The use of Radio Frequency Identification technology – or RFID – has been in existence for decades in other industries. While its potential in aviation is recognised as vast, overall readiness to adopt RFID into operations has been slow to materialise. The logistics of incorporating the technology, and the advantages RFID can offer operators, maintenance facilities and spares providers, are explored.

Tracking components using RFID

Radio frequency identification (RFID) tags are an identification technology that operates on radio frequency waves to transfer data. In an aviation environment, this can be between a 'tagged' aircraft component, and a reader or scanning device. An RFID tag consists of a microchip and antenna that operate at different bandwidths or frequencies. While it is a relatively new addition to aviation processes, RFID has been in existence since the 1980s.

Within the aviation industry, operators and maintenance facilities focus on using RFID technology on components, including: structural and cabin-based components; rotables/rotating parts; repairable equipment; and emergency equipment. The data and level of information a tag needs to show will vary according to which category a component falls into. For example, the frequency of checks relating to the part, and the amount of memory needed to be stored on the tag will determine the most suitable tag type for the component.

In 2012 easyJet became the first operator to introduce RFID-tagged lifejackets to its Airbus fleet. This enabled easy access to essential maintenance information, such as the lifejacket's date of manufacture, and part and serial numbers. Such heightened access to part information can save a huge amount of time when monitoring aircraft during line and base checks. This will be investigated further throughout this article.

Boeing has also extended the industry interest in RFID potential by incorporating the technology into tracking other critical aircraft components. Examples are determining the replacement history of insulation blankets, seat covers, and floor panels. Working with Fujitsu, Boeing now offers an RFID Integrated Solutions system to assist operators with implementing RFID.

Headquartered in Chennai, India, Ramco is an enterprise resource planning (ERP) software vendor that provides its own RFID solutions for customers via its software, also called Ramco. "RFID has been used to automate transactions, such as parts issue, return, mechanic carrying out task, and shelf life of parts," explains Ranganathan Jagannathan, senior vice president of aviation business. "Ramco is integrated with RFID middleware -- these include handheld devices or mobile or physically-mounted scanners. This middleware supports various processes in daily maintenance and airline operations. For example, RFIDs can be used in tracing the tools used by the mechanic or shop personnel. The tools issued can now be easily traced to the job and the person who have used them, which makes it easy to manage the tools and protect the aircraft from foreign object damage," continues Jagannathan.

RFID Tags

An RFID tag is similar to a barcode in appearance. The most basic format consists of a regular paper label that has barcode type scanning codes -- known as an 'identifier' -- however, with an RFID chip installed at the back of the label. Rather than a barcode having to be visible for a scanning device to read information, the RFID chip will just have to be within range of the scanner in order for the device to pick up and read its information.

This range will depend on the 'frequency' of the radio waves associated with the tag-type, alongside the amount of information required to be stored, which will, of course, depend on the complexity of the component with which the tag is associated.

Data contained by an RFID tag include part and serial numbers, date of manufacture, expiration date, and perhaps location of the part on the aircraft. A 'low memory' RFID tag could hold this information. A 'high-memory' RFID tag would also contain this data, and additional, more sophisticated, part information, such as maintenance history, and the ability to add as many as 500 characters of rewritable free text, enabling a mechanic to add more customised data, such as part damage history.

The International Air Transport Association (IATA) has created industry guidelines on introducing RFID into everyday airline operations. Guidelines include suggestions on how to maximise the benefits of RFID, and encourage the use of a common data format between operators and participants to make the transition as easy as possible. Looking at the bigger picture, the use of RFID also furthers the possibilities for the industry to become fully paperless, an initiative that remains at the forefront of the industry's determination to evolve. "Although RFID has served other industries successfully, such as retail and pharmaceuticals, its implementation in the aviation industry has been slow," acknowledges Chris Markou, head of operational cost management and flight operations at IATA. "One of the reasons for this is that the aviation industry is heavily regulated due to safety requirements. Complication is added by requirements of cross-border transferability; the information has to travel and be internationally understood

AJ Walter is considering adopting RFID technology into its operations. This will drastically reduce the need for paperwork inside its warehouses.

and accepted among organisations.

"Ultimately, it does not take only technology to get RFID working, but also the regulator's consent, and the adoption of the same standards by all industry stakeholders. All this takes time."

