IFE systems have evolved into several categories, resulting in a wide range of hardware capital costs. Low-cost wireless systems have stimulated demand from a range of airlines that had not previously fitted their fleets with IFE hardware. Charles Williams examines the arguments for embedded and wireless systems.

IFE systems: embedded versus wireless hardware

Constant development in the technological functionality of in-flight entertainment (IFE) systems has changed the relative differences between embedded and wireless hardware systems. The number of aircraft being fitted with wireless IFE systems has been steadily increasing. Not only are wireless systems cheaper than embedded systems, but their capacity and functionality has continued to advance at a steady and impressive pace. There are now several types of wireless IFE systems, raising the issue of how they compare, and how big the differences are between the main categories and sub-categories.

IFE system options

IFE systems fall into four main categories: embedded or hardwired; wireless; portable; and standalone. With development of specialised systems and connectivity, there is now a fifth, hybrid category, comprising embedded and wireless hardware.

Embedded systems are available from four main manufacturers: Panasonic, Thales, Zodiac Aerospace and Rockwell Collins. Panasonic has 65-80% of the market for new embedded system installations, while Thales and Zodiac share most of the rest of the market. Other vendors provide systems to a small number of airlines.

Embedded systems have always been installed on widebodies for long-haul operations. A few airlines, such as jetBlue and Virgin America, have embedded systems on short-haul and narrowbody fleets to give them a product advantage over other US domestic carriers, however. jetBlue has a Thales system with large hi-resolution screens installed. Other than this, few other fleets or cabins have traditionally had any IFE hardware installed.

"The market for embedded systems has remained consistent, since 97% of widebodies on order, and destined for long-haul operations, will have embedded IFE systems fitted on the production line or shortly after delivery. This includes virtually all 4,000 passenger-configured aircraft," says Craig Foster, senior consultant at Valour Consultancy. "The market for embedded systems appears to be holding, and undiminished by the advent of wireless systems."

Jon Norris, senior director for integrated solutions at Panasonic Avionics Corporation, explains that embedded systems can be fitted on the production line, retrofitted to replace old systems, or upgrades. "Line fits account for 40% of new systems, while retrofits account for about 60% of embedded systems that are installed. Aircraft manufacturers restrict what systems can be fitted on the production line, and these are shown in the manufacturer's catalogue. Being available as a line fit item requires a particular approval process.

The advent of wireless systems in 2012 was made possible by internal cabin connectivity and tablet computers. The main feature of a wireless system is transmission of content to tablet devices wirelessly over a WiFi network in the cabin from wireless access points (WAPs).

Wireless systems have several benefits: their capital cost is less than 10% of an embedded system's; they have low on-going operating costs; they are light and simple; and passengers can use their own personal electronic devices (PEDs) to view and use the content.

"Introduction of wireless systems meant that IFE became affordable for airlines, passenger cabins and aircraft that could not have justified the capital cost of a hardwired system," says Jimmy von Korff, co-founder of Immfly. "Airlines that would not have embedded systems include those that operate a large number of narrowbodies used for short-haul and low-cost operations, or those that are replacing old generation embedded systems on short- and medium-haul fleets.

Von Korff points out that wireless systems fit with new interior hardware being installed by some airlines. "An airline can buy new-generation slim seats, and use a wireless IFE system that has airline-supplied tablets or PEDs mounted in slots in the seatbacks," says von Korff. "This is not possible with an embedded system, which requires thicker seats. The slim seats save weight, and can also add a row of seats on a narrowbody."

Foster cites estimates that 4,000-5,000 narrowbodies out of a global fleet of 15,000 are fitted with wireless systems. This number continues to grow steadily.

Continual development of hardware technology, growing use of internal cabin WiFi and external satcom connectivity, airline applications, and higher passenger expectations have led to the development of hybrid IFE solutions.

These are IFE systems that provide both a traditional seatback or in-seat screen for viewing films or selecting audio files, while the aircraft is also fitted with external and internal connectivity. This allows passengers to control the IFE system via their PEDs. PEDs are used to send and receive e-mails and text messages, and to access the internet. A PED can also be used to control the main IFE system remotely via an app provided by the airline and hosted on their device. The link between the PED and in-seat IFE system can be via the WiFi signal in the cabin, or a bluetooth connection.

