Wearable devices are spoken of, but rarely seen, on the flightdeck and in the maintenance hangar. The devices themselves have become more sophisticated, and yet mainstream adoption has not occurred. The developments and limitations presented by wearable devices are investigated.

Developments in wearable technologies

In aviation, adoption is not quick to occur. New, or 'disruptive' technology is only accepted via rigorous and slow trial phases, borne of the need to be sure that the technology, or device, in question will help and not hinder standard operating procedures (SOPs). Technology's interaction with data, such as maintenance status or task information being displayed via a computer application (app), brings its own, further set of questions for regulators, such as the integrity, reliability and security of these data when interfaced with the technology.

These questions initially started with the onset of paperless processes *(see Wearable technologies in aircraft maintenance, Aircraft Commerce, February/March 2015, page 52)*. The potential of voice-recognition work is also explored in the previous article. It is widely recognised that without paperless processes, the true potential of mobile or wearable technology cannot be realised.

The concept of paperless processes has been slow to mature in that some parts of the industry still rely on paper. Paperless maintenance, however, is steadily becoming the norm, or at organisations.

The benefits of paperless processes have proven to be undeniable. Trax illustrates the business case for electronic task cards in paperless maintenance. "For the average maintenance, repair & overhaul (MRO) organisation, it may have taken five minutes of administrative work to print off, write up and sign off tasks," begins Chris Reed, managing director at Trax. "The mechanic may have had to walk to a part store to check on stock. If you translate this to 60,000 task cards produced by a small MRO over the course of one year, then it would take about 300,000 minutes to administer these tasks.

"This time equates to the working hours of two and a half employees," continues Reed. "In addition to the obvious cost saving of more than two salaries, there are hidden cost savings to be made by not printing and storing these task cards."

Once paperless processes were proven, the implementation of mobile technology followed, but this too took time to take off. "Most people today own a smartphone or tablet and are familiar with the technology," explains Paul Saunders, operations director at Conduce Group Limited. "As a result acceptance in IT has evolved from the use of a desktop 10 years ago, and this has fed into the aviation industry."

The iPad is one of the most popular mobile devices. It has proven its suitability in various environments in aviation. Its ergonomic similarity to the iPhone means that training is relatively easy, since most users are familiar with the way an iPhone works. "iPad minis have the smallest screen size allowable for maintenance and flight deck processes," says Reed. "While an iPhone has the same level of functionality, its screen size does not make it a sensible choice for viewing manuals."

iPhones and iPads operate on an iOS platform, which is developed by Apple. Android is another example of an operating system. Original equipment manufacturers (OEMs) of mobile and

The introduction of apps has allowed information to be transferred between IT systems and devices, for instance from desktop computer to mobile device, via a maintenance & engineering (M&E) system.

Conduce is now working with the Windows 10 system, which has advanced the Windows platform's capability to support mobile and wearable devices.

wearable devices, will likely align devices to a single operating system, although there will be some devices that are available in versions for multiple operating systems. An example is the Panasonic Toughpad, which has versions available for both Windows and Android.

Saunders explains that the frameworks built to support mobile devices have undergone several revisions, due to the improvements in operating systems such as Windows. "Windows XP did not have mobility platforms established, whereas Windows 8 has more infrastructure built in, which can support mobile and wearable technologies," says Saunders. "Software has to be rewritten every time a customer wishes to upgrade to a new system." Windows 10 is the latest system that Conduce is working with. "Each successive version is becoming lighter and able to adapt to new wearable or mobile technologies," explains Saunders. "Windows 8, for instance, tried to be a single platform that was capable of running an device. Windows 10 has advanced this concept." Systems' increased sophistication means that in theory, a wearable device should work 'out of the box'.

Many factors that slowed the progression of cloud-based or mobile technology have therefore been overcome. Connectivity, for instance, used to be an issue, yet now software is emerging that can be used offline, and can store information that will automatically upload when a connection is available via data, SATCOM, or wireless internet. The software can send messages to devices to confirm the transfer of data. Historic data can also be overwritten to prevent discrepancies. Data integrity is therefore on the rise, and today's software is focused on promoting its importance. Conduce has been working with a Bahrain-based operator to roll out electronic techlogs (ETLs) across its fleet. Connectivity and the reliability of data transmission was one of its key concerns when trialling the ETL. "Some of the locations that the operator few to presented challenges for the ETL signal," describes Saunders. "We expected a transmission rate of 70-80%, but our client achieved a rate of almost 98% on more than 1,000 sectors."

"Airports are now configuring themselves for everyday paperless requirements," adds Reed. "New antennae are being installed to provide signals strong enough to transmit data reliably. Users such as flight crew and line therefore do not have to rely on the strength of a phone signal."

It seems, therefore, that wearable technology is the natural next step up from paperless maintenance and mobile technology. Yet since *Aircraft Commerce's* last article on the subject, almost two years ago, wearable technology does not appear to have evolved at the same rate as mobile technology. This article explores the research being made into the potential of wearable technology, and the steps needed to optimise the functionality of wearable devices in the aviation industry. Some gaps need to be overcome. "Large scale adoption at the end user level is taking time," acknowledges Ranganathan Jagannathan, senior vice president of aviation business, at Ramco Systems.

