The aircraft cabin environment with all its components and services is an area where airlines and an increasing range of suppliers are using innovations to optimise the elusive passenger experience. The main elements of the aircraft cabin evolution are examined here.

The evolution of aircraft seating & cabin technologies

Passenger cabins are evolving quickly, whether on ultra-large aircraft, such as the A380, or smaller types as well as regional aircraft. This is an overview of the interwoven trends and expectations. It is clear that an airline cabin is no longer just a group of individual technologies, but an intricate collection of individual service elements.

The in-flight product

One element driving cabin evolution is introduction of ultra-long-haul routes. On longer flights passenger comfort becomes a larger issue; physical discomfort needs to be addressed to prevent passenger dissatisfaction or even illness.

Qantas has introduced a direct London-to-Perth route and is preparing for even longer routes from the Australian east coast to London, as well as the US east coast. On the Perth route Qantas analysed passenger suggestions and expectations

The most popular suggestions involved facilitating socialisation on long flights, such as providing café areas, as well as innovative designs to non-seat areas. There also needs to be separation between common areas and individual space.

Similarly, the use of narrowbody aircraft on long-haul routes will affect food service as well as size and composition of premium seating.

Increased differentiation in seating options, together with sophisticated revenue management and digital technologies to respond to customer demand allows airlines to fine-tune and sell seating capacity up to the last minute.

One element needing to be addressed is changing passenger demographics.

Passenger environment

There is an increased focus toward providing a healthier in-flight environment through ambient technology. An ageing and less-mobile population will affect passenger requirements.

Older generation aircraft provide a cabin pressure at the equivalent of 6,000-8,000 feet above sea level, while cabin pressure in the A350 and 787 is about 6,000 feet. This is a significant difference, since most people tend to feel the impact of altitude sickness at about 8,000 feet.

Another element is cabin humidity. Dehydration is a major contributor to passenger discomfort, causing fatigue, as well as a number of minor ailments.

Average cabin humidity levels are 5-12%, with the lowest levels usually in premium classes due to lower seating density. The minimum level of relative humidity at which the body is most comfortable is 20%.

Light is an important cabin design component in providing passenger comfort. The Airbus Airspace product, for example, uses light as a central design element.

There is also a focus on providing a pleasant environment, including elimination of unpleasant smells in washrooms or from auxiliary power unit (APU) exhaust or de-icing liquid.

A recent consideration is passenger mood management, starting with basic cabin design elements, such as colours and surfaces. Airlines also are introducing mood lighting to minimise the effects of jetlag and using technology to measure passenger movement and in-flight wellbeing.

Passenger infrastructure

Personal electronic devices (PEDs) also have revolutionised travel, with apps that provide information on carriers, weather forecasts, pre-flight selection of meals and movies.

PEDs have had a massive impact on the airline-passenger relationship, allowing carriers to create a new range of touch-points with passengers.

Power systems

Supply of in-seat power is becoming a basic utility.

There is a range of power solutions available, from stand-by 110-volt AC sockets via high-power USB charging devices to wireless, inductive charging. The latest trends in consumer electronics are key to developing and deploying successful products. The discussion around USB-A or USB-C charging plugs is indicative of the impact of consumer electronics on air transport, illustrating the dilemma some vendors face to wait for the maturity of the next generation plug, or to develop a solution that allows for an easy upgrade or swap-out.

At the same time the industry is looking at induction-charging solutions, such as inductive power transmission (IPT), which provides the benefit of a cable-free environment. IPT works by having a power transmission pad correspond with a compatible receiver in a portable device. While initially targeted at the business jet market, several

The passenger's PED, using the cabin WiFi network, is becoming the most important tool for the airlines to engage with and entertain the passenger, as well as giving them back control.

providers are looking at technologies that can be used on commercial aircraft.

Some system houses even offer solutions that turn the utility character of a power system into a potential for revenue generation.

