SICK AG WHITEPAPER

IDENTIFICATION TECHNOLOGIES OVERVIEW

AUTHOR

Dr Tobias Hofmann
Technical Industry Manager Intralogistics
at SICK AG in Waldkirch, Germany

SUMMARY

Almost any application in the area of automatic identification (auto ID) raises fundamental questions as to the appropriate identification technology. Three identification technologies have dominated the market for many years: RFID, laser-based and image-based identification. Due to constant technical progress, and with it the further development of technologies, better solutions to existing ID problems can constantly be provided and additional applications developed.

As each technology has different strengths, and the fields of application and requirements are extremely varied, none of the technologies is a sure-fire solution for all auto ID applications. The optimum identification technology for a particular application must always be individually tailored to the technical and general economic conditions. Regardless of the technology used, a uniform cross-technology and cross-application device platform can have a positive influence on the price-performance ratio.

SICK
Sensor Intelligence.

Table of contents

8017739/2015_03
Subject to change without notice

FROM THE APPLICATION TO THE RIGHT IDENTIFICATION TECHNOLOGY

If a solution needs to be found for an object identification application, then the precise requirements for the application need to be specified first and there needs to be detailed consideration of the existing framework conditions. Only in this way will it be possible to ensure that the solution meets all of the client's requirements and is also neither undersized nor oversized.

The basic aim is to determine what level of automation needs to be achieved. Does the data need to be saved centrally or decentrally, and how securely does the data need to be saved? Is it an open or closed circuit, and do singulated objects or an accumulation of multiple objects need to be identified? Does a material flow concept according to a particular standard need to be implemented? Is there a need for analysis and further processing of the read results, for example compiling read rate statistics? If there is, does the software need to record the read data at the application, line, plant or company level?

These and other questions about the purpose of identification are followed by questions about the technical requirements, and the properties of the objects that need to be identified. Important information includes, for example, the shape, size, speed and the material of the objects, the type, position and orientation of the code, the read distance, the need for reading on several sides of the object and the maximum number of objects and codes per time unit.

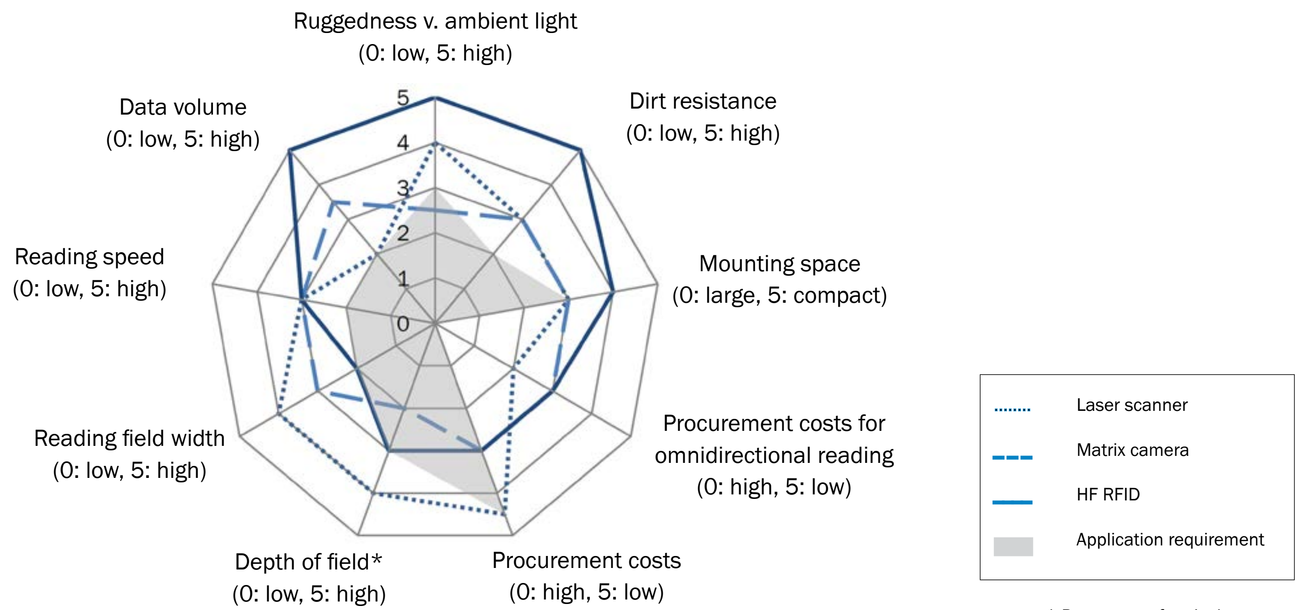
If all of these questions have been answered and the task to be solved has been clearly defined, then the selection of suitable identification technology can be started. Table 1 provides an overview of the features of the three most common identification technologies — RFID, laser-based and image-based identification.

