realise the promise of the fully connected smart home, the Innovation Board recommends continued research into ways that identification of "things" can enable better digital connectivity to support the growth of smart systems, especially in the areas of factory automation, logistics automation, process automation and in healthcare applications. By leveraging the power of open standards, the future of interconnected devices will demand that "trust moves with data" in increasingly secure ways.

Other interesting trends to watch

While Mass Customisation (a trend featured in the first and second edition Trend Reports) has not advanced as expected in the retail sector, two related concepts have emerged: limited edition products and personalised healthcare. **Limited edition products** have become popular, especially in apparel and footwear. By creating scarcity or exclusivity – sometimes by partnering with an entertainment or sports celebrity – brands are able to use special releases of products to drive consumer excitement in their brand and thereby create rapid sales for their product.[26] **Personalised healthcare**, such as personalised medicine and gene therapy, has propelled healthcare of the future, enabling treatment of some medical conditions previously seen as untouchable.[27] Considering these examples, it will be interesting to observe how techniques evolve to efficiently create small batch products and treatments that could impact other sectors as well.

6 in 10 Gen Z consumers have discovered a new product or brand via social media.

– Capgemini Research Institute, 2023

[21] *What matters to today's consumer 2023.* (January 2023). Capgemini Research Institute. https://www.capgemini.com/insights/research-library/what-matters-to-todays-consumer-2023/

[22] Purdy, Mark. *Building a great customer experience in the metaverse.* (3 April 2023). Harvard Business Review. https://hbr.org/2023/04/building-a-great-customer-experience-in-the-metaverse

[23] Newman, Jared. *The smart home is flailing as a concept—because it sucks*. (2 August 2021). Fast Company. https://www.fastcompany.com/90660570/the-smart-home-is-flailing-as-a-concept-because-it-sucks

[24] *Worldwide Shipments of Smart Home Devices Continue to Decline in 2023, Slump Expected to Last into 2024.* (27 June 2023). International Data Corporation. https://www.idc.com/getdoc.jsp?containerId=prUS50994923

[25] Curryer, Emily. *IoT in 2023 and beyond.* (16 March 2023). Tech Informed. https://techinformed.com/iot-in-2023-and-beyond

[26] Moore, Kaleigh. *Limited Drops in Retail - Everything You Need To Know.* (13 July 2021). Shopify Retail Blog. https://www.shopify.com/retail/limited-drops

[27] Cox, David. *The quest for the era of personalised medicine.* (2 June 2023). BBC. https://www.bbc.com/future/article/20230602-are-we-entering-the-era-of-personalised-medicine

Trends in healthcare

In the last trend research report, we dedicated a section to highlight trends and technologies in the healthcare sector. With the development of the GS1 Healthcare Strategy 2023-2027 came the opportunity for GS1 to build a more detailed process to identify, assess and analyse healthcare trends in more depth. Why is this important? GS1 Healthcare works to ensure implementation of our standards in the areas that serve healthcare now and into the future. To do that effectively, regular assessment of trends on which we must engage is essential.

In developing the strategy, the team reviewed the ever-changing healthcare environment and saw a range of trends that will be considered in future work, but that also are important context for this report. These include an increased emphasis on **patient empowerment** that has placed elevated expectations on how healthcare providers need to evolve their approach to patient treatment and engagement. In addition, the amount of health data that can be collected and processed thanks to the **internet of things** (IoT) and **artificial intelligence** algorithms are enabling more accurate diagnoses and treatments, driving enhancement of **personalised medicine**, and even enabling **telehealth**. Further, as 80% of healthcare providers plan to increase investment in technology and digital solutions over the next five years[28], **digital transformation** will play a key role in improving ways to treat patients effectively without physical consultations, reducing strains at points of care and providing improved access to isolated or impoverished populations. And in the midst of more data is the challenge of **data privacy** – how can personal health data be collected and analysed without compromising patients' rights to privacy? With all this in mind, the GS1 Healthcare team will be infusing technology scouting into their work starting in 2023 so that GS1 can continue to understand how to leverage emerging technologies to adapt to the needs of healthcare for today and tomorrow.

[28] Marr, Bernard. *The Five Biggest Healthcare Tech Trends in 2022.* (10 January 2022). Forbes. https://www.forbes.com/sites/bernardmarr/2022/01/10/the-five-biggest-healthcare-tech-trends-in-2022/

Technologies enabling business trends

Revisiting the key enabling technologies that were analysed in the first and second editions of this report has reinforced the fact that no single enabling technology can solve every problem. Companies and organisations need to investigate a variety of approaches to identify potential solution alternatives to increasingly complex business problems. Over the past few years, many of the technologies we have investigated have evolved or changed and we continue to explore how these support the prioritised business trends.

