Scoping of ID Application Matching

Alan Thorne, Duncan McFarlane, Kevin Le Goff, and Ajith Parlikad

Auto-ID Labs, University of Cambridge, UK

This report presents the scope of work for the ID Application matching theme of the Aero-ID Project. This theme arises from the realisation that the selection of ID technologies for the Aerospace sector is a complex process, and in particular, the use of RFID is frequently by no means a certainty. Hence the development of tools and guidelines to help sponsors with this process is beneficial in supporting adoption of ID technologies in this sector.

This report provides the sponsors of the Aero-ID programme with preliminary information about the types of decisions that have to be considered when selecting an ID solution for various types of applications. It highlights characterisation approaches that have been used previously by the Cambridge Auto-ID Lab in understanding the nature of data that different types of ID solutions provide. A review of different ID technologies is also provided in preliminary form.

The report goes on to propose that research needs to be carried out to identify environmental characteristics and measures that describe the required physical attributes of ID applications to be deployed. This will be achieved through case studies, examining different technologies under experimental conditions, and characterising usage mode requirements in various applications across the aerospace sector.

The output from this activity would be in the form of guidelines and possibly an ID selection tool.

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1. Introduction

This report outlines the capabilities and shortcomings of various identification (ID) technologies and provides preliminary insights for analysing issues with regard to matching these technologies with particular applications.

1.1. Aims of the Report

Identity - "that which can distinguish one thing from another" - is a critical piece of information enabling many diverse business processes and applications in numerous business sectors today. To ensure that the business process can take full advantage of identity information, it is essential that the physical requirements of the business application and the technical capability of the ID technology match.

The aim of this report is to introduce benefits and obstacles that different ID technologies bring to applications in the aerospace sector. The report will highlight a number of criteria and measures that should be considered when choosing an ID technology for a particular application. These measures will allow researchers and sponsors to quickly categorise and understand the requirements of different aerospace processes making use of identity information for today and tomorrow. This will allow the next stages of the research theme to examine and provide guidelines and tools that can be used for the selection of different ID technologies. This may go on to examine how different technologies may interoperate, providing complementary solutions.

Identity information can support many different decision processes within business systems, depending on how visible the data is made to back end systems and the capabilities of the network infrastructure to share this information. For this report we focus primarily on the capabilities of ID solutions to support decision processes locally and the suitability of these technologies for integration into networked information architectures (see Figure 1).

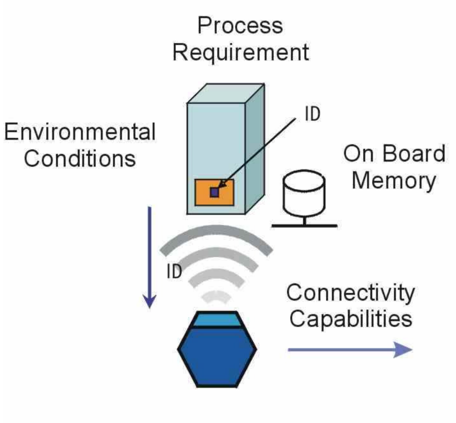

Figure 1: Scope of ID analysis

1.2. Structure of the Report

The report is structured in the following way: In section 2, we provide a background to problem and the decisions involved in choosing an ID technology for use in particular applications. This section will also offer a first brush at identifying the key technology characteristics that may be used as selection criteria. Section 3 reviews different ID technologies that are offered in the market today and describes the benefits and problems associated with each. Drawing from these two sections, a preliminary comparison of the ID technologies is presented in section 4. Section 5 finally concludes the report and provides a summary of the key issues presented here.

2. Background to ID Technology Selection

In this section we provide a short background to the way in which ID solutions are selected, the way ID-derived data is used and on the impact that ID data quality can have.

2.1. Decisions in selecting an ID technology

It is a fairly complex decision to choose an appropriate ID solution for a particular application, and there are potentially many different solutions that would provide a working system. Below is a list of questions that highlight a number of issues that should be considered. (Please note this is not exhaustive list but provides ideas to be considered when reading this report).

a) What identity standards are currently being used or are appropriate for this process?

ISO, UID, EAN, UCC, EPC Global, etc.

b) What are legal / legislative / regulatory issues in using a particular identification technology?

Laser Light, Radiation levels, RF power, Global RF frequency bands, Interference, etc.

c) What are the technical issues in using a particular identification technology?

Integration into process control / middleware systems, etc.

d) What process data is required to support the decision in the business process?

Direction of product flow, temperature of product, pass / fail analysis, historic data, etc.

e) What is the physical process at the point where the identity is going to be obtained?

Constrained direction of flow, orientation of product, speed of motion, configuration of products, etc.

f) What are the environmental issues that the identification technology would have to handle?

Non line of sight, Non RF friendly materials, RF noisy environment, physically dirty environment, etc.

g) What are the costs / benefits that the identity information brings to the business process?

