



## RESEARCH REPORT

# Advancing Logistics Operations Through Intelligent Data Capture

Using 2D Data Carriers for Efficient and Accurate Warehouse Operations

IN COLLABORATION WITH VDC RESEARCH

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**70%**

of logistics organizations experience barcode readability issues weekly



**43%**

seek increased transparency in sourcing and traceability



**36%**

aim to improve inventory management and asset tracking



**47%**

cite enhanced information exchange for investing in 2D

In today's fast-paced data-driven supply chain environment, outdated logistics systems, fragmented labeling practices, and manual processes are no longer sustainable. The need for real-time traceability, inventory management, and smooth operations calls for more standardized logistics practices.

In order for products to move efficiently through the supply chain and create a system that can adapt to potential disruptions, more automated data capture is required, building on the foundation of supply chain standards.

This exclusive report from VDC Research, commissioned by GS1 US®, explores how intelligent data capture—powered by 2D barcodes and global standards—is transforming logistics operations across industries.

## Introduction

Standards are more important than ever before in the context of today's challenging economy, because they are the foundation for clear, understandable exchanges that keep costs down for everyone by reducing complexity. By implementing standards, the logistics of international supply chains are more efficient, more sustainable, and more profitable. Well-designed supply chain standards play a very important role in day-to-day business operations: They reduce complexity between and within organizations. They make it easier to make the right decisions about purchasing hardware, software and equipment; and then they reduce the costs of implementation, integration and maintenance. They facilitate collaboration between trading partners in the supply chain, making it quicker and easier to identify items, share information (like order quantities, availability, or specific characteristics), order and receive parts or ingredients from suppliers, or ship goods to customers.

## Evolution of Multi-Dimensional Intelligent Data Capture Requirements in Logistics Environments

In today's global logistics landscape, the demand for real-time visibility, traceability, and compliance is transforming how organizations view data capture. Traditional 1D barcode systems are no longer sufficient to meet evolving operational and regulatory requirements. The increasing complexity of global supply chains, coupled with the need to trace products back to their origin, has led to the rise of multi-dimensional (2D) data capture technologies.

These next level data carriers, including QR codes and Data Matrix symbologies, enable greater information density and are better suited to capture complex data elements required for traceability, compliance, and inventory control. Intelligent data capture solutions are now foundational to warehouse automation, enhancing both accuracy and responsiveness.

The evolution is driven by digital transformation initiatives, traceability mandates like FSMA 204 and 21 CFR Part 11, as well as increasing consumer demand for transparency. These pressures necessitate automated, high-fidelity data capture that can verify product origins, track movement through the supply chain, and unique identification standards such as those provided by GS1.

## Aligning Operational Improvement Initiatives in Logistics Environments with Material Handling and Data Capture Solutions

To remain competitive, logistics operations must align improvement initiatives with next-generation data capture technologies. Material handling systems, when integrated with data-rich scanning capabilities, offer streamlined processes from receiving to shipping. These integrations enable:

- *Reduced picking and shipping errors*
- *Accelerated throughput with minimal manual intervention*
- *Enhanced WMS integration and inventory accuracy*
- *Real-time asset tracking and traceability*

Digitization and automation also support compliance with federal mandates and customer labeling requirements. Industry-wide adoption of automation tools, AI integration, and high-speed imaging is facilitating efficient warehouse operations. Examples include rapid WMS deployment models, advanced scanner integrations, and SDK platforms that streamline barcode data extraction.

