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Is RFID an improvement over barcodes?

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Introduction

Ged Cairns
Head of Business Unit SPS
Brother UK

The hype surrounding RFID technology has died down somewhat in recent years but the technology seems to have become well-established and is considered the standard in many industries, from automotive manufacturing to healthcare. However, in the majority of logistics warehouses, the barcode continues to reign supreme – despite the widely held belief that this competing technology has long passed its best-before date. Is this yet further evidence that the logistics sector is lagging behind on the journey towards digitalisation?

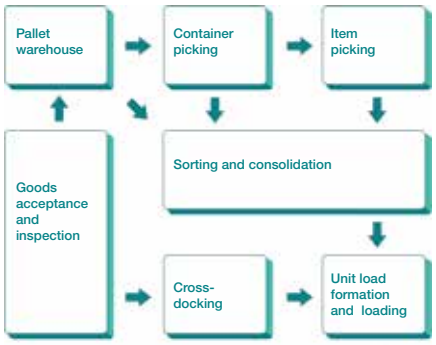
In spite of its undisputed benefits, RFID technology can present companies with a number of challenges which, in conjunction with the associated financial considerations, give businesses reason to consider barcode technology instead.
In this whitepaper, we take an in-depth look at the multifaceted considerations that businesses need to take into account in RFID projects – and explain why the barcode could be the better choice in some cases.

The automatic identification process

The efficiency of a logistics process can be expressed as a ratio of logistics costs to logistics output. Automatic identification technologies such as barcodes and RFID help to maximise the flow of materials and information, and ultimately boost logistics output.

In warehouses, these technologies can be deployed not only when goods enter and leave the facility, but also in picking and inventory applications.

Figure 1: Material flow in distribution centres



Source: Siepenkort

Barcode and RFID systems essentially follow the same working processes:

1. **Read the data**
2. **Compare the data with a database**
3. **Output the information**

However, RFID allows for a higher degree of automation.

The unique feature of RFID technology is that objects can be identified regardless of their position and be identified en masse. In combination with the relevant IT infrastructure, this means that companies can record and process material flows automatically in real time.

As there is no human intervention required real-world disruption is reduced, meaning shorter lead times and optimised information flows – paving the way for integration with the Internet of Things (IoT) and other digital transformation initiatives in the sector.

Practical examples:

- A dock equipped with RFID portals can inform the forklift driver that they are loading the wrong pallet onto a truck.
- Bulk reading of the labelled boxes on a pallet enables staff to check that the pallet contains the correct products in the right quantities.
- Marking with RFID transponders makes the locations of forklifts more visible, allowing for the allocation of nearby pallets and next job efficiencies.

Table 1: Process improvements with RFID

Area of application in warehouse	Process improvement
Incoming goods	Automated recording of incoming goods Quality control Quantity checking Storage area allocation
Storage area management, inventory and picking	Position detection Stock control, stock notifications, stock planning Supports chaotic storage Monitoring (status monitoring, tracing, best-before dates)
Outgoing goods	Issuing documentation Confirmation of receipt Notification to freight carrier/driver