Budget for technology installation, integration and training enabling a profitable business solution.

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When considering the basic seven questions above, it can be seen that the ID technology solutions workspace is a complex array of interlinked business processes, technology capabilities and legislative requirements. To help start simplify this workspace, the Cambridge Auto-ID Lab has made use of three basic performance measures that can be used in identifying the particular ID technology characteristics that make them suitable for particular applications.

2.2. Performance measures related to the nature of ID data

This section highlights three basic performance measures that can be used in identifying the specific ID technology characteristics that make them suitable for particular applications. It should be noticed that these performance measures are predominantly related to the nature of the data that the ID solution will provide. (The diagram below shows the characteristics of ID technologies performing in their optimum conditions. Section 3 highlights some of the limitations that should be considered when using a particular technology.)

Timeliness*: is a measure of how fast ID information can be provided by the ID solution.*

Slow Fast

Accuracy: *is a measure of data accuracy provided by the ID solution.*

Error Prone Near Perfect

Completeness: *is a measure of data available form the ID solution to enable a decision.*

Incomplete Near Complete

(* Depends on network access capability)

We can now make some comparisons between different ID technologies using the three quality dimensions associated with product data, namely timeliness, accuracy and completeness of the information available. The diagram below in Figure 2 shows the characteristics of manual data entry systems, bar code systems, RFID systems and networked RFID systems.

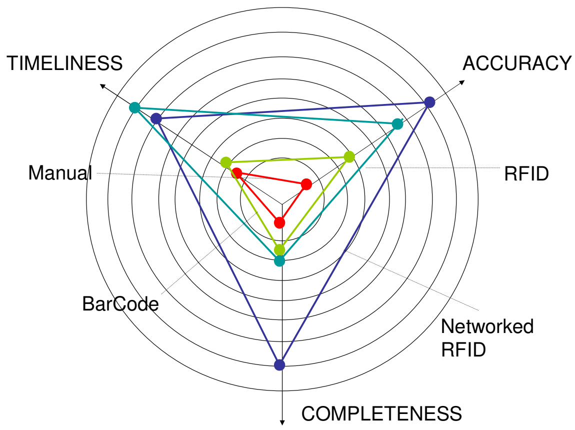

Figure 2: Dimensions describing ID data quality

When considering the characteristics of the four technologies in Figure 2, it can be seen that the manual identification system is a poor performer. It is slow, prone to operator error and provides a limited amount of data. In comparison the semi automated solution such as a bar code system, is much faster, less prone to operator error and, depending on the bar code format used, can provide more information. RFID delivers a large improvement in performance as it is a fully automated solution, providing much faster read rates and kilobytes of data. Networked RFID goes the next step providing many of the advantages of RFID, but with the added capability of allowing RFID data to be linked with unlimited amounts of networked data.

When choosing an ID technology for a specific process, the quality measures described above provide guidelines about the nature of the data that the ID solution will provide. However, when reviewing the questions in section 2.1 (***Decisions in selecting an ID technology***) it can be seen that this only answers part of the problem and a large number of issues around characteristics of the physical environment still need to be addressed. (ID read range, Material effects, Environmental effects, Cost, etc.)

2.3. Characterisation of the physical environment

This section of the report highlights some of the future research work needed to be undertaken for the identification of the physical characteristics of environments important for the operation of ID technologies in the aerospace sector. This includes areas such as ID read range, RF absorption in material and cost.

Below are a number of issues that should be considered when characterising an environment where ID applications are to be used. These issues have been identified in performing RFID trial activities within the FMCG sector.

Legislative: *Standards bodies, Global frequency bands, RF power levels, Emission levels, Safety requirements.*

Fundamental requirements: *Non-line of sight reads, Simultaneous reads, Speed of part motion, Unique Identifiers, Mixed product types, Component level identification, Sub assembly level identification, Product level identification, Reusable asset, Cost.*

Integration: *Direction of product flow, Event driven read's, Sensory information, Pass or Fail process conditions.*

Environment: *Dirty environment, high temperature extremes, RF noisy area, variation in product location and orientation, RF friendliness of area.*

Part marking: *High shock levels, chemical exposure, non RF friendly materials, high temperature extremes, Surface suitability, Operational life.*