IFPL (Inflight Peripherals Ltd) suggests that airlines commercialise the provision of power with the company's 'charge for charge' solution.

Wireless infrastructure

Wireless cabin architecture represents a breakthrough in cabin technology. Beginning as an afterthought for introduction of Connection by Boeing internet access on aircraft over 10 years ago, in-flight WiFi has become the preferred in-cabin data infrastructure.

Applications using this infrastructure can be categorised as either applications that use the wireless cabin network for interaction with passengers or interaction outside of an aircraft, or applications for airline operational purposes.

Usage of in-cabin PEDs allows airlines to replace or enhance embedded IFE. PEDs also allow dual screening. Content can be transferred from a PED to an embedded system or vice versa. A passenger can use the network to interact with the crew, with the PED being the controlling device.

Wireless IFE has emerged as a valuable tool for airlines, especially in combination with a passenger's PED, allowing carriers to reduce investment in embedded IFE systems. Reduced costs come at a relatively small price, which is the need to provide an in-seat power system, as well as a high-performance WiFi network and, where planned, a similarly good outside connectivity system. Because of the much lower complexity of wireless IFE systems, several new system houses have emerged and have been successful in convincing some carriers to acquire their solutions.

There are several system houses that offer portable wireless IFE solutions, thereby avoiding the substantial modification costs for installed equipment and keeping the loose equipment status. Some of those are moving towards a solution that plugs into the aircraft power supply (an example, Flymingo by Interactive Mobility) to overcome the difficulty charging cycles sometimes cause.

There is an increasing number of airline operational applications that use the cabin WiFi network. Typical examples are interaction with a passenger concerning a drink order or communication with fellow crew members about a special food requirements, or communication from a crew member's remote PED about adjusting in-cabin temperature.

Toilets

Airlines are looking at toilet design. Toilet designers are always focussed on weight reduction, reduced water consumption and higher reliability. Composite and thermoplastic technologies provide better material strength as well as weight savings.

Size of the average toilet in economy has shrunk over the past decade in line with cabin densification. Similar to the galley, the toilet is often regarded as a mirror of an airline's quality. Apart from shrinking the toilet, new concepts have emerged, such as micro-toilets and urinals (Zodiac Aerospace), replacing one standard toilet with two urinals. While the airline wants as many passenger "touchpoints" as possible, it is different regarding the toilet where touchless activation of water faucets, soap dispensers, and the toilet itself is the preferred technology. Touchless activation usually is achieved through sensors that use capacitive or infrared technology.

Increasing demand for hygiene has led to development of high-tech antibacterial and self-cleaning coatings. Meanwhile, new projection technologies as well as the variety of amenities airlines provide to passengers offer opportunities for an airline to showcase its brand.

Many technological developments are driven by economy class requirements. In roomier premium cabins, toilets are designed for comfort as well as function.

Passenger interaction

Airlines constantly seek to engage and remain relevant throughout the journey, mainly via passenger PEDs and the airline app. Younger travellers, especially Y and Z (digital natives) and to a lesser extent generation X (digital immigrants), rely heavily on PEDs.

The aviation industry has failed to understand the importance of technology when preparing for the future. Decision-makers at airlines and system houses often lack insight into the importance of technology, resulting in design decisions driven by less important requirements.

Galley evolution

Galleys traditionally have been functional areas for the heating of previously prepared food. Some airlines have sought to create a hospitable and welcoming impression of the galley area by providing snacks and drinks.

Digital billboards also are being used (Lufthansa/LG) in prominent places in the galley area for advertising.

Some carriers that operate larger widebody aircraft, have reintroduced on-board lounges, including Emirates, Etihad Airways, Korean Air, Qatar Airways and Virgin Atlantic. These lounges are individually designed, and vary significantly in size and service offerings.