	RFID	Laser	Image line scan/matrix
1D bar code	–	✔	✔
2D code	–	-	✔
Transponders	✔	-	-
Line of sight	not required	required	required
Costs of a label	> 0.05 €	< 0.005 € (label)	< 0.005 € (label)
Procuring the label	Purchase	Purchase, label printing on standard printer	Purchase, label printing on standard printer
Maximum storage capacity of the label	high	low	medium
Maximum reading field width	very large	large	large | average
Depth of field*	N.A.	high	low | average
Omnidirectional reading	very well suited	min. 2 devices needed	well suited
Maximum object speed	2 m/s to 20 m/s, depending on application	5 m/s	6 m/s
Sensitivity to external light	no influence	very low	low
Impairment due to dirt and wear	low	medium	medium
Metals/liquids in the surroundings	have an influence	no influence	no influence

* Parameter of optical systems

Table 1: Overview of the features of the different identification technologies in industrial use. The specified values and classifications must be seen as typical values in the area of industrial auto ID, which may vary depending on the requirements of the specific application.

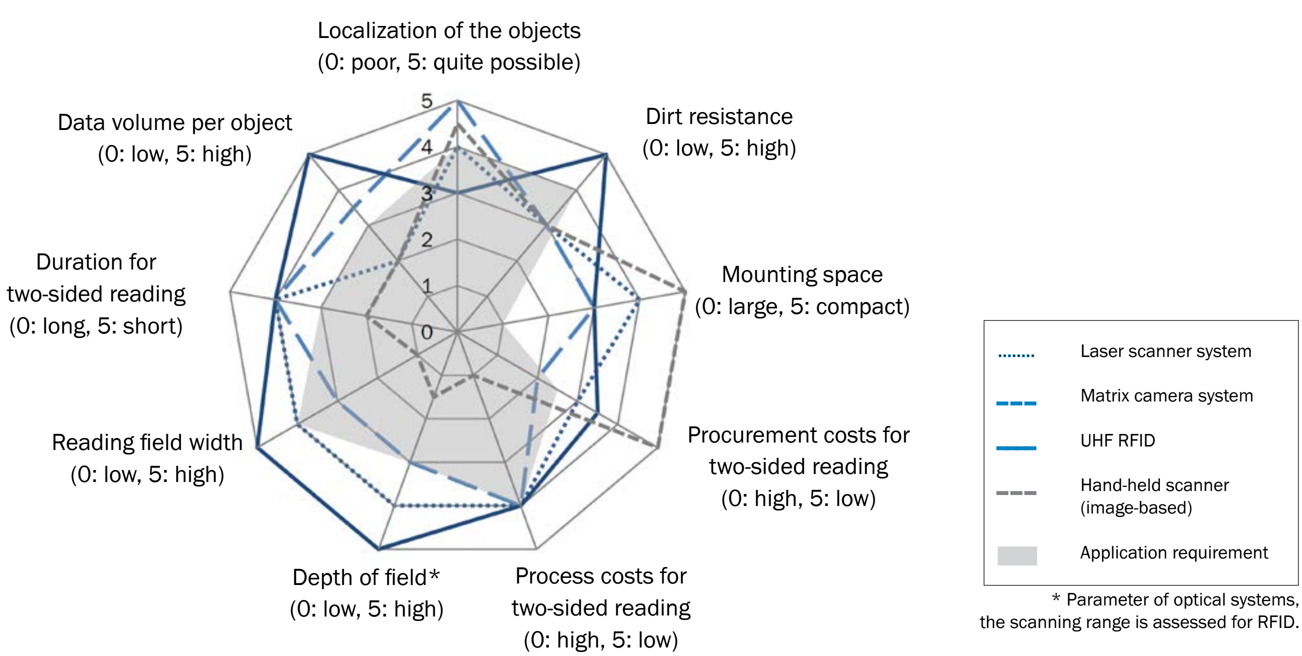
1A: Example application in the area of container identification



