10 Emerging trends

Introduction to chapter 10

One of the most important technologies that have drastically affected the operations of companies are the automatic identification and data capture (Auto-ID) technologies, which allow the quick and easy retrieval and storage of information at the same time. These technologies include widely used technologies such as magnetic stripe, radio frequency identification (RFID), voice and vision identification, biometrics, smart cards, etc. In this chapter, key technologies used in automatic product identification, such as RFID and barcodes, are described, along with the use of drones and remotely piloted vehicles. Emerging trends in the Green Supply Chain, Sustainable Marketing and e-commerce are also discussed.

Learning objectives

After reading this chapter, you will be able to answer the following questions:

- What are the main technologies of automatic identification and data acquisition in Warehousing and Logistics Management in general?
- How do barcode, quick response code (QRcode) technologies, and radio frequency identification (RFID) work?
- What are the main advantages and disadvantages of these technologies?
- Which are the areas of their application and usage?

Structure

10.1 Auto-ID technologies
10.2 Modern logistics and supply chain technologies
10.3 Green Marketing and green supply chain management

10.1 Auto-ID technologies

Barcodes and Radio Frequency Identification (RFID) technology are different forms of Automatic Identification and Data Capture (AIDC) technology.

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10.1.1 Barcodes

Barcodes are a simple graphic design using parallel bars and blank spaces of variable width they are arranged in a specific predefined sequence representing a corresponding number, letter or symbol, and they include various data. These black and white bars are printed straight onto product packaging. Special readers called barcode scanners turn those bars and spaces into useful information.

The design, printing and display of barcodes on each product follows specific rules: each black-and-white sequence called the Universal Product Code (UPC), provides relevant information corresponding to each individual product. Barcodes are widely used because they streamline data entry and increase the speed and accuracy of reading and exporting information. Barcodes are also widely accepted due to their low error rate, and are now considered the most efficient method of data entry; they are also the most popular method of monitoring and transmitting data, and have replaced other methods.

The way barcodes work is relatively simple. Scanners interpret barcodes' graphically encoded information and convert it into a sequence of numbers and letters. Quite simply, when the scanner reads the product, it sends the information to a computer as if it were written on a keyboard. The section below describes the most important types of barcodes and the range of data that each of them can contain.

Barcode types

Different types of barcode templates are used for different purposes. These are called symbologies. Each symbology is a template that defines the printed symbol and how a device, such as a barcode scanner, reads and decodes the printed symbol. The specification of a symbology includes the coding of a message as lines and intervals, start and end indicators, the size of the "quiet zone" required before and after the barcode, and the calculation of a checksum (Lotlikar et al, 2013). Symbols may contain numeric information, alphanumeric strings, or a combination of numeric and alphabet characters. All three types of barcodes are considered one-dimensional (1D). Two-dimensional (2D) barcodes are square or rectangular in shape and contain many small dots arranged in a single pattern (Figure 10.1).

The most important barcode symbologies are presented below:

- CODE 39: This is the easiest code to use in alphanumeric barcodes, which are designed to allow character control. It is a variable-length barcode that uses five black lines and four white spaces to define a character. This symbology encodes 44 characters.
- CODE 93: This is a variable-length barcode encoding 47 characters. It is called CODE 93 because each character is made up of nine elements arranged in three bars with their adjacent spaces.

1D-Barcode 2D-Barcode

Figure 10.1 One- and two-dimensional barcodes.