One option introduced by Korean Air on its A380 fleet is replacement of 13

With The Residence Etihad has gone beyond First Class taking the concept of personal space to the extreme.

economy seats at the back of the lower deck with an in-flight duty-free shop.

The innovation was precipitated after the carrier's duty-free sales took a hit when the airport retailer sales were heavily promoted. The carrier aims to more than compensate revenue loss from ticket sales with income from advertising and sales in the duty-free shop.

Air New Zealand has introduced the Skycouch on its 787s, converting a row of three economy seats into a couch or even a play area. The entire row will be booked for one party.

Other innovations are being considered to maximise revenue-producing space, such as creating sleeping bunks in the crown or cargo area, as well as providing exercise areas (such as treadmills and rowing devices) would fall under that category.

A final area for on-board interaction is the virtual world, based on the WiFi-driven intranet in the cabin, allowing passengers to exchange messages, play games and watch movies.

The most crucial on-board interaction occurs between passengers and cabin crew. In addition to functioning in a security role, cabin crew have evolved into brand ambassadors.

With the increasing complexity of technology and passenger PED-driven services on-board an aircraft, amidst more differentiated classes/services and increasing seating density, the cabin crew needs to be able to perform more functions and be able to control the cabin environment. Not surprisingly, cabin management systems (CMS), for example, Intellicabin by BAE Systems, respond to this, incorporating additional functions, especially around IFE and connectivity systems. In addition, CMSs allow functions and status, such as in-seat power systems and dimmable windows, to be monitored and controlled. Typical CMS architecture includes a central attendant control panel, plus multiple handheld devices that allow for system access and control. In future the cabin Internet of Things (IoT) will bring additional functions that will need to be monitored and controlled via the CMS.

Cabin crew can use these technologies to deliver a more bespoke and individualised service, whether simply meals and drinks on demand, support for the WiFi network or an all-round concierge service that allows for help with onward connections. Solutions that use augmented reality, such as wearable displays (glasses, watches), have proven to be particularly useful in helping crew access passenger-related information.

Technologies also allow passengers to bypass cabin crew. An example is the pair-and-pay technology used by the Spanish low-cost airline Level, where passenger PEDs are used for on-board shopping. Passengers connect a PED with the individual seatback system to browse and buy a range of goods and services.

Evolving classes

For long-haul flights, increased focus on redefinition of personal space for each passenger is required. Airlines recently have attempted to overcome lack of physical space by offering passengers the ability to work, access social media and even interact with other passengers through messages or games.

Many of these efforts are facilitated by provision of internet access, as well as in-seat power, to enable the use of passenger PEDs.

First class and beyond

Many airlines have come to the conclusion that first-class service is expensive in terms of use of cabin space, especially when seats are occupied by passengers burning points from a frequent flyer programme. Several carriers are reducing the size of the first-class cabin, or simply abandoning it.

There are also some products that counter this trend. An example is Etihad's 'Residence Suite,' a novel multi-room private suite, offering a shower, proper bedroom and concierge service. Overall, however, the concept of a first-class cabin is of decreasing relevance.

Business class

Airlines have understood the need to invest more in the business-class cabin, the most profitable class of service and where the ratio of cabin real estate versus revenue is favourable. There is an overall trend of eliminating first-class service in favour of business class, while upgrading business-class travel closer to previous first-class service.

An overarching theme in the design is the concept of 'ownership of space' (Zodiac), and passenger control over their environment. Zodiac describes the design philosophy behind this trend as extension of personalisation of the travel experience.

A central element in most business-class upgrades is focus on 180-degree flat beds that are long enough for comfort. The challenge for airlines, however, is that, while increasing passenger density throughout the cabin, airlines are trying to increase comfort and living space per each individual seat. At the same time full aisle access for each passenger, more side furniture and personal space for stowage, additional table surfaces to operate more devices are in high demand. There is also a need to offer more privacy, either through personal dividers or the ability to turn a two-seat group into a private compartment to offer a shared experience. With increased space comes

The most interesting battle ground in cabin seating is in the economy classes where various innovators pursue the seemingly conflicting goals of densification and passenger comfort.

the issue of viewing distance between the monitor and the passenger, resulting inevitably in larger IFE screens.