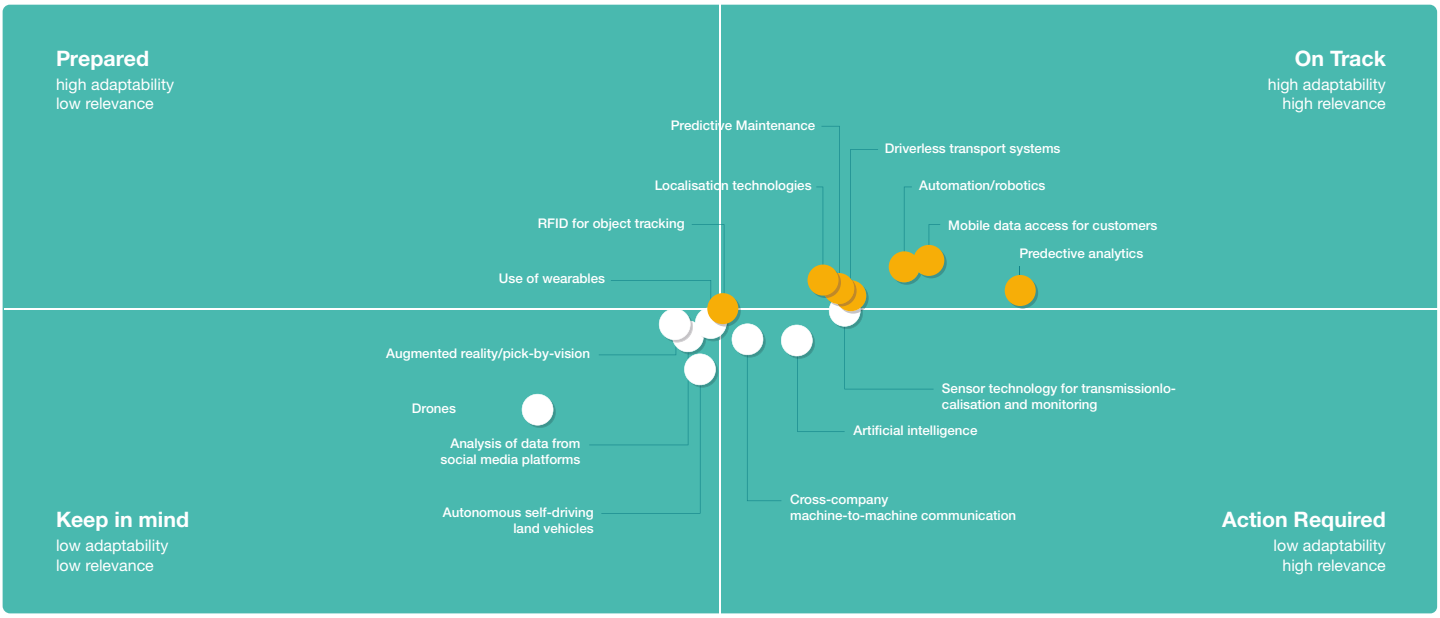
Source: Franke/Dangelmaier

Understanding RFID implementation

The benefits of RFID are clear to see, which begs the question why only 15 percent of logistics experts and IT professionals in this sector view RFID as “very important” for object tracking in their companies.

The main barriers to adoption are most likely the perceived cost and complexity of rolling out new technologies. Many companies are content to wait and see which market leaders and key technologies emerge before they look to incorporate the technology into their own business.
However, the advent of RFID technology has long since passed and its early adopters can clearly evidence the transformative power of greater automation. Despite RFID becoming a firmly established technology with key market leaders in the transportation and logistics sector, as well as various others, many logistics companies still view technologies such as driverless transport systems, robotics and predictive analysis as far more relevant and feasible projects.

Fig. 2: The relevance and adaptability of technologies



Source: BVL Logistics Monitor 2018

Strategic considerations for the use of RFID

One of the limitations of RFID is that all partners in the supply chain must use it, to derive the maximum benefit from the technology. An independently controlled logistics system, effectively 'RFID as an island', will fall short of delivering on the financial benefits the organisation is hoping to achieve.

Involving all parts of the supply chain

In a supply chain with end-to-end RFID, the required data should ideally be available at any time. This enables immediate action to be taken if processes change.