- CODE 128: This is an alphanumeric, very high-density, solid variable-length barcode that can encode the full set of 128 ASCII characters. Each character is represented by three bars and three positions with a total number of 11 units.
- UPC-A/UPC-E: UPC-A is a twelve-digit code created by the Uniform Code Council (UCC), where the first six digits represent the product type and the manufacturer's code, while the next five digits form a unique product identifier. The last number is a control character based on the previous 11 digits. UPC-E is a six-digit symbol similar to UPC-A which is mainly used on small products.
- EAN8/EAN13: The European Article Numbering (EAN) system is the European version of the UPC symbology, often referred to as an International Article Number. It is used for products that require registration of the country of origin. EAN8 and EAN13 are fixed-length barcodes used to encode eight or thirteen characters. In their simplest form, the first 3 characters indicate the country of the company that distributes the product, the next characters refer to the business and the product, and the last character is the control digit.
- RSS-14: The RSS-14 (Reduced Space Symbology), also referred to as the GS1 DataBar, encodes the complete 14-digit EAN and UCC data identifier into a symbol that can be scanned directly with appropriately configured laser scanners. These are the latest types of barcodes for limited-space recognition, created by EAN and UCC, to improve the information flow. RSS codes are mainly targeted for supermarkets and pharmacies, where products can be very small and errors need to be drastically reduced
- CODABAR: This is a variable-length barcode that can encode 16 data characters, and is the most widely used form of encoding. It is mainly used with numeric data, but it also encodes six special characters. CODABAR also uses the characters A,B,C and D, but only as start and end characters, and not in the body of the data message.
- INTERLEAVEAD 2 OF 5: This is a variable-length multiple-of-two high-density numeric barcode that uses five black bars and five spaces to define a character (two fives). Two characters are encoded in each character, one in black bars and one in the spaces. Two of the black bars and two of the white bars are wide, while all the others are narrow. INTERLEAVED 2 OF 5 includes a quiet zone at the beginning, the start character, the coded data, the end character, and a quiet zone at the end.
- DISCRETE 2 OF 5: This is a variable-length numerical symbology similar in logic to that of INTERLEAVED 2 of 5. It differs in that data is contained only in the bars and not in the spaces, which is why it is not as high density as that of INTERLEAVED 2 OF 5. The use of DISCRETE 2 OF 5 is not very common.
- POSTNET: This is a symbolic representation of fixed length (5, 6, 9 or 11 characters) that uses a fixed width of bars and spaces. The information is encoded by varying the height of the bar between the two values. POSTNET barcodes are placed on the bottom right of envelopes or postcards and are used to expedite the processing of postal items with automatic equipment and the provision of reduced postage costs.
- PDF417: This is a variable, two-dimensional, stacked symbol that can store up to 2710 digits, 1850 printable ASCII characters or 1108 binary characters per symbol. PDF417 is designed with selected error correction levels. Its high data capacity can be useful in cases of products moving between markets.

- DATA MATRIX: This is a two-dimensional matrix barcode consisting of black and white modules arranged in a square or rectangular pattern. Each data matrix consists of two compact adjacent L-shaped contours and two others consisting of alternating dark and less dark units. Within these limits, there are rows and columns of cells encoding information. A Data Matrix barcode can store up to 2335 alphanumeric characters.
- MAXICODE: This is a two-dimensional symbolic grid that contains hexagonal units (dots) arranged around a single pattern detector with three concentric circles in a one-inch square. MAXICODE is used by UPS (United Parcel Service) in packaging parcels for sorting and shipping labels. MAXICODE encodes two messages, a primary message and a secondary message. The main message usually encodes the zip code, country code and a service number category.
- QR Code: The Quick Response (QR) code is a two-dimensional linear matrix barcode. The QR Code has 3 large squares or written signs at the corners that define the top of the barcode. QR codes support various different types of data, numeric, alphanumeric, bytes, etc. The QR Code is capable of encoding 7089 numbers, 4296 alphanumeric characters, and 2953 bytes, and has three levels of built-in error detection.
- AZTEC Code: The AZTEC code is a high-density two-dimensional matrix barcode string that can encode 3832 digits, 3067 alphanumeric characters, or 1914 bytes of data. This notation is not widely supported by open-source software, as is the QR Code. Compared to the latter, AZTEC codes require less space but can store more information. The symbol is built into a square grid with a bull's eye pattern in the center. The size of the symbol varies but it is possible to specify the unit size of the square dot, which is the smallest element of the symbol, and the amount of error correction. The smallest Aztec symbol is a 15-unit box that encodes up to 14 digits, with an error correction rate of 40%.

Advantages of using barcodes

The use of barcodes to identify products offers businesses a wealth of advantages and benefits. Businesses can use barcode technology to improve accuracy, speed and efficiency without requiring significant costs (Garg, 2012). In particular, the use of barcode technology increases accuracy as human errors are significantly reduced. Barcodes provide a reliable way to accurately read encrypted information, while the application of technology completely eliminates the possibility of human error as employees can instantly locate packages and products with a high degree of precision (Fatima and Ansari, 2017). Product information is accurate and human copying/typing errors are eliminated.

