The IoT is inevitably becoming part of our daily lives on the ground. A central question - purely rhetorical - is, whether this will be the case on the aircraft. Will airlines be prepared to use it? The technology is here. Is the industry nimble enough to adopt it as rapidly as on the ground?

The use IoT in airports & passenger cabin operations

The Internet of Things (IoT) is a network of physical devices, vehicles, home appliances and other items that are equipped with electronics, software, sensors, actuators and connectivity. The network enables these objects to connect and exchange data. Each item or 'thing' in the network can be uniquely identified by its embedded computing system and is able to operate in the current internet infrastructure. The term 'things' can be described as a mixture of hardware, software, data and services. The IoT allows everyday objects to be connected via a network or networks, so that they can operate smartly, safely and more intelligently. The availability of small, generally low-cost sensors that can be relatively easily installed enables relevant data to be harnessed.

The IoT is already strongly positioned, with some experts estimating that the IoT will consist of 25-30 billion objects by 2020, and that by this time the global market value of IoT will reach $7.1 trillion.

Smartphones are packed with sensors that track motion, orientation and various environmental conditions. In addition, sports tracking devices and smart home solutions also track a variety of data.

Underlying this is connectivity. According to a study by Routehappy, from early 2017 more than 70 airlines globally were offering full inflight WiFi. Aircraft connectivity is becoming an essential infrastructure element, with projections that at least 80% of commercial aircraft will have it within the next few years.

What solutions are being used?

The IoT has been around the aviation industry for several years. It began to be adopted in maintenance and repair organisations (MROs) with sensors in engines, followed by the porting of manuals onto tablets, the use of wearable devices on the shop floor, fully connected hangars, the use of sensors in equipment for tracking purposes, and automated data transmissions from aircraft to the MRO database. With inflight connectivity becoming ubiquitous, airlines are more aware of potential benefits of the IoT in aircraft.

IoT offers several key improvements to airline operations, with huge potential to streamline operations and generate cost savings. Main benefits stem from:

a. Availability of real-time data ranging from passenger records to maintenance data. The data can be used by applications that previously required large quantities of paper. Real-time data can be used on a very small or very large scale. An example is crowdsourcing weather data through the network of airborne weather radars in aircraft flying over an area at any point in time.

b. Increased reliability throughout the airline, including early detection of potentially faulty components or sub-systems, or getting early insight into bottlenecks in workflows.

c. Transparency of gathered data and its intelligent utilisation can enhance airline operations in many areas.

Required infrastructure

As a foundation, the IoT needs a reliable network infrastructure that supports the large range of IoT-enabled sensors and smart devices. In addition, location technology, such as beacons, and the right business intelligence and software solutions are essential for the IoT to fulfil its potential.

The introduction of the 787 and A350 have demonstrated to the industry that its existing IT infrastructure and operational processes are not ready for the sudden availability of huge amounts of aircraft data.

One problem airlines face is the patchwork of legacy technologies and systems that forms the operational environment. Paper processes, ageing and patchy networks, whether wireless or wired, and a range of disparate sub-systems, such as passenger service systems, departure control systems, or loyalty management systems are not ideal to establish a unified IT infrastructure.

Much valuable historical data is stored in these outdated legacy systems. This includes booking data, flight data, and loyalty transactions, all of which would be useful in helping to optimise passenger engagement. One solution to this could be Application Programming Interface (API) layers that would need to integrate with third-party solutions.

Enhancing travel experience

While passenger travel starts with the booking process, the IoT that underpins the airport experience in particular is bound to reinvent the customer journey. The consultancy Deloitte argues that the IoT will not only increase revenues for all involved parties, but will improve the overall passenger experience.

- Arrival and Check-in:

Passengers can log onto airport WiFi or receive notifications through smartphones about the check-in location, and can use a portable electronic device (PED) for a speedy bag-drop (facilitated by electronic luggage tags) and check-in via the barcode on the screen.

Electronic tags also enable passengers to trace luggage throughout the journey. The airport operator or airline can use the IoT for cue management by remotely recognising bottlenecks and allocating resources accordingly.

- Moving through the airport:

Passengers are identified by various beacons and receive personalised messages from retailers or notifications from the airline about flights. There is a

The IoT gives airport operators and their vendors a tool to create personalised travel experience for each passenger, that makes them feel as if it were Christmas and their birthday together.

movement about 'smart retail' that uses the IoT to maximise benefit for the retailer and passenger.

- Security:

A variety of technologies, often involving biometric data, can be used with the underlying IoT in the security process.