IFE evolution

IFE systems began as overhead screens mounted in the passenger cabin. The earliest systems were based on small cinema projectors that projected movies onto white screens on cabin bulkheads.

Later-generation dropdown, overhead screens were based on large TV monitors in the ceiling, mounted at a downward angle. Passengers had no choice over the

Embedded IFE systems have in most cases only been installed on widebody aircraft operated on major long-haul routes. This market is likely to remain for embedded, hardwired systems. These systems are increasing in sophisitication, and are now evolving into hybrid systems.

choice or timing of films.

Overhead screen systems offer a low-cost and simple solution, and have been used mostly on narrowbodies. Rockwell Collins provides its PAVES overhead system. While market sentiment may be that wireless systems are making embedded systems obsolete, Panasonic points out that demand for overhead systems is strong. "Airlines in China are using overhead systems for domestic operations, as an example of a particular market," says Norris. "The need comes from airlines that want to avoid providing an elaborate system with a lot of content choice."

In-seat systems

The first in-seat or embedded systems offered a wider choice of content, and for the first time gave passengers the freedom to select content, rather than all of them watching the same film at the same time.

Configuration of the first in-seat systems included a low-resolution seatback screen, combined with an in-seat control device stowed in the seat armrest. Content was controlled via processors located in metal boxes under the seats.

The content of these first-generation in-seat or embedded systems was limited to a relatively small number of films, pre-recorded TV shows, albums or music collections, some pre-recorded radio shows, and a basic moving map function.

Systems were fed by hardwire connections from a central server, so the entire system was vulnerable to a single server failure. Systems were also complex and susceptible to damage by passengers, including under-seat distribution and processor boxes, screens, hardwiring connections, and control units.

A development in the late 1990s was the in-flight telephone that required an L-band satellite communication (satcom) system, mostly used for long-range navigation. Calls were via handsets stowed in the seat. Connection quality was poor and passenger uptake was low. A few airlines installed the system, which was discarded after a few years.

Initial improvement of first-generation IFE systems increased the amount of audio and visual content, offered more games, provided higher-resolution, often larger, screens, and improved the handheld passenger controls. Some embedded systems included touch screen controls.

Further developments in embedded IFE system hardware in recent years have seen credit card swiping mechanisms being added, as well as charging ports for devices with USB and HDMI cable ports and sockets. USB parts are required to charge devices, while HDMI ports are used to transfer content, such as the passenger's own movies, from a PED to the IFE screen.

These developments have followed as passengers' expectations have grown over the past five to 10 years.

The cost of hardware for an embedded system starts at $2 million for an A320 family or 737 family narrowbody, rising to $5 million or more for a large widebody such as a 747 or A380. The overall cost for hardware will be up to $10,000 per seat for the more elaborate systems with higher capability.

There will be additional costs for high bandwidth external connectivity hardware, installation, content and ongoing operation.

Wireless systems

A wireless system transmits content from the IFE server over an in-cabin WiFi signal from several WAPs located in the cabin ceiling, to individual CE tablet computers and other devices. Each passenger can use a PED that holds software for making content selections and performing other activities, while providing a high resolution screen for displaying content.

Manufacturers of wireless IFE systems include Lufthansa Systems, KID Systeme, Immfly, Airfi, Bluebox, PaxLife and Arconics. Thales, Panasonic and Rockwell Collins, which are suppliers of embedded systems, now also provide wireless ones. Thales' system was launched by All Nippon Airways in 2013. It is also used by Royal Brunei and United Airlines.

Wireless systems have become feasible due to the availability of in-cabin WiFi networks and the capability of PEDs. The main attraction of a wireless IFE system is that it needs less infrastructure than an embedded system, mainly due to the absence of wiring and processor boxes. Wireless systems are lighter, have lower on-going operating costs, are quicker to install, and have lower installation and capital costs than embedded systems.