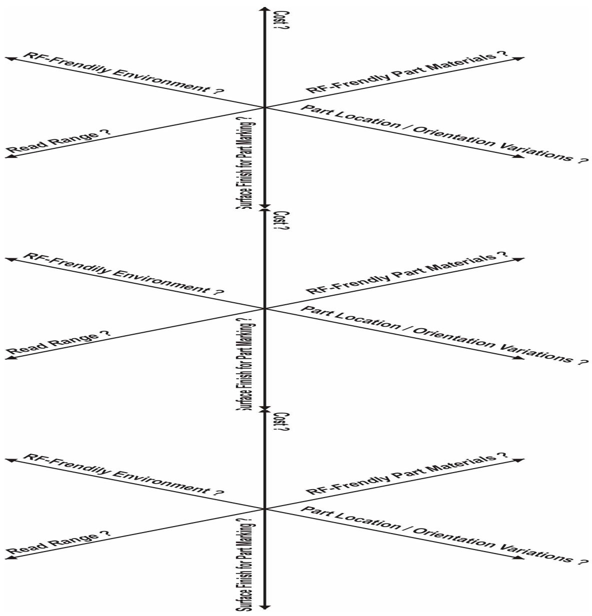

Figure 3: Possible axis's for physical environment characterisation

The next steps in this research work would be to perform a number of case studies on different applications across the aerospace sector, reflecting on previously gained knowledge from the FMCG activities. This would provide valuable data that could be used in providing aerospace specific characterisation measures. Figure 3 provides an initial guess at the types of axes that may be important.

3. ID Technology Review

The following section of the report provides some background material about the type of ID Technologies that may be important for applications in the Aero Sector. It should be noted that this is a brief introduction and will need to be expanded as this research activity continues. Technologies covered in this review are Barcode, Contact Memory Buttons, RFID, Magnetic strips, Optical strips, Optical Character Recognition, and Visidot. At the end of the section there is a comparison chart of the different technologies.

3.1. Barcode Technology

3.1.1. Overview of Barcode Technology

Barcode systems have been around for over 25 years and they are a familiar part of everyday life. They are optical systems, encoding identification data into light and dark stripes either directly onto a part or a label. The labels are cheap to produce and come in different levels of robustness depending on the application.

The scanners work by passing a light beam across the striped label and decoding the reflected signal. The optical scanners are inexpensive for the majority of semi automated solutions but as higher levels of automated data capture are required the price increases significantly.

There are four main types of scanners, Barcode Readers, Barcode Wands, CCD readers, and Laser Scanners, each having specific advantages and disadvantages. Barcode Wands are pen shaped devices and they use a LED light source at the tip of the pen. To scan a barcode the wand is physically dragged across the bar-code in a smooth steady motion. (Manually operated / contact device).

CCD readers use an array of sensors approximately 3 inches wide to read a barcode. CCD readers provide a non-contact solution. The device must be held approximately 1/2 inch from the barcode to achieve a successfully read. (Manually operated / non contact device / requires alignment with product)

Laser Scanners are by far the most versatile and efficient devices for reading barcodes. They are capable of reading different types of barcodes at distance of up to 30 feet and can handle limited variation in product orientation. (Semi automated / non-contact / handle limited product alignment variation)

A number of standards have been established over the years for encoding data onto labels. These standards have traditionally been clustered around business sectors and application areas, although they are merging into de-facto standards and being used more universally today. Depending on the amount of data needed to be stored on the label there are several different options available, but tending to fall into two categories, one dimensional or two dimensional barcodes.

Symbology	Data Capacity
UPC-A	12 numeric digits - 11 user specified and 1 check digit.
UPC-E	7 numeric digits - 6 user specified and 1 check digit.
EAN-8	8 numeric digits - 7 user specified and 1 check digit.
EAN-13	13 numeric digits - 12 user specified and 1 check digit.
Code 39 Code 93 Code 128 EAN-UCC 128	Variable length alphanumeric data - the practical upper limit is dependent on the scanner and is typically between 20 and 40 characters. Code 128 is more efficient at encoding data than Code 39 or Code 93. Code 128 is the best choice for most general barcode applications. Code 39 and Code 128 are both very widely used while Code 93 is rarely used.
I 2 of 5	Variable length numeric data - the practical upper limit is dependent on the scanner and is typically between 20 and 50 characters.
Data Matrix	Data can consist of any type of data including binary or alphanumeric and be up to 3116 bytes in length. (Visidot described in section 2.7.0)
Aztec	Data can consist of any type of data including binary or alphanumeric and be up to 3750 bytes in length.
Maxicode	Maxicode can hold up to 93 alphanumeric characters or 138 numeric digits. Maxicode is used almost exclusively for United Parcel Service package identification.
PDF417	PDF417 is a little more complex and it is difficult to say exactly what its capacity is because it depends greatly on the type of data that is encoded in a PDF417 symbol as well as the amount of error correction capacity that is required. For general binary data with no error correction enabled, a single PDF417 symbol can hold up to 1108 bytes. If the data consists of all numeric digits, then a single PDF417 symbol can hold up to 2725 digits. If the data consists of alphanumeric data, a maximum of 1850 bytes can be encoded. If there is a mix of alphanumeric and binary data, the capacity will be somewhere between 1108 and 1850 bytes and will depend on the content of the data.