The information collected by barcode scanning has a uniform structure. The symbology is standardized, depending on the type of barcode applied, and is not only universally accepted but also universally understood. In addition to uniformity, the structure provides the benefit of easy adaptation to the requirements of additional applications (e.g. cellphone apps) and the ability to operate in conjunction with other information technologies).

The processes involved in the collection of product information, data processing and data transmission using barcodes are not just facilitated, but significantly improve the speed of registration and recognition of packages and products. In both industry and retail, product identification, checking and identification time can be accomplished in minutes. A typical example of the speed offered by this particular technology lies in the fact that a single employee can hit dozens or even hundreds of products in just a few minutes. Tracking stock and product/package movements in the various phases of the supply chain is an easy process that can be done at any moment in time. At the same time, the speed that products move increases due to partial elimination of manual work, the time taken to record information is limited, and recording these details is made by direct transfer of this information with a simple scan of the barcode.

An additional advantage of using barcodes is the fact that companies can use technology to maintain strict and accurate inventory control. Warehouses have the ability to scan barcodes on packages as they enter and exit the facility, thereby keeping a record of all the packages in the warehouse (Martin, 2017). When these packages reach the retailers, warehouse staff can scan the products as they go on the shelves and compare these files with the barcode files that are scanned into the inventory registry (Martin, 2017). All the above processes enable companies to control the level of inventory in warehouses or internally in the business, e.g. on the supermarket shelves. This form of control also simplifies the process of monitoring packages or products to facilitate the detection of shortages (Evans, 2018). In addition, improving the automation facility offered by the use of barcodes allows for improvements to be made in the quality of the business; it enhances functionality and the productive process and improves the efficiency of the employees, who, without the use of the barcode, would be working long hours in the management and recording of inventory (Martin, 2017).

A significant advantage of using a barcode is the reduced costs (Rahaman, 2016). The operation of the equipment is simple in its use and this contributes significantly to the low cost of this particular equipment (McCathie, 2004; Rahaman, 2016). The availability of cheap equipment and their increased use have made barcodes an affordable technology that can be used by any business (McCathie, 2004). Especially in large companies, barcode technology can be significantly cheaper than other methods of product control and inventory (Evans, 2018). Even in small businesses, the availability of free barcode applications from various sources on the Internet can significantly contribute to the use of technology at the lowest possible cost (Evans, 2018). Finally, after its application, the technology itself can lead to reduced company staff costs since many employees were needed in the past to identify and manage products, especially in large companies (Rahaman, 2016).

Disadvantages of using barcodes

Labels make it easy for barcode scanners and computers to recognize the product. However, there are some technical drawbacks to using barcodes that can reduce the performance of automated recognition systems (Martin, 2017). When a tag is damaged or does not exist on the product, it creates recognition problems. Damaged labels make it difficult to detect a product. If the 12-digit number on the label can be damaged to the point that it is not legible, this can lead to delays and the overall inefficiency of the scanning and information collection process (Martin, 2017). Environmental factors can cause alterations and problems in the identification process, e.g. rain, dust and dirt. Another major drawback is the fact that barcodes take up space on the product packaging. They should be printed in a place where they can be easily seen and read (Martin, 2017). This means that the barcode must be in such a position that it is aligned and can be read by special readers.

The peculiarity of the barcode format helps avoid its distortion and does not allow changes in the case of typographical errors. An important issue that can affect stock may arise in cases where similar products are registered during the inventory process with the same barcode to save time; each product has, in essence, a unique barcode, and must be scanned separately. Time-wise, although barcodes are a huge advantage, they can also be a significant disadvantage if the barcode on the product does not match the correct product or if the scanner is not working properly (Martin, 2017). Finally, although the use of barcodes is now widespread, there is still the disadvantage of cost when starting up a new business, both for the purchase and installation of the necessary equipment and for the training of employees on how to use the equipment.