Wireless systems fall into two classes: airline-owned tablets; and those that rely on passengers' PEDs. "A modern tablet or smartphone has the same functionality or more as an embedded seatback screen. Innovation cycles for CE devices tend to be 18-24 months, so the capability of IFE systems is steadily improves," says Gerald Schreiber, chief executive officer at PaxLife.

KID Systeme manufactures a wireless system called SkyFi. Johannes Ferstle, product manager for connectivity systems at KID, says: "About 98% of people have a PED, and statistics show that 73-78% of them have two PEDs, while 50% have three: a smartphone, a tablet and a laptop."

The cost of hardware for a wireless system is $150,000-200,000 for a standard narrowbody. PED-based systems have the advantage of avoiding the cost of investing in tablet devices.

Wireless systems have the capacity for the same functionality as the latest generation of embedded systems. "The

Portable IFE systems provide the lowest capitral cost and quckkest to instal IFE system available. Moreover, they have the same level of functionality as wireless systems.

main difference between airline-owned hardware and PEDs is that the early window (EW) content of the latest films is only available on airline-owned devices because of Hollywood studios' licensing laws," says Schreiber. "Studios are nervous about individuals taking content that is being shown in movie theatres and cinemas, and so will only allow EW content on airline-owned devices. PED-based systems only have late window (LW) content. EW content used to become LW content after six months, but this time gap is now decreasing, in most cases to three months. Warner Brothers has reduced this to two months. Content update cycles that most airlines use have also shortened, so passengers can now see movies on an IFE system three or four months after release."

A further advantage of a wireless system is that tablet devices can regularly and easily be replaced as technology progresses, whereas the screens and processors of embedded systems may only be updated every eight to 10 years.

Airlines most attracted to wireless IFE systems are those operating traditional and full-service, short-haul scheduled routes, low-cost carriers (LCCs), and inclusive tour charter airlines in Europe. Examples of major airlines with wireless IFE systems include United on short-haul, domestic US operations, and Lufthansa. "Lufthansa has equipped 20 narrowbodies with a wireless system provided by BoardConnect, a Lufthansa Systems product," says Jan-Peter Gaense, director of project and certification of BoardConnect at Lufthansa Systems. "Lufthansa is also in the process of deploying external connectivity with Inmarsat's Global XPress Ka-band system. This will later be the full European Aviation Network (EAN) when it is fully operational. The rest of Lufthansa Group's A320 family fleet will be equipped with BoardConnect by 2020. This includes full EAN connectivity, and the IFE system portal and server. This means that about 180 A320 family aircraft will be equipped for Lufthansa, 30 for Austrian, and 60 for Eurowings."

Canadian airline Westjet is an example of a LCC selecting a wireless IFE system. This is provided by Panasonic, and includes its in-cabin WiFi connectivity system eXConnect.

Another group selecting wireless IFE systems includes those seeking a low capital cost option to replace ageing embedded IFE hardware or dropdown screen systems with limited content. An example is Philippine Airlines, which has replaced an in-seat system with a wireless configuration. This includes its widebody fleet that is used for regional services.

IFE functionality

The capability of original embedded IFE systems was the supply of movies and cartoons, audio files, games, and a basic moving map display.

The first advance in IFE systems has been improved screen resolution (and in some cases screen size), and increased server and overall system capacity. This has increased in some cases to allow hundreds of movies to be held on the server, rather than several dozen only.

There have been other improvements. The first of these was the introduction of remote hand controls, giving passengers more flexibility, especially in premium cabins, and convenience when passengers are also using personal devices.

Recently, there has been an array of ancillary revenue-generating features added to the functionality of IFE systems. One particular development has been the introduction of airline apps hosted on passengers' devices. Airline apps act as airline branding tools, and will have the same appearance and functionality or operability as an airline's website.

Basic airline apps include personal details and frequent flyer programme data, allowing passengers to manage bookings and reservations and electronic boarding passes several days pre-flight. They can be used to make reservations, and to provide destination information.

Advanced apps include: details of IFE content for passengers with reservations; goods available from in-flight shops; on-line shopping; and the ability to pre-order drinks and meals and choose IFE content before check-in.