(Source of table: *TALtech*)

3.1.2. The value of Barcode

A number of simple observations about the nature of Barcode systems are described below:

Observation 1 (Benefits): The production of barcode labels is relatively cheap and they can be attached to a product or application area as required. Data standards are mature and starting to merge across application boundaries. Due to the optical nature of the technology it is not susceptible to performance degradation due to the materials that the labels are attached to.

Observation 2 (Problems): Barcodes are read only devices, once printed the data cannot be changed. Data can only be read when the reader is in line of sight of the barcode and the amount of data that can be stored on the labels is limited. Only one label can be read at any time making this technology fairly slow, with no potential for simultaneous read capability.

3.2. Contact Memory Buttons

3.2.1. Overview of contact memory buttons

Contact memory buttons are passive read / write electronic devices designed to work in extreme operating environments. They are coin style devices as in Figure 4 housed in rugged metal cases and come in a number of diameters from 8mm through to 30mm. Depending on the style and size of device they can hold up to 8 Mega bites of data in EEPROM non-volatile memory. The devices can support security password mechanisms and data correction algorithms to ensure accuracy of data over the 100 year life of the device.

Figure 4: Contact memory button

The reader comprises of a hand-held contact probe, which connects to a standard RS232 serial port on most standard computers. The probe has to make contact with the tag, but not in a specific orientation. This provides an electrical contact which ensures all power and data signals are mated between the probe and the memory button. Different styles of probes can be purchased depending on the user interface that is required. These can range from the simple pen probe as discussed above through to sophisticated PDA style devices where an operator can retrieve, view and edit information on the tag. (Manually operated / contact device)

Most of the standards for contact memory buttons are concerned with build quality, ensuring that they are rugged enough for industrial and military applications. Communication standards tend to be proprietary and specific to technology vendors.

3.2.2. The value of Contact Memory Buttons

A number of simple observations about the nature of Contact Memory Buttons are described below:

Observation 1 (Benefits): Contact memory buttons are physically robust devices that can be attached to products or application areas as required. Their performance will not degrade depending on the material that the label is being attached to. They have a large R/W memory storage capability, supporting security protocols and have an operating life time of 100 Years.

Observation 2 (Problems): Contact memory buttons are contact devices and by their nature are only suitable for semi automated applications. Only one button can be read at any time and this makes this technology fairly slow, with no potential for simultaneous read capabilities. Vendors proscribe proprietary communications mechanisms.

3.3. Radio Frequency Identification

3.3.1. Overview of RFID & Networking of RFID

RFID - or Radio Frequency Identification – has emerged over the last six years as a contender to replace barcoding as a broadly adopted industrial identification mechanism[1]. The advantage of this technology is that it allows for simultaneous, non-line-of-sight, automated ID inspections. By contrast, a barcode provides single line of sight ID inspections which are difficult to fully automate.

There is no single classification for a RFID tag, and in fact there is a range of classes from simple (often referred to as Class 1) to quite complex (often referred to as Class 4) tags. This spectrum is illustrated in Figure 5 demonstrating the ranges of memory, power, sensing capabilities etc. that can be achieved with RFID based systems.

[1] See McFarlane, D, Thorne, A, RFID Applications, IFM Position Paper, University of Cambridge, March, 2005

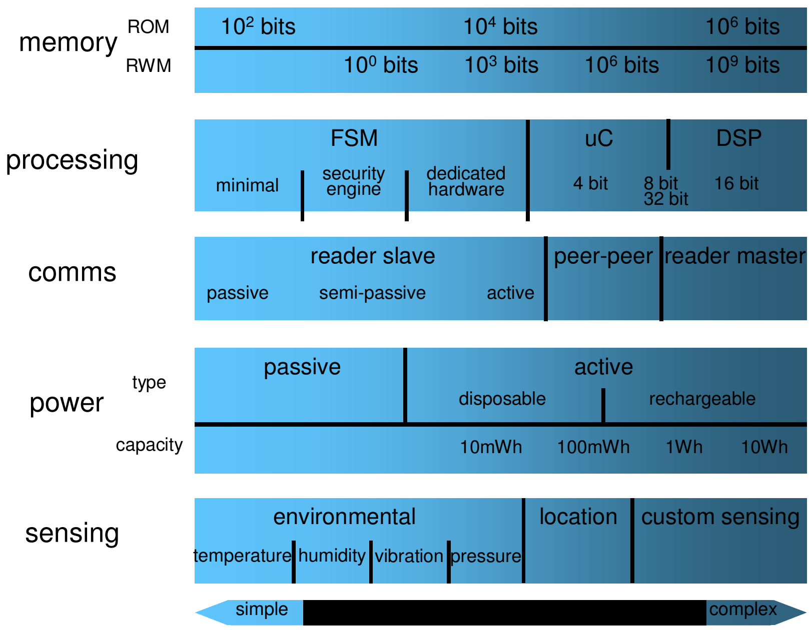

Figure 5: Spectrum of Tag Classifications

Networked RFID

A key development of RFID technologies is their suitability to being integrated into *networked* systems. This has been done primarily as a means of minimising the *cost* of the RFID tag by allowing product data to be held in linked computer memory rather than on board the tag. However, the development also provides a more general mechanism for *synchronising* tag based data with product related data held in any one of the multiple data bases that trace a product's lifecycle. The system can therefore be the underpinning of track and trace solutions.