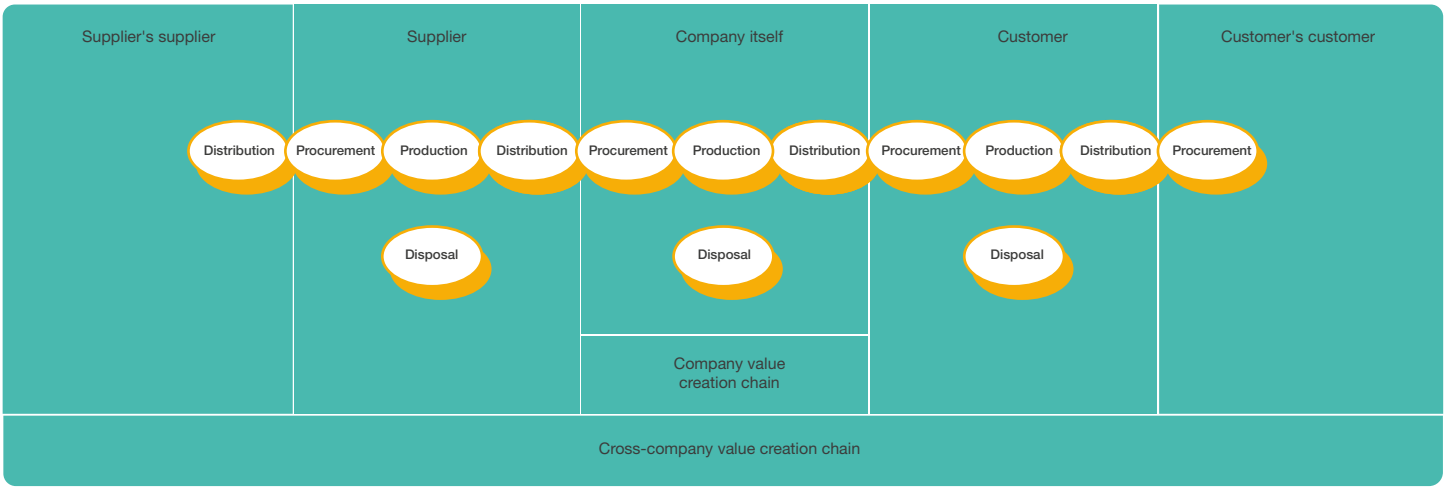
In the instance where sub-units, or components, of a delivery need to be separated or collated, and are not marked with RFID tags, the picking process is affected. Teams would be forced to return to manual data entry, negating the time gains targeted through the introduction of automation.

Therefore, without the universal uptake of RFID technology across the supply chain there remains a significant possibility that a successful internal implementation may yet still result in limited benefit and underused potential.

For warehouses holding a wide range of items from a variety of suppliers, the likelihood of persuading all manufacturers to agree to implementing RFID into their process is low, and the pace of change is, at best, incredibly slow. And despite US companies like Walmart forcing their suppliers to implement RFID, there are still those who will choose to walk away given such an ultimatum.

As globalisation further impacts the business landscape, with more manufacturers outsourcing the production of individual products and product components, the reality of convincing all parties to switch to RFID becomes increasingly slim, creating another stumbling block for any planned RFID project.

Fig. 3: Areas relevant to SCM



Source: Schuh/Stich

Pilot projects and visions should be viewed critically

There are plenty of well publicised case studies for RFID, but it's certainly worth scratching the surface of these to assess the true value of the technology.

- Tesco reported that in a pilot project, it was able to reduce the process time for truck unloading from 23 to 3 minutes, thanks to RFID and bulk detection.
- In a pilot project, German retailer, Kaufhof Warenhaus AG tested RFID gates for outgoing goods checks at the warehouse. Its data recording process became 9 times more efficient as a result.

While these numbers may grab the headlines, it's important to note that these successes were achieved in individual applications. The information does not provide any indication of how these applications will more broadly affect business processes.

On closer inspection, it is also evident that many of these success stories relied on the integration of a networked IT system or were achieved as part of a wider change in processes. In such cases, RFID technology was only a minor contributing factor in the success of the project. It is also important to remember that the logistics sector already applies a high level of automation in its processes. If a company is already using barcodes, the added value provided by RFID is limited.

So the question is: What can we achieve without RFID?

Example: Transhipment processes in cross-docking

A recent study* on the impact of RFID on the productivity of cross-docking centres in the retail sector concludes that the technology does not function as an enabler of process optimisation in its own right.

Rather than resolving bottlenecks, it shifts them to another location resulting in a low overall improvement in productivity. Subsequently and counter-intuitively, this can generate yet more processes.

Example: Monitoring stock levels in retail

In sectors such as retail, RFID is relied on to enable retailers and suppliers to check, at any time, which goods have been sold and where stock needs to be topped up. Yet, this same information can also be obtained with existing systems using barcode technology.

RFID: The difficulty in demonstrating cost-effectiveness

The costs of RFID implementation depend, to a large extent, on the company's own unique structure and layout. Factors such as RFID frequency, the existing system architecture type and finally how the technology is physically implemented are all key factors.

It is a fundamental requirement of any technology implementation to be able to accurately report upon its efficacy and return on investment. Yet, whether in the form of KPIs, productivity analyses (data envelopment analysis) or simulation-supported productivity surveys, instruments for measuring logistics performance can only ever look at partial areas, leaving companies wondering: How can logistics performance be calculated and demonstrated in a methodical way?