10.1.2 Radio frequency identification

RFID is an acronym for Radio Frequency Identification (RFID); product identification is made via radio frequency, referring to a technology by which digital data encoded in RFID tags or smart labels is identified by a reader/recorder through radio waves (Lotlikar et al, 2013). RFID technology is a further development of barcode technology and is applied in a similar way to how data on a tag is recognized, by a device that stores the information in a database. To accomplish this process, RFID technology uses radio waves to identify, locate, collect and store information about objects bearing RFID tags or smart tags.

RFID systems consist of three parts: an RFID tag or smart tag, an RFID reader and intermediate software. RFID tags contain an integrated circuit and an antenna, which are used to transmit data to the RFID reader. The reader then converts the radio waves into a more useful data format. The information collected from the tags is then transferred to a central computer system via a communications interface, where the data can be stored in a database and analyzed later. An important element for interpreting the information is the intermediate software, which functions as the communication means between the RFID reader and the information system where the database data is stored (Figure 10.2).

Most *RFID tags* consist of at least two main parts. One is an antenna, which receives radio frequency (RF) waves, and the second is an integrated circuit (IC), which ranges in size from a few bits to several kilobytes; this is used to process and store data, as well as in the configuration and reconfiguration of radio waves received and sent by the antenna. The tag is occasionally referred to as a transmitter, which is attached to some kind of item or the packaging, and it contains a unique serial number called the electronic product code (EPC). The tag also consists of a protective film that holds the pieces together and protects them from various environmental conditions; the kind of material used here depends on the application (Khan, Sharma and Prabhu, 2009).

Additional features of RFID tags are obtained depending either on the type, where the categorization is done on passive or active tags, or by the read and/or write options in the integrated circuit built into the tag, or by the operating frequency of the RFID system (Lotlikar et al, 2013; Parkash, Kundu and Kaur, 2012). According to the first classification, passive tags are “powered” only by magnetic or electromagnetic waves coming from the RFID reader. This is the only way to communicate with the RFID

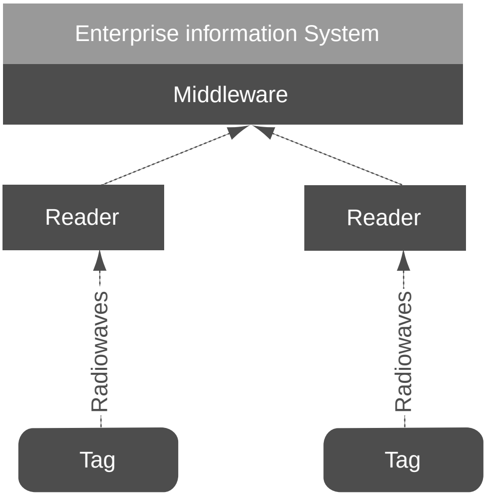

Figure 10.2 Main parts of RFID.

reader (Lotlikar et al, 2013). The tagged object does not have a radio frequency transmitter to generate its own radio frequency signals (Kamdar, Sharma and Nayak, 2016). Battery-free passive tags use the input signal from the RFID reader to power the built-in integrated circuit. The passive feature and the lack of battery are two different characteristics of the tag that are often confused (CNRFID, 2018). There are also tags with passive battery assistance called semi-passive tags that have a built-in rechargeable or non-rechargeable battery to power the internal circuits or connected sensors or activators. This power source is not used to generate any kind of radio frequency signal, as the tag is always passive.

Active tags on the other hand have their own radio frequency transmitter. They can send radio frequency signals to the RFID reader as they receive a complete command, and they can also operate without an external command (Kaur and Sengupta, 2016; Parkash, Kundu and Kaur, 2012). Since generating a radio frequency signal requires a lot of energy, active tags often have internal built-in power supply. Semi-active tags have exactly the same properties as active ones but they remain idle until they receive a signal from the reader that will activate them. Active tags allow transmission at any time but this comes in a larger size and a larger cost, while battery life cannot currently exceed 10 years (Kamdar, Sharma and Nayak, 2016). Non-active (passive) tags are the most widely used, as they are smaller and cost less to implement.

The purpose of RFID technology is to uniquely identify tagged objects, so the least information that the integrated chip must contain is the digital identifier that the reader can access (CNRFID, 2018Kaur and Sengupta, 2016; Parkash, Kundu and Kaur, 2012). If the chip has no other memory, it is known as a Read-Only chip (CNRFID, 2018). All information about the tagged product is stored on remote information systems and can be recalled using the unique identifier. In some cases, the unique number incorporated in the construction is not sufficient for its final implementation (CNRFID, 2018). Therefore, there are chips that contain a free memory where the end-users of the RFID system can write their own specific number.