Such a *networked RFID* system comprises of the following elements. (See Figure 6 also)

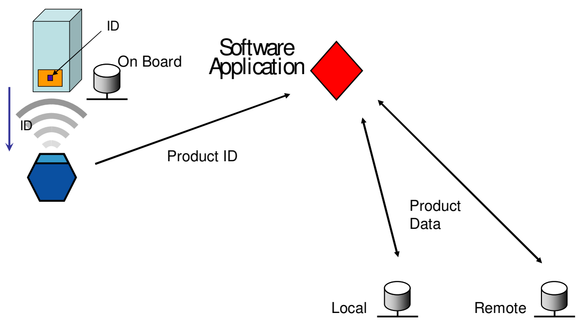

Figure 6: Networking RFID

1. A unique identification number which is assigned to a particular item.

2. An identity tag that is attached to the item with a chip capable of storing *at a minimum* a unique identification number. The tag is capable of communicating this number electronically.
3. Networked RFID readers and data processing systems that are capable of collecting signals from multiple tags at high speed (hundreds per second) and of pre-processing this
data in order to eliminate duplications, redundancies and misreads.
4. One or more networked databases that store the product information, and a means of locating and retrieving that data on demand.

3.3.2. The Value of RFID

A number of simple observations about the nature of RFID systems are described below:

Observation 1 (Benefits): Improved information quality can provide benefits if, and only if, it leads to improved decisions and actions. In the context of support engineering this means that RFID deployment in condition monitoring must be linked to improving, extending and potentially re-engineering current support practices. (Compare a) and b) in Figure 7.)

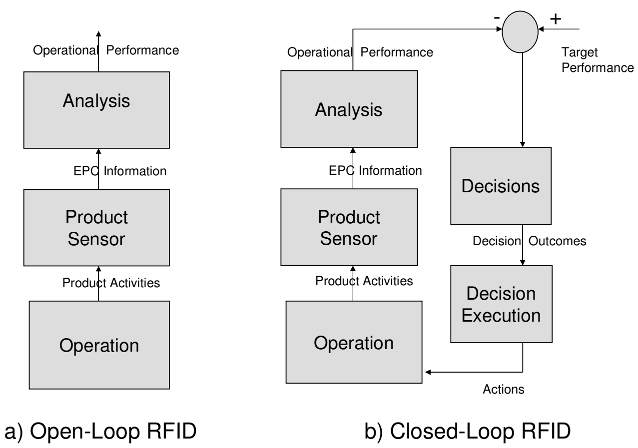

Figure 7: Open and Closed Loop RFID Application

Observation 2 (Problems): RFID systems are subject to a number of limitations that are inherent to the physical properties of RF communications, as well as legal stipulations around their operation in different countries. These limitations can include factors such as tag interrogation and programming speeds, read ranges that are possible, detuning effects due to materials such as water and metals within the vicinity of the tag or readers, product / reader orientation limitations and interference due to electrical and wireless communication devices in the local area. Many of the limitations listed above can be solved and many successful RFID installations have been achieved, although it is important to realise that this is very dependent on the skill of the installation engineer and it would be foolish to believe that an installation could be reproduced in a new location or catering for a different product and achieve the same results. Guidelines around reader installations to achieve product visibility across the entire supply chain are limited and get even more complicated when dealing with trading partners.

3.4. Magnetic Strips

3.4.1. Overview of Magnetic Strips

The magnetic strips have been around for many years and can be found on many everyday objects such as credit cards and store loyalty cards. There are a number of world wide ISO standards as well as many proprietary standards for storing data on these types of devices. They have a read / write capability and are made from a magnetic recording medium, similar to that found in a music cassette and or videotapes. The magnetic strip has data encoded onto it by exposing it to strong magnetic fields in different directions. This results in the data being encoded as segments of tape, magnetically polarised in different directions. Data capacity of these types of devices is dependent on the size of the magnetic strip and the encoding algorithm used. A traditional ID card could be expected to store up to 4k bytes of information.

Figure 8: Magnetic strips

The reader consists of a magnetic pickup head as found in most tape recorders. It is normally configured into a card reader assembly. Information is read from the strip as it is swiped across the pickup head, resulting in voltages being induced in the pickup coils and amplified before being processed by a micro controller or PC. (Manually operated / contact device)

3.4.2. The value of Magnetic strips

A number of simple observations about the nature of magnetic strip systems are described below:

Observation 1 (Benefits): Magnetic strip systems are mainly suited to personal identification and require contact between the reader and the card, providing a good level of security. ISO Data standards for personal identity are mature and in place.