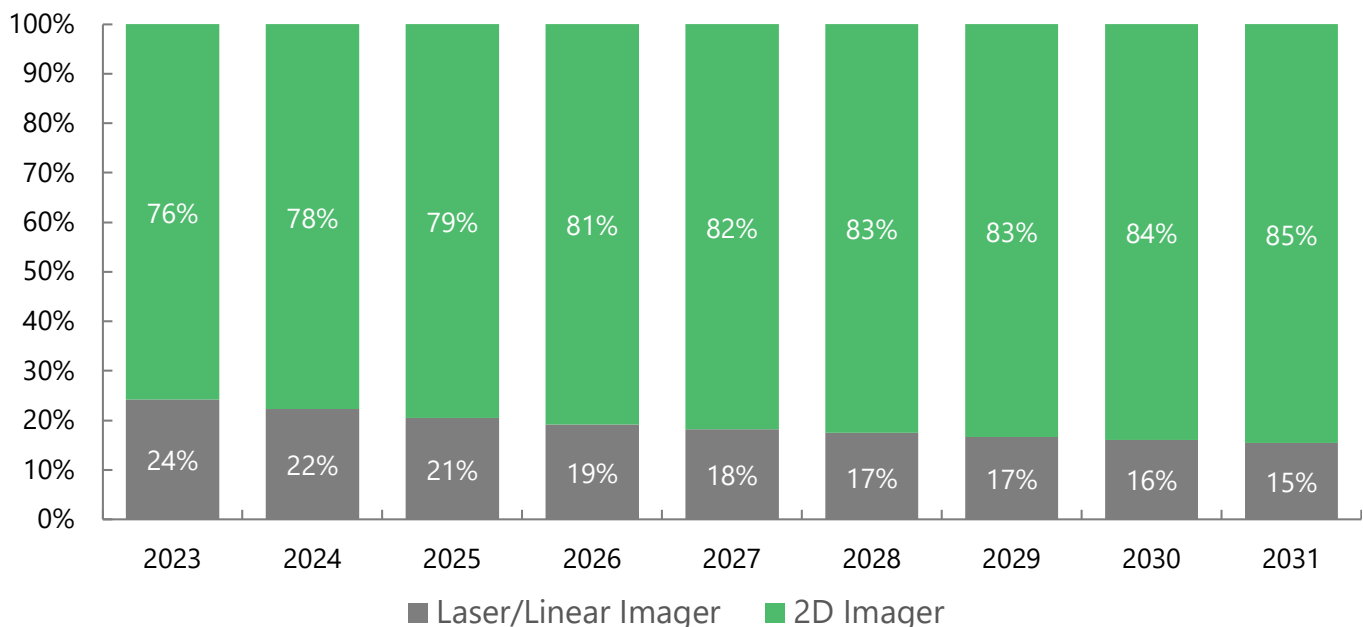
With the rise in shipment volumes and increased complexity in handling smaller batch sizes, warehouse operators must rethink their reluctance to invest in updated technologies. The increasing prevalence of multi-barcode labels, labeling inconsistencies, and non-compliant packaging make modern data capture and validation systems indispensable.

## Current State of Data Capture Solutions in Logistics Environments

Barcoding is ubiquitous in warehousing environments, supporting the ability to track-and-trace inventory movement and ensure accurate order fulfillment. Barcodes are incorporated into all functional workflows leading to benefits ranging from enhanced accuracy and operational efficiencies to real-time visibility into stock levels and lower risk of stock discrepancies. Seamless compatibility with backend WMS applications or other systems of record is key to ensure smooth, error-free operations free of manual intervention.