Through the analysis of these enabling technologies, some were combined or renamed for simplification or clarification. Each also includes either a comment on their connection to key business trends, or an observation on their connection to GS1 and the industries that they serve.

As with the business trends discussed above, each technology disruptor was evaluated to determine which are rapidly increasing in importance, those that are accelerating, and those that are making steady progress. The technology disruptors include:

- Artificial intelligence (A.I.)
- IoT and sensors (previously IoT, sensors and biometrics)
- Verifiable credentials and decentralised identifiers
- Open, structured and linked data
- Robotics and automation (combining Robotics and Autonomous logistics)
- Spatial computing (previously Augmented, virtual and mixed reality)
- Computer vision

Other trends to watch:

- Blockchain and distributed data
- Biometrics and voice recognition (previously voice recognition)

Rapidly increasing in importance

Artificial intelligence (A.I.)

No technology has received more recent attention than generative A.I., models that leverage large collections of human language and unstructured information across the web to enable automatic generation of text responses or images from conversational style inputs. While there has been a big spotlight on how these systems will disrupt software development and education[29], other industries are starting to identify how generative A.I. can be beneficial for automated customer service chat bots, improved data accuracy, inventory management and supporting cashierless retail technology.[30] Yet as generative A.I. is used to produce new images and other creative content, a key challenge will be how to authoritatively identify this content and how to ensure knowledge of the origin of the content, perhaps through the use of watermarks, metadata and/or GS1 identity, which could identify the source of both A.I. generated images and human-generated photos and content.

As industries adapt to these new rapidly evolving generative A.I. and other machine learning technologies, companies will seek opportunities to optimise operations, increase automation and revolutionise their customer service activities. While A.I. is poised to impact virtually every trend, it will have a particular impact in enabling supply chain digitalisation and smart everything and connected things.

Accelerating in importance

IoT and sensors

IoT and related technologies are key to enable the digitalisation of enterprises and supply chains. Central to businesses, consumers, patients and caregivers are handheld smart phones and other devices that create a central hub for connecting smart systems together.[31] Additionally, connected sensors and RFID tags offer other opportunities to capture and use real-time data that can improve decision making across the enterprise.[32] As supply chain digitalisation initiatives increase, IoT and sensors will play an important role in advancements in smart warehouses, circular economy and traceability applications.

[29] Gordon, Cindy. *How Are Educators Reacting To Chat GPT?* (30 April 2023). Forbes. https://www.forbes.com/sites/cindygordon/2023/04/30/how-are-educators-reacting-to-chat-gpt/

[30] Bowman, Jeremy. *How AI Is Changing the Retail Industry.* (10 July 2023). The Motley Fool. https://www.fool.com/investing/stock-market/market-sectors/information-technology/ai-stocks/ai-in-retail/

[31] Kawamoto, Dawn. *20 IoT Devices Connecting the World.* Built In. https://builtin.com/internet-things/iot-devices

[32] Meixner, Anne. *Enablers And Barriers For Connecting Diverse Data.* (9 November 2021). Semiconductor Engineering. https://semiengineering.com/enablers-and-barriers-for-connecting-diverse-data/

"Verifiable credentials are a new way of securely storing and sharing information about yourself, products, or your business."

– Akif Khan, Gartner Research, 2022

Verifiable credentials and decentralised identifiers

As highlighted in the last report, bridging the physical to the digital requires new techniques to manage "identity", verify claims and create trust that is scalable for increasingly distributed data. This is where verifiable credentials (VCs) and decentralised identifiers (DIDs) come into play as important, rapidly emerging technology enablers. While these are still nascent concepts, advances in exploring "Bring Your Own Identity" systems offer opportunities for consumers and patients to more easily protect themselves in their interactions with organisations.[33] For example, by offering consumers the ability to create a digital loyalty card that can be managed as a verifiable credential, they can control which data is used by stores depending on the application. This means that consumers could provide age verification for alcohol purchases while preventing the store from accessing or storing other personal information.[34] And, beyond being a benefit for consumers to manage their personal data, VCs and DIDs can offer other B2B and B2C advantages for products throughout global supply chains, such as verifying claims of organic certification of a product for retail stores and consumers alike.[35]

The Innovation Board sees verifiable credentials and decentralised identifiers as critical technology enablers that offer future capabilities to increase trust in identity and in the data associated with things. Programmes like Verified by GS1 and the ability of services to provide links to other sources of data are generating valuable pilot activities that will continue to explore the role for GS1, understand how to leverage expertise and partnerships in this space and explore potential use cases of a future framework where "trust moves with data."