- Lounges:

Whether it is access to lounges or personalised services due to frequent flyer status, the passenger experience can be facilitated through use of the IoT.

- Boarding can be speeded up substantially through solutions, such as 'scan and go,' using an app on the passenger's PED. The airline can also notify passengers who are in danger of being late.
- These notifications are also available throughout the airport, informing passengers about flight delays, gate changes or simply whether the luggage of a late check-in passenger was loaded.
- Landing and connections:

Similar to pre-flight, personalised messages can be sent throughout the airport after arrival. Gate connections, walking time or likely waiting time at immigration are all types of data that can be transmitted to the PED. The immigration and customs process can be facilitated, for example, with the use of biometric kiosks as part of the airport IoT.

- Information on baggage tracking, using radio frequency identification (RFID) technology, and the baggage claim process can be provided via notifications to the passenger concerning status of their luggage, the baggage carousel, and likely waiting time. Airlines can proactively send messages in case there is need for service recovery. In such situations, passengers often complain about not knowing what is going on, rather than actual loss of luggage. With a proactive service recovery, the airline can reduce reputational damage.

Example projects

Turkish Airlines (THY)

Turkish Airlines (THY) is using the IoT extensively at airports, mainly at the carrier's Istanbul hub. THY has identified several areas for innovation, including use of IoT with wearables and robotics, as well as use of virtual reality (VR) and Augmented Reality (AR).

In a variety of live projects, THY is testing the IoT as a platform for real-time indoor positioning and wayfinding, customer tracking and equipment monitoring, according to Serdar Gurbuz, digital innovation manager at THY, who wants to enhance the overall 'digital customer experience' as an essential element of the carrier's strategy.

THY uses other technologies, such as Bluetooth Low Energy (BLE), in its beacon technology in the airport lounge to communicate with Apple iOS devices, and chatbots (artificial conversational entities) for the check-in process.

Finnair

In its quest to maximise ancillary revenue, Finnair is using the variety of digital touchpoints with passengers. These touchpoints include the complimentary Nordic SkyWiFi portal, as well as the onboard in-flight entertainment system (IFE) system.

The system allows Finnair to differentiate onboard products and services, depending on whether it is a long- or short-haul flight, aircraft type, and geographic region. Finnair coined the phrase 'glocalising,' which means operating on a global scale while localising services based on customer needs, and simplifying options with the possibility of bundling services for a diverse customer base. An example of this is offering Alipay to Asian customers.

Changing cabin products

There are several trends regarding products and services used in the aircraft cabin that will reshape the passenger experience. Many of these will have a direct impact on the required communication network and inevitably will require extensive use of the IoT.

- New airlines or airline models are emerging that seek to differentiate themselves from the outset. Carriers, such as Joon in France, were set up to cater for the needs of millennials or digital natives. Even ultra-low-cost carriers, such as US-based Spirit Airlines, are focused on improving passenger experience through wireless technology.
- On the supplier side, vertical integration or cooperation (for example, EAN and Seamless Air Alliance) becomes prominent as passenger and airlines see travel holistically, rather than as a collection of unrelated services. Connectivity and the IoT are critical assets in providing global, high-speed connectivity and a unified passenger experience throughout the journey.
- Substantial changes in seating arrangements alter the physical environment for passengers. While there is a wave of new premium-economy products on offer, some carriers are aiming for densification in the cabin, especially in economy. Premium-economy products appear to be successful, as upsell opportunities usually outweigh the revenue dilution some carriers feared for business classes. In addition to offering slightly more space, these products are enhanced through better services.
- The IFE & connectivity (IFEC) landscape is changing dramatically. The IFEC 'system' uses the passenger PED as the core enabling technology.

While embedded and bring-your-own-device (BYOD) solutions probably will

Turkish Airlines' strategy involves the Internet of Things extensively. Amongst other purposes is the improvement of the digital customer experience across the whole travel engagement. The latest technologies help the airline become a truly global carrier.

remain part of many long-haul products, wireless networks are clearly becoming the preferred delivery mechanism to embedded in-seat screens and to passenger PEDs. Some experts forecast that the embedded screen will become simply a display device for content stored and operated from the passenger PED. The pairing of the passenger's PED with the embedded IFE system will become routine. With these trends in connectivity, the IoT emerges as the underlying enabling technology platform.

In line with these developments, the role of content becomes more of a focal point, with hardware components becoming increasingly commoditised.

- Content selection and delivery are changing dramatically. Passengers are driving selection of content, for example, on the airline website during the booking process. They can electronically preview content, prearrange a playlist, and pre-order meals. On board the aircraft, their PEDs can connect and synchronise automatically with the embedded system. There is also a trend for passengers to manage IFE content and other services via PEDs in the cabin.