Another important design element in business class is light. From mood lighting in the general cabin area to individual adjustable reading lights or the availability of lights in the footwell or stowage areas, airlines have realised that light is an essential element for passengers to control the on-board environment.

On short-haul routes there are developments in business-class service. One example is the extension of Aer Lingus' A321LR operation into continental Europe, meaning that there will be lie-flat business-class seats on flights between Dublin and continental Europe.

The discussion about extended business-class routes has also rekindled the move towards a more flexible LOPA (layout of passenger accommodation). There is a demand for the ability to adapt classes by seasons. For example, more economy service during the summer, or possibly even changes overnight, depending on the booking situation. Some airlines previously made such modifications between classes by moving the dividing curtains to increase business cabin, but this is no longer feasible.

Premium economy

Another option to reassigning cabin real estate from either reduced first-class or reduced and/or densified economy class are premium economy products, which have been successful over recent years with multiple carriers. Several carriers have introduced this service tier with differentiating features, ranging from an increase in seat pitch up to completely new seats, together with upgraded food and beverage service. The huge growth in this area can be attributed to the big gap between the previous economy and business classes. Typical network carriers have introduced these economy-plus classes as an additional service. Low-cost carriers (LCCs) on the other hand, generally operate a one-class configuration on short haul routes, but often adopt a premium class on long-haul routes. Examples are Joon, Level and Norwegian. These premium classes are often similar to business-class services of the 1980s and 1990s.

Economy space

Within the economy space, Etihad has introduced a product with extra leg room. This product does not fall within the scope of a premium economy product because it is missing the other features of premium economy, such as a better food service and amenities.

Economy

Airlines tend to earn more revenue from either passenger fares in the premium classes or from ancillary revenues. Economy classes are generally seen simply as revenue contributors. This explains why airlines are keen to increase the number of seats in economy (densification) and use passenger PEDs for entertainment to save system costs, weight and maintenance complexity.

The challenge for airlines, however, is that, while increasing passenger density throughout the cabin, airlines are trying to increase comfort and living space per each seat.

Similar to developments in premium classes, the overall principle is for passengers to feel that they do not just occupy a seat, but have their own living space on the aircraft. Sometimes simple ideas result in improvements in perception. An example is introduction of an extendable arm for the meal table in the middle of the tray, which reduces interference with the knees.

There are developments throughout the industry relating to individual seats. While densification enables airlines to maximise cabin utilisation, efforts are also made to maximise the micro-spaces around each seat and optimise utilisation. Space maximisation is achieved largely through reduction of obstructive IFE or power equipment near the floor, as well as eliminating the potential annoyance of knees touching the tray table.

Another key element in space maximisation comes in the form of ultra-slim backrests. Their impact on knee and legroom are big drivers of space perception.

In addition to space creation, airlines' overarching targets are weight savings, as well as increasing reliability and maintainability. Innovativeness in the economy space seat market is becoming apparent as new vendors enter the market. Some vendors have an automotive industry background, others are joint ventures of players in other areas of the cabin. The increasing sophistication of the design process and adaptability to anthropomorphic needs allows for a fine-tuned design. New technologies, such as carbon fibres, especially for the heavy seat frames, allow weight reduction while simultaneously increasing structural strength. An example of a successful startup is Mirrus Aircraft Seating, which won the contract for AirAsia's fleet of 304 A320NEOs.