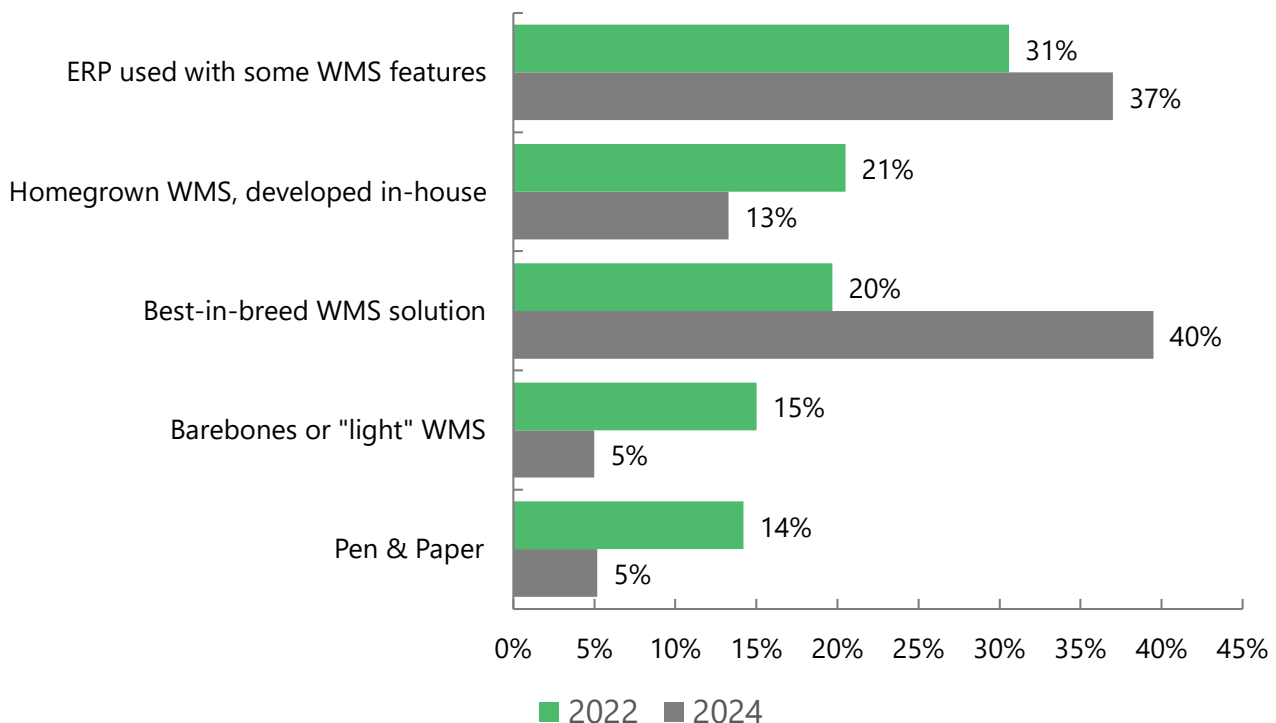
A challenge for many organizations as they look to modernize their operational visibility and adopt intelligent data capture solutions is the status of their data capture and backend systems infrastructure. Today's warehouses and fulfillment centers are still predominantly scanning linear/1D barcodes to support their operations, though 2D data carrier adoption is growing due to regulatory pressures and workflow inefficiencies. The installed base of barcode scanners has shifted recently in favor of camera-based scanners capable of scanning all barcodes including 2D data carriers (legacy laser scanning and linear imaging technology is only capable of decoding 1D or linear barcodes such as GS1-128 or EAN/UPC codes). Although 1D codes and in particular GS1-128 are the primary barcodes scanned in logistics settings, the ability to also read 2D data carriers has continued to rise, future-proofing systems with 2D imagers with superior performance for complex data capture and labeling scenarios. Additional functionality enabled by camera-based 2D imagers include the ability to read multiple barcodes simultaneously, OCR capabilities and the ability to inspect labels for quality. Solutions increasingly incorporate ML/AI functionality to analyze barcode readability and provide preemptive maintenance alerts.

Exhibit 1: Share of Data Capture Device Installed Base by Technology In Logistics Environments



Like upgrading data capture infrastructure to read data-rich data carriers such as 2D symbologies, backend systems of record (WMS, ERP, etc.) need to be updated to be able to parse the additional data. Having the necessary functionality to parse large amounts of data by enterprise applications has been an issue for over 8 in 10 organizations according to VDC Research's survey. Although logistics technology investment makers have traditionally been slow to upgrade existing systems and invest in new technologies, with the use of legacy/home grown applications pervasive, recent operational pressures have accelerated the upgrade cycle considerably. Organizations have invested significantly in best-in-breed WMS solutions and WMS suites in existing ERP applications while reducing their reliance on homegrown applications and/or "WMS lite" solutions.

Exhibit 2: WMS Used to Support Warehouse/Fulfillment Center



## Labeling Challenges Contributing to Logistics Inefficiencies

Supplier labeling is critical to generate traceability information for use across the entire supply chain. Barcodes are the de facto standard to help facilitate inventory traceability in warehouses. Data capture systems allow companies to provide accurate information about raw materials, manufacturing processes, and distribution networks, ultimately enhancing consumer confidence and highlighting organizations' commitment to building supply chain resilience and promoting transparency. However, it is not always feasible for companies to get their suppliers to adhere to the same labeling standards – including the template, format, and type – with the same data validation and verification capabilities.