Smart tags differ from RFID tags in that they incorporate both RFID and barcode technologies. They are made up of a sticker that has a built-in RFID tag insert and may also have a barcode and/or other printed information. The advantage of this tag format is that it can be used by both RFID readers and barcode scanners, and people can read some of the characters. Smart tags can be used in areas where the final product may enter a product identification system that does not know the scanner reader format. Therefore, through the combination of RFID and barcode technology, smart tags can cover all identification cases.

The *RFID reader* is used to communicate with tags that can be detected within the range of its antenna. It consists of three main parts: the control section, the high-frequency interface and an antenna. It is usually located in a fixed position and is used mainly to retrieve RFID tag data via radio frequencies.

The *antenna* is one of the key players in RFID systems. An RFID reader communicates with a tag through the reader's antenna which transmits radio frequency signals from a reading transmitter to the environment and receives a response from the tags. The antenna is the key element used to receive and transmit the signal to and from tags.

RFID *Middleware Software* is a radio frequency identification system that lies between readers and business applications. This intermediate software has many functions and plays an important role in the operation and management of RFID systems. It manages RFID readers and printers, facilitates communication between these devices and business applications, and manages, filters, collects and interprets data from RFID tags.

Advantages of using RFID

Although RFID is not expected to completely replace the widely used barcodes, the following advantages indicate the special value of this particular technology in the business world. RFID is an automatic recognition technology that has no visibility restrictions (Michael and McCathie, 2005; Want, 2006). An RFID reader can scan a tag as long as it is within the frequency range. The advantage of this feature is not only the remote identification of the products, even if there are obstacles between the tag and the reader, but that the information can also be collected from the tags without the need for human intervention. Not requiring human involvement in the scanning process makes scanning a cheaper and faster process compared to barcode technology.

RFID systems can also scan multiple objects simultaneously (Parkash, Kundu and Kaur, 2012). This allows a variety of goods to be scanned without requiring employees to make eye contact with each item individually. The speed and convenience provided by this feature can be compared to the time and difficulty involved in barcode scanning, as the operator must not only scan each product but also has to align the reader in exactly the right position in order to scan successfully. RFID readers can operate simultaneously and detect tags in milliseconds. The ease in detecting multiple tags within the radio frequency range also eliminates human error during data collection, since there are times (especially in the case of barcodes) when scanner users forget to scan or they scan the wrong barcode. This highlights the importance of RFID technology in the management of large stock volumes, particularly in warehouse management (Michael and McCathie, 2005).

RFID tags may also contain more information than a single or restricted identifier that other identification systems carry. Tags that also allow writing (and not just reading or recognition) allow information to be added or data to be changed. An additional advantage of RFID technology is the ability to implant tags on objects within plastic covers, thus enhancing the quality of the identification tag and making it less sensitive to adverse conditions such as dust, chemicals and physical damage. The tag also offers the ability to store large volumes of data in a single identifier. The capacity for distributed data storage can increase system-wide fault tolerance.

Disadvantages of using RFID

Although RFID technology is quite old (it was developed in the 1970s), its high cost limits its use in larger companies (Finch, 2018). Even when costs are reduced, RFID systems are still more expensive to build and use than other alternative systems such as visual barcode scanning. The software and support staff that are also needed to install and operate RFID readers can be more expensive compared to staff employed to use barcode scanners (Finch, 2018). However, as already mentioned, RFID systems bring their own cost advantages, such as reduced labor costs and improved efficiency.

There are also significant issues that must be dealt with concerning scanning. Water, static discharge or high power magnetic voltage can destroy the tags. Despite their overall reliability, RFID systems can experience problems when scanning objects if metal or water is present: metallic and wet surfaces tend to reflect radio waves, making tags unfit for reading. Hence, RFID tags cannot be read well when placed on metal or liquid objects or when these objects are located between the reader and the tag.