* Parameter of optical systems, the scanning range is assessed for RFID.

Diagram 1A: Performance comparison using an example application from the area of container identification
Identification of small load carriers (SLC) made of plastic on a roller conveyor (clearance of 2 cm on each side) with zero pressure accumulation shortly before picking in a warehouse. The SLCs are transported back into the warehouse after picking; no group reading is required. The lateral mounting space available equals 15 cm. The position of the label and its orientation is known (due to two-sided labeling or also, in the case of RFID, the marking on the underside and reading from below) and is always the same. Omni-directional reading is therefore not needed. There is a line of sight. A low data volume is saved on the labels and the labels must not be rewritten. The SLCs have a distance of at least 15 cm and are transported at a transport speed of less than 2 m/s. The warehouse has windows and it must be anticipated that there will be average-intensity incidence of external light. The risk of contamination and wear is rather low.

1B: Example application in the area of load verification



* Parameter of optical systems, the scanning range is assessed for RFID.

Diagram 1B: Load verification of Europool pallets in the area of receiving and shipping
The pallets are loaded with 1.5 m-high boxes, where the box sides end precisely at the edge of the pallet (without, e.g., overhang). The labels applied to the sides of the boxes must be scanned on two opposite sides of the pallet, where no omnidirectional reading is needed. Line of sight is present, however the risk of contamination of the bar code label is relatively high. The detection is carried out inside the building with no sunlight. The loaded pallets pass the reading station at 0.3 m/s, in which case the position of the pallet sides is precisely known to ±10 cm. The mounting area for the system is not limited. The pallet throughput per day is very high, therefore performance is important. The boxes contain no or only small amounts of liquid and metal.

As the table shows, the ID technologies have different strengths both in terms of technical specifications, and in terms of sensitivity to ambient influences. Therefore, an individual decision needs to be made for the application about which technologies are best suited, and offer the user an optimum solution from an economic perspective. For two example applications, diagrams 1A and 1B show a performance comparison between typical representatives of the individual technologies. The aim is to select the identification technology with the best price-performance ratio, in which case the benefits are justified by:

- optimum reading performance
- reduced post-processing
- minimum integration, maintenance and repair work
- maximum throughput
- high data availability and transparency
- There are additional benefits due to functions such as, for example, live image or detecting the bar code quality.

Just like the selection of technology, the weighting of the individual factors must be carried out in an application-specific manner.

Certain applications also benefit from a combination of the different technologies, e.g., self-bag drops and luggage sorting systems at airports (Figure 1). In this case, the simultaneous use of bar code and RFID increases the luggage identification rate and therefore reduces the work for subsequent manual sorting.

Figure 1: Combinations of the RFID and laser scanner technologies are used, for example, at airports in luggage identification systems for luggage sorting (left) and in self-bag drops (right).

The next three sections present the individual ID technologies in greater detail. A final paragraph then deals with the selection criteria not dependent on technology.

The various identification technologies complement each other excellently and allow the user to find the optimum technical and economic solution for their application.