In fact, seven in ten organizations experience barcode readability-related challenges at least once a week in logistics environments contributing to logistics inefficiencies and the cost of operations. Included among the leading challenges are:

- *Multi-code labels leading to scanning confusion*
- *Labeling inconsistencies among supply chain partners*
- *Lack of standardization in barcode placement and symbology*
- *Need to relabel items increasing cost and creating workflow bottlenecks*
- *Legacy WMS systems unable to parse 2D data efficiently*

*“When our vendors put multiple barcodes on packages, it is problematic for us as our receivers don’t know/care what information is there. Since the number of barcodes on a package is not always consistent, we find it very difficult to consistently capture the relevant information. Our associates are not equipped to handle/manage the randomness of barcode placement and presence”*

*–Food Service Distributor*

Exhibit 3: Frequency of Barcode Readability Issues

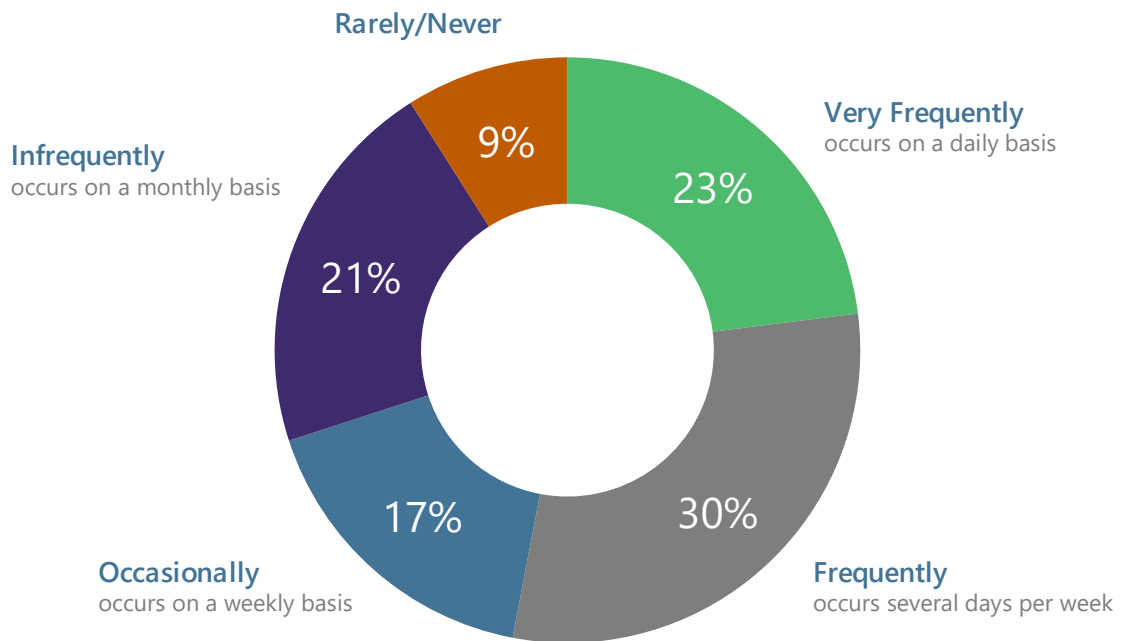
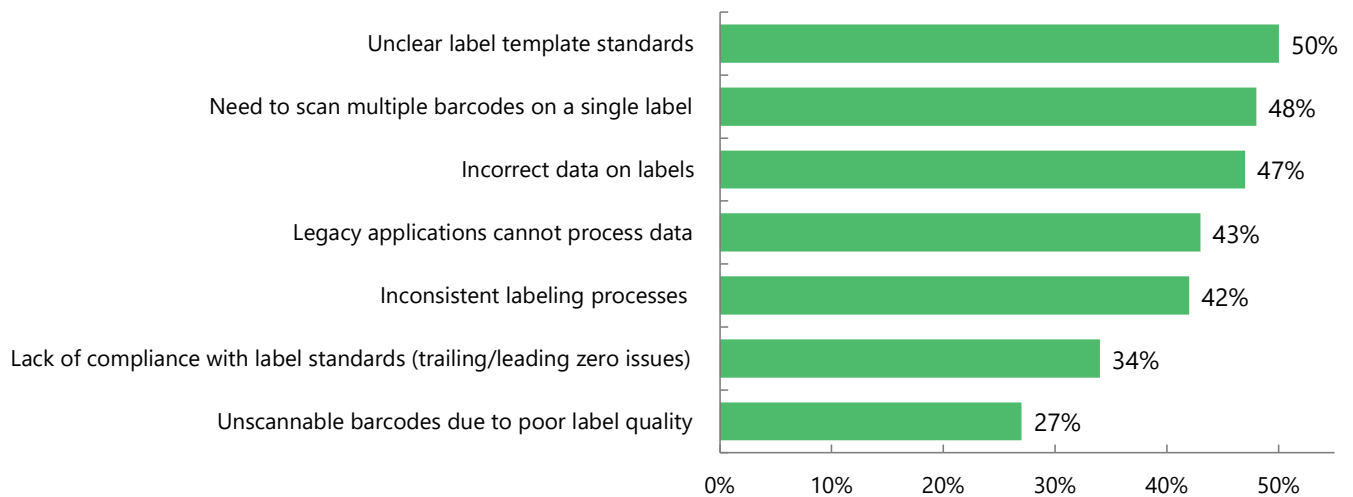