Cost drivers

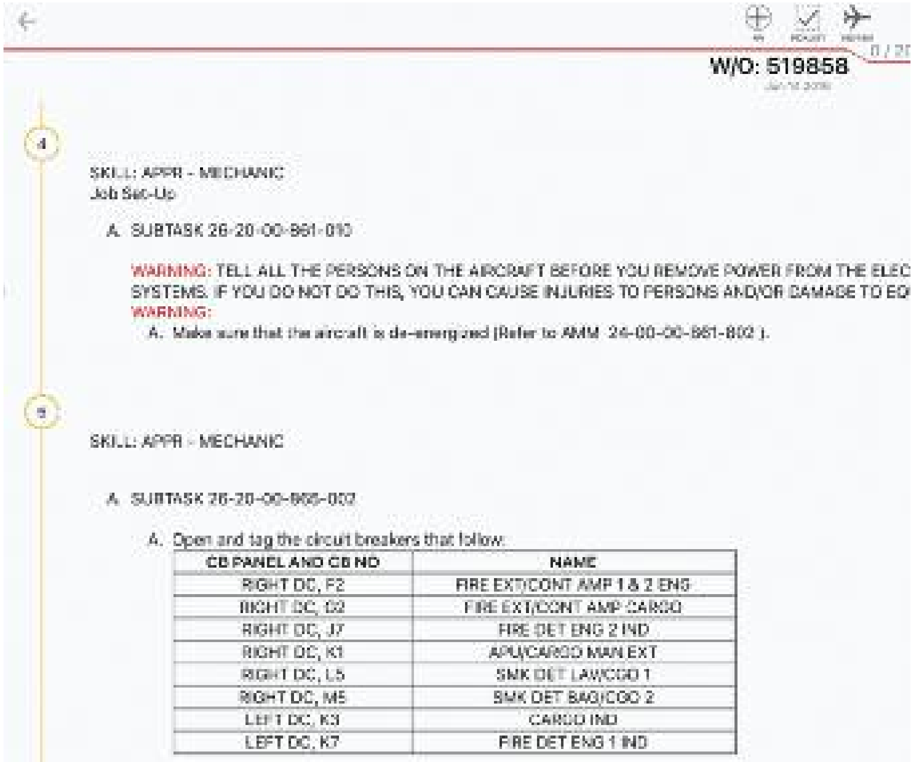
Just like the mobile device, operators and MROs need to be sure that wearables will quantifiably increase the efficiency of their operations. The IFS Aerospace and Defence Centre of Excellence, believes that there is significant argument to promote the ability of wearables in achieving this. "Research by the Wall Street Journal showed that in many cases, 99% of the revenue received per flight by airlines is needed to just break even, due to the high base costs incurred in operation," explains Espen Olsen, director business development and sales, IFS Aerospace & Defence. "To illustrate, airlines' largest costs are fuel and salaries, which account for 29% and 20% of revenue respectively. It is difficult to reduce salaries because of the global competition for qualified mechanics.

"One key area where an airline can boost profits is maintenance," continues Olsen. "This is where wearables and mobile developments are having the biggest impact. On a typical 100-seat flight, maintenance accounts for 11%, or 11 seats, of the airline's total revenue, so it only makes 1%, or one seat, of profit. This means if airline operators can reduce their maintenance costs by just 10% by improving MRO efficiency with wearable technology, then they could double profits to the equivalent of two seats."

It is not just maintenance where wearable technology is being trialled or researched. Its place on the flightdeck cannot be ignored. The industry's acceptance of ETLs has ensured the regular appearance of mobile devices such as tablets or laptops in the cockpit. ETLs effectively bridge the gap between what goes on in the flightdeck, and what goes on in the hangar. With progress slowly but surely being made with wearables and mobile technology on the shop floor, attention is now turning to transposing these benefits to flight crew.

It still took time for ETLs to become popular. "The first ETL appeared on the 777 about 15 years ago," explains Reed. "It has still taken over 10 years for this to become mainstream. A big factor was the cost of laptops and software at the time, whereas people have laptops as standard now."

Conduce recently developed a return on investment (ROI) calculator for



Trax's TaskControl application allows maintenance control to assign work orders and task cards to a mechanic. This information can be received by the mechanic via an iPad or other mobile device.

operators that have yet to move to ETLs. "Confidence has grown in the numbers," says Saunders. "A big driver for companies is arguably the saving in the production, distribution and transmittal of paper."

Other drivers to use ETLs are more difficult to quantify. Saunders describes seeing operators that use paper techlogs take up to 30 days to file the techlog information into a maintenance system. "Maintenance events have been overflown, and due to the 30-day lapse, the paper techlogs contain data that are not visible or correct," he adds. "It is difficult to put a dollar value on cutting 30 days to 30 seconds, by filing an ETL via a data connection. "There is an obvious logical benefit that is intangible, yet it is the tangible evidence of ETLs, such as the cost of paper and cost-saving, that has presented the best case for finance departments." This sort of evidence will drive wearable devices' popularity in aviation forward.

Maintenance IT vendors are keen to promote the use of wearable technology. "Ramco Aviation Software has been successfully extended for access through multiple wearable devices such as Smart watches, for technology demonstration with various usage scenarios in aircraft maintenance. We are also in the trial phase with Microsoft HoloLens, in our Singapore MRO Lab," says Jagannathan, "We have seen a surge in demand for mobile and wearable technology across the aviation market, with increased attention from leading airlines and MROs, to embrace new technologies, as an effective tool to improve operational efficiency."