Thales has developed hi-tech capability for a passenger seat that allows short-range wireless communication with a passenger's device. Data from the airline app in their device can be transmitted to the receiver the seat, and transferred to the IFE system. The cabin crew can then deliver the pre-ordered meals and drinks to the correct passenger. The IFE system will prepare the selected movies and audio files. Thales says several technologies are needed to provide this connection, including an NFC reader, bluetooth and a barcode. The first iteration of the technology has recently entered service with Air Caraibes.

Ancillary revenues

Other advances in IFE systems relate to generating ancillary revenues, and collecting passenger data related to IFE utilisation and spending behaviour. Airline apps and IFE systems can now provide in-flight shopping in real time, requiring minimal internal cabin connectivity in the case of wireless IFE systems since passenger selections will be transmitted wirelessly to the IFE server to inform cabin crew. Most airlines are wary of providing in-flight shopping without the ability to conduct real-time credit transactions, due to risk of credit card fraud. This requires the aircraft to have external connectivity, although the bandwidth of L-band systems used for long-range navigation are sufficient.

Hardware vendor IFPL has developed an NFC reader that can be installed in a

The Lufthansa group of airlines has now committed itself to installing a wireless IFE system provided by Lufthansa Systems for its combined fleet of A320 family aircraft.

seatback. This can be used for live credit card transactions or payments with Apple Pay and other NFC payment wallets. The system prevents credit card fraud through off-line payment card industry (PCI) security standards.

Another feature of modern IFE systems is an interactive moving map display that provides detailed information in high resolution. Modern moving map systems provide multiple viewing angles.

A feature of particular interest to airlines is generating revenues from the sale of destination-related products, such as hotel and transport reservations, theatre tickets, excursions and restaurants. Products can be listed in the airline app and IFE system, and via the map display.

Sale of destination-related products will be made in real time, through each vendor's booking engine. This may require an external connectivity link to the ground, where the vendor's booking and reservation system is located.

"A particular attraction of PED-based wireless systems is that, as passengers browse the internet, send e-mails and shop, in-flight data relating to personal information and shopping behaviour can be collected and analysed," says Schreiber. "The quality of data collected this way is superior to that collected by embedded systems."

Live TV

A few airlines are now providing live TV services. This is complicated since it partly depends on the IFE and external connectivity systems' configuration. It also depends on whether the service being provided is broadcast TV, as in domestic residences, or internet protocol TV (IPTV).

Live broadcast TV on board aircraft operating over North America generally only requires two live TV channels. These will usually be news and sports.

Live TV has been relatively easy to provide across North America because Ku-band satellite systems were developed for broadcast TV to domestic residences, and so easily adapted for commercial aircraft. These are the same satcom systems used for internet connectivity.

Some Ku-band services, such as Direct TV, only work with an embedded IFE system. An example of an airline offering live broadcast TV via an embedded IFE system is jetBlue in the US.

Other Ku-band systems can operate with both wireless and embedded systems. Certain Ku-band systems only work with broadcast TV, while others will work with both IPTV and broadcast TV. IPTV, however, requires a higher bandwidth Ku-band system.

While broadcast TV is available to domestic residences, IPTV can only be viewed at specific authorised end points, such as aircraft, ships and hotels. The shows on IPTV are transmitted by a licensee via satellite. An example of this is Southwest Airlines using IPTV provided by GEE via Ku-band satcom.

GEE acquires rights from TV companies to deliver programmes and shows to particular geographic areas and end points. The content is the same as broadcast TV shows, as it is provided by companies such as CNN and BBC, but it is edited by the IPTV providers.

A main issue is satcom connectivity, and the compatibility of the aircraft's satcom antenna, which will only point to one satellite at any time. This may have to be shared with the internet service on an aircraft. This is not an issue for IPTV when flying over the US, since the same Ku-band satellite provides internet connectivity. However, it is an issue over the UK and Europe, for example, since the BBC uses a different satellite to transmit broadcast TV to one that transmits internet connectivity to aircraft. The aircraft therefore needs two satellite antennae: one for the TV; and one for other cabin connectivity.