Observation 2 (Problems): Magnetic strip systems use a magnetic communications mechanism making them susceptible to performance degradation when in close proximity to metallic objects and magnetic fields. Bringing these devices into magnetic fields can be detrimental and result in information being erased from the device. Only one device can be read at any time making this technology very slow. The expected operating life of magnetic strips is fairly low, but dependent on usage.

3.5. Optical Strips

3.5.1. Overview of Optical Strips

Optical strips use a more modern technology than the magnetic strips discussed above. The fundamental difference being that it is a read only optical medium that is programmed at the point of manufacture with WORM characteristics for data storage. It is being used in many of magnetic strip applications where there is a need for higher data capacity. In an optical ID card application up to 6 Mbytes of information can be stored.

3.5.2. The value of Optical Strips

A number of simple observations about the nature of optical strip systems are described below:

Observation 1 (Benefits): Optical strip systems are mainly suited to personal identification and require close proximity between the reader and the card. This provides a good level of security and the storage medium provides a high data storage capacity.

Observation 2 (Problems): Optical strip systems use an optical line of sight communication mechanism making them susceptible to poor performance in dirty environments. Only one device can be read at any time making this technology very slow. The expected operating life of an optical strip is currently guaranteed for up to 10 years.

3.6. Optical Character Recognition

3.6.1. Overview of Optical Character Recognition

Optical character recognition (OCR) is the translation of optically scanned images such as printed or written text characters on a label into digital characters, effectively converting hard-copy materials into data files that can be edited and otherwise manipulated on a computer. This is a process that is performed by vision systems and software tools to automate the recognition of human readable characters.

The combination of vision systems and character recognition software running on a high powered computer platform can provide a very powerful identification technology. It has the added capability of performing quality control processes, recognising unexpected shapes or dimensions.

On many applications there is a requirement to use both barcode identifiers and human readable information. On these types of labels a space age futuristic type of character set, specifically designed to provide optimum performance under OCR analysis, is used.

3.6.2. The value of Optical Character Recognition

A number of simple observations about the nature of OCR are described below:

Observation 1 (Benefits): The production of OCR labels is relatively cheap as the only cost involved is the cost incurred in printing the labels. Due to the optical nature of the technology, the performance is not affected by the materials that the labels are attached to. It also offers a very good use of space.

Observation 2 (Problems): Similar to optical strip and barcode systems, OCR systems use an optical line of sight communication mechanism making them susceptible to poor performance in dirty environments. Only one device can be read at any time making this technology very slow.

3.7. Visidot technology

3.7.1. Overview of Visidot technology

Visidot technology makes use of two dimensional data matrixes and sophisticated software recognition algorithms to deliver accurate and cost effective automated identification technology. It has been under development for the last seven years and has been used extensively in the retail supply chain and the automotive manufacturing sector. Visidot is an optical technology that is capable of identifying and decoding hundreds of unique standard barcodes simultaneously in a single read. Two dimensional matrix codes are a globally accepted barcode symbology, recognised by several international standards organizations and leading industry associations. (ISO, AIM, ANSI, SAE, ATA, AIAG, NASA & DOD.)

Two dimensional data matrix can provide an efficient medium for storing large amounts of data in a small space. The storage capacity is related to the size of the matrix, but has a capacity to hold up to 3,116 numeric digits, 2,334 alphanumeric characters or 1,556 8-bit ASCII characters.

An advantage of two dimensional data matrixes is that only 20% of the matrix contrast is needed to achieve high levels of accuracy. This means that they can be successfully used in direct part marking applications, printing directly on to the part, metal peening the part or laser etching the part. Due to the CCD scanning technology that is used with the Visidot solution, it is possible to recognise matrixes when they are upside down or in unexpected orientations. (Have to be in line of sight of the CCD scanner).

Figure 9: EAN-128 pallet label with a 2D Data Matrix

3.7.2. The value of Visidot technology

A number of simple observations about the nature of Visidot technology are described below:

Observation 1 (Benefits): This technology uses data matrixes, which are an extension to Barcodes, and make use of sophisticated data compression mechanisms to provide large data capacities. Due to the optical nature of the technology it is not susceptible to performance degradation from the material that the labels are being attached to. The readers are capable of performing simultaneous ID reads and handling orientation and range variations of the product.

Observation 2 (Problems): Visidots are read only devices, and once printed the data cannot be changed. Data can only be read when the reader is in line of sight of the data matrixes.