It is regulatory endorsement that will also help push the operators and MROs into adopting new technologies. "We have seen a great shift in acceptance from both EASA and the FAA toward wearable technology," says Dror Yahav, vice president commercial aviation at Elbit Systems. "In principle, both EASA and the FAA are pushing towards having head-up-display (HUD) technology made more available, and a wearable HUD is the most natural way to achieve it. This push has been as a result of a proof of concept (POC) plan using our product, the Skylens, that has illustrated the benefits of wearable technology in general." The Skylens is covered later on.

This confidence from the FAA and EASA has been echoed in some new regulatory material that has been since published. "New regulations specifically mention that wearable HUD devices can be considered a HUD equivalent on the flight deck," explains Yahav. "EASA has also released some guidance material that provides details of the way to certify and approve wearable HUD, the Skylens in particular.

"On top of this activity, both agencies are working along with representatives from the industry, as part of SAE committee, to establish an agreed requirement for future certification plans," adds Yahav.

Apps in maintenance

The introduction of apps has allowed information to be transferred between IT systems and devices, for instance from desktop computer to mobile device, via a maintenance & engineering (M&E) system. This should naturally evolve into its application with a wearable device. The app is the most significant element to the mobile device's functionality in a maintenance or flight operations environment.

Trax is the developer of a series of IOS apps that are accessed using a tablet, and interface with its core M&E system, TRAX and eMRO. "Current utilisation is much lower in MRO than in flight operations," says Reed. "Crew are essentially at the top of the information chain in aviation. Using the PilotLog app, pilots enter defects, fill in pilot logs, record fuel uplift, and establish the significance of a defect using ATA chapter analysis. They can also raise technical logs (techlogs), that can be signed off via the app." There is a separate app, called CabinLog, for cabin crew to record cabin defects.

Since the development of apps suitable for the MRO environment, however, mobile technology has become more applicable to maintenance. Interest in its potential is now starting to build, and OEMs are starting to take note.

It is the information recorded on the flightdeck that has led to maintenance-related data making its way to the hangar and the shop floor. After all, there is little point in turning the efficient data stream generated in the cockpit back into paper on the ground. Trax eMRO and the IOS apps have been specially designed for mobile devices in a maintenance environment. The functionality of apps such as these, developed exclusively for maintenance processes, has helped mobile technology in maintenance become more visible.

For instance, data gathered from the flight deck in PilotLog feeds into the QuickTurn app, which is used by line mechanics. QuickTurn allows the mechanic to view open defects, and defer tasks, view photos of findings, and so on.

Any tasks established as a result of findings from the QuickTurn app feed into Trax's TaskControl app. From here, work orders are assigned to the defects (which are given by maintenance control). Once a mechanic completes a task, they can swipe right to sign it off.

Electronic signatures were an important step in enabling mobile MRO processes. It has taken some time for regulatory authorities to authorise their use. Fingerprint scanning has allowed secure and reliable electronic sign-off

Mechanic Anywhere is a maintenance execution app developed by Ramco that supports mechanics and engineers. As explained by Ramco, the focus of developers needs to be in furthering apps across all phases of the aviation industry.

during inspections.

The information from Trax's apps is made visible to the maintenance controller via a production dashboard, Production Control. The dashboard displays information such as task status, work completed, and tasks outstanding.

These listed apps all then feed into an M&E system such as TRAX. "All information is fed into the Cloud, which can connect and interact with any Cloud-connected system," explains Reed.

Developing and receiving approvals for these apps, for both flight operations and maintenance-based processes, has taken time. "Our first web-based mobile app took three years to develop," adds Reed. By creating IOS apps that are native to iPads, it has become simpler to integrate mobile devices with M&E systems, and so for operators and MROs to change their traditional procedures. The same now needs to happen to wearable technology.

The mobile movement

Ramco's focus on being the leading solution provider on mobile and wearable platforms has resulted in a slew of apps handling experience usage scenarios. Its suite of 'Anywhere Apps' is designed for the cockpit and the maintenance hangar. "The suite includes Fly Anywhere, which is an electronic flight bag (EFB) for pilots," says Jagannathan. "Mechanic Anywhere is a maintenance execution support app for mechanics and engineers, and Warehouse Anywhere is used by warehouse and parts store supervisors to monitor stock levels, such as there are more such apps."

"We have realized the importance of the Apps covering all the phases of aviation Maintenance business, from the flight deck to the overall maintenance environment execution and customer engagement, in order to progress mobile and therefore wearable Mobile technology adoption in aviation," continues Jagannathan. "While EFB solutions have been on the market for a long time, and with the technology being fairly mature, attention has moved towards mobility in maintenance solutions.

"We are now finding more demand for mobile solutions in maintenance and warehouse management areas," says Jagannathan. "Ultimately, we see the entire ecosystem being supported on a mobile platform, covering customers, suppliers, operators and OEMs."

An app is developed by taking into account what it needs to do in its environment. "Task cards, for example, need to be assigned, viewed and signed off on an app, for the app to be suitably functional," says Reed. "Some interaction is needed, and developers must illustrate this functionality in the app.

"For a mobile device, it is important to decide what needs to be done on the move, and what can be done within the device," continues Reed. "For instance, Apple has iOS core guidelines that dictate how to present an app as something that can be understood by most users first time round. Swiping left or right is a common technique used to unlock or approve something, for example."