Paperless initiative

IATA is working to establish a universal standard of operation among aviation industry stakeholders, from airlines to maintenance providers, to spares suppliers. Examples of past industry initiatives that IATA has implemented are e-ticketing, and baggage and cargo tracking. RFID has formed part of IATA's latest efforts to encourage paperless operations. "RFID is the obvious technological choice to allow airlines to reduce operational costs, while improving the traceability and visibility of their assets," explains Markou. "Once developed to its full potential, it can become one of the biggest enablers to eliminate or reduce the paper trail.

"The use of RFID for warehousing and logistics is the most popular and developed application at the moment. Using RFID tags, it is possible to identify and move items across production units several times faster than using a paper trail or traditional barcodes," continues Markou. "It eliminates human error and improves data integrity and reliability, allowing movement of items to be tracked in real time."

"Naturally, we are currently concentrating our biggest efforts on the types of RFID technologies that are the most popular with airlines," says Markou. "In that sense, UHF RFID technology has been mentioned the most by users, and it is the only one that we know has been approved by regulators. As technology evolves, and industry stakeholders experience using this technology, other types of RFID may also become popular."

Traditional tagging

RFID is the key to processing and receiving information at a far greater rate, and with more accuracy, than traditional component-tagging methods, such as barcodes. Headquartered in Florida, TRAX offers maintenance and engineering (M&E) software, TRAX Maintenance, that can be integrated to process information received by an RFID scanner. TRAX has also worked on several RFID pilot projects, principally working with one specific customer to incorporate RFID-tracked lifejackets into its fleet. "With traditional barcodes, there is a distinct one-to-one relationship," says Chris Reed, managing director at TRAX. "A mechanic working on the shop floor can only scan one barcode at a time, component by component. While this has always been straightforward process, barcode functionality is extremely limited. In the context of checking the presence and maintenance status of a lifejacket, where mass counting of items is required, scanning a barcode is very time-consuming.

"For example, it can take about 10 hours to check the lifejackets on a widebody aircraft using barcode technology. Information, such as whether there is a lifejacket for every seat, may need to be investigated daily, whereas whether a lifejacket needs replacing may be a task included in an A check. Using RFID, these processes now take minutes for the mechanic carrying out the task, and the information processed by the scanner can interface directly with an M&E system," continues Reed. "Obviously, this implies huge savings for an operator or MRO. Similarly, stock checks can also be carried out almost instantaneously for spares providers."

Unlike a barcode label, an RFID tag does not require direct visual contact line of sight with the identifier, so contact with the label is not necessary. "There is, therefore, less risk of damaging the identifier," explains Markou at IATA. "The barcode can be damaged by scratches, or diluting the font, while it is common for the actual barcode label to become unstuck. So, in terms of reliability and integrity of identifier data, RFID can be far more effective."

Types of RFID tagging

Predominantly, there are two categories of RFID systems: passive and active tags. Active tags include their own power sources, while passive tags do not have a battery. "Different types of tags will store varying amounts of information, depending on the frequency at which they operate, or on whether the tag includes a battery," explains Reed at TRAX. RFID systems are differentiated by the frequency band in which they operate. Altogether, there are low frequency (LF), high frequency (HF), and ultra-high frequency (UHF) band widths.

Passive tags

In passive tags, a radio signal is transmitted between the tag and the reader, and reader antenna. This signal then powers the RFID tag. Generally, passive RFID is recognised as a low cost, disposable tag for users. Passive tags can be mounted on a conductive material (also known as a substrate), or sandwiched between an adhesive layer and a paper label. In order to make the passive tag more resistant to extreme conditions, it may also be embedded within devices, and its adaptive abilities make it best suited to track goods in the supply chain for users. Passive RFID is also commonly used in warehouses and distribution centres. Although the tag typically has a short read range, the

RFID middleware interfaces directly with user M&E systems; meaning stock levels and components' status are recorded as real time data.

status of assets in a warehouse can be regularly monitored by setting up readers in fixed locations.

UHF RFID tags

UHF RFID typically has the fastest rate of data transfer, but these tags are the most sensitive to interference, so product manufacturers have had to optimise their performance in difficult environments through design revisions. UHF tags are currently the most popular type of RFID used in the aviation industry.

BAP tags

A battery-assisted passive (BAP) RFID tag is another type of passive tag. It does, however, contain an integral power source (most commonly a battery). Most passive RFID tags use energy from the RFID reader's signal to power on the tag's chip and backscatter (reflecting the radio signal from the tag) to the reader. Unlike transponders and active tags, BAP tags do not have their own transmitters.