Another concept being addressed by seat manufacturers is the use of staggered seating architecture, resulting in the middle seat being located slightly further back compared to the two adjacent seats. Another trend is incorporation of more flexibility in usage of the seat. For example, Molon Labe introduced a side-slip seat, allowing more individualised comfort, as well as the benefits of faster boarding by widening the aisle. The company also introduced a 'booster' seat that folds on top of itself to offer a seat

Is this what the future cabin will look like? Please remember how many innovative concepts were thought to fail at first, but then became standard later.

for children or more legroom. A similar booster option is also part of the Rebel.aero S2 seat, which features a three-point seat harnesses rather than the traditional seat-belt across the hip.

There is also a new concept by Recaro, called the Flex Seat. Unused seat rows can be folded to allow the rows in front to be pulled apart, increasing spacing between rows.

Economy minus?

There are other unusual concepts in seating that may evoke airline interest. The Skyrider 2.0 from Aviointeriors aims to achieve ultra-high density in economy by increasing passenger numbers in by 20%. In this concept, there will be poles between the floor and cabin ceiling to secure the seats. These seats are similar to narrow bus seats, with the difference that the biggest structural element is the backrest, the structural item that offers support mostly in the horizontal plain for high-impact situations. Most of the weight is borne by a passenger's legs.

Evolving supplier base

Given the way technologies and their utilisation in the cabin are converging more companies are working together on the swiftly evolving cabin environment.

Examples of such collaborations are the iCabin Research Initiative and the Seamless Air Alliance. iCabin's aim is to perform research for a future networked intelligent aircraft cabin. This will involve connection and integration of separate cabin applications, such as seating, galleys and toilets, without cabling to get a real-time overview of the status of all cabin systems.

The Seamless Air Alliance, which is growing in members, is an industry group whose purpose is to drive global change by bringing industries and technologies together to make inflight internet easy to access. At the same time the Seamless Air Alliance aims at defining standards and increasing interoperability in this domain.

An example of this is the Waterfront business-class seat project between Panasonic, Teague and B/E Aerospace. The Formation Design Group is an example of how the future passenger experience will be driven by PEDs brought on-board by the passengers. In this concept a passenger's smart PED becomes the controlling device for the seat, as well as IFE&C functions, through an app the passenger downloads before a flight. Such an airline app includes typical functions, such as boarding passes and meal choices, as well as allowing a passenger to connect to the aircraft system once on-board, for example, to synchronise content for a more personalised passenger experience. Part of synchronisation is the ability to use the embedded IFE system to display personal content. Following the trend towards multi-screening, the Waterfront seat allows the use of multiple PEDs, from smartphones to laptops.

In terms of physical features, the Waterfront layout is designed for a reverse herringbone pattern, with each seat being contained in its own pod, achieving privacy through a sliding door. The passenger controls various physical functions around the seat, such as: light, including in areas, such as the footwell or shoe storage area; and heating or cooling, again by individual areas around the seat. Waterfront allows an individualised food and beverage service by enabling orders to be placed from the seat via the PED. The need to create an individual room rather than a seat is underlined by a 'do not disturb' sign, as well as a wake-up call function.

Trends and technologies

Evolution of the cabin will affect all types of aircraft. While the starting point of the evolution often comes from long-haul routes, it will not stop on typical widebody aircraft.

The increasing use of narrowbodies on long-haul routes, as well as increased replacement of turboprops with regional jets, will lead to many new concepts finding their way onto smaller narrowbodies. Embraer, for example, has a two-abreast-only configuration, rather than the 'middle-seat free' arrangement on wider narrowbodies.

Vertical expansion

With growth in the LCC sector and subsequent response of network carriers increasingly to charge for hold baggage, more storage capacity is needed in overhead bins in all classes, since passengers carry more hand luggage. There is also the need to free up space for passengers in the floor areas. Densification of seating also results in the need to create as much space as possible in other areas. There is also the need to accommodate an increasing number of portable wireless IFE systems. In addition to overhead bins on either side of the cabin, additional storage capacity is created by devices in the cabin centreline. An example is the Centerline Ceiling Stowage unit from HAECO.