Singapore Airlines' Companion App was the first of its kind, enabling passengers to search available IFE offerings, pre-select programmes and control the seatback IFE system from a PED.

Variety of content choice also is increasing, ranging from self-improvement courses to virtual reality solutions (Qantas). It is certain that on-demand content will evolve to become standard.

- For airlines, this is valuable since they no longer have the expense of installing and maintaining passenger control units that take up space in the seat and are prone to breaking. At the same time, they allow passengers to personalise the travel experience.

Since most passengers carry smart devices, airlines would be foolish not to use them as key enablers for passenger empowerment. Passengers can communicate with cabin crew through PEDs, control the environment (light, air conditioning), check on toilet availability, and order catering.

- Airlines recognise the need to engage with passengers throughout the journey, as well as empower them, since the in-flight experience is only one of a series of touch points that generate data on passenger behaviour and preferences that are useful in providing personalised marketing to passengers. Lufthansa, for example, has a programme called Smile (Surpass My Individual Lufthansa Experience) to harness the power of collated data in providing a personalised passenger experience.
- Towards a broader passenger experience, the IoT naturally forms a platform to connect devices and services.
- Connected cabin and onboard wireless networks are becoming common, and their use is growing exponentially. Given the increase in number of PEDs carried by passengers, some calculations suggest a future ratio of 1.5 WiFi-enabled devices per passenger. Additionally, there is the growth of data capacity to and from the aircraft. Within the last several years, this has increased by orders of magnitude through the increase in satellite capacity from L- via Ku- to Ka-band, as well as the establishment of Air-To-Ground (ATG) networks that enable or promise very substantial data rates.

Finally, there is the growing number of applications and in-cabin services that use wireless networks. In-cabin IoT will require increased capacity and processing power from these networks.

It may be that at one point the bottleneck in provision of connectivity through in-cabin wireless networks will no longer be data capacity to and from the aircraft, but rather the system's ability to optimise and prioritise delivery on board the aircraft to each wirelessly connected device.

- At the same time, there is a realisation that the content supply chain infrastructure and processes can be used for other new in-cabin services. The idea of a cabin IT platform is spreading with several companies spearheading the process. One example is Axinom, with its approach to enabling the cabin IT infrastructure to become an open platform, instead of a closed and proprietary system, like the classic IFE systems in the past. Ralph Wagner, chief operating officer at Axinom, sees enormous potential in the completely connected passenger: last-minute upgrades at the start of a journey for a passenger that suddenly realises how restricted their seat is; or provision of tailored destination deals, driven by information from the passenger's frequent flyer profile.
- Driven by the economic models of low-cost carriers (LCCs), operators across the spectrum now realise the need to maximise ancillary revenues. Recently there has been a rapid evolution of possibilities for ancillary revenues. Many airlines, but especially LCCs, now offer a wider range of products and services for purchase before, during and after the flight, including: in-flight services (upgrades) and products; travel insurance; lounge access; pre-seating; WiFi connectivity; priority check-in; and destination-related products, such as rental cars, hotels, events, or even mobile phone credits.
- Airlines are able to gather large amounts of data on passenger behaviour and preferences before the flight through the carrier's website, as well as in flight via the aircraft's embedded WiFi. Airlines are able to use this data to analyse a passenger's digital preferences, enabling a carrier, as well as advertisers and service providers, to fine-tune offerings to the individual passenger level.

A highly sophisticated way of differentiating its onboard products enables Finnair to maximise onboard ancillary revenues, while catering for the variety of customer subgroups on a more individualised basis.

Cabin crew role

One element of the passenger experience that is rarely addressed is the interaction with the cabin crew.

The role of the cabin crew is evolving towards passenger support, in addition to traditional requirements concerning safety and service. With integration of capabilities and data that new technologies offer, the role of the cabin crew has the potential to evolve into that of airline brand ambassador. To this end, several airlines are now providing onboard concierge service. Whether it is 'Concierge in the Sky' service from Air New Zealand or the 'Holidaymaker' approach taken by TUI Airways, the role of the enabled cabin crew is to provide a more personalised experience.

Enabling technologies

Central to enabling the connected crew are connected devices, mainly tablets, smart mobiles and wearables. Tablets can be powerful tools for cabin crew personnel by handling a range of data and transactions. Utilisation allows for three main areas of benefit:

- Real-time passenger information:

Through the in-cabin IoT or at the gate, a crew's tablets can collate up-to-date information on passengers, such as frequent flyer status, personal preferences, special meal requirements, previous upgrade purchases, connecting flight information, and baggage status.