There are two main Ku-band configurations. One has pinpoint spotbeams which require the TV signal to be delivered to every spotbeam, and therefore duplicated. Wide beam Ku-band satellites cover a wide area, and so deliver IPTV and broadcast TV cheaply to aircraft. Ka-band satellites are spotbeam, so they have the same technical disadvantage of spotbeam Ku-band satellites.

A further issue of live TV is licensing laws. Live TV across large countries, such as the US, causes few problems. It is a complex issue across Europe, however, with a large number of small countries. Viewing a country's TV channels in other countries requires payment of additional licensing fees, making it uneconomic. A large number of live TV channels are also needed for airlines operating across Europe due to the number of languages spoken across the continent.

Streaming content

Another recent feature is streaming of content from ground-based sources. A prime example is movies from Netflix. This requires high bandwidth external connectivity, which may be paid for by the passenger.

All of these new technologies, capabilities and functionalities can be used on embedded and wireless systems. Combined with the capital and operating cost advantages of wireless systems, this means that the market for wireless IFE hardware is promising.

Wireless categories

In addition to wireless systems based on airline- and passenger-owned tablets, there are other categories of wireless IFE systems.

The first of these, and the most basic

in terms of hardware and aircraft infrastructure, is standalone IFE systems. These are based on airline-owned tablets, pre-programmed with audio and visual content. The content is not streamed, so the system neither requires a server that holds content, or WAPs in the cabin.

The system does, however, require the airline to invest in enough tablets to satisfy demand. Investment in hundreds, or probably thousands of devices is needed, all of which must have content loaded on them. The airline also needs to have storage and re-charging carts on board the aircraft. Tablets will have to be re-charged and cleaned between flights, so dual sets are likely to be needed. Airlines also have to consider the possibility of theft by passengers. An example of a standalone IFE system is Bluebox's Ai system, which is used by Hawaiian Airlines.

Standalone systems have the disadvantage of being unable to generate ancillary revenues. The absence of any connectivity also means that passengers are unable to make text calls, send e-mails, or browse the internet and use social media. Surveys indicate this has an increasing influence on airline choice, particularly among younger passengers.

A recent addition to the group of wireless IFE systems is portable hardware, introduced by Lufthansa Systems, Bluebox and Arconics.

Lufthansa Systems is the first vendor to put a portable system into service, with Eurowings in 2016. A portable system has a similar configuration to a wireless system, with the airline having the choice of airline- or passenger-owned tablet devices. The advantage of a portable system is that the server, content management, and WiFi signal transmitter are all in a small box that weighs about 2Kg (4.4lbs). This can be installed quickly in a convenient position, such as an overhead locker or in the galley. The system also has the advantage of not requiring any hardware or infrastructure installation, so it does not require any certification. A portable system can also be linked with an external connectivity system.

Each portable box can serve up to 50 passengers at once. Three units will be needed on an aircraft the size of an A320 or 737-800.

A portable system has the advantage of having the same capacity for content as the server on a wireless IFE system. It can also be used to sell destination-related ancillary products, and provide a latest generation interactive moving map and destination guides.

Portable IFE systems, therefore, have the overall advantage of providing an airline with a quick-to-install, and low initial capital cost system with a high level of functionality and capability.

They can be used to sell most ancillary revenue products, so they will appeal especially to LCCs, charter airlines and short-haul scheduled operators.

Hybrid IFE systems

Availability of high-capacity external connectivity and internal cabin WiFi signals has led to high passenger demand for the same level of connectivity services as received on the ground. More airlines are providing this service.

Airlines initially charged for this service, and still do in certain situations. Availability of connectivity influences passengers choice of airline, and some airlines offer this on a complimentary basis. Other airlines have secured sponsorship for external connectivity or use ancillary revenues to subsidise cost.

The provision of free or low-cost connectivity on board aircraft has therefore led to airlines combining embedded hardware with connectivity for passengers to use for their PEDs. PEDs can be used by passengers at the same time as using the embedded IFE.