Table 2: Example list of cost components

	Implementation costs	Operating costs
External costs 	**Service costs** - Consulting - Installation, roll-out - Development, interface programming - Training **Material costs for initial equipment and accessories** **Initial investments** - Hardware for IT and RFID (e.g. servers, terminals, RFID label printers, readers) - Middleware, databases, applications, licences - Logistics infrastructure **Investments in any sub-sequent expansions**	**Service costs** - Hosting, service provision - Administration, maintenance, support - Data protection, back-up, data transfer **Material costs** - Replacements - Wear parts - Consumables
Internal costs 	**Staffing costs for project employees** **Services** **Infrastructure costs**	**Staffing costs** - Operative employees in IT - Operative employees in warehouse **Workplace costs** **Infrastructure costs** **Training**

Source: Richter

> There are three points to note: Firstly, there are many potentially important barriers that should be taken into account before any RFID implementation project. Secondly, depending on the context, integration obstacles in particular should be taken into account as part of the analysis of cost-effectiveness, as these obstacles can have a drastic impact on the cost/benefit ratio... Thirdly, the fact that the very action of analysing cost-effectiveness is difficult is an obstacle in itself, and is deemed significant by half of all surveyed RFID users...

Dr Daniel Gille, Institute for Informatics and Society, University of Freiburg. Research focus: IT cost-effectiveness analyses, particularly RFID and smart objects

Technical considerations for implementing RFID

In reality, few companies have the internal expertise required to implement RFID technology themselves, which inevitably sees most RFID projects requiring the use of external consultants.

> **“One of the obstacles is the lack of methodical support when implementing RFID projects in logistics. ... However, an integrated approach to project management – to provide consistent, methodical support throughout implementation – is essential to long-term success.”**

Prof. Dr.-Ing. Dipl.- Wi.-Ing. Willibald A. Günthner, Professor of Materials Handling, Material Flows and Logistics at the Technical University of Munich, founder of the RFID User Centre Munich

RFID requires the necessary expertise

The implementation of RFID technology is complex for a number of reasons, not least the sheer number of decisions required to simply define your setup. This means that specialist knowledge is required to ensure that due diligence is given to elements such as:

- The selection of components
- The selection of working frequency ranges
- Type of transponder
- Whether to use an open or closed system
- Selection of RFID reading and writing devices, including sourcing the expertise needed to code the RFID tags
- Application of standards

If the wrong RFID components are selected, the functioning of the entire system will be impaired. Similarly, companies can end up using systems with inappropriate ranges, excessively high error rates or unsuitable tags.

Before deploying RFID, a decision must be made as to whether the product, the pallet or the rack is to be marked. The frequency ranges are also key, as they determine the technical capability of the system. Closely related to this decision is the choice of transponder, and how these devices are secured. Companies must also determine at the planning stage whether they wish to integrate fixed or mobile readers.

The configuration of readers and tags is one of the most challenging aspects of an RFID installation. Employees must be trained to handle and store tags correctly.

External influences

While RFID technology is viewed as particularly well-suited to harsh environments, automated processes and scanning inventory at scale, errors can still occur due to issues like electromagnetic interference and ‘shadows’ caused by metals and liquids.

In fact, many things can influence an RFID system. Its performance is also affected by cable attenuation as well as free space and material attenuation (reflections, scatter and absorption). A series of tests using a passive UHF transponder, capable of reading unobstructed tags at 200cm, found that reading distance could be significantly reduced in a number of common cases:

Table 3: Factors affecting the reading distance of RFID transponders

Tag behind empty plastic pot	138 cm
Tag behind plastic pot filled with water	31 cm
Tag behind 1 x 1 wire mesh	10 cm

Source: Helmus /ETSI (European Telecommunications Standards Institute)

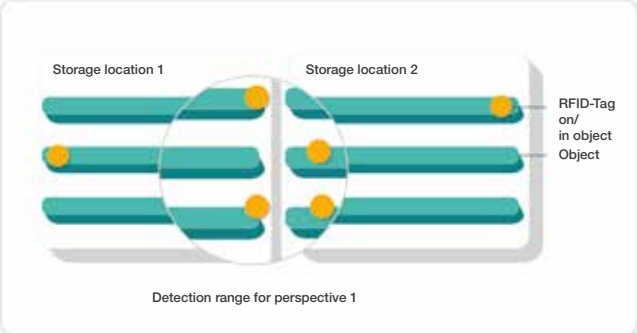
Though tags could still be read, the impact on mass reading was clear and highlights that physical process change would likely be necessary in order to accurately capture all tags.