- Enhanced retail experience:

Tablets can be used as tools to create bespoke personalised offers, based on passenger profile, preference and previous buying decisions.

The range of available products is constantly increasing, including goods that can be delivered to a passenger at destination or at home. Destination-based activities, including but not limited to hotels, transport, excursions and entertainment tickets, have become more common as a part of in-flight retail.

The tablet operates as a point-of-sale terminal, capable of handling different payment methods, including credit cards, physical and virtual vouchers, bonus points, contactless cards, and cash, as well as more advanced methods, such as 'Pay with Amazon.' On US-based low-cost carrier Southwest Airlines, it is possible to pay for cabin WiFi using the system.

Apart from facilitating the onboard sales process, a crew tablet streamlines the logistics of onboard sales. With sensors in the trolleys or galleys, connected through the cabin IoT, stock lists can be updated automatically, with data collated for future analysis.

Airline crews can also earn commissions from the onboard sales of goods and services provided by the carrier as well as third-parties.

- Operational efficiencies:

Passengers can interact more efficiently with the cabin crew through electronic devices, instead of using call buttons to place orders.

The crew can also create and access electronic reports, such as cabin maintenance reports, in-flight reports, catering reports, as well as various manuals. Digitising paper processes results in efficiencies as well as timely and accurate data flows.

The crew can also use tablets to control cabin lighting, temperature and humidity, and to track the status of duty-free trolleys or catering equipment and goods using information gathered from sensors in the cabin.

The crew also can monitor passenger wellbeing if the device is integrated into a network of related sensors across the aircraft. If the crew identifies, for example, that a passenger is cold, that passenger can be offered a blanket.

Other cabin elements

Apart from the most important utilisation of the in-cabin IoT, facilitating passenger interaction and comfort, there are several other areas where the IoT in the cabin is already being used or can be used to ensure a more efficient operation.

As emergency medical care equipment must always be in perfect order, it needs to be controlled and monitored.

There are items in the toilets that can involve the IoT, starting with smoke detectors or occupancy sensors, down to devices that determine water or soap levels and lighting.

Cabin cameras, of which there will be a number in the future, need to transmit data inside the aircraft to the crew and a storage device.

Galleys that have multiple devices, such as ovens, refrigerators and coffee machines all need to be checked for functionality and operability.

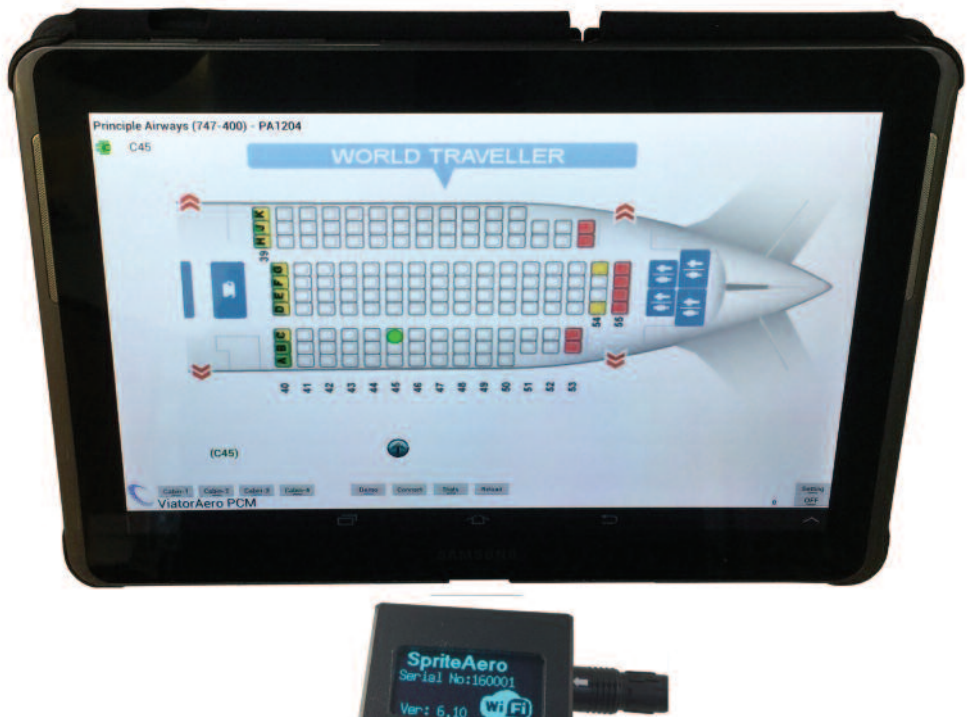
Utilisation of overhead bins, a constant source of trouble, particularly on narrowbody aircraft, could be optimised through sensors connected to the IoT. Passengers could pre-book bin space, and there could be electronic alerts warning of full bins or those not properly closed.