The embedded system and seatback screen is used to watch movies or listen to audio content. A passenger can use a PED as a remote device to control the

Wireless IFE systems have been able to stimulate their own market on account of their low capital cost. Wireless systems are being installed on short-haul fleets operated by major and low-cost airlines that previously would not have invested in embedded systems.

embedded system, order meals and drinks, browse the internet, view destination guides and related ancillary products, and shop on-line.

Not only are hybrid systems used in premium cabins with high functionality IFE systems, USB and HDMI ports in economy seats allow another permutation of a hybrid system.

Embedded vs wireless

The issue of embedded versus wireless IFE systems comes down to capital and on-going operating cost, and system functionality and capability.

"The capital costs for system installation of an embedded configuration range from $2 million for standard narrowbodies to $5 million for the largest widebodies," says Foster at Valour Consultancy. "This compares to $150,000 for the hardware of a PED-based wireless system. A further $400,000 would be incurred for an external connectivity system, the satellite antenna alone costing about $150,000. An embedded system with external connectivity for a narrowbody would then have a capital cost of $2.5 million."

Despite on-going operating costs and providing content, the significant difference between the two main choices is capital cost.

The choice for an airline is probably clear, despite the sentiment that wireless systems will take a large share of the market from embedded systems. Passengers in all classes expect an embedded system on long-haul flights, while also using their own devices if the hardware on board allows a hybrid configuration. "It is, therefore, unlikely that airlines operating widebodies in the major long-haul markets will discontinue embedded systems, and instead adopt wireless systems, even in economy classes," says Foster. "A high capability embedded system will be seen by major airlines as a necessity for competitive reasons. Wireless systems are, therefore, unlikely to penetrate this market.

"Conversely, wireless systems are mainly being installed by airlines on aircraft that previously did not have an embedded system because it was prohibitively expensive," continues Foster. "They have therefore, created a market for themselves, rather than being a threat to the main embedded market. There are a few examples of airlines that have replaced embedded systems with wireless ones. A main market for this is widebodies used on short- and medium-haul services."

"Embedded systems have had some unfortunate features in the past," says David Thomas, vice president for business development at IFPL. "IFE systems have to be designed with the integration of aircraft seats in mind. Seats are designed by just two companies, however, so certain compromises may have to be made. An example is putting certain features, such as a USB port, in awkward places.

"The objective in recent years has been to improve the aesthetics of embedded systems, and placing features and ports in accessible and convenient places," continues Thomas. "This applies to all peripherals, including NFC readers, charging ports, and HDMI outlets used by the passenger to move content from the PED to the IFE screen in a hybrid system."

While the ergonomics of IFE systems are important, particularly in economy class, they do not take away the main issue of the higher capital cost of embedded systems. "I expect the selection of wireless systems by airlines to rise, but then see embedded systems make a comeback," says Thomas.

Ancillary revenue generation will have an increasing influence on an airline's decision over system selection. "It is possible to turn an embedded system into a revenue platform, and with an NFC reader the system can generate in-flight shopping," says Thomas. "Virtual reality and augmented reality can now be included with embedded systems, but this is not possible with wireless hardware. At the very least this can be provided to enhance the passenger experience, and may be used to add a further stream of ancillary revenue."

Thomas argues that it will be possible to provide an embedded system at a reduced capital cost over the next four years. The main cost elements are the power cables to the seats, and the processor and screen for each seat. "These main elements are coming down in price. A mini android, which has similar capability to a PED, can be bought for $40-50. This and the main parts of a screen, the power ports, the passenger control unit, and a range of other new technologies coming down the line, will all contribute to reducing the capital cost of an embedded system. I predict that in a few years the hardware of an embedded system, not including any external connectivity hardware, will cost $500 per seat. In addition to this, there will be the cost of integrating the system on the aircraft. This compares to a current cost of $5,000-10,000 per seat. The change that is likely to be seen over the next few years is a reduction in a system's capital cost, and an increase in the ancillary revenue generated. A possible development is that IFE vendors will become service providers, and no longer be hardware providers. Rather than embedded systems getting down to a cost close to wireless systems and splitting the market, this development is most likely to lead to a high portion of airlines choosing to have hybrid systems." AC