Radio Frequency Identification (RFID)

RFID has several unique selling points:

- OMNIDIRECTIONAL READING
- SHORT READ CYCLES and the option for BULK READING
- POSSIBILITY OF REWRITING the tags and HIGH STORAGE CAPACITY
- NO LINE OF SIGHT to the RFID tag required
- LARGE DISTANCES BETWEEN THE READING POINT AND OBJECT
- CAN EASILY BE USED UNDER HARSH AMBIENT CONDITIONS

The majority of RFID-based identification solutions are implemented using passive transponders (Figure 2), and for this reason the following sections will only consider these systems. In contrast to active transponders, which allow for scanning ranges of more than one hundred meters, passive transponders do not have their own energy source, and are therefore less expensive. The RFID transponder systems are divided, according to the frequency of the radio waves used, into near-field technologies, such as low frequency (LF) and high frequency (HF), and far-field technologies, such as ultra-high frequency (UHF). Near-field and far-field technologies fundamentally differ in terms of the way the energy and data transmission works, because the dominant physical effects vary with the transmission frequency.

Figure 2: Passive HF and UHF RFID transponders in various forms facilitate the attachment to objects and the use as identification cards. The antenna and chip designs of UHF and HF tags differ considerably due to the different ways that the energy and data transmission work (tag on the far right: UHF, the rest: HF).

LF (30 – 300 kHz) and HF (3 – 30 MHz) transponder systems have a range of a few centimeters to around one meter. HF transponders may have high storage capacities of up to 8 kB. They are mainly used in factory automation, production and access control systems. The low scanning range is advantageous for many applications, because it effectively prevents the unwanted identification of transponders outside the measuring range. UHF far-field technology (normally 866 – 928 MHz), on the other hand, allows for working distances of six meters. Due to the high data transmission rate and the possibility for bulk reading recording, it is particularly suitable for the automotive industry and logistics automation, particularly in the textiles and clothing industry. For these reasons, and due to the uniform international radio and data standard, UHF RFID is the most widespread RFID technology in logistics automation. For example, UHF read and write devices increase the process speed on incoming and outgoing goods lines by identifying objects equipped with transponders on a pallet when going through a gate (Figure 3). The bulk reading of up to 300 tags per second without line of sight makes singulation of the object unnecessary. The maximum possible transport speed in this case depends on various factors, including the size of the reading field, the number of transponders that are in it and the data volume that is transmitted. Due to the beam characteristics of the antennae, the RFID tags must be a particular minimum distance from each other. Depending on the transponder used, alignment of the transponder antennae relative to the read antenna or the use of two or more read devices may also be required.

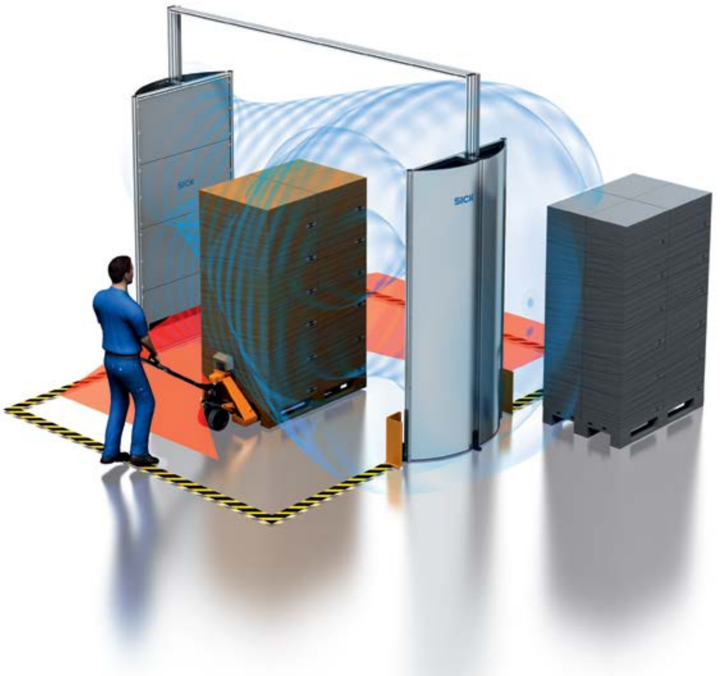


Figure 3: The RFID gate from SICK (RFGS Pro) identifies RFID-marked objects on a pallet when going through the gate. Tags outside of the measuring range are reliably filtered out.