Olsen outlines that the IFS approach is that mobile apps should:

- Only give mechanics the functionality in the app which they need for the specific task in front of them.
- Only offer the functionality in a form they are familiar with, such as a mobile app, as it increases efficiency and effectiveness.
- Allow operation of the technology when engineers are wearing safety equipment, for example when a mechanic is wearing safety equipment, such as gloves.
- Be agile and simple to create or adapt, in the event that modifications, for instance to maintenance tasks or repairs, need to be made.
- Avoid clutter of information, which should be kept concise.

Connectivity has been raised as an issue when introducing mobile devices within a maintenance environment. The MRO hangar presents different challenges to the signal-strength issues experienced by an aircraft that is flying to remote airports. "Tail docks often pose problems for mechanics working in these areas, trying to establish connections on their iPads or Toughpads," adds Reed. "The ability to work off-line when required allows them to easily overcome this challenge. Products that need an online connection will not function in these environments".

"One of our customers, a major US-based carrier, sees the use of mobile apps and devices as a first step towards digital transformation," says Jagannathan. "To start with, by achieving 95% paperless operations they plan to eliminate a lot of productivity overheads like cumbersome paperwork, hard-copy filing and management, manual data entries and human errors."

Approvals & data formats

As has been broadly covered in previous articles *(see ETLs and paperless line maintenance, Aircraft Commerce, June/July 2015, page 51 and Tracking components using RFID, Aircraft Commerce, December 2015/January 2016, page 57)*, regulators need to advocate disruptive technologies for companies to invest and realise the potentials of that technology. "Cockpit technology typically requires FAA or EASA regulatory approval, while some maintenance processes such as task card sign-off has needed local approvals from authorities like the UK's Civil Aviation Authority (CAA)," says Reed. "Line

Swiss Aviation Services have conducted extensive studies into the viability of wearable devices in their current forms within maintenance. Viewing, carrying out and signing off task requirements were the main actions trialled, using smart glasses and watches.

maintenance involvement is often approved as part of the organisation's general maintenance approval.

"While European regulators are more harmonised in their attitudes, Trax typically finds the FAA to be more subjective in its opinions," adds Reed. "Approvals and requirements often vary from representative to representative." Reed explains that an FAA representative's view on technology, for instance whether they typically rely on mobile devices, will affect their stance on its place in aviation.

"With many pilots using iPads to display approach plates, airport diagrams and other digital documentation, the FAA released InFO 11011, to clarify when authorisation is needed to use the device as a Class 1 EFB," states Jagannathan. "The FAA circular 120-76C lists the requirements for part 121, 125, 135, or 91 subpart F (part 91F) and part 91 subpart K (part 91K) operators, which want to replace required paper information, or use other select functions of an EFB.

"Before using an iPad as a Class 1 EFB, when operating under Part 91K, 125, or 135, authorisation must be received from the principal inspector," continues Jagannathan. "The procedures for obtaining this approval are contained in FAA Order 8900.1 and AC 120-76C. OpSpec/MSpec paragraph A061 authorises the use of the iPad or any similar EFB device. At the end of a successful evaluation period, the operator will receive authorisation to use the iPad in lieu of certain paper references.

"During the approval process, the operator will need to develop training programmes and operational procedures to use the EFB in compliance with FAA guidance," adds Jagannathan.

Unifying the data formats of various maintenance and flight operations documentation was an initial barrier that stalled the use of mobile devices initially. "With the proven use of mobile technology, most of these challenges have already been overcome, so it is now less of a problem for wearable technology," says Saunders.

Wearable in maintenance

"While our customers are using mobile devices in greater numbers, none are using (or trialling) wearable devices at this stage," says Cameron Hood, chief executive officer (CEO) at NVable. NVable is the developer of CoNVerge, a software that provides ETL capabilities to operators, such as British Airways (BA) Cityflyer. CoNVerge also offers fault database analysis, compliance checks and document management as part of its core functions.

"The industry is only now getting comfortable with the use of mobile technology as part of the maintenance process," continues Hood. "This is accompanied by a greater acceptance of Cloud computing as the delivery mechanism. However, broad acceptance of wearables is not quite there, probably because, although the technology is interesting, there needs to be a very good practical application for them."

IFS Aerospace and Defence is beginning to drive its mobile customers towards the benefits that wearable devices can provide. "We have evolved our mobile offering with solutions that are designed for wearable technology," begins Olsen. "We want to see maintenance project managers receiving real-time notifications on changes to a maintenance job, or interacting with an ERP system on their smartwatches.

"It is this transition from mobile to wearable devices, that is bringing greater functionality to workers already using mobile devices," continues Olsen. "Users receive instant notifications on devices, such as the Apple Watch, as soon as a task status in IFS Applications has changed.

"For instance, a mechanic might be examining a fault on an aircraft, with the required panel open and the task in progress. Traditionally they would assess the situation, identify a specific manufacturer part number, return to the warehouse to retrieve the relevant part and then perhaps find that it is not in stock. This all takes time. Using a mobile or wearable device allows the mechanic to identify the asset, see immediately whether it is available and arrange for someone to bring it to them in-situ to carry out the repair and complete certified documentation," says Olsen.