4. Preliminary Comparison of ID Technologies

4.1. Overview

From the technology section above it can be seen that there are a number of technologies that can be used to provide identity solutions, although as discussed some technologies have clear advantages over others for particular applications. In this next section of the report a first attempt at an ID selection chart has been produced. The chart highlights a number of parameters that are significant in describing the capabilities of these different technologies, when evaluating them for different applications. An example of this would be **Operational Considerations.**

- **Environmental Influences.** (e.g. Misty, limiting the use of Optical Systems)
- **Simultaneous Reads.** (e.g. can ID's be captured simultaneously)
- **Orientation.** (e.g. What are the reader product orientation requirements)
- **Line of Sight.** (e.g. Is it a purely line of sight technology "Optical")

4.2. Technology comparison chart

Table 1: ID Selection chart (This chart shows many of the current ID technologies that are being used today in the manufacturing application area)

Auto-ID Technologies			ASSESSMENT CRITERIA																	
			Power	Data transfer				Errors			Operating conditions				Data		Other			
			Power source	Reading speed	Reading in motion	Re-write capability	Read range	Human errors	Reading errors	Self correction capability	Environmental influence	Simultaneous reading	Orientation	Line of sight	Data storage capacity	Security	Size	Maximum lifetime	Price	
Barcode	Label	1D	Nil	Depends on reader		No	Depends on reader	Read twice/ forget to read	< less than 1 error in 1 to 3 millions characters scanned	no	dust, moisture, etc. can damage or hide the barcode	Depends on reader			8 to 30 bytes	Nil	17 to 95 mm side	until barcode is not damaged	printing cost	
		2D								Redundancy (to recover a damaged code)					2Kbto 4Kbytes		17 to 95 mm side			
	Reader	Wands	Mains/ Battery	2 scans/sec	no		contact		Require the barcode to be on a flat surface	can correct some reading errors		no	perpendicular	contact required	N/A			Can damage the barcode after repeated readings because of contact		
		CCD readers		100 scans/sec	up to several meters/sec		1/2 inch		Reading from irregular surface possible	can read more accurately a damaged bar code		yes		line of sight required				more durable because no moving parts		
		Laser scanners		30 to 50 scans/sec			up to 30 feet			can correct some reading errors		no	Larger range of orientations possible	line of sight required				manufacturer guarantee		
Contact memory button			non volatile memory	< 2 sec per scan	No	Yes	contact	Read twice/ forget to read	close to 100% reads	no	resistant to water, oil, dust greas radiation, weather extremes as well as electromagnetic fields	no	orientation not an issue	contact required	4KBytes to 8 Mbytes	Password protection	height : 2,11mm - 5,1 mm; dia : 7,56 mm - 28,6 mm	100 years or 1,000,000 write cycles	$0,75 - $6	

Table 1 (...Contd)

Auto-ID Technologies	ASSESSMENT CRITERIA																
	Power	Data transfer				Errors			Operating conditions				Data		Other		
	Power source	Reading speed	Reading in motion	Re-write capability	Read range	Human errors	Reading errors	Self correction capability	Environmental influence	Simultaneous reading	Orientation	Line of sight	Data storage capacity	Security	Size	Maximum lifetime	Price
RFID	provided by reader or Battery (depending on tag type)	50 to 500 tags/sec	yes (up to 150 miles/hour)	Yes	0,1 to 30 meters	Nil (Automated)	Variable with environment. Tends to be close to 100% (gen2)	CRC	water, metal, human body, etc. can affect tag performance	yes	Mostly not an issue	no line of sight required	32 bytes to 32 Kbytes	data encryption and password protection	around 50 mm side	10 years or 100 000 rewrite	10c - $100
AIDC labels: 2D Datamatrix or visidot colorcode	Nil	hundreds /sec	yes	No	up to 30 meters	forget to read	99,7% announced	can recover some damaged codes	not affected by water metal or RF	yes	orientation not an issue	line of sight required	2kbytes	Nil	same as 2D barcode	until barcode is not damaged	
Magnetic strip	Nil		No	Yes	contact	forget to read	close to 100%	no	magnetic fields can affect performance	no	need to be flat	near contact or few mm	upto 4kb	Close proximity required	credit card	low, depending on usage	15c - $0,75
Optical strip	Nil		no	No	fixed distance	forget to read	close to 100%	no	poor performance in dirty environments	no	need to be flat	near contact or few mm	1MBytes to 4,8 Mbytes	Close proximity required	credit card	upto 10 years	$6-$10
magnetic recognition	Nil		yes		contact	reading error	99.70%	no	magnetic fields can affect performance	no		contact required	few characters	Nil	low density high use of space	manufacturer guarantee	printing cost
Optical recognition (OCR)	Nil		yes (high speed)		close proximity	reading error	99,9975% reading accuracy	no	poor performance in dirty environments	no		near contact	few characters	Nil	low density high use of space	manufacturer guarantee	printing cost

Table 2: RFID Selection Chart (This chart shows details that are specific to the different types of RFID technologies available today)