Cabin crew can control the status of window shades that need to be up during take-off and landing using a sensor to detect irregularities. There are also technologies to dim windows electronically. Safety equipment, such as life vests and oxygen equipment with fixed life limits, needs to be monitored for functionality and replacement. Sensors can transmit these data and issue alerts if some of this equipment needs attention.

Companies using IoT

Cabin hardware: FliteTrak

FliteTrak has a suite of monitoring devices that can be deployed in 'smart seating.' These devices feature sensors in



FliteTrak utilises the cabin IoT extensively. Their sensors in seat, seatbelts, and overhead bins provide information to monitor passenger's wellbeing and activity, and the cabin overall.

seats, seat belts, in-seat trays and embedded IFE systems. The solution for the seats is based on low-power sensors that monitor movement in the seat through various pressure points. Too much or too little movement can be indicative of an uncomfortable or unwell passenger.

There are sensors in the seatbelt to detect whether it is closed properly. There is also a solution to detect whether passengers have failed to put mobile phones into flight mode. Other sensors measure cabin temperature and humidity.

This smart seating is bound to have a substantial impact on management and predictive maintenance of the cabin.

Infrastructure as a platform: Axinom

Axinom operates a digital platform that allows operators, as well as solution providers, to interact with each other. Coming from the media supply chain side with early core products such as CMS, DRM and CDS, Axinom realised that the infrastructure it uses to deliver content could also be used as a platform to support services other than just IFEC.

Central to this concept is the ability to use the original media server for other applications. This requires virtual separation of server capabilities to allow parallel usage of the same server for multiple data flows for which Axinom has an innovative solution.

Platform as a start point: Gogo

Gogo, known to most as a WiFi provider in airline cabins, is clearly moving towards becoming a platform for the total connected aircraft. GoGo has a systems-to-systems approach for anything from connect weather systems, airports, baggage-handling systems and catering, built on the IoT, including the IoT in the cabin.

The future

Most airlines realise that the IoT, whether on the ground or on the aircraft, can be used effectively to optimise operations and cater to passenger requirements.

In addition to the IoT, a variety of other in-cabin technologies is emerging, such as artificial intelligence and machine learning, blockchain technology, as well as solutions that use augmented reality or virtual reality. Several of these will become more prominent in the short term.

Some of these new technologies or solutions, include:

- Developments around LiFi, that is, wireless data transmission through light. The benefit is that the lighting infrastructure could be used, with no need to establish additional wireless networks.
- The identity management process throughout the journey could be simplified dramatically through a single passenger token in combination with blockchain technology. For example, secure biometric authentication could be used as the underlying mechanism. In an IoT-enabled travel environment, whether on the aircraft or before or after flight, such a solution could be used instead of passports, boarding passes, and lounge passes. For example, SITA OnAir is exploring this technology further.
- Finally, an example that looks fairly futuristic, but that could nevertheless become a reality: ingestible digital pills that include sensors to wirelessly monitor health information from inside a passenger's body related to, for example, sleep, eating or exercise patterns. These could work in conjunction with in-cabin sleep monitors, as well as health-related data generated from passenger wearables and smartphones. British Airways has thought about such a solution as part of a quest to provide the best possible onboard travel environment.

All of these technologies, including the IoT as the underlying platform, will be powered by software. The required data analytics that will inevitably be developed with these technologies will fundamentally change the way airlines and related organisations operate.

Embracing the IoT, however, does not only mean embracing new technology, but new partners and ways of doing business. There will be new and unusual partnerships emerging. Airlines' IT departments will become more interwoven into other organisations, especially in engineering departments. There will also be realisation that external collaborations in a variety of novel ways are more effective than establishing or maintaining in-house capabilities.

The required wider perspective on organisational aspects will also have a positive impact on the industry's struggle to make a business case for such basic projects as the decision for external aircraft connectivity. This is partly because many airlines are confused about connectivity provision and benefits.

There is also the question of cyber security when using wireless networks onboard the aircraft. With the latest regulatory requirements from the European Union (EU) mandating a completely new approach to cyber security, the industry needs to think how to integrate these into operations.

General Data Protection Regulation (GDPR) requirements concerning use of personal data have now come into force.

There is also the less well-known EU directive for network and information systems, NIS Directive, addressing cyber protection of critical infrastructure entities, including airports and airlines.