Exhibit 4: Leading Barcode Readability Issues



## Leading 2D Solution Investment Value Propositions

There is a significant opportunity to enhance logistics operations while addressing increasing serialization requirements through broader adoption of data-rich 2D data carrier symbologies. Implementing 2D data carriers offers higher data capacity and smaller physical footprint, improved reliability and error correction, enhanced security among others.

|   |   |
|---|---|
| Higher Data Capacity                      | <p><b>More Information:</b> 2D data carriers can store significantly more data—up to 7,000 characters compared to the 48 character limit in the commonly used GS1 128.</p> <p><b>Supports Multiple Data Types:</b> They can encode alphanumeric characters, binary data, and even special characters like images or URLs.</p> |
| Smaller Physical Footprint                | <p><b>Compact Design:</b> Because data is encoded both horizontally and vertically, 2D data carriers can be much smaller than 1D barcodes while storing more information.</p> <p><b>Space-Efficient:</b> Ideal for small products, documents, or surfaces where space is limited.</p>   |
| Improved Reliability and Error Correction | <p><b>Built-in Error Correction:</b> Many 2D symbologies (e.g., QR Code, Data Matrix) include error correction algorithms (e.g., Reed-Solomon), allowing them to be read even if partially damaged or obscured.</p> <p><b>Redundancy:</b> Data redundancy improves readability under harsh conditions.</p>                    |
| Fast and Flexible Scanning                | <p><b>Omnidirectional Reading:</b> 2D data carriers can be read from any angle, increasing scan speed and user convenience.</p> <p><b>Imaging Scanners:</b> These are capable of reading both 1D and 2D data carriers, often from screens as well as printed materials.</p>   |
| Enhanced Security and Traceability        | <p><b>Data Encryption:</b> Support for encrypted content makes them useful in secure applications such as ID cards and ticketing.</p> <p><b>Serialization and Tracking:</b> They support unique identification for improved product traceability and anti-counterfeiting.</p>   |
| Cost and Operational Efficiency           | <p><b>Reduction in Printing Costs:</b> Smaller labels and fewer required labels per item can reduce material and printing expenses.</p> <p><b>Automation Friendly:</b> Suitable for high-speed automated environments like conveyors and production lines.</p>  |

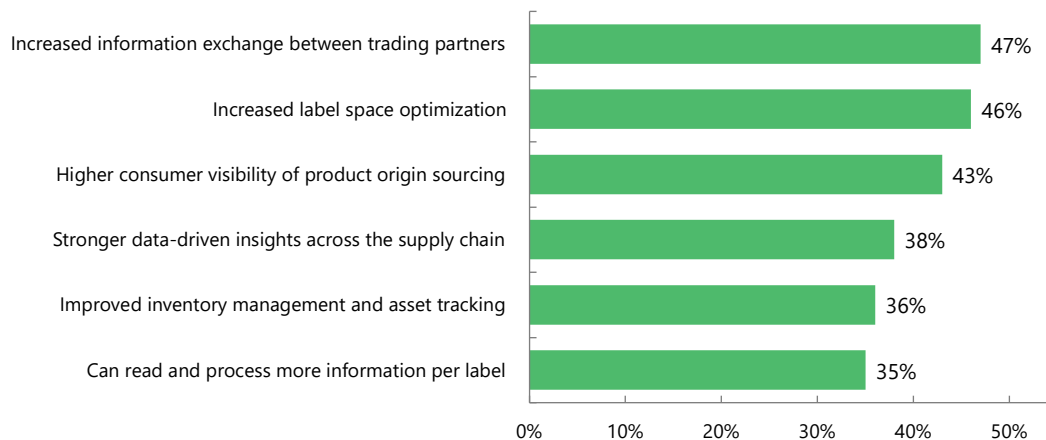


In logistics environments specifically, investments in 2D data capture systems are being driven by:

- *Enhanced information exchange with partners (47%)*
- *Increased transparency in sourcing and traceability (43%)*
- *Improved inventory management and asset tracking (36%)*

These capabilities enable better data consolidation, label space optimization, and faster, error-free compliance reporting. 2D symbologies also reduce the number of scans required and support dynamic content like lot codes, catch weights, and expiration dates.