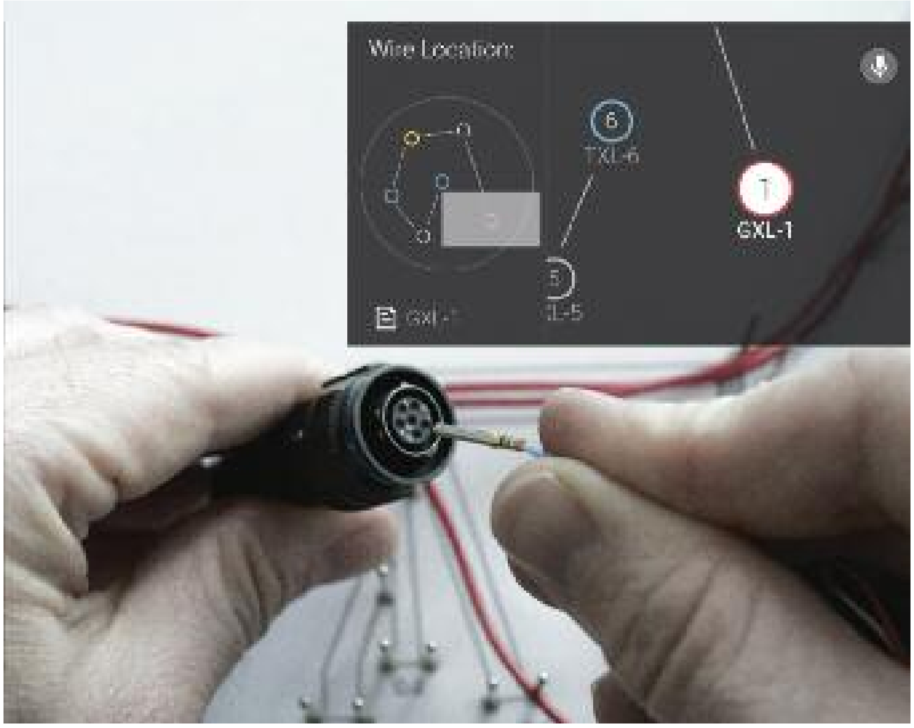
Devices

Current wearable devices on the market include the Vuzix M100, the Recon Jet, and XM Reality in addition to the Google Glass. These have not been designed specially for aviation or general maintenance processes.

The Microsoft Hololens is a purpose-built device so it offers more benefits than other devices. "The Hololens is an example of a next generation device," says Saunders. "It has bigger screen real estate, and better processing power. It is targeted at meeting the requirements needed of a rugged, maintenance focused wearable device." While not yet generally available, the price is suggested to be about $2,000.

"10-15% of our customer base has already adopted wearable or mobile technology in maintenance management, while others are working towards trial phases," says Olsen.

"In the future, mobile and wearable



The Skylight platform is developed by APX Labs. It bridges the gap between the user, the wearable device and the MRO's system of record. The platform is configured to provide information to the user hands-free.

solutions will increasingly incorporate context-aware capabilities," summarises Olsen. "By recognising where people are and what they do, designers will be able to create attentive applications that look at what is going on and react appropriately. For example, teleporting, sometimes called 'follow-me' computing, is a tool that dynamically maps the user interface onto the resources of the surrounding computer and communication facilities in office complexes."

Olsen goes on to explain that in a maintenance environment, this could be adapted so that relevant applications can 'follow' a worker moving around maintenance locations or even different equipment and process bays in an aircraft, and be available as required. The maintenance station will recognise which member of the maintenance team is going to use it, based on an identity tag or even body profile, and preselect that person's authorised maintenance or repair task schedules. If directly linked to equipment health monitors, it could automatically add high priority preventative maintenance tasks to a repair schedule being undertaken in the same location.

Wearable limitations

While wearable technology will only begin to flourish after paperless and mobile processes have fully developed, wearable devices have presented their own set of limitations, which has further stunted presence in aviation. Swiss Aviation Software (Swiss-AS), the developer of the AMOS software solution, has recently undertaken studies into the applicability of wearable devices. These were situated in maintenance processes. "Our research and development department (R&D) performed various case studies in 2015," explains Ronald Schaeuffele, chief executive officer at Swiss-AS. "These are related to the Google Glass and smartwatches.

"We conducted a useability study via functional prototypes of devices that operated on Android. The useability study was restricted to core functions in each case, such as viewing, carrying out and signing off task requirements, to make the device as simple and efficient as possible," adds Schaeuffele. "We discovered that each device was only truly useful for notifications, for instance alerting mechanics to a task status changing. We were unable to sign off tasks on Google Glass, which is a key functional requirement that handheld mobile devices in contrast to wearables are able to achieve.

"The Google Glass is also fragile," continues Schaeuffele. "Particularly when compared to an iPad or Toughpad. And while a smart watch offers a little more in the way of potential, because it could be used to approve workflows, for example, interaction is still very limited using these consumer devices." Battery life was also disappointing, and not suitable for the level of work required of the device.

"The current generation of wearable devices is simply not geared for the functional demands of MROs," says Schaeuffele. "It is mobile phones and tablets that are still able to provide the best balance between usability and size."

Smartwatches could be used as an addition to a mobile device for notifications and micro-interactions, for example, but not for more complex interactions or to display detailed information. Swiss-AS is therefore waiting for technology and standards to evolve before reinvestigating wearables.

"The screen size and processing power of Google Glass in its current form is too limited, and not a satisfactory replacement for a tablet," adds Saunders. "Wearables are seen as an enhancement or extension of a mobile device."

These findings raise the question of whether using consumer devices is the real problem behind the slow adoption of aviation wearables, particularly ones geared for maintenance tasks. Consumer devices hold aesthetic quality in almost equal importance to device functionality. Rugged, robust design does not necessarily equate to a desirable, commercial product in a mainstream consumer market. Would a wearable device that is designed specifically for the aviation environment fare better?