Open, structured and linked data

While generative A.I. systems are showing the possibilities of creating knowledge from vast amounts of unstructured data across the web, the concepts around open, structured and linked data continue to be powerful mechanisms for widely mapping and communicating information.[36] As organisations evaluate elements of their data governance approach, such as data architecture, storage, security and modelling, the key to ensuring interoperability and enabling better data quality lies in the use of standardised and structured data.[37] And achieving the promise of supply chain digitalisation starts by not only having structured data, but also ensuring data can be linked across open networks to achieve the greatest impact.

The Innovation Board believes that the continued development of the GS1 Web Vocabulary and migration toward a single semantic representation of the GS1 System are important contributions in this area. Additionally, progress toward increased adoption of the GS1 Global Data Model will be essential.

Continued importance

Robotics and automation

No application better illustrates the integration of robotics and automation than smart warehouses. As the logistics industry has adapted to more consumers working, shopping and receiving healthcare treatment in their homes, e-commerce providers, marketplaces and other supplier organisations have ramped up their ability to improve automation and manage the sharp increase in online orders moving through warehouses.[38] Advances have included autonomous robots that move heavy objects seamlessly around human workers, automatic reorganisation to optimise space and pinch-grasping and vacuum-suction tools to improve robotic picking and fulfilment.[39] Additionally, use of autonomous robotics is advancing to improve last-mile solutions, such as restocking of store shelves, facilitating customer pickup at the store and even providing autonomous delivery right to the consumer or patient's home.[40]

Robotics, A.I. and computer vision are working in combination to impact a variety of trends, including supply chain digitalisation and smart everything.

[33] Khan, Akif. *Market Guide for Identity Proofing and Affirmation.* (2 March 2022). Gartner Research. https://emtemp.gcom.cloud/ngw/eventassets/en/conferences/2023/iam18/documents/iam-2023-market-guide-for-identity-proofing-and-affirmation.pdf

[34] Andrade-Walz, Alex. *Reimagining Customer Loyalty Programs With Verifiable Credentials: A Pravici Case Study.* (15 April 2023). Evernym. https://www.evernym.com/blog/customer-loyalty-verifiable-credentials/

[35] *Verifiable Credentials Use Cases.* W3C. https://www.w3.org/TR/vc-use-cases/

[36] *Benefits of the Linked Data Approach*. W3C. https://www.w3.org/2005/Incubator/lld/wiki/Benefits

[37] Olavsrud, Thor. *What is data governance? Best practices for managing data assets.* (24 March 2023). CIO. https://www.cio.com/article/202183/what-is-data-governance-a-best-practices-framework-for-managing-data-assets.html

[38] Sandee, Helco. *Reshaping the Future of Logistics: An Outlook on Warehousing Automation Trends* (13 April 2023). Supply Chain Brain. https://www.supplychainbrain.com/blogs/1-think-tank/post/36991-reshaping-the-future-of-logistics-an-outlook-on-warehousing-automation-trends

[39] Garland, Max. *6 warehouse robotic innovations Amazon showcased in 2022*. (15 December 2022). Supplychain Dive. https://www.supplychaindive.com/news/warehouse-robotics-automation-innovations-amazon-showcased-2022/638115/

[40] Yonhap. *7-Eleven South Korea to test robot delivery with startup.* (19 June 2023). Inside Retail Asia. https://insideretail.asia/2023/06/19/7-eleven-south-korea-to-test-robot-delivery-with-startup/

Spatial computing

Spatial computing is a relatively new term that encompasses the technology that blends computer capabilities with the physical world, expanding on augmented and virtual reality (AR/VR) technologies.[41] While the high cost of wearable consumer headsets has kept these devices relegated to more niche gaming or entertainment applications, spatial computing can enable training and education of healthcare providers and workers in industrial applications. Additionally, in healthcare settings, virtual reality can aid in assisting remote surgeries, while augmented reality devices can support medical procedures by providing real time information on patients and their medical history records, thereby improving efficiency and reducing errors.[42] While spatial computing and related technologies may be slow to achieve wide adoption, it is important to follow how this integrated computing approach can be leveraged for future smart and connected systems.