### Exhibit 5: Leading 2D Symbology Adoption Benefits



By adopting 2D data carriers, other technologies can be implemented such as high-speed decoding engines, drone-integrated scan solutions, AI-assisted vision tools, and mobile SDKs designed to parse complex labels in milliseconds. Industry adopters prioritize reduction in human error, improved data quality, and compatibility with existing ERP and WMS platforms.

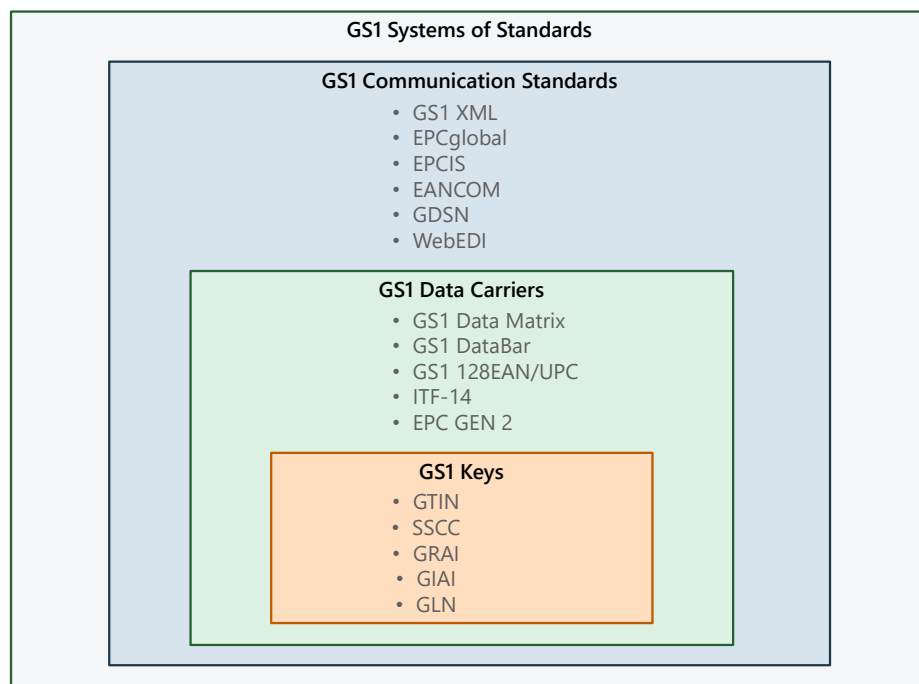
Current 2D applications are prominent in medical, pharmaceutical, and fresh food sectors where serialized data, expiration tracking, and lot-level traceability are essential. Real-time data capture and parsing enable end-to-end inventory control and compliance.

*“Companies want to capture more information and adhere to regulatory requirements to demonstrate the chain of custody. This helps them understand where that inventory is at any given point in time and how that product is being distributed and fulfilled by the sell-through date, so that the product doesn't sit on the shelves and wind up expiring before getting to the POS”*

–WMS ISV

## Value of GS1 System of Standards in Running Efficient Warehouse Operations

GS1 creates and manages a proper and well-designed system of standards for the global supply chain. Some organizations develop their own proprietary solutions and others use standards that are designed for a specific industry or regional market. While they serve a purpose, they lack the global reach, scalability and robustness of GS1's System of Standards. This system is designed around three key building blocks: GS1 Identification (ID) Keys, GS1 Automatic Identification Data Carriers and GS1 Data Sharing Standards. GS1 ID Keys and Application Identifiers (AI) are designed to work with the GS1 Data Carriers. GS1 Data Sharing Standards primarily deal with transactional data, acknowledging the completion of a transaction. For example, visibility data, occurrences of physical events or enabling master data sharing among trading partners.



Leading GS1 System of Standards benefits include:

### 1. Streamlined Scanning and Data Capture:

GS1 barcodes, including 2D data carriers like GS1 DataMatrix, allow for a single scan to capture all necessary product information, reducing manual data entry and the risk of errors. This efficiency translates to faster processing times for receiving, put-away, picking, and packing operations. 2D data carriers can hold more data than traditional 1D barcodes, enabling the encoding of additional attributes like expiration dates, batch numbers, and other relevant information.