RFID type		Standards	ASSESSMENT CRITERIA												
			Power	Data transfer				Errors		Operating conditions		Data		Other	
			Power source	Reading speed	Reading in motion	Re-write capability	Read range	Reading errors	Self correction capability	Environmental influence	Orientation	Data storage capacity	Security	Size	Price
Active	UHF (800/900 Mhz) & Hyper F		battery	2MB/s	Up to 150 miles/hour	Yes	Up to 30 meters	close to 100%	CRC	Perturbation by metal, attenuation with water and human body	Uses a dipole antennae and it requires a scalar product to obtain a good reading	32 KB read/write	Encryption, password	around 50 mm	$2-$100
Passive	LOW F (125 kHz)	ISO 18000-2	Induction from electromagnetic waves emitted by the reader	<10 KB/s	20 miles/hour	No	3 meters	Antenna field is dependent on the environment	CRC	Perturbation by metal, attenuation with water and human body	The plane of the tag antenna needs to be approximately parallel to the plane of the reader antenna	64 bits to several Kbytes	Encryption, password	around 50 mm	10 cents
	H F (13,56 Mhz)	Class 1 HF + ISO 18000/3 + ISO 14443, 15963		<100 KB/s (10 to 30 tags per second)	3 meters/sec spaced 0,10m	Yes	10 meters								50 cents
	UHF (860/960 Mhz)	Class 1 Gen 2+ISO 18000/6 (C) + ISO 18000/6 (A,B)	Magnetic induction	<2MB/s	150 miles/hour		Up to 30m				Uses a dipole antennae and it requires a scalar product to obtain a good reading				25-50 cents
	Hyper F (2,45 Ghz) (microwave)	ISO 18000-4	Induction from electromagnetic waves emitted by the reader	<2MB/s			Up to 30m								
Semi -passive			Battery used only when an induction signal from the reader is emitted	~ 2MB/s	Yes	Yes	10m		CRC	Perturbation by metal, attenuation with water and human body	Uses a dipole antennae and it requires a scalar product to obtain a good reading	32 KB read/write	Encryption, password	around 50 mm	$10
Magnetic strips (flying Null technology, chips are replaced by magnetic material)			Induction	less than with chips	Yes	No	~1m	close to 100%		Resistant to heat (over 200℃) and pressure, tags can be embedded into virtually any non metallic product	No effect	Limited data storage(same as 1D or 2D barcode read only)	Nil	few cms	<1 cent

Table 2 (...Contd)

RFID type	Standards	ASSESSMENT CRITERIA													
		Power	Data transfer				Errors		Operating conditions		Data		Other	
		Power source	Reading speed	Reading in motion	Re-write capability	Read range	Reading errors	Self correction capability	Environmental influence	Orientation	Data storage capacity	Security	Size	Price
Acoustic Saw (2,45Ghz)		Piezo-electric effect	<2MB/s	Yes	No	3 to 20m	close to 100%		No problems with water and metal products/ resistant to high temperature, high energy x-rays, gamma ray sterilisation more prone to interference	No effect	64 to 96 bytes	Nil	smaller antenna	
Gen 2	Gen 2		128 kbps (reader-tag) and 640 (tag-reader) 10 times more than GEN 1	Yes	Yes	Up to 30m	close to 100%	8 checks to ensure that the tag response is valid	Pertubation by metal, attenuation with water and human body		Higher memory not restricted by standards	Encyption, password	<50mm	25 cents/tag

5. Conclusions

In this report we have provided a good overview of ID technologies prevalent today. Evidently, each technology offers certain functionalities and suffers from certain drawbacks. The choice of appropriate technology for a given application requires a proper requirements analysis and matching those requirements with the capabilities offered by the technologies. Below, we summarise the key issues in ID application matching. We also describe the next steps to be taken in this research project.

5.1. Summary of Key Issues in ID Applications Matching

- Identifying and reviewing the key ID technologies that are being used in the Aerospace sector. Understanding their current capabilities and limitations.
- Reviewing a number of applications and processes where ID information is being captured across the Aerospace sector. This may include part manufacture, logistics, production assembly and maintenance and service. It is very important during this activity to understand the environmental parameters that are associated with these applications and processes.
- Examine and review the use of mix of ID technologies across the Aerospace sector. Develop some guide lines that will help influence the future selection of ID technologies used for part marking with a broader view of supply chain and maintenance requirements.

5.2. Next Steps

The next stage of this work is to identify some of the key physical characteristics of parts and environments where ID solutions need to be performed in the aerospace sector. A characterisation model for these environmental conditions needs to be produced. This can then be used in conjunction with the characterisation model used in section 4 describing the nature of the data that is provided by identification systems.

Once a better way of categorising the physical environmental characteristics of ID solutions is determined, it will be possible to develop guidelines and selection tools for the choice of specific ID solutions for different applications across the aerospace sector. This can then be used to examine the interoperability of complementary ID technologies in different applications.

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