When combined with the high storage capacity, tags that can be rewritten open up the possibility for decentralized data management: Object-specific information can be saved, updated and called up at any time on the transponder without having to be connected to a central system. This means that objects equipped with RFID transponders can be tracked along the entire logistics or production chain. For example, load carriers, which often circulate in large numbers can be located and tracked, and are therefore guaranteed to find the way back to their own inventory. In addition, compliance with particular quality standards can be ensured, e.g., the running of all process steps or remaining within maximum temperature and humidity values.

The use of RFID is also beneficial when there are harsh ambient conditions, e.g. temperatures of -40 °C and ice formation, or there are heavy mechanical loads on the objects to be identified. Optical technologies always require a line of sight in order to detect the code and are therefore more sensitive to wear or contamination, and are therefore also more maintenance-intensive than an RFID-based system.

In spite of the fact that purchase prices have dropped greatly, RFID transponders are more expensive that simple labels with 1D or 2D codes, which any user can print themselves. Even though RFID tags can be reused, and are also very rugged, the additional costs often only pay off for closed circuits or in the event of cross-company use of the technology.

Due to the physical properties of the radio waves, consideration must be given to liquids and metals in the read field when designing the system: Liquids absorb UHF frequency radiation, metals disrupt the radio waves and reflect (UHF) or absorb (HF) them. In many cases, adapted antenna and system designs can balance out these disruptive factors and allow for high read rates even in complex environments, but they require additional technical or planning work.

Additional information on RFID in intralogistics can be found in the white paper "Process optimization in intralogistics using RFID" (R. Schittenhelm, V. Glöckle). ➜ www.sick.com/whitepaper_rfid

Bar Code Scanner

The main advantages of a laser-based bar code reader are:

- excellent DEPTH OF FIELD
- large READING FIELD WIDTH
- NOT SENSITIVE TO EXTERNAL LIGHT SOURCES
- NO ADDITIONAL ILLUMINATION NEEDED
- EASY CODE READING WHEN OBJECT IS STILL AND ACCELERATING
- LOW COSTS

Laser scanners have an excellent depth of field and are therefore able to identify bar codes on objects of different heights without any problem. Due to the large fields of view of up to 60°, just one device covers most conveyor belt widths. Therefore, among other things, laser scanners are ideally suited to use in the area of courier, express and parcel services or storage and conveyor technology (Figures 4 and 5).

Figure 4: Oscillating mirror scanners read bar codes within a specified range, even in poor lighting conditions.

Laser scanners exclusively read 1D codes, and they can also detect damaged or contaminated codes thanks to sophisticated algorithms. If the bar code elements are oriented parallel (ladder orientation) or orthogonal (garden fence orientation) to the direction of movement of the bar code, then an individual laser scanner can read the codes. Line scanners direct a laser beam along one line, grid scanners direct a laser beam along several parallel lines, and detect the intensity of the laser light reflected from the light and dark elements of the bar code. Line scanners use the movement of the bar code for error-corrected reading and are mainly used for codes in ladder orientation.

Figure 5: Laser scanners are widely used in warehouses because they securely identify the load carriers when laterally mounted on the conveyor system. The diagram shows a line scanner which is activated by a photoelectric sensor.

Grid scanners also offer a high level of redundancy for codes in the picket fence orientation. Laser scanners from a third category, oscillating mirror scanners, scan a specified area and can therefore record several bar codes, which are in positions that are not fixed. In order to securely detect codes in all orientations, several scanners are mounted rotated towards each other, typically two scanners at a 90° angle.

Red or invisible infrared laser light ensures a very good contrast for the very commonly used black/white bar codes. Due to the high intensity of the laser beam, the lighting conditions in the environment have no negative influence on the read performance of a laser scanner. This leads to reliable detection of bar codes and, together with the lack of dependence on external illumination, to straight-forward mounting.

High scanning frequencies of up to 1.2 kHz permit bar code identification even with high object speeds of up to 5 m/s. In contrast to line scan cameras, depending on the technology, laser scanners read the codes even during acceleration processes, for example when approaching a belt, without requiring speed information.