**2. Improved Accuracy and Inventory Control:**

By using unique identifiers and standardized data formats, GS1 ensures that product information is consistently and accurately captured throughout the warehouse. This accuracy is crucial for inventory management, preventing stockouts, overstocking, and reducing the need for manual cycle counts. Real-time visibility into inventory levels and locations, enabled by GS1 barcode scanning, allows for better decision-making and optimized order fulfillment.

**3. Enhanced Collaboration and Traceability:**

GS1 standards facilitate seamless communication and collaboration between different parts of the supply chain, including suppliers, warehouses, and customers. This interoperability enables better tracking of products throughout the supply chain, enhancing traceability and visibility. In case of recalls or quality issues, GS1 standards enable efficient identification and location of affected products, reducing potential damage to the business and ensuring consumer safety.

**4. Cost Reduction and Increased Efficiency:**

By automating data capture and reducing manual processes, GS1 standards can significantly reduce labor costs and improve overall operational efficiency. The reduced need for manual data entry also minimizes errors and the associated costs of rework and returns. The ability to quickly and accurately identify, locate, and track products allows for better resource allocation and reduced waste, leading to further cost savings.

The GS1 system of standards, including its unique identification and 2D data carrier technologies, provides a powerful framework for creating efficient and accurate warehouse operations. By streamlining processes, reducing errors, and enhancing visibility and collaboration, GS1 standards help businesses to optimize their supply chain, reduce costs, and improve customer satisfaction.

*"We are actively educating our customers on the benefit of adopting GS1 standards and we have those in place internally. A lot of the larger distributors and retailers are fully compliant, but we also deal with a lot of smaller distributors and retailer partners who are not."*

*—US Paper Products Manufacturer*

## Transforming Logistics Operations with Standards-Based Intelligent Data Capture

Global logistics is evolving—and the time to modernize is now. Outdated systems and fragmented product identification practices are no longer sustainable in an era demanding real-time visibility, traceability, and regulatory compliance. With the rising complexity of supply chains, traditional data carriers are falling short. Leading organizations are already upgrading to 2D data carriers and intelligent data capture solutions—and seeing measurable gains in accuracy, efficiency, and compliance. According to VDC's Research, **70% of logistics organizations face barcode readability issues weekly**—issues that directly increase costs and create bottlenecks. With consumer demand for transparency and regulatory scrutiny on the rise, now is the moment to invest in scalable, standards-based solutions.

### Why Act Today?

The GS1 system of standards, including its unique identification and 2D data carrier technologies, provides a powerful framework for creating efficient and accurate warehouse operations. By streamlining processes, reducing errors, and enhancing visibility and collaboration, GS1 standards help businesses to optimize their supply chain, reduce costs, and improve customer satisfaction.

- **Single-scan efficiency:** *Capture expiration dates, lot codes, batch numbers, and more.*
- **Label quality validation** *and multi-barcode reading for complex packaging.*
- **Enhanced partner collaboration** *and traceability across global operations.*
- **Faster compliance reporting** *and reduced relabeling costs.*
- **Cut costs and complexity** *with global GS1 standards*

# About the Authors



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David has more than ten years of experience covering the markets for enterprise and government mobility solutions, wireless data communication technologies and automatic data-capture research and consulting. David focuses on identifying the key drivers and enablers in the adoption of mobile and wireless solutions among mobile workers in the extended enterprise. David's consulting and strategic advisory experience is far reaching and includes technology and market opportunity assessments, technology penetration and adoption enablers, partner profiling and development, new product development and M&A due diligence support. David has extensive primary market research management and execution experience to support market sizing and forecasting, total cost of ownership (TCO), comparative product performance evaluation, competitive benchmarking and end user requirements analysis. David is a graduate of Boston University (BSBA).

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Richa is a Consultant working for VDC's AutoID & Data Capture practice. She has been tracking the markets for a range of AIDC technologies at VDC since 2010, including, but not limited to, barcode scanners and printers, labeling solutions, machine vision solutions, and robotics automation. Over the years, she has undertaken market opportunity sizing and forecasting, competitive landscape analysis, and offered strategic marketing assistance, while also providing valuable thought leadership for this technology segment. Richa holds a degree in Computer Engineering and an MBA from India.

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# About VDC Research

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