Malfunctions still occur when scanning multiple objects at the same time within a range, as problems arise if tag signals collide or if two readers interfere with each other's signals (Finch, 2018; Want, 2006). Tag conflict occurs when there are too many tags in a limited area. The RFID tag reader activates multiple tags at the same time, which reflects their signals back to the reader, a process that leads to tag collision and the RFID reader cannot differentiate between incoming data. RFID reader conflict occurs when the area of coverage managed by one RFID reader overlaps with another reader's area of coverage. This causes signal interference and multiple readings of the same tag. The reader can also activate a tag from a product that does not belong to the company (e.g. a clothing label that has already been sold and is now being worn by the customer).

Finally, RFID technology highlights some security issues. Unauthorized devices may be able to read or even change data on tags without the knowledge of the person that owns the item. Radiofrequency channel attacks can capture RFID data as it passes through a tag to a reader, which could give the attacker access to codes, information or even personal data stored within the information system, which should be secure and confidential.

10.2 Modern logistics and supply chain technologies

All modern logistics and supply chain technologies have one thing in common: they are market-driven applications, not technology-driven ones, even though they are based on advanced technology. Quite simply, they have been developed because the companies themselves have requested their creation. These solutions mainly refer to two functions of the logistics system: storage and transportation.

The *storage* function encompasses the continuous and real-time monitoring of stocks, their automatic replenishment, the autonomous identification of objects/materials, as well as the optimization of daily tasks, particularly the collection of products, placement and routing of inter-transportation systems. The best examples of these include automatic stock replenishment using "smart" boxes, shelves, etc. that use sensors or cameras to calculate the number of pieces they contain and are to be used in a production line; when the stock levels "fall" below the ordering point, they send a signal to place a refill order. Such solutions in a wider application can dynamically help design the processes involved in logistics planning and production systems to cope with changes in demand, as well as changes in the internal and external business environment. Demand through the chain can be better-predicted thanks to more sophisticated market signals, which translate into demand for production capacity, storage and logistics support needs, and changes in raw materials requirements.

Mode of *transportation* allows company warehouses and distribution centers to connect with stores, and more generally with points of sale. This allows for proper planning of warehousing, transportation and distribution network processes to be made. There are some interesting cases of companies that have introduced cellular transport systems which include groups of autonomous vehicles that can "read" their environment using laser scanners, infrared sensors and RFID chips to navigate autonomously through storage spaces. Each one has the ability to make autonomous decisions about movement, route selection and transit priorities, by sharing data about its location and condition with other vehicles. In the event of problems or differences, the team reacts on its own and resolves or addresses the problems in an appropriate manner.

The number of solutions is in fact so large that presenting them initially requires their classification based on specific criteria which also could be their *goals*:

1 *Interconnectivity*, where the main goal of these solutions is to ensure good communication and cooperation of all available business resources (people, technology and information) that exist and operate in different operational areas of a company, as well as between member companies of a supply chain.
2 *Transparency of information*, where business resources retain and exchange data and useful information.
3 *Decision support*, allowing information to be made available to the right executives who need to make the right decisions quickly and redesign their business logistics systems effectively. In particular, these executives should have all the important information made available to them, which mainly refers to the execution of orders and their relationship with business associates.
4 *Automation*, enabling the resources of a company (systems, storage means, intra-handling, transportation and distribution) to operate autonomously, streamlining their use and optimizing logistics processes, e.g. solutions aimed at minimizing errors, the autonomous movement of vehicles, etc.

Table 10.1 presents an indicative list of these solutions grouped according to their implementation goal.

Companies that have adopted these technological and business solutions have the following common features:

Table 10.1 Industry 4.0 technologies

Goal	*Description*	*Available technological solutions*
Interconnectivity	Ability to communicate all available business resources	• Internet-of-Things • Cloud computing • Smartphones and respective apps • Pay-per-use: software as a service, infrastructure as a service and platform as a service
Information transparency	Business resources retain data and useful information	• Automatic recognition technologies for objects (barcodes, RFID, GR code) • RFID technology • Smart sensors • Augmented reality and smart glasses • Real-time locating systems
Decision support	The information is available to the appropriate executives	• Big data analysis • Business intelligence • Artificial intelligence • Preventive data analysis and simulation • Digital twins
Automation	Business resources operate autonomously by optimizing logistics processes	• Robotic systems • Cellular transport systems • Pick-by-voice and pick-by-light systems • Embedded systems • Drones

- They take full advantage of systems autonomy and their ability to perform or support the execution of tasks that are either difficult or time-consuming for humans.
- They provide a complete picture of the business situation, providing direct information, and only when there is an immediate requirement for action to be taken by employees.
- They assist executives in designing more efficient and effective processes, policies and practices, and
- They ensure vertical (interdepartmental) and horizontal (inter-business) integration.