Active RFID tags

In active RFID systems, a tag has its own transmitter and power source/ battery. Active tags broadcast their own signal to transmit the information stored on their microchips. "Active tags are usually the most expensive, and are best suited to rotable components," explains Reed. "Active tags can store maintenance history data such as repair information, so they are usually used on high-value, longer life components"

Active RFID systems typically operate in the UHF band, and can sometimes have a range of up to 100 metres with the assistance of a power source. There are two main types of active tags: transponders and beacons. A transponder is switched on only when it receives a radio signal from a reader. It will then power on and transmit a signal back. This intermittent transfer of data means that a transponder is able to conserve battery life. A beacons is able to track the precise location of an asset, and is, therefore, most used for real-time data requirements. A beacon will send out signals at pre-set intervals; this can be set at every few seconds or minutes depending on requirements of the user.

Cost of RFID

A business must compare the cost of investing in RFID technology, with the apparent significant operational savings it will provide. "RFID readers can cost about $1,000 each, and the printer about $3,000, depending on the type of tag being printed and level of data users need to encode," describes Reed. "Also, while the cheapest, most basic passive tag can cost as little as $1 for 20 tags, a more sophisticated active tag can cost as much as $5. It follows that active tags are most suited for high-value rotables," says Reed. Since TRAX Maintenance is already configured to incorporate RFID-received data, there is no real additional software cost for those already using TRAX as its M&E system. "We have two ways to interface with RFID data," adds Reed. "There is a mobile solution, where we write a programme for the mobile device (such as a scanner) that sends information back to the TRAX system. This has the highest level of functionality for the user.

"Also, we have a mode for fixed RFID readers. This is most commonly used in tool stores on the shop floor, where the reader is static to record which tooling is removed from, and replaced in, the tool store. We have a screen on the TRAX software, called the RFID control panel, that will track and display whether each tool has been issued, received or transferred and which mechanic is responsible," continues Reed.

"A typical RFID solution has software and hardware parts," explains Jagannathan at Ramco. "The hardware, such as handheld scanning devices, fixed readers, and RFID tags, can be bought directly from middleware providers. The total cost varies, based on the number of tags and devices the customer wants, and also on the function someone wants to build for the RFID to track."

Read reach

One potential issue with initial RFID operation is the complexity of read reach. Read reach is how far in practice the tag will transmit information to be received by a scanner. With a variety of tags available that operate at different bandwidths and frequencies, it stands to reason that when on board an aircraft (or taking a stock check in a warehouse) that the scanner may identify more than one part that falls into the frequency set.

The read distance is determined by the individual RFID reader and antenna power, material and thickness of material covering or coating the tag, the type of antenna the tag uses, and the material surrounding the RFID tag. In practice, therefore, the actual read reach of the tag and reader may differ from the range specified by the original equipment manufacturer (OEM). Proximity to water, or electromagnetic waves will diminish the reach.

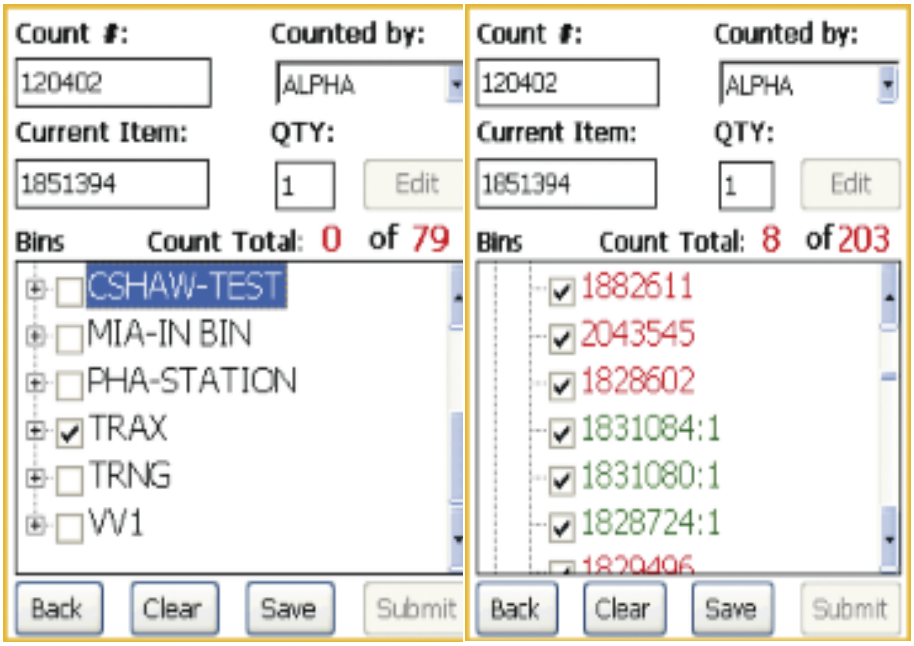
Generally speaking, RFID tag maximum read versus frequency distances are as follows:

- Up to 135kHZ

Tags with a frequency up to 135kHz are typically termed as LF passive RFID tags. These have a read distance of up to 30cm, although in reality it is often less than this. If attached to metal, the read range of a LF passive RFID tag can be increased.