The crown area has long functioned as a place for air conditioning ducts, but also as crew rest area. Now there are suggestions to use this space as a passenger-sleeping area, or as an additional baggage stowage room.

Some design houses are looking at solutions that allow for increased

Concepts like the Air Lair pod-style seating cleverly combine the goals for maximising the use of the vertical dimension in the cabin with the need for more personalisation.

individualisation for each passenger, while improving utilisation of vertical spaces. These are pod seats that can be staggered vertically, thereby using the relatively large available space between the floor level and the aircraft crown. An example is Factory Design's Air Lair concept, which offers an organically-shaped individual room, like a sitting and sleeping cocoon with its own controls for light, sound and temperature.

Lower deck

The cargo hold has been used as a crew rest area for several years. With a decline in cargo yields, airlines might be inclined to use this area to generate more passenger-related revenues. A project to use lower deck space for passenger services is run by Airbus and Zodiac Aerospace, which is partnering in the development of stackable sleeping compartments to be loaded into the aircraft like cargo containers. Each compartment will have an IFE screen, individual air conditioning, light and the usual emergency provisions for every seat. According to Airbus, the team is also looking at developing other modules for working, meeting or socialising. This may be attractive to executives accustomed to spending non-productive time while travelling.

Higher tech solutions

The increasing utility and quality of display technologies may stimulate another dramatic change to the aircraft cabin by allowing for windowless cabins. Savings in terms of weight, production time and maintenance would be substantial, and safety would not be compromised. In fact, the higher structural integrity of the fuselage would increase safety. As can already be seen on Emirates' the middle section of Emirates' first class cabins on its 777-300ER, the outside world view is displayed on the cabin's inner wall via fibre-optic technology. This kind of technology could be deployed throughout the cabin. Airlines would need to overcome passengers' desire to 'see what is going on' with new projection technology.

A next step concerns passengers' ability to charge their devices wirelessly. The industry is probably going to move in some classes relatively quickly, in airline cabin timeframes, from having no in-seat charging, via cumbersome wired solutions with swiftly evolving connection devices, towards wireless charging as a default solution.

IoT and digitalisation

While connectivity on-board and with the outside world is an enabling infrastructural necessity, it is already bringing the IoT onto the aircraft, resulting in the obvious benefits of digitalising many more processes. So far, typical cabin IoT use cases have been identified around seat occupancy, seat-belt closed status, overhead bin status (full, closed), various toilet indicators and sensors, water supply levels, and coffee machine status. Naturally, most or all of these new solutions require some form of artificial intelligence (AI) to turn the collated data into useful information that is shared appropriately. This in turn raises the question of cybersecurity in those cabin networks. Cybersecurity will become another element of passenger comfort, at least in digital terms.

Immersive IFE is a logical consequence of the trend toward increased personalisation. In addition to allowing for a very realistic IFE experience, immersive technology is also a perfect tool for the airline to replace available physical personal space with an alternative experience that allows a passenger to escape the realisation of confinement.

Biometrics

Similar to the success path biometrics have been following, especially on the airport part of the journey with anything from check-in via passport control to gate controls, these technologies will inevitably find their way into the cabin. With applications such as immigration control from the seat using the in-IFE camera for facial recognition and payment solutions that use fingerprint or voice-recognition technologies, there are a range of biometric solutions that will enhance passenger experience. If governments can rely on this technology to identify people, there will also be applications in the aircraft cabin.

There more technologies available already or definitely will have an impact on how the aircraft cabin will evolve. For example, 3D printing has been seen as a technology that enables more fine-tuned designs for various parts of cabin hardware. Blockchain technology can facilitate a variety of processes around payments and authentications, simplifying the lives of crews and passengers. Meanwhile, upcoming 5G cellular technology promises another order of magnitude of data transmissions at reduced costs.

With developments over the past several years, the market is bound to offer designs in aircraft cabins that have not been seen before on commercial aircraft.