Computer vision

The market for computer vision systems is expected to double over the next few years, reaching almost US$30 billion by 2026.[43] As computer vision becomes important in spatial computing, advances in A.I. will also enhance the ways that it can be deployed across more applications. In the retail sector, top computer vision applications include analysing customer behaviour in the store as well as improving store layout and inventory management.[44] Of great interest is the growth of cashierless retail, which leverages A.I. and computer vision systems for "grab and go" checkout-free experiences for consumers.[45] In healthcare, computer vision is being deployed to assist with diagnostic image analysis and disease diagnosis, provide surgical guidance and even enabling patient monitoring in healthcare settings.[46]

Additionally, computer vision is a key technology that complements developments in both robotics and autonomous logistics, and is an enabler of many business trends, notably smart everything and supply chain digitalisation.

Other interesting enabling technologies to watch:

Blockchain and distributed data: A chaotic roller coaster of crypto and NFT activity in 2022 has taken quite a bit of excitement out of blockchain. Additionally, applications have been slow to proliferate beyond banking. Despite this, because cryptographic authentication techniques are emerging that leverage distributed data concepts, these technologies should be tracked to see what utility may emerge for supply chain and traceability applications.

Biometrics and voice recognition: While face recognition has become commonplace for enabling personal authentication for smart phones, voice recognition and personal assistant advances have been limited to simple commands for controlling smart speakers or interacting with smart phones. While the capability of voice recognition seems to have matured, the promise of smart speakers to enable "conversational commerce" has not yet materialised. It will be important, however, to continue to track the ways that voice, facial and other biometric recognition can be incorporated into new applications, especially related to the ways that generative A.I. may incorporate voice-based conversations to replace text-based interactions.

Additive manufacturing: While 3D printing has been used for rapid prototyping and can be an enabler for low-volume manufacturing, additive manufacturing is also becoming more of a focus in healthcare. Using materials beyond plastics and resins, bio-printing with polymeric biomaterials is now possible. While not yet mainstream, printing of organs and other bio components is currently in development with encouraging results.[47]

41 Dickson, Ben. *What is spatial computing? A basic explainer.* (15 June 2023). PC Magazine. https://www.pcmag.com/how-to/what-is-spatial-computing-a-basic-explainer

42 Price, Lloyd. *Ready Healthcare One: Is spatial computing the next big trend in HealthTech?* (19 April 2023). HealthTech M&A. https://www.healthcare.digital/single-post/ready-healthcare-one-it-spacial-computing-the-next-big-trend-in-healthtech

43 *Computer Vision Market Size, Share, Trends and Analysis, 2023-2026*. (19 May 2023). Global Data. https://www.globaldata.com/store/report/computer-vision-market-analysis/

44 Bianchi, Aaron. *The Future of Retail: How Computer Vision is Modernizing Retail.* (6 February 2023). Digital Divide Data Blog. https://www.digitaldividedata.com/blog/computer-vision-retail

45 Annavajjhala, Ravi. *Cashierless Stores Are Getting A Mind Of Their Own.* (29 September 2022). Forbes. https://www.forbes.com/sites/forbestechcouncil/2022/09/29/cashierless-stores-are-getting-a-mind-of-their-own

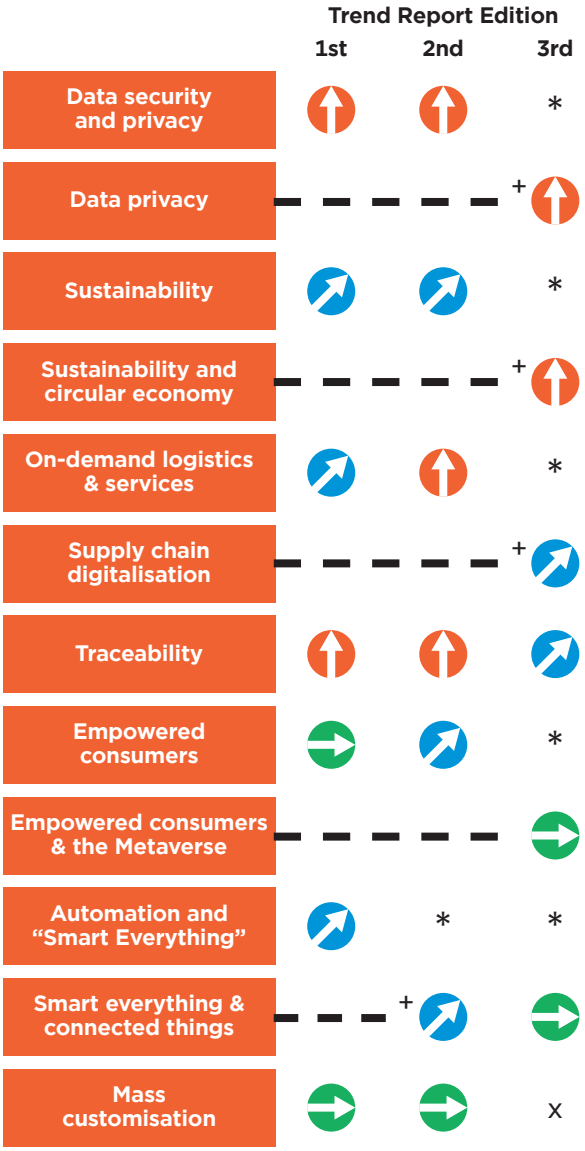
46 Esteva, Andre, et al. *Deep learning-enabled medical computer vision.* (8 January 2021). Nature. https://www.nature.com/articles/s41746-020-00376-2