- 13.56MHz.

This is the standard frequency



The TRAX software offers an 'RFID control panel' that is able inventory movements and toolbox availability. This overview includes monitoring the removal of tools by mechanics for use on the shop floor, and encourages efficient and reliable equipment use.

associated with HF passive RFID tags. Maximum read distance is in the region of 1.5 metres (m) although usually less than 1m. The read range can be extended using a custom antenna combined with a multi-port reader. This should enable longer tag read distances for the user.

• 860-960MHz.

This frequency range is used for UHF passive RFID tags. The read distance of a UHF passive tag is at least over 1m.

• 433MHz

With the assistance of the power source that accompanies an active tag, a UHF active RFID tag has typical read capabilities of up to 500m.

• 2.45GHz

Tags operating at this frequency are recognised as super high frequency active RFID tags. Due to their read range of around 100m, they are recognised as best suited for providing real-time location (RTL) data transfer.

"Read reach is one of the few issues experienced so far in RFID use," highlights Reed. "If a mechanic is trying to read the tag of a lifejacket, the RFID scanner will pick up all the other tags in range that operate at, or within, the same frequency. Instead of just a single component's information, therefore, you may pick up many others as well, which can be confusing. It all depends on how the scanner software is formatted to receive data," summarises Reed.

Unifying RFID

As noted earlier, it is essential that universal standards are respected by those incorporating RFID, to maximise data integrity among participants and make the implementation process more attractive. "Efforts to standardise and harmonise RFID tagging have been on-going for more than 10 years," explains Markou. "A great job was done by the airline working groups to address various aspects of these standards, such as: ATA e-business Spec 2000, which addresses data coding for data transfers; and SAE's AS5678A, designed to identify minimum performance requirements specific to the passive UHF RFID tag for use on aircraft parts.

Overall, data standards are important to encourage ease of implementation for those trialling new technologies. As explored in recent articles *(see M&E and CMS configuration case studies, page 58, Issue 102)*, lack of user adherence to data standards can complicate integration processes. Introducing a standard for RFID relatively early on in the industry's use the technology should aid user confidence in the ease of installing RFID technology into operations.

Tracking components

"Component tracking is another important area in which RFID could play an effective role," explains Jagannathan at Ramco. "While GPS enables tracking of objects between buildings or locations that are even farther apart, it doesn't do a great job within a small premise or location. RFIDs can easily fill this void by pinpointing a component, GSE or other critical objects between shop floors, hangars, or within the zones of the store. RFIDs also play a key role in detecting component shelf life, alerting the system to upkeep inventory that are on the verge of shelf life decay."

Delta TechOps is investigating the various ways in which RFID can benefit its component tracking processes. Delta began using RFID for O2 generators on board its aircraft fleet in 2011, and progressed to tagging emergency equipment in 2013. It also began using RFID for component tracking in its logistics department in 2013.

Today, all Delta TechOps RFID products have the ability to read outside vendor-installed RFID tags. "We continue to work with RFID products so the vendor's RFID tags can be directly used in our RFID systems," explains Mike Moore, vice president of engine and component maintenance.

"Currently Delta tracks components through the logistics inventory system, using a front-end device controller. This front-end controller sends all tracking information to our system of record, says Dale Brubaker, managing director for inventory and logistics.

"On aircraft, component tracking for emergency equipment, such as lifevests, is performed using an RFID scanning device. Information stored on the equipment tags includes presence and location, along with expiration date," says Moore. "Overall, Delta has inducted more than half its fleet for onboard RFID scanning for emergency equipment."

"RFID component tracking is used for on all our 24/7 domestic line logistics. We anticipate rolling out RFID for inventory tracking in all domestic line logistics stations by the end of 2016," says Brubaker

Delta began researching the various advantages RFID can offer as early as 2008. "This is when Delta began the initial discussions about using RFID (for O2 generators)," continues Moore. "In early 2009, Delta began working with vendors in an attempt to get an RFID solution. Early in 2011 Delta ordered handheld scanners to begin testing connectivity issues. We then trialled this through the month of May 2011. Eventual go-live for RFID was signed off soon after this trial period and has been on-going since that time."