The costs of an individual laser scanner are typically lower than those for a corresponding camera alternative. However, the cost for the omni-directional reading of bar codes is similarly high to that of a camera-based system due to the higher number of individual devices required. The average service lives of industrial laser scanners and cameras are around the same, and therefore have no influence on the consideration of costs. In many systems, the devices have been working reliably without interruption for more than a decade.

Bar code labels are widely used in many fields of application, because they are inexpensive to buy in comparison with RFID tags, and are also standardized around the world. The general advantages of bar codes obviously apply both for laser-based and also for image-based bar code reading devices. The labels can be applied to almost any object. Alternatively, the codes can also be applied directly to the materials, e.g., using laser marking or dot peen marking. If limited space on the objects to be marked restricts the size of the codes, then bar codes with reduced bar heights or 2D codes are used.

2D codes have a greater data density than 1D bar codes, and therefore take up a considerably smaller area for the same amount of data. If 2D bar codes need to be read, then laser-based code readers can no longer be considered as a solution and an image-based system must be used.

Image-based code readers

Image-based identification technology stands out from other identification technologies due to the following advantages:

- FLEXIBILITY in code reading (1D, 2D and plain text)
- LIVE IMAGE AND IMAGE STORAGE for analysis or data archiving
- OMNIDIRECTIONAL READING with just one device
- READING POOR CODE QUALITIES
- Use of GREATLY VARYING MODULE SIZES

Image-based code readers are characterized by their flexibility in the selection of the code type. In addition to 1D bar codes, they use various image processing algorithms to identify both plain text and 2D codes, such as the frequently used data matrix, QR or maxi codes (Figure 6). It is therefore easily possible to switch from 1D bar codes to 2D bar codes.

Figure 6: Package services often use a combination of 1D and 2D codes (here a maxi code).

If the orientation of a code in a level is not precisely defined and is variable in the application, then an individual image-based code reader can reliably detect all codes irrespective of their orientation. This advantage becomes clear for codes with short bar lengths in particular, because in this area, even with two reading devices, a laser-based solution does not achieve such good read rates as the camera-based reader. In applications with poor code quality, for example due to weak contrast or partial destruction, image-based code readers achieve reliable read results due to the corrective image processing algorithms. This reduces the amount of manual post-processing that is needed.

An additional added benefit of image-based code readers is the live image function and the ability to save images, which allows for use in other processes, such as text recognition or video coding. With the aid of images, it is possible to easily identify and analyze causes for non-reading, and the information obtained can ultimately be used for process optimization. Image processing algorithms classify non-reading according to typical, specified error patterns, such as large-scale code destruction, no codes being present or deteriorating print quality. The images recorded are often archived and used for documentation purposes in order, for example, to handle guarantee cases better.

Most image-based code readers are based on line scan or matrix cameras. Line scan cameras only have one light-sensitive line, which consists of up to 17,000 pixels arranged in a linear manner. In order to record a two-dimensional image, therefore, either the object has to be passed under the camera or the camera has to be moved along the object (Figure 7). The benefits of line scan cameras include, among other things, the very high scanning frequencies of up to around 70 kHz, which allow for fast transport speeds, and an enlarged field of view compared with matrix cameras. However, as is the case for laser scanners, the fixed detection angle requires a sophisticated structure in order to restrict the occurrence of reflections to a minimum. The speed of the relative movement between object and camera must be known and considered in the calculation of the overall image, as otherwise the image may display distortions. Compared with laser scanners and matrix cameras, line scan cameras offer the highest resolution with a large field of vision width, but require greater mounting space due to their size.

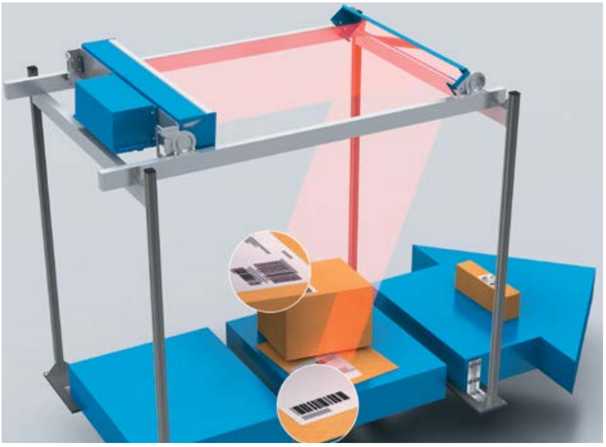


Figure 7: A line scan camera identifies 1D and 2D codes on objects of different heights, which are carried through the camera's reading area by belt.