47 Pohang University of Science & Technology. *Larger and more lifelike: What is the future of bioprinted organs?* (21 September 2022). Phys.org. https://phys.org/news/2022-09-larger-life-like-future-bioprinted.html

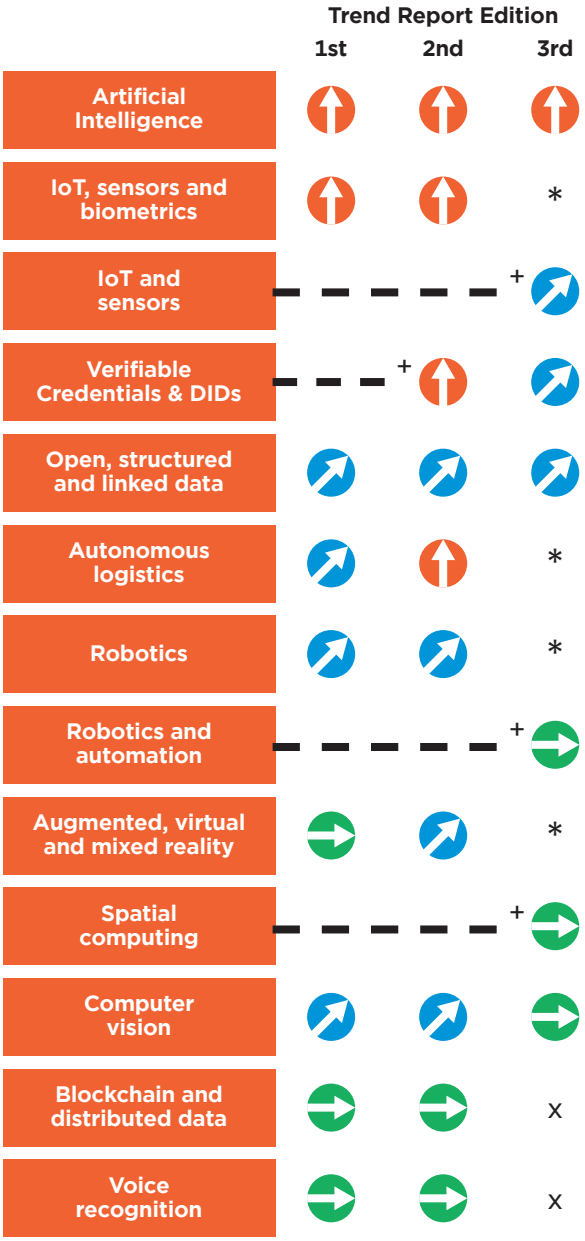
Shifts in business trends and technologies over the past five years

Over the last five years, we've issued three Trend Research reports. The graphics below show the trajectories of each of the prioritised Business Trends and Technology Enablers over the three issues of the report, noting those that were new in either the second or third edition report, those that were replaced with other trends/technologies, and those that have stopped being included as prioritised Business Trends or Technology Enablers.

Business Trends changes over the last five years



Technology Enablers over the last five years



Legend:
+ year introduced
* replaced with a new trend/technology
x removed from the trend report

Recommendations

As you've seen in this third edition of the GS1 Innovation Board Trend Research Report, the disruptions of the past years have forced acceleration of many digital transformation elements. A cornerstone of any digital transformation are the concepts that are core to the GS1 system: globally unique identification, a common data language, a commitment to interoperability and a firm belief that business value achieved through data sharing is amplified through the use of standards.