Issues with imprecision

RFID tags have a very high read quota but, should anything impact readability, bulk detection on a single pallet can incur the risk that some parts will not be detected. The subsequent process of locating and removing these parts manually is undeniably time-consuming.

Conversely, long-range RFID technology introduces the possibility of overreach. In this scenario, the system reads transponders in adjacent pallets that should not have been read at all.

FIG. 4: Imprecision with long-range RFID



Source: Helmus

Therefore, many of the proposed advantages of an RFID system may, in practice, actually prove to be disadvantages.

A few questions worth considering:

How can you read just one tag if multiple tags are positioned next to one another?

How can you find the position of a tag that has been built into the object?

Does RFID offer any advantages compared to newer technologies such as computer vision?

Middleware

RFID is a useful solution if you are handling high-value, sensitive or short-life goods. In addition to the technology itself, you will also need a way to organise the system with relevant information and communication technology and IT systems. RFID hardware only reads tags and provide the data it obtains. Companies need middleware to link this hardware to their IT system and to make the data available to their existing warehouse management system (WMS) or enterprise resource planning (ERP) system.

> **“Firstly, suitable middleware must filter out only the data that is actually needed, because ERP systems generally only require a fraction of the data gathered. Secondly, it must pass on the data so that all companies in the value creation chain can benefit from it and to minimise friction losses.”**
>
> **Sprenger, Wecker: RFID – A Guide**

Data security

One of the widely acknowledged concerns around contactless technology is the threat of the interception of data between devices – and this is specifically applicable to communications between reading devices and RFID tags.

If the data generated by scanning an RFID tag is to be used along the entire supply chain, the user must not only create the infrastructure required for this to happen, but also protect the data against unauthorised access by third parties.

A great deal of data is transmitted in unencrypted format, which means that it can be read with any widely available scanner. In commercial settings, this means that companies run the risk of their competitors attempting to spy on their RFID product data.

On a more personal level, a link may be made between a person and a tag, allowing that person to be tracked. The technology allows users to identify a person based on their proximity to a tagged product and then to track their route past multiple readers. With this in mind, it is important to take steps to protect against unauthorised data reading.

Does the barcode have the edge over RFID?

We've explored a huge number of benefits surrounding RFID and it's clear to see that it's a powerful technology when harnessed correctly. However, we have also seen that there are a range of complex considerations to examine to identify its suitability for use in operations.

Electronic and character-based auto ID systems all have different technical specifications and respond differently to environmental factors. For this reason, it's important to decide which solution is best-suited to your individual requirements and which system offers you best value for money.

Instead of being usurped by new technologies, the barcode remains a mainstay in the industry, on account of constant evolution and development. There are many advantages of barcodes which, to many, still give it the edge over newer auto ID technologies. Over the years, developers have created countless new types of barcode with specific characteristics. Of all the different types available, two-dimensional (2D) codes offer particularly high stability and good data capacity.

The benefits of barcodes

- Low costs
- Large field of vision
- High depth of field
- Not affected by metals or liquids
- Omnidirectional reading possible (grid scanner or 2D barcode)
- Used for identification purposes
- Standardised for global use

Table 4: Possible use cases for barcodes and RFID

	Barcode	RFID	Possible use case
Identification	Yes	Yes	Smart picking (data glasses)
Tracking and tracing (discreet methods)	Yes, when in visual contact with the scanner.	Yes	Smart warehouse
Monitoring stock levels	No	In part (sensor RFID)	Real-time monitoring of sensitive goods

Higher storage capacity with 2D barcodes

RFID is not the only technology that can be used to transport data to manage warehouse stock and control production processes.

In recent years, the 2D barcode – used in conjunction with camera-based code readers – has been fine-tuned and perfected. In addition to product codes, 2D barcodes store batch numbers, production data and product features. The data matrices of 2D barcodes also contain sufficient space for a degree of redundancy. With error correction integrated directly into the code, faster reading rates can be achieved.

Code 49, for example, was developed for space travel logistics and offers a high level of accuracy achieved by three error correction processes. GS1 DataMatrix is the global standard in the healthcare sector, and the Aztec Code is a recognised standard for rail tickets. QR ("quick response") codes boast exceptionally fast reading speeds and can be used to encrypt 4296 characters, equivalent to half a page of A4 text.