The solutions are many: companies need only to be acquainted with them and consider their acquisition and implementation.

10.2.1 Warehouse management system (WMS)

Over the last decade, work in large distribution centers has become more complex, while the number of products on the move is growing more and more, making the implementation of IT solutions a one-way street. But even before that, many companies had already recognized the importance of the computerized warehouse and had already started investing in business information systems.

Initially, companies installed applications related to a single functional area of the logistics system, such as materials handling, receipt and execution of orders, etc. Then, Material Requirement Planning (MRP) systems tried to connect more than one operation, such as marketing and sales, production management and inventory management. Manufacturing Resources Planning (MRP II) added more features, such as production planning, capacity requirements planning, pricing, etc. Enterprise Resource Planning (ERP) systems potentially had the ability to manage processes involving all parts of the business and decision support at all levels. They also possessed natural and functional units (modules) for the management of the warehouse and the stock, providing accurate real-time information about the inventory, and ensuring their dissemination with the other subsystems of ERP. In practice, it has been shown that ERP did not meet the special and increased storage requirements regarding the monitoring and control of warehouse operations from the moment the goods or materials enter it until they leave. Specialized vertical systems promised to fill this gap by providing additional automation and optimization capabilities.

The technological solution that prevailed in the market for warehouse and inventory management was the specialized WMS. WMS manage all the work performed in a warehouse or distribution center, namely: the entry of products to the warehouse, their proper storage, inventory management, product collection, packaging procedures, product processing for orders, and the management of the warehouse's (or distribution center's) human resources. WMS are typically associated with tools for automatic data recognition and input, barcodes and radiofrequency technologies (RFID).

A standard WMS manages accurate and valid information that allows the business to minimize stocks, improve the routing and scheduling of inbound and outbound vehicles, and to generally improve customer service levels. These are all achieved on the one hand by increasing the efficiency of the materials handling equipment, and on the other hand, by the availability of storage space.

Most WMS have a core trunk of activities that are accompanied by a wide range of specialized subsystems, which are implemented based on the activities and requirements of the business and its industry, whose main goal is to offer greater added value to the company's customer. This core trunk includes:

- Receipt management that encompasses updating expected receipts, control/identification of receipts through barcodes, creation of new tags, palletization (or not) of packaging, etc.
- Management of loads and location arrangements, ensuring optimal storage, with the application of Pareto's Law (20/80 rule) designed for fast-moving products, etc.
- Warehouse document management, support for multiple storage systems, coding of locations per distribution center and per specific feature (e.g. sector, column, etc.).
- Supervision and management of multiple unit loads (packages and units of measurement).
- Order processing, which includes order grouping, issuance of relevant reports and monitoring their progress.
- Managing product supply based on current demand or historical sales data, by applying appropriate mathematical forecasting models

- Managing the collection of ordered items, which includes serial collection, minimization of the number of routes that the picker makes, support in the collection process for each possible sales unit (box, pallet and piece), use of RFID equipment, etc.
- Human resource management, such as shift planning, identification of the job requirements, workflow monitoring, etc.
- Issuance of reports and statistical data for all the above functions.

The benefits of implementing WMS include the following:

- Reduction of stock shortages by providing full inventory supervision, continuous monitoring of the available quantity and immediate reporting of shortages below permissible limits, allowing stock reduction to the lowest possible level and minimizing the cost of maintaining stocks.
- Shorter product delivery cycles (shipping/handling packaging, delivery and return).
- Reduction of labor costs and significant resource savings.
- Increasing the level of service and accuracy in the respective product deliveries.
- Limiting the element of human error (e.g. in data entry) related to the execution of daily tasks.
- Informing the managers, through reports, about warehouse issues (e.g. stock shortages).
- Optimizing the use of staff and equipment, which lead to increased productivity at the lowest possible cost.
- Reduction of storage needs by the use of automated storage space management and optimization practices, which help towards cost reduction and the full exploitation of storage facilities.