The Innovation Board continues to emphasise the power of leveraging these standards to enable access to data about products, locations, services and things, and believes that many of these trends and technologies will advance successfully only when companies and partners adhere to a standards mindset.

The Innovation Board recommendations highlighted throughout this report are summarised below.

1. **Continue the work of extending the core value of Verified by GS1 to include industry adoption of links to other sources of data.** The last two years have begun to show the core value of having broad access to basic information about all GS1 identifiers through use of the Verified by GS1 services available globally. The Innovation Board believes in the importance of continued work to ensure that the killer use cases that industry has priortised for Verified by GS1 are enabled at scale. This will require connection of all of the GS1 identifiers licensed around the world to those links to relevant and authoritative sources of data about the things that carry GS1 identity.
   As the global migration to 2D accelerates (see next recommendation), organisations will begin to unlock the ability to use data in the GS1 Registries to power their own internal shopper apps. Meanwhile, regulators will advance the state of the art by connecting a simple 2D scan to a wide variety of valuable information, such as certification and credentials, provenance and logistics data, sustainability and ethical sourcing information.
2. **Adoption of next generation 2D barcodes powered by GS1 must accelerate to support the digital transformation of industry.** GS1 DataMatrix has been deployed over the past decade across many countries to improve product identification and traceability in the healthcare sector. Now, with the opportunity to leverage both GS1 DataMatrix and QR Codes with GS1 Digital Link syntax for retail applications, brands and retailers can enhance product safety and improve inventory accuracy all while connecting consumers to online information and experiences...and still enable "beep" at checkout. While some top use cases for 2D barcodes are already emerging (such as up to 40% reduced food waste for fresh foods), additional use cases will be realised as companies embrace the opportunities to use more product data over the coming years.
3. **Building an ecosystem of increasing trust in identity and in data should be an essential focus for GS1 and for the industries that they serve.** As supply chains become increasingly digitised...data must be shared between trading partners and with consumers and patients in ways that enhance trust everywhere. The technology enablers of VCs and DIDs are expected to play a significant role here, and the enabler of "linked, open data" will also contribute toward ensuring that many more organisations are able to share their own data about products, places and things in ways that drive increases in trust. GS1 must partner with industry to unlock a future where "trust moves with data."
4. **Flexibility will ensure more robust, resilient and adaptive supply chains.** In the face of continuous disruption, organisations need to continuously innovate and test new approaches to strengthen their processes and ability to adapt quickly. Ensuring interoperability across industry implementations will provide the best possible insurance against disruption, as interoperable ecosystems have significantly more ways that they can adapt and thrive in the face of unexpected changes in the landscape.
5. **Collaboration is more essential than ever.** The challenges that industry faces have never been more consistent around the world and there's never been a more opportune time to collaborate to address these challenges. The increasingly global reach and impact of regulatory developments is challenging corporate timelines and established plans and priorities. Engaging in active collaboration with many internal and external stakeholders, including those across your entire industry, has never been more important. The neutral, virtual communities that GS1 convenes to advance standards and Core Data Services will be more important into the future than they have ever been.
6. **Innovation must accelerate if we are to keep up. Innovation must step-change if we are to thrive.** Continued exploration of trends and technologies is vital to understand how both industry and GS1 must evolve and change to thrive in an increasingly disruptive and uncertain world. GS1 must continue to leverage innovation learnings from its members and from other organisations around the world to help expand and extend GS1's system of standards to serve global commerce in new and meaningful ways.

For more information about the GS1 Trend Research Report and GS1 Innovation, contact GS1 at innovation@gs1.org.

About GS1

GS1 is a neutral, not-for-profit organisation that provides global standards for efficient business communication. We are best known for the barcode, named in 2016 by the BBC as one of "the 50 things that made the world economy." GS1 standards improve the efficiency, safety and visibility of supply chains across physical and digital channels in 25 sectors. We enable organisations of all types and sizes to identify, capture and share information seamlessly. Our scale and reach – local Member Organisations in 116 countries, more than 2 million user companies and over 10 billion transactions every day – help ensure that GS1 standards create a common language that supports systems and processes across the globe. Find out more at www.gs1.org.

GS1 AISBL

Blue Tower, Avenue Louise 326, bte 10
BE 1050 Brussels, Belgium
T +32 2 788 78 00
E contactus@gs1.org

www.gs1.org

Connect with GS1