While not currently used in maintenance, Elbit System's HUD product, the Skylens, is being trialled by flightcrews in the cockpit. "We believe that a lot could be achieved with EFBs and other technologies derived from the consumer market. Nevertheless, providing the pilot augmented vision information during critical phases of flight (take-off and landing) is completely different domain where professional equipment that has been specifically designed for the task is required," says Yahav.

Even now, there remains only a handful of wearable prototype devices, for operators and MROs to consider. "Simply put, there are more mobile technology options available than wearables," says Reed. "Everyone has a smartphone, but not everyone has a smartwatch yet. This acceptance needs to take place before wearable technology develops."

As wearables come to be viewed as a more accessible technology by operators and MROs, their popularity should increase. Rather than apps, which work well with mobile devices, software platforms need to be developed that focus on wearable technology. These platforms must be able to interface with apps, M&E systems and wearable devices, and set standards for switching between tasks on a wearable device, or accepting a change to a workflow, for example. This is so that when a company buys wearable devices, regardless of the make or type, there is a standard software format that

Elbit System's Skylens utilises combined vision systems (CVS). CVS is a fusion of live video combined with synthetic 3D images and flight symbols, to provide flight crew with enhanced viewing capabilities in difficult weather.

can easily adopt typical maintenance processes and requirements easily, such as viewing work orders, workflows, and task instructions.

APX Labs

APX Labs has developed the Skylight platform, whose server application runs either on a Cloud system, or the customer's local network. It bridges the gap between the user, the wearable device and the MRO's systems of record. APX Labs has configured the software so that it presents the exact information given by the records back to the users, handsfree.

Skylight is being trialled by OEMs, including Boeing, which is using the Skylight platform with Google Glass in its wiring harness manufacturing processes, instead of a portable document format (PDF) of assembly instructions accessed via laptops. "By using Google Glass in this manufacturing process, the OEM saw a 25% improvement in performance," says Aaron Tate, vice president of customer solutions at APX Labs. "This was due to the worker not having to leave the site, or pivot back-and-forth to view a file on a laptop."

Initially developed in 2010, the Skylight platform focused on the potential of smartglasses in military applications. Its core areas of attention are now maintenance, manufacturing and logistics within the aerospace industry, where APX Labs has seen the most adoption.

It has also seen interest build up in wearable technology over the past two years, explaining that there has been a large increase in customers wanting to deploy devices in their processes. "We see most interest from manufacturers at this stage, which are essentially at the top of the chain and have the leverage to distribute both technology and user experience," continues Tate.

The Skylight platform is designed to be adaptable to any wearable device, although it is currently interfaced on only Google Glass, Vuzix M100 and Recon Jet. "When new devices are announced that are commercially available and apply to industrial use, we acquire and port Skylight to the device," adds Tate.

The Skylight platform also has to naturally integrate with a customer's M&E system. APX Labs establishes an add-in framework with the system that also acts as an adaptor, allowing one or many users to access the Skylight server. "This framework allows you to connect with databases, enterprise resource planning (ERP) systems, SAP and M&E software," continues Tate. "The processing power of the Skylight platform means that numerous document sources can be merged into a single workstream. This saves more time as users do not have to constantly log in and out to access information across various systems."

Last, the Skylight platform's web application means that experts, such as an OEM representative, can connect via the server, identify which mechanics are online, and communicate with each online user. By using the device that Skylight is interfaced with to make and receive video calls, the expert can help diagnose problems remotely. "This is particularly useful for on-wing and line maintenance support," says Tate.

Customers wishing to adopt the Skylight platform have access to a pilot programme for a maximum of six months. "It typically takes three months to prove the value and develop a business case," says Tate. "Once APX Labs has established customer metrics, such as what the customer needs from its device, we assist the IT team to connect devices, and deploy Skylight on either the Cloud or behind their firewall." APX also connects the Skylight platform to the add-in systems.

Security management is crucial in ensuring data integrity, explains Tate. It is one of the main considerations when introducing a new device to systems. Data have to be encrypted on the device and in transit, for instance.