Barcode symbologies

Improved resilience

2D barcodes are very robust, even when damaged. This is because the information is contained within the code multiple times, and because the code also contains automatic error correction.

Even 1D barcodes – which are read with laser scanners – have developed so much in recent years that now, even damaged or soiled codes are recognised. In many cases, if a company already has a functioning barcode system in place, it makes more sense to prioritise upgrading the existing system with powerful hardware over switching to a new technology.

Fig. 5: Brother TJ-4020TN industrial label printer with thermal transfer printing

Even with the improvements in reading damaged barcodes, it pays to invest in technology that delivers efficiently scannable media every time. Thermal transfer technology produces durable and exceptionally sharp prints. The colour is melted onto the label from a ribbon, meaning the colour is absorbed into the label, producing a barcode that is resistant to ageing, heat and abrasion. Depending on the ribbon and label material used, labels can also be created that are unaffected by water and chemicals, making the technology ideal for applications that demand robust and durable results.

The latest Brother printers support all common international barcodes, from established standards to the newly developed 1D codes (EAN, UPC, Code39, Code 128, LOGMARS etc.), as well as 2D codes.

Automatic scanning

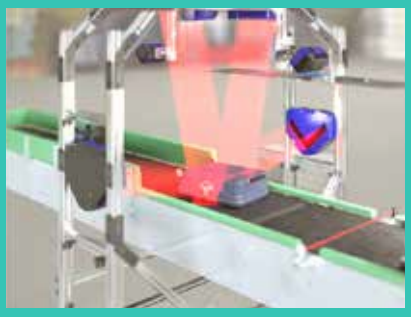


Fig. 6: Application for an omnidirectional laser scanner.

Source: Datalogic

One of the final pieces in the puzzle is to ensure that readers match the standards of your processes. With grid scanners, there is no need to align the 1D barcode and if barcode scanners are mounted on a conveyor belt, there is no need for direct user interaction for validation purposes.

On the other hand, direct interaction with the user may be desirable in some cases. In many applications, mobile barcode scanning allows the handled product to be validated immediately, while also keeping costs down and making it simple to generate labels.

RFID v barcode technology

Table 5: A comparison of various auto ID technologies for industry **Source: Helmus**

	LF RFID	UHF RFID	1D barcode (laser scan)	2D barcode (image capture)
Contactless identification	yes	yes	yes	yes
Readable without visual contact	yes	yes	no	no
Omnidirectional reading	very good	very good	Min. 2 devices needed	good
Absorbed by	Non-metallic materials or materials containing water	Non-metallic materials or materials containing water	Opaque materials	Opaque materials
Reflected by	Metallic materials	Metallic materials	Opaque materials	Opaque materials
Bulk detection	no	yes	no	yes
Data density	very high	very high	low	medium
Detection speed	high	very high	low	high
Machine readability	good	good	good	good
Rewritable memory	yes	yes	no	no
Integration of data carrier into product	possible	possible	possible	possible
Security potential with copy protection/ encryption	very high	very high	low	low
Range	low	high	low	high
Data protection concerns	high	high	low	low

Conclusion

Although RFID systems can be introduced to derive a benefit in many applications, they are not always the best option from a cost and efficiency perspective, and in some instances may not be needed at all. Continually evolving technologies, such as barcodes, may turn out to be more suited to many organisations than an RFID-based solution.

Organisations only stand to reap the benefits of the more powerful RFID technology in situations where full adoption by stakeholders along the value creation chain is in place. In open systems and in supply chains that involve a large number of partners, it is incredibly difficult to determine the costs and – in particular – the expected benefits of RFID in advance

Key takeaways

RFID is a valuable technology that can be used to increase transparency, quality and efficiency in logistics processes. However, achieving this requires a major process overhaul. Integrating the technology into company processes is complex, and it can be difficult to demonstrate a financial payoff.

If RFID is deployed purely as a replacement for barcodes, there is normally no economic benefit. Barcode technology is often perfectly adequate for smart picking and smart warehouse applications, and this technology should not be replaced unnecessarily.

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Brother UK Ltd
Shepley St, Audenshaw,
Manchester M34 5JD

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