The way that matrix cameras work is similar to the digital cameras known from photography (Figure 8). The object is reproduced on a flat sensor and a two-dimensional image is saved in which the codes are then detected. Typical image recording rates of the industrial cameras used for auto ID are in the region of 25 – 100 Hz. In addition to a greater depth of field, the increased read stability with poor code quality and reflections is a key advantage in comparison with line scan cameras. The increased read stability is a result of the recording of one and the same object area from different recording angles and in successive records. In contrast to line scan cameras, bar code identification is possible even when the object is at a standstill or in start/stop situations.

Figure 8: Matrix cameras read printed or directly marked 1D and 2D codes, for example during the package sorting process (left) or for unique identification of parts such as motor blocks during production (right).

Depending on the application, either a line scan camera or a matrix camera may be more suitable for 2D codes, which means that different considerations are needed. Ambient light is a challenge for matrix cameras in particular, which needs to be overcome using good technology and planning.

Both image-based and laser-based code readers are optical methods, and therefore a line of sight is indispensable. Contaminations and other influences which restrict the view, e.g., a lens that freezes over, can be counteracted using special coatings on the lens, automatic cleaning units, larger lenses and heating. A sophisticated structure minimizes the time needed for maintenance.

TECHNOLOGY-INDEPENDENT CRITERIA

In addition to the technical requirements, the economic perspectives also play a central role in the selection of the optimum ID technology. Hard and soft factors, such as integration and maintenance work, control and visualization options, flexibility in component selection and services contribute to the investment security and future viability, and therefore to the profitability of an acquisition.

A uniform cross-technology and cross-application device platform, which uses the same connectors, configuration and visualization software irrespective of the technology used, has a very positive influence on these criteria.

Due to its flexibility, this kind of uniform platform is mainly beneficial if, during the planning phase, there is not yet final clarity in relation to the technical requirements, it is probable that technology will be changed or expanded, or several identification technologies are used within a company. For example, process optimizations or changing requirements in the process may require a subsequent replacement or additional introduction of ID technologies. This particularly affects warehouses, because suppliers and customers play a role in specifying the technology and packaging that is used for incoming and outgoing goods. If their requirements differ, then the ID technology used in the warehouse will have to be adjusted accordingly. Converting to a new technology, e.g. RIFD, is often problematic. In addition, the change between different bar code variants, bar code positions, object heights and object surfaces can cause problems. In both cases, a uniform device platform allows for easy changes in technology, both in terms of a complete replacement or in the event of an upgrade to hybrid systems.

If only one isolated, clearly outlined individual application needs to be dealt with, and if there are no other identification technologies in the company, then the advantages of a uniform platform are modified.

Conclusion

Due to the number of fields of application, none of the identification technologies is suitable for all applications. The technology that is best for a particular application is the one with the best price-performance ratio in the individual area of conflict between technical and economic requirements. Therefore, all identification technologies should be included at the start of the selection process, and then gradually eliminated in view of the problem that needs to be solved.

There is no one perfect technology, but the right solution exists for almost any auto ID application.

8017739/2015_03

8017739/2015_03/CSCLA_AS

FURTHER LINKS

White paper "Process optimization in intralogistics using RFID": ➜ www.sick.com/whitepaper_rfid

4D*pro* video: ➜ www.sick.com/4Dpro_video

More information on 4D*pro:* ➜ www.sick-4Dpro.com

More information on RFID: ➜ www.sick.com/rfid

More information on bar code scanners: ➜ www.sick.com/bar_code_scanners

More information on image-based code readers: ➜ www.sick.com/image-based_code_readers

SICK AG | Waldkirch | Germany | www.sick.com

Sensor Intelligence.