Elbit Systems

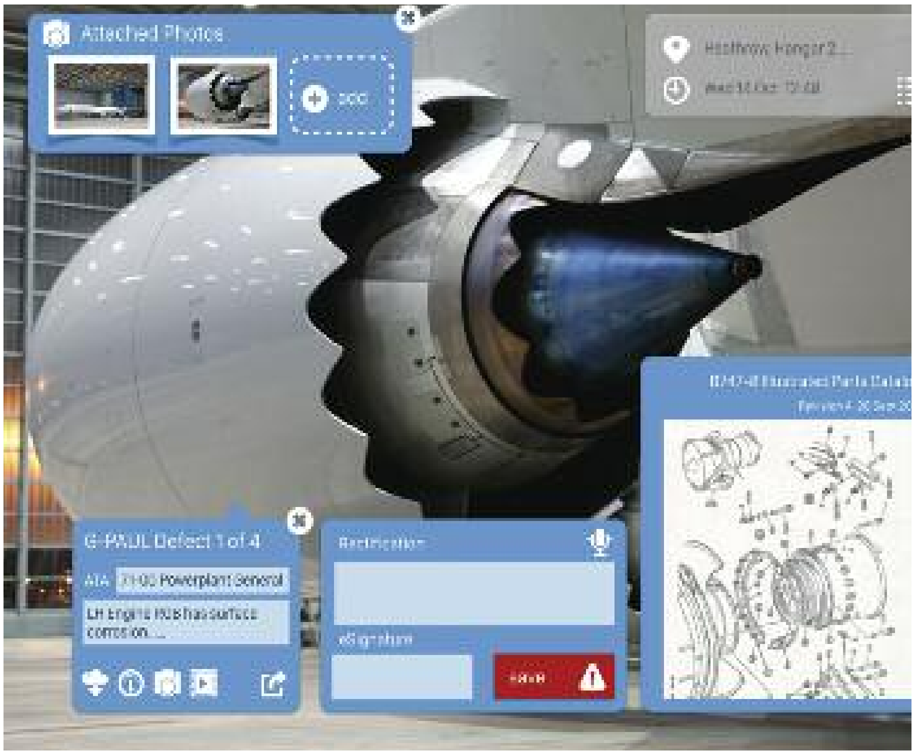
Designed by Elbit Systems, the Skylens is an enhanced flight vision system (EFVS). It displays high-resolution information, images and video on a high-transparency visor, providing pilots with head-up-and-out capabilities. It is geared towards enhancing flight safety and improving the efficiency of flight operations, by allowing turboprop aircraft to land in small VFR airfields. Aircraft equipped with EFVS are capable of take-off and landing in low visibility conditions and in locations that non-EFVS equipped aircraft cannot approach.

In October 2016, Elbit announced a partnership with ATR, in which ATR-42 and -72 aircraft will use the Skylens to take-offs and landings in low visibility conditions. As a launch customer, once again an OEM is able to demonstrate the various uses and applicability of wearable technology for customers, such as operators and MROs, to establish its true potential.

The Skylens is not a mainstream consumer product, unlike Google Glass. Its design is rugged, functional and built with a specific purpose. It is built for an established role in aviation, rather than an existing product that is being configured for alternate purposes. This approach separates it from many other wearables. "Skylens is designed to be used as a primary flight display (PFD)," begins Yahav. "As a result, the product has to meet the strictest design assurance levels.

"In addition, the Skylens system needs to be able to overlay accurately enhanced vision systems (EVS) live video, on top of the real environment along with a Synthetic Vision System (SVS), which is a three-dimensional (3-D) representation of the environment," continues Yahav.

"Conformal symbology is graphics that matches the real world, such as a horizon line that has to be present on top of the real horizon," continues Yahav. "Another example would be flight path



Augmented reality (AR) can in theory assist mechanics in performing complex maintenance tasks. This is by providing overlays and task instruction hands-free to mechanics, thereby removing the need to revert to paper records or PDF records on an iPad. Conduce advise that solid business cases need to be established before wearables and AR can really develop.

vector, which indicates where the airplane is heading or synthetic vision which overlays the real environment."

"The need in conformal symbols and real time video, is unique to airborne applications rather, than the maintenance environment, therefore it has a significant impact on the system design and intended use," adds Yahav.

The benefits of using a Skylens are clear. "Operators should expect better performance in terms of fewer delays, cancelled flights and a shorter average sector," highlights Yahav. "In addition, by using EFVS we believe that some customers will be able to expand their operations to new airports where challenging weather conditions were previously a barrier."

On top of operational improvements, it has been proven in various test cases that operating an airplane, while flying 'head out' using HUD EVS images, contribute significantly to safety while reducing accident and incidents results in maintenance costs and airplane down time.

Software grammar

It is important to note that, aside from supporting platforms and the availability of wearable devices, recognition of typical user habits will also help the industry's perception of wearable potential. When using a smartphone, for example, it is generally known that to turn a document page one has to swipe left or right. The same goes for many touchscreen devices, and this logic is universally undertaken in the mobile device group. This will partly work for a smartwatch, which is a wearable, although it also has a touch screen. "A wearable device might now be able to work 'out of the box', but this is not necessarily from a 'user' perspective yet," explains Saunders. "Typically recognised actions for mobile devices, for instance pinching the screen to zoom on an image, or scrolling through pages, do not exist yet for wearable devices such as Google Glass." Guidelines on how these actions can be achieved without a physical keyboard or touchpad, need to be set.

Software development kits (SDKs) are also instrumental in interfacing customer systems with a new wearable product. "Manufacturers of wearable devices typically provide SDKs and application programming interfaces (APIs) to the software developers, in order for software to communicate with the devices," explains Jagannathan. "There are two principal ways that wearable devices can communicate with M&E systems. First, by writing wrapper programmes around various functions of M&E products (in line with its base technology), which could call the APIs provided by the wearable device manufacturers. Second, by creating a programme that leverages the SDKs provided by the wearable device manufacturers and call the APIs that need to be written inside the M&E Systems, to establish communication between the two systems."

Market adoption

Trax has a customer that has ordered 750 iPad minis for use within its line and base maintenance processes, and is going live with mobile maintenance processes. "Once a decision has been made, integration does not take as long as many customers think," says Reed. "The process to set up apps tailored to the new customer's M&E requirements, can take four to six weeks, mostly because of training." For an existing customer that already uses the Trax Software, this process might be a couple of weeks.

"At the moment a couple of dozen operators have performed a ground evaluation of the Skylens, and the overall reaction was extremely positive," says Yahav. "About a dozen will continue to a flight test evaluation in the final configuration, which is being conducted."