To incorporate RFID into its logistics processes, Delta commenced RFID component tracking in Atlanta using aircraft wheels as the trial product for tracking. After implementation in 2014, and introduction of the RFID controller, RFID was rolled out to cover the remainder of logistics for component tracking in 2015. Delta MRO Services has also worked with some maintenance customers to show how to implement similar programmes into operations.

The next step for Delta will be

RFID is now used by several operators to check on the presence and status of emergency equipment, such as whether each seat has a life vest stored underneath. Manual checks on large aircraft are time consuming and take considerable man-hours to complete.

applying an RFID tag to the documentation that is associated with all rotables and key repairable parts. "These RFID tags will be used to track these parts throughout the logistics and distribution system" explains Brubaker. "The use of RFID tracking will then complement our current tracking system for components.

"Spares ordering will continue to be done through our ERP system. We continue to apply RFID tagging to the documentation associated with components during the inbound receipt process at all of our 'live' line logistics locations, and will begin tagging components on the outbound process by applying RFID tags to the parts in our component 'Box Shops'. Lastly, we are continuing to use handheld scanners to complete RFID tasks," says Brubaker .

Potential of RFID

Once the use of RFID becomes more common in the industry, its potential can begin to emerge. "Ultimately, RFID could extend to high-temperature, or 'hot section' engine parts, that could help track engine condition and maintenance," highlights Reed at TRAX. "Other electronic options are slowly becoming available, such as the EASA Form 1." Form 1 is the authorised release certificate for aircraft parts. It states that a part was manufactured or repaired in accordance with approved design data. The scope of a battery-assisted tag means that Form 1 could now be installed on the RFID tag.

Other documents that can be stored on a tag, and therefore assist the tracking of components, could include delivery documents, such as the airway bill and delivery notes. The ability to form a detailed catalogue of a component's maintenance history is arguably most economically viable for high-value components for which active tags are already recommended.

Although RFID is plainly critical to encouraging efficiency in operations, it does not eliminate the need for paper. "It is not quite paperless when one has to print a tag, yet it absolutely encourages faster data collation and transfer," confirms Reed.

Another consideration of RFID and its potential uses is in structural repair assessments. Traditionally, a mechanic may spend hours treating a corroded part in preparation to inspect and then repair it. What can sometimes occur after the cleaning process is that damage is uncovered that exceeds limitations for use set by the OEM. The part then has to be discarded and replaced, with treatment time ultimately wasted. If an automated identification technology (AIT) sensor is placed in areas where corrosion is common, it could transfer real-time data back to a user system that could send a notification once the material has met certain OEM-designated limits for stress and corrosion.

The future

"It is too soon to speculate on the overall uptake of the RFID technology," summarises Markou at IATA. "The airline community is in varying stages of testing it. The leading OEMs engage with RFID technology while designing and assembling their products, as well as aftermarket solution providers. Operational efficiencies, performance and cost, however, will ultimately dictate the future of RFID."

Based in West Sussex in the UK, AJ Walter Aviation (AJW) specialises in supplying, repairing and leasing commercial aircraft parts. As such, the company is well-positioned to explore the potential business plan of implementing RFID, alongside the benefits it has the potential to offer AJW's processes.

"As part of our innovation programme, and initially in relation to the multi-year cost-per-flight contract AJW holds with easyJet, we will be working to identify RFID possibilities throughout its supply chain, and will be looking at where we can use it best to make operation as efficient as possible," explains Andy Smith, group operations director at AJW Aviation.

"The business case for RFID technology is compelling. Gains in safety and efficiency are huge and AJW is actively working on making this a reality with pilot projects and using it with complementary technology, such as GPS tracking and low-energy beacons," continues Smith.

"RFID has been in development for several years and has started to appear on the new Airbus and Boeing platforms, but we are seeing it limited to cabin equipment," says Smith. "Transition for use with rotable units, where back-to-birth history can be recorded, would be a major leap in innovation.

"We are keeping up-to-date with the ATA E-Business Group and as an IATA strategic partner," summarises Smith.

The aviation industry has always been inherently slow to adopt new procedures, since safety is undeniably its overriding priority. Operators and maintenance providers have needed to show irrefutably that not only will technological advancements save them costs that are not at the expense of safety, but that these initiatives will further increase safety management and encourage the industry's economical expansion. This applies to the use of RFID as much as it ever has to all parts of the industry's determination to evolve into paperless operations. AC