10.2.2 Geographic information systems in logistics services

Since the 1960s when they first appeared in the USA and Canada, the first Geographic Information Systems (GIS), which had the form of an integrated information system, have evolved significantly as a valuable multi-tool for enhanced spatial perception and data analysis. The use of new technologies and systems using GIS (e.g. satellites, GPS, internet and cloud applications, RFID technologies, smart sensors, drones, etc.) is an additional development that could be utilized to a large extent by Logistics and Supply Chain Management, for the more efficient management of large volumes of data from existing business information systems, as well as data related to socioeconomic issues (humanitarian logistics, demographic data, marketing, etc.) and environmental issues (climate change, vehicle energy management, etc.).

This can be achieved in Near-Real-Time (e.g. https://www.marinetraffic.com), as well as real-time (e.g. http://www.mobithess.gr), as maximum use is made today of the basic functions of GIS through interconnected networks and systems, to collect, store, process and visualize (via maps) data that have a spatial entity (presence of information in the location defined by geographical coordinates).

The combination of continuous developments in systems of Informatics with Augmented Reality, Artificial Intelligence, Autonomous Vehicles, as well as Internal Warehouse Mapping and Light Detection and Ranging (LIDAR) applications lead to a new and wider range of GIS applications for logistics. The development of a new (5G) telecommunications network with a wide range of digital developments can provide effective solutions to important problems in the day-to-day workings of companies, organizations and even the ordinary citizen who has access to logistics-related services (e.g. real-time geo-traceability monitoring of products via the internet, management and optimization of routing issues, traffic-related information on a city road network, etc.).

Moving on to a more socio-central use of GIS compared to logistics, we can include crisis management in the event of the emergence of natural disasters, such as earthquakes, forest fires, floods, etc. In such cases, the benefits are great, both in terms of the prevention and management of these problems, but also in their resolution in the aftermath (e.g. spatial management of the food supply chain, first aid, etc.), in order to minimize the negative effects and, wherever possible, to eliminate the loss of human lives.

10.3 Green marketing and green supply chain management

"By 2050 we aim for zero emissions from our supply chain." This statement received a lot of attention when it was made by the CEO of Deutsche Post DHL, a leading global logistics service provider. It is the practical implementation of a new supply chain management model based on the reuse, repair, and renewal of existing materials and products, in contrast to the linear model that prevailed in the past. It allows materials to be used for a much longer period of time while simultaneously minimizing the use of natural resources. Simply put, this is the growth model where all waste is reused or recycled.

In essence, the Circular Supply Chain is the transition from a vertical "production-consumption-disposal" model to a closed circular model where products can be disassembled and reused with minimal processing. On this basis, what was previously considered waste can be converted into raw material and reinserted back into the supply chain.

The basic goals and principles of this new SCM model are as follows:

1 The (geographically) smaller the circle, the more profitable and efficient the supply chain,
2 Circles have no beginning or end: the value created and maintained replaces the added value of the corresponding linear models,
3 The speed of circular flows is of vital significance,
4 Reuse, repair and reconstruction without change of ownership is more cost-effective, and
5 A well-functioning market significantly increases the success of a business initiative based on the new model.

To the above, we would also add that production restructuring based on a circular economy model, in addition to the change in strategy by companies and organizations, presupposes cooperation between all links of a supply chain, including inter-disciplinary links between actors operating in different business environments, in the context of an "industrial coexistence".

To this end, the European Commission has adopted a new, ambitious package of measures to help businesses, local governments and consumers make the transition to a stronger and more cyclical economy, where resources are used more sustainably. The proposed measures will contribute to a fuller product life cycle with greater recycling and reuse, and are expected to bring benefits to both the environment and the economy. The relevant plans derive maximum value and use from all available raw materials, products and waste, promoting energy savings and reducing greenhouse gas emissions. A key component of the circular economy model is the fact that the proposals cover the full life cycle of products, from production and consumption to waste management and the purchase of secondary raw materials.