The future of wearables

"Mobile strategies are now common in maintenance hangars to replace time-consuming paper-based processes," summarises Olsen. "The next stage of mobile development is augmented reality, using mobile devices that are now relied on every day, to drive efficiency even further.

"Augmented reality is an example of digital transformation that dramatically improves the job of maintenance workers," continues Oslen. "A common problem facing operators and MROs is having people with the right skill sets in the right place at the right time. There is no even dispersal across the globe of maintenance personnel trained in repairing the latest Boeing and Airbus aircraft, for instance."

By using a remote expert to assist in complex maintenance via a wearable or mobile device, MROs can broaden the capabilities of mechanics by 'augmenting' skills with virtual over-the-shoulder coaching. Through smartglasses, engineers can see the expert's real-time and interactive demonstration of the repair job right in front of their eyes. These skills can be leveraged anywhere, anytime with the capability of modern mobile technology.

Wearables with augmented reality can automatically identify the spare part required by a field mechanic. Information on the appearance, part number and maintenance task required can then be fed through to the mechanic's wearable device, negating the need to manually or physically scan barcodes or consult technology documents. "With wearable technology automatically cross-matching barcodes, stock or part numbers, or even better, integrating with electronic

The Skylens is an example of AR applied on the flightdeck. This image shows flight symbols displayed on the Skylens. The technology allows flight crew to keep 'eyes out' and able to focus on the landing and take-off process. The Skylens is known as a heads-up display (HUD).

technical documents, the mechanic can ensure the right item is demanded or fitted," adds Olsen. "This has the benefit of reducing time-consuming document and database searches. Increased autonomy, due to wearable and mobile MRO functionality, means the mechanic spends less time 'downing tools', but rather improving MRO efficiency."

"Augmented and virtual realities (VR) are being tried out under several situations," says Jagannathan. "These include assisting mechanics in performing inspections, and identifying part numbers on an airframe. The application and viability of VR is still evolving, via emerging technologies such as machine learning, artificial intelligence (AI) and deep learning." It is these trending capabilities that may allow wearable devices to diagnose component defects and faults in the future. "For now, a few large MROs are testing portable 3-D scanners, which could capture measurements of dents and damages," describes Jagannathan. He explains that to develop overlay images via a wearable device, OEMs provide SDK that helps in identifying real objects. This overlays contextual information, on top of the real object. This contextual information could be in the form of another image or video, which augments the information that can be perceived from the physical object.

It may be too early to expect adoption of augmented reality in the near future. "From our research, we have seen that while augmented reality 'can' do complex work instructions and work in 3-D, in practice a mechanic does not need a detailed overlay to do their jobs," says Tate. "APX Labs is more interested in the potential of assisted reality." Assisted reality takes the form of short bursts of information, fed to a wearable device. This information may consist of images, short pointers and instructions rather than a sophisticated or expensive overlay.

"Ultimately, a mechanic does not need to be shown how to unscrew a bolt, but would find a prompt on where to locate the bolt a useful aid," adds Tate.

"Within the maintenance environment, augmented reality is not currently worth it," says Reed. "Set-up costs will need to come down to make it accessible across the industry. For example, Trax carried out a demonstration project to investigate AR use. Just to get a computer aided design (CAD) engineer and graphics artist to develop the mock-up images took three months. In our experience the process is too complex to be viable at this stage.

"More tools are needed to make adopting AR easier," says Reed. "If an engine undergoes a modification, for example, then the process to redesign the overlay file is too lengthy right now. OEMs need to begin funding these processes to ensure long-term potential."

Skylens is, of course, an example of applied augmented reality on the flightdeck. In this environment, the industry is eager to see more adoption of the technology, according to Elbit Systems. "An example for using an AR system is while flying inside a cloud toward landing in an airport," describes Yahav. "While conducting the approach, the pilot relies on the symbols presented on the Skylens, while in the background image the SVS provides excellent situational awareness. As the pilot progresses towards landing, the EVS image, also appears in the display.

"While in the last stage of landing, the pilot starts to see the real airport since it is a semi-transparent device," continues Yahav. "This allows the pilot to complete the landing based upon natural vision, but with the aid of symbols and background video."

Summary

"To ensure the success and recognition of wearable technology in aviation, we need to make sure that processes and devices do not change too quickly, leading to early adopters rushing to implement things ahead of their time. This approach may mean that the technology does not function to its true potential," says Reed.

"The industry is relatively cautious in adopting new IT, partly because the regulators are also cautious," adds Hood. "The use of tablet PCs and mobile technology is now so ubiquitous that it is an accepted norm in the industry. This has encouraged a broader acceptance. I think it is only natural that wearables will follow the same path. Personally, I think augmented reality has the greatest potential for many applications, and once the technology is mature enough then I am sure both will be useful tools."

"To establish strong business cases for finance departments, device OEMs and software vendors need to determine a good baseline of hidden, less thought of costs that are due to historic processes, such as duplicating data, faxing paper, over-flying maintenance records, and fines from regulators as a result of these errors," says Saunders. "These costs add up quickly for large operators. Cost implications for inaccurate data inputs also need to be determined."

"iPads and mobile devices are beginning to be deployed in a variety of enterprise applications," summarises Tate. "The next generation of wearable devices when they come out will encourage their usage to increase. It is a repeat of the adoption processes we saw for 'smart' mobile phones, such as the early model Blackberry. These had no data applications, and limited connectivity. Greater device capability helped confidence in the product skyrocket. The same